NASA Technical Memorandum 100987

Ice/Frost/Debris Assessment For Space Shuttle Mission STS-26R

November 7, 1988

National Aeronautics and
Space Administration

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Gregory N. Katnik
Scott A, Higginbotham
The John F. Kennedy Space Center, NASA

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ICE/FROST/DEBRIS ASSESSMENT
FOR
SPACE SHUTTLE MISSION
STS-26R
SEPTEMBER 29, 1988

Prepared By:

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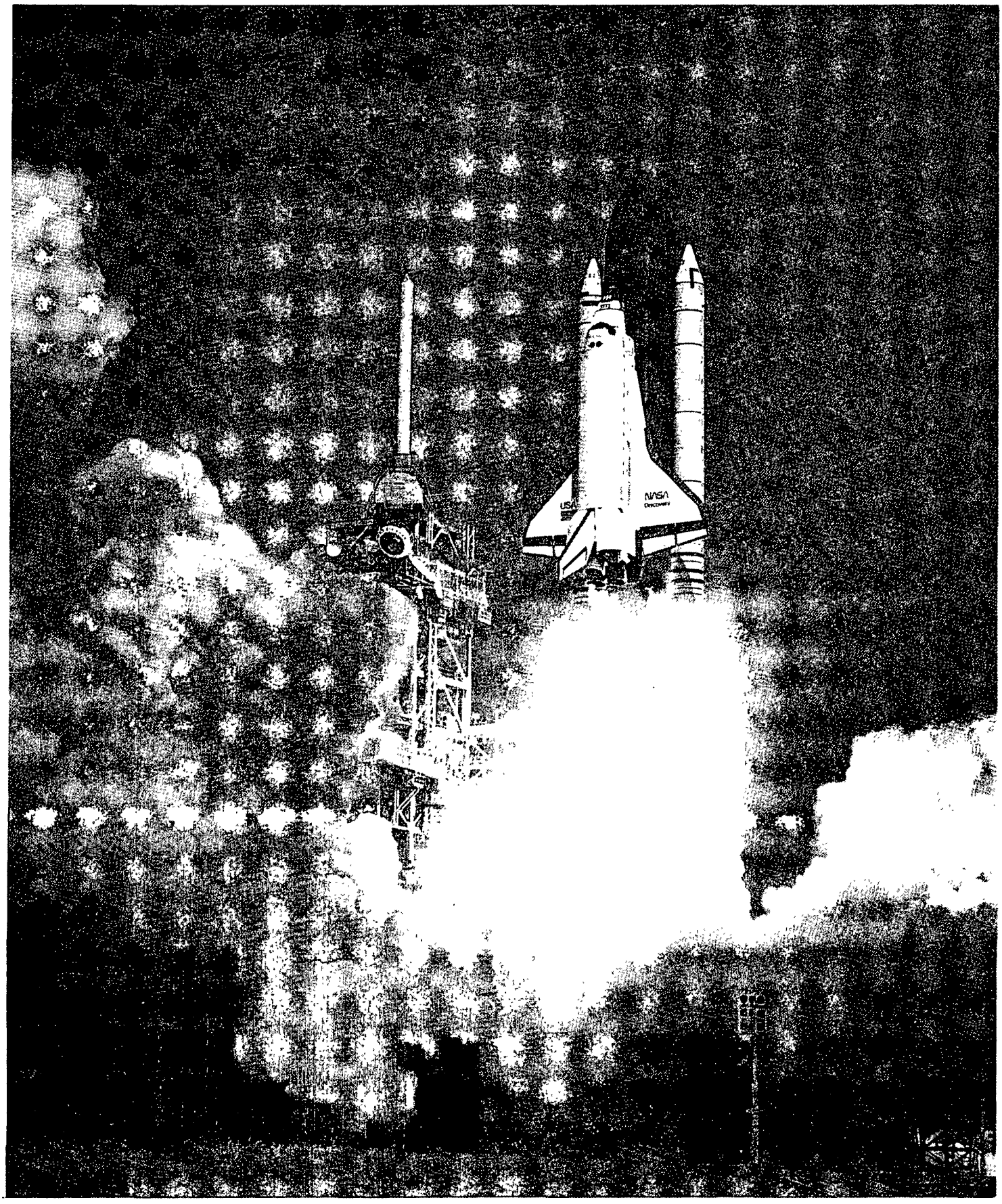
FORWARD

The Debris Team is continuing its effort to develop and implement measures to control damage from debris in the Shuttle operational environment and to make the control measures a part of routine processing and operations.



STS-26R LAUNCH

1.0 KSC ICE/FROST/DEBRIS TEAM ACTIVITIES

Team Composition: NASA KSC, NASA MSFC, NASA JSC, LSOC SPC, RI - DOWNEY, MMMSS, USBI - BPC

Team Activities:

1) Prelaunch Pad Debris Inspection

Objective:	Identify and evaluate potential debris material/sources. Baseline debris and debris sources existing from previous launches.
Areas:	MLP deck, ORB and SRB flame exhaust holes, FSS, Shuttle vehicle external surfaces
Time:	L - 1 day
Requirements:	OMRSD S00U00.030 - An engineering debris inspection team shall inspect the shuttle and launch pad to identify/resolve potential debris sources. The prelaunch vehicle/pad configuration shall be documented/photographed.
Documents:	OMI T6447
Report:	Generate PR's and recommend corrective actions to pad managers.

2) Launch Countdown Firing Room 2

Objective:	Evaluate ice/frost accumulation on the shuttle vehicle and/or any observed debris utilizing OTV cameras.
Areas:	MLP deck, FSS, Shuttle vehicle external surfaces
Time:	T - 6 hours to Launch + 1 hour or propellant drainback
Requirements:	OMRSD S00FB0.005 - Monitor and video tape record ET TPS surfaces during loading through prepressurization. OMRSD S00FC0.021 - Monitor various areas of the ET from start of propellant loading through prepressurization.
Documents:	OMI S0007, OMI S6444
Report:	OIS call to NTD, generate IPR's.

3) Ice/Frost TPS and Debris Inspection

Objective:	Evaluate any ice formation as potential debris material. Identify and evaluate any ORB, ET, or SRB TPS anomaly which may be a debris source or safety of flight concern. Identify and evaluate any other possible facility or vehicle anomaly.
Areas:	MLP deck, FSS, Shuttle vehicle external surfaces
Time:	T - 3 hours (during 2 hour BIH)
Requirements:	OMRSD S00U00.020 - An engineering debris inspection team shall inspect the shuttle for ice/frost, TPS, and debris anomalies after cryo propellant loading. Evaluate, document, and photograph all anomalies. During shuttle walkdown inspect orbiter aft engine compartment (externally) for water condensation and/or ice formation in or between aft compartment tiles An IR scan is required during the shuttle inspection to verify ET surface temperatures. During shuttle walkdown, inspect ET TPS areas which cannot be observed by the OTV system.
Documents:	OMI S0007, OMI S6444
Report:	Briefing to NTD, Launch Director, Shuttle management; generate IPR's.

4) Post Launch Pad Debris Inspection

Objectives:	Locate and identify debris that could have damaged the Shuttle vehicle during launch.
Areas:	MLP deck, flame exhaust holes and trenches, FSS, pad surfaces and slopes, extension of trenches to perimeter fence, walkdown of the beach from Playlinda to Complex 40, aerial overview of inaccessible areas.
Time:	Launch + 3 hours (after pad safing, before washdown)
Requirements:	OMRSD S00U00.010 - An engineering debris inspection team shall perform a post launch pad/area inspection to identify any lost flight or ground systems hardware

	and resultant debris sources. The post launch pad/area configuration shall be documented/photographed.
Documents:	OMI S0007, OMI S2005
Report:	Verbal briefing to LTD; generate PR's.

5) Launch Data Review

Objective:	Detailed review of high speed films video tapes, and photographs from pad cameras and range trackers to determine possible launch damage to the flight vehicle. Identify debris and debris sources.
Time:	Launch + 1 day to Launch + 6 days
Requirements:	OMRSD S00U00.011 - An engineering film review and analysis shall be performed on all engineering launch film as soon as possible to identify any debris damage to the space shuttle vehicle. Identify flight vehicle or ground system damage that could affect orbiter flight operations or future SSV launches.
Report:	Results submitted to Intercenter Engineering Photo Analysis Committee; generate PR's.

6) SRB Post Flight/Retrieval Inspection

Objective:	Evaluate potential SRB debris sources. Data will be correlated with observed Orbiter post landing TPS damage.
Areas:	SRB external surfaces (Hangar AF, CCAFS)
Time:	Launch + 24 hours (after on-dock, before hydrolasing)
Requirements:	OMRSD S00U00.013 - An engineering debris damage inspection team shall perform a post retrieval inspection of the SRB's to identify any damage caused by launch debris. Any anomalies must be documented/ photographed and coordinated with the results of the post launch shuttle/pad area debris inspection.
Documents:	OMI B8001
Report:	Generate PR's.

7) Orbiter Post Landing Debris Damage Assessment

Objective:	Identify and evaluate areas of damage to Orbiter TPS due to debris and correlate, if possible, source and time of occurrence. Additionally, the runway is inspected for debris and sources of debris.
Areas:	Orbiter TPS surfaces, runway
Time:	After vehicle safing on runway, before towing
Requirements:	OMRSD S00U00.040 - An engineering debris inspection team shall perform a prelanding runway inspection to identify, document, and collect debris that could result in orbiter damage. Runway debris and any facility anomalies which cannot be removed/corrected shall be documented/photographed.
Requirements:	OMRSD S00U00.050 - An engineering debris inspection team shall perform a post landing runway inspection to identify and resolve potential debris sources that may have caused vehicle damage but was not present or was not identified during pre-launch runway inspection. Obtain photographic documentation or any debris, debris sources, or flight hardware that may have been lost on landing.
Requirements:	OMRSD S00U00.060 - An engineering debris inspection team shall map, document, and photograph debris-related Orbiter TPS damage and debris sources.
Requirements:	OMRSD S00U00.012 - An engineering debris damage inspection team shall perform a post landing inspection of the orbiter vehicle to identify any damage caused by launch debris. Any anomalies must be documented/ photographed and coordinated with the results of the post launch shuttle/pad area debris inspection.
Requirements:	OMRSD V09AJ0.095 - An engineering debris inspection team shall perform temperature measurements of RCC Nose Cap and RCC RH Wing Leading Edge Panels 9 and 17.
Documents:	OMI S0026, OMI S0027, OMI S0028

Report: Briefing to NASA Convoy Commander and generate PR's.

8) Level II report

Objective: Compile and correlate data from all inspections and analyses. Results of the debris assessment, along with recommendations for corrective actions, are presented directly to Level II via SIR and PRCB. Paper copy of complete report follows in 3 - 4 weeks. (Ref NASA Technical Memorandum series).

2.0 WET COUNTDOWN DEMONSTRATION TEST (WCDDT) SCRUB - LH2 Leak, LOX Pump Problems

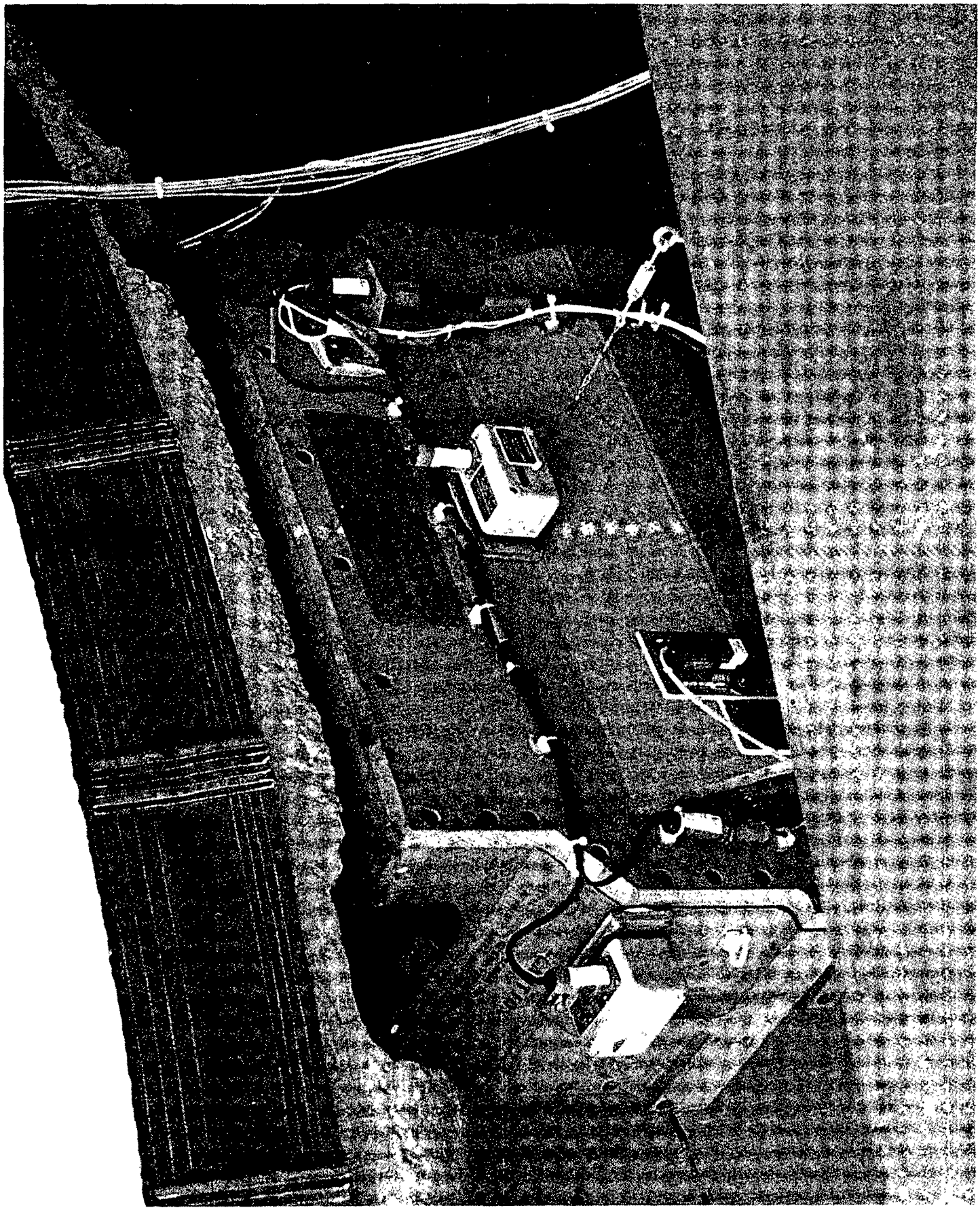
2.1 PRE-TANKING SSV/PAD DEBRIS INSPECTION

A pre-tanking inspection of the pad and Shuttle vehicle was conducted on July 27, 1988. The detailed walkdown of Launch Pad 39B and MLP-2 also included the flight elements OV-103 Discovery, ET-28 (LWT-21), and BIO-29. Documentary photographs were taken of facility anomalies, potential sources of vehicle damaging debris, and new vehicle/pad configurations.

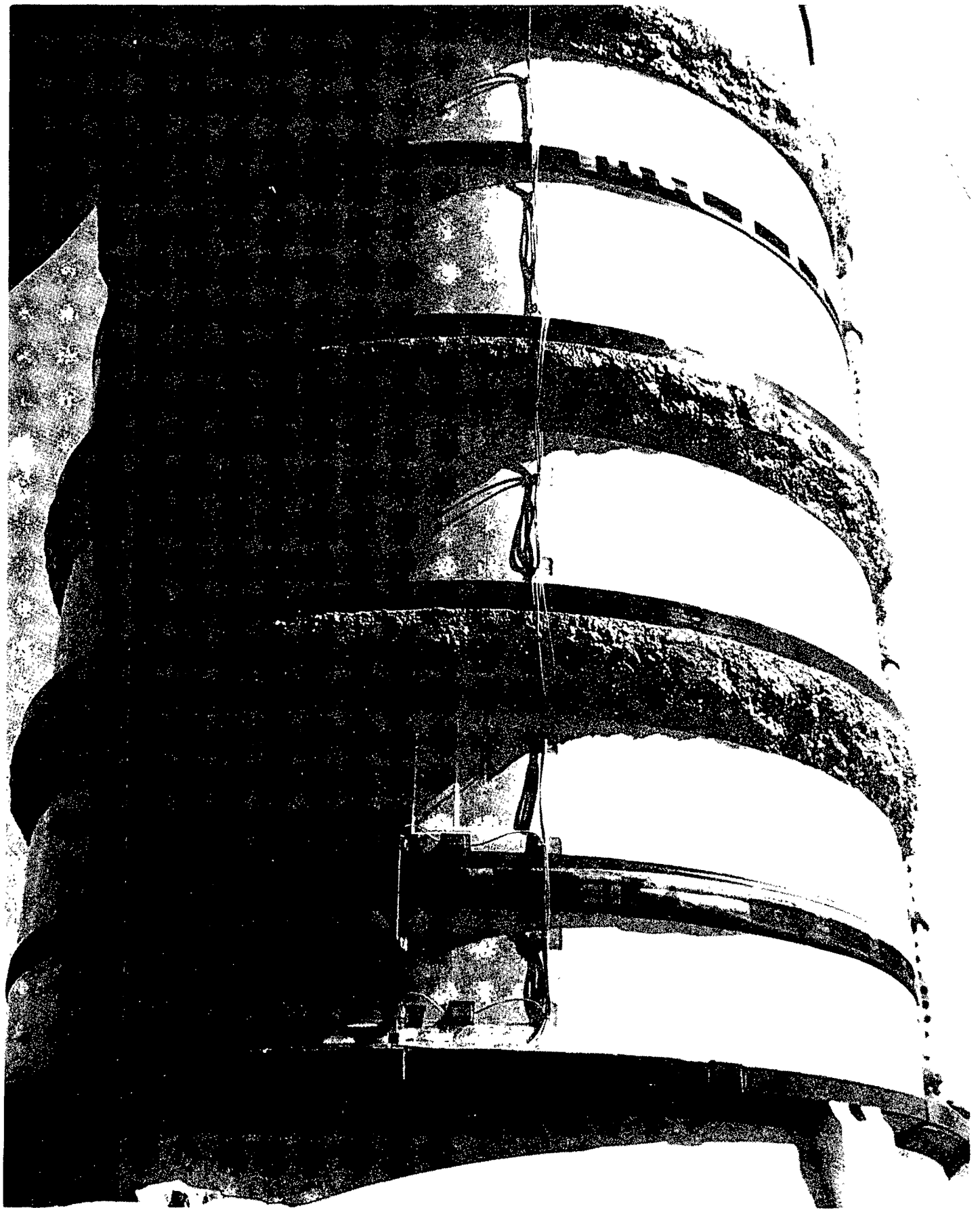
Although the WCDDT requirement for pad/MLP cleanliness is not as tight as the launch requirement, the overall cleanliness of the pad was considered good.

The most notable vehicle configuration changes were the addition of SRB joint heater umbilicals, DFI on the booster cases with associated cork closeouts, and redesigned HDP debris containers. Only one vehicle configuration anomaly was observed during this inspection. Orbiter baggie material separated from the LO2 umbilical at a section along the upper forward side.

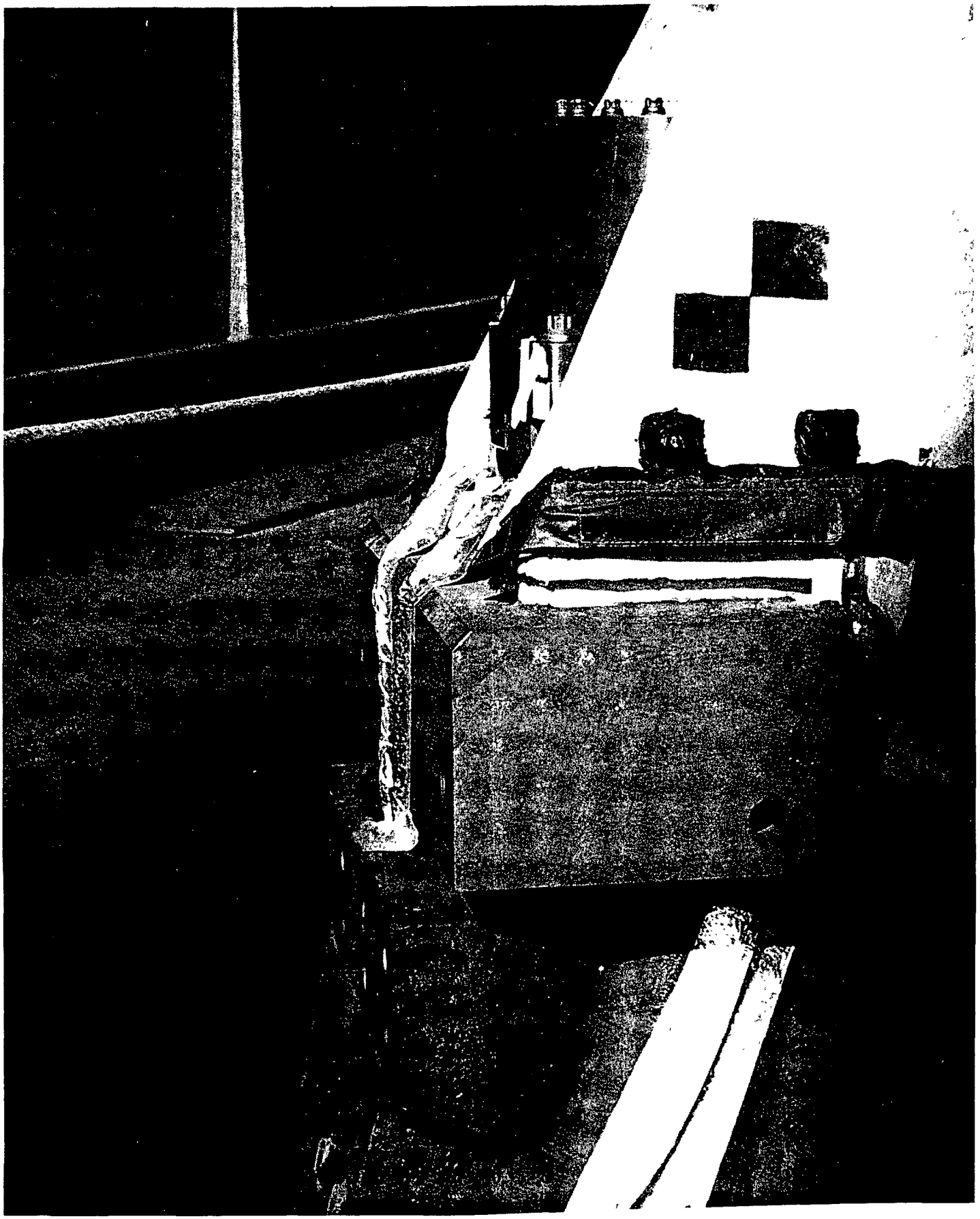
The facility was significantly modified with the addition of the Orbiter Weather Protection System, which consists of a +Y door attached to and retracted with the RSS and a -Y door anchored to the FSS. However, the system eliminates the use of the bi-fold ET doors and the RSS roof seals due to the updated RI vehicle excursion model.



SRB JOINT HEATER UMBILICAL. RED CLAMP AND INSTRUMENTATION CABLES ARE FOR FRF ONLY AND ARE REMOVED BEFORE FLIGHT.



SRB INSTRUMENTATION FOR FRF ONLY. MEASURED JOINT FREE PLAY WAS TWO-THIRDS THAT OF PRE-26R JOINT.



REDESIGNED HOLDDOWN POST DEBRIS CONTAINER AND CHAMFER ON HOLDDOWN POST SHOE FOR PYRO CABLES.

2.2 ICE/FROST INSPECTION

Problems with the LOX pumps and a LH2 leak scrubbed the WCDDT with only 7% of cryogenic propellants on board. No ice/frost inspection was conducted. However, the Ice Prediction computer program was run from 2130 to 0130 hours and the results are tabulated in Figure 1.

The WCDDT Scrub summary of ice/frost console observation anomalies consists of one OTV observation and two post drain inspection findings.

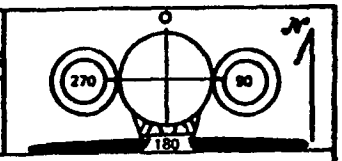
Anomaly 001 documented vapors from the LOX feedline bellows at Station XT-1980. This item was investigated by IPR 26RV-0689 and was no constraint to tanking. Subsequent borescope inspection and helium purge mass spectrometer tests revealed no leak. Vapors were caused by cold air emanating from uninsulated LO2 feedline bellows during cryogenic loading.

A crack in the ablator on the aft side of the LH2 feedline bellows was discovered during the post drain inspection and was documented in Anomaly 002. This item was evaluated in IPR 26RV-0700 and found to be exposed GX6300 adhesive bondlines.

A foam repair on the LH2 aft dome apex exhibited a broken bond line and was protruding above the adjacent surface (Anomaly 003). This area of foam was removed and repaired with PDL per PR ET-28-TS-0205.

STS- 26R	TEST: WCDDT (Scrub - LH2 Leak, LOX Pumps)	DATE: 7/28/88	T-0 TIME: 0700 DATE: 7/28/88

ORBITER	ET	SRB	MLP	PAD	LO_2	LH_2
OV-103	28 LWT-21	BI029	2	39-B	CHILLDOWN TIME: FAST FILL TIME: SLOW FILL TIME: REPLENISH TIME:	CHILLDOWN TIME: FAST FILL TIME: SLOW FILL TIME: REPLENISH TIME:



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL. HUM. %	DEW PT °F	WIND VEL. KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
2132	81.2	92	78.8	5	105	II	2.95	72.1	+.0032	-.1850	II	2.95	66.7	+.0052	-.1532	II	2.75	64.9	.0054	-.1377	II	6.10	71.5	+.0063	-.2913
2147	81.1	93	79.0	5	99	II	2.95	72.2	+.0033	-.1858	II	2.95	66.8	+.0052	-.1539	II	2.75	65.0	.0055	-.1383	II	6.10	71.6	+.0065	-.2927
2200	80.9	92	78.5	4.5	114	II	2.65	71.2	+.0032	-.1687	II	2.65	65.4	+.0050	-.1373	II	1.44	59.0	.0046	-.1148	II	6.26	71.3	+.0063	-.2946
2215	80.8	94	79.0	5	111	II	2.95	72.1	+.0034	-.1851	II	2.95	66.7	+.0053	-.1532	II	2.75	64.9	.0056	-.1377	II	6.10	71.5	+.0065	-.2918
2231	80.8	95	79.4	5	111	II	2.95	72.3	+.0034	-.1866	II	2.95	66.9	+.0054	-.1546	II	2.75	65.1	.0056	-.1390	II	6.10	71.8	+.0066	-.2944
2245	80.8	95	79.3	5	108.5	II	2.95	72.3	+.0034	-.1866	II	2.95	66.9	+.0054	-.1546	II	2.75	65.1	.0056	-.1390	II	6.10	71.8	+.0066	-.2944
2300	80.5	95	79.0	5	117	II	2.95	72.0	+.0034	-.1844	II	2.95	66.6	+.0053	-.1525	II	1.60	59.1	.0047	-.1155	II	6.95	72.2	+.0067	-.3288
2315	79.6	96	78.4	5	139.5	II	2.95	71.2	+.0034	-.1793	II	2.95	65.7	+.0053	-.1476	II	1.60	58.1	.0047	-.1105	II	6.95	71.5	+.0068	-.3199
2330	79.5	96	78.3	5	143	II	2.95	71.0	+.0034	-.1786	II	2.95	65.6	+.0053	-.1469	II	1.60	58.0	.0047	-.1098	II	6.95	71.3	+.0068	-.3186
2345	79.5	96	78.3	5	147.5	II	2.95	71.0	+.0034	-.1786	II	2.95	65.6	+.0053	-.1469	II	1.60	58.0	.0047	-.1098	II	6.95	71.3	+.0068	-.3186
0000	79.3	96	78.1	5	143	II	2.95	70.8	+.0034	-.1772	II	2.95	65.3	+.0053	-.1455	II	1.60	57.7	.0047	-.1085	II	6.95	71.1	+.0067	-.3160
0015	79.2	96	78.0	5	140	II	2.95	70.7	+.0034	-.1765	II	2.95	65.2	+.0053	-.1448	II	1.60	57.6	.0047	-.1078	II	6.95	71.0	+.0067	-.3147
0030	79.4	96	78.2	5	145	II	2.95	70.9	+.0034	-.1779	II	2.95	65.4	+.0053	-.1462	II	1.60	57.9	.0047	-.1092	II	6.95	71.2	+.0068	-.3173
0045	79.1	96	77.9	4	150.5	II	2.36	69.3	+.0033	-.148	II	2.36	62.9	+.0049	-.1171	II	1.28	57.5	.0046	-.1071	II	5.56	69.4	+.0065	-.2536
0100	79.2	96	78.0	5	143	II	2.95	70.7	+.0034	-.1765	II	2.95	65.2	+.0053	-.1448	II	1.60	57.6	.0047	-.1078	II	6.95	71.0	+.0067	-.3147

EGG/V-340

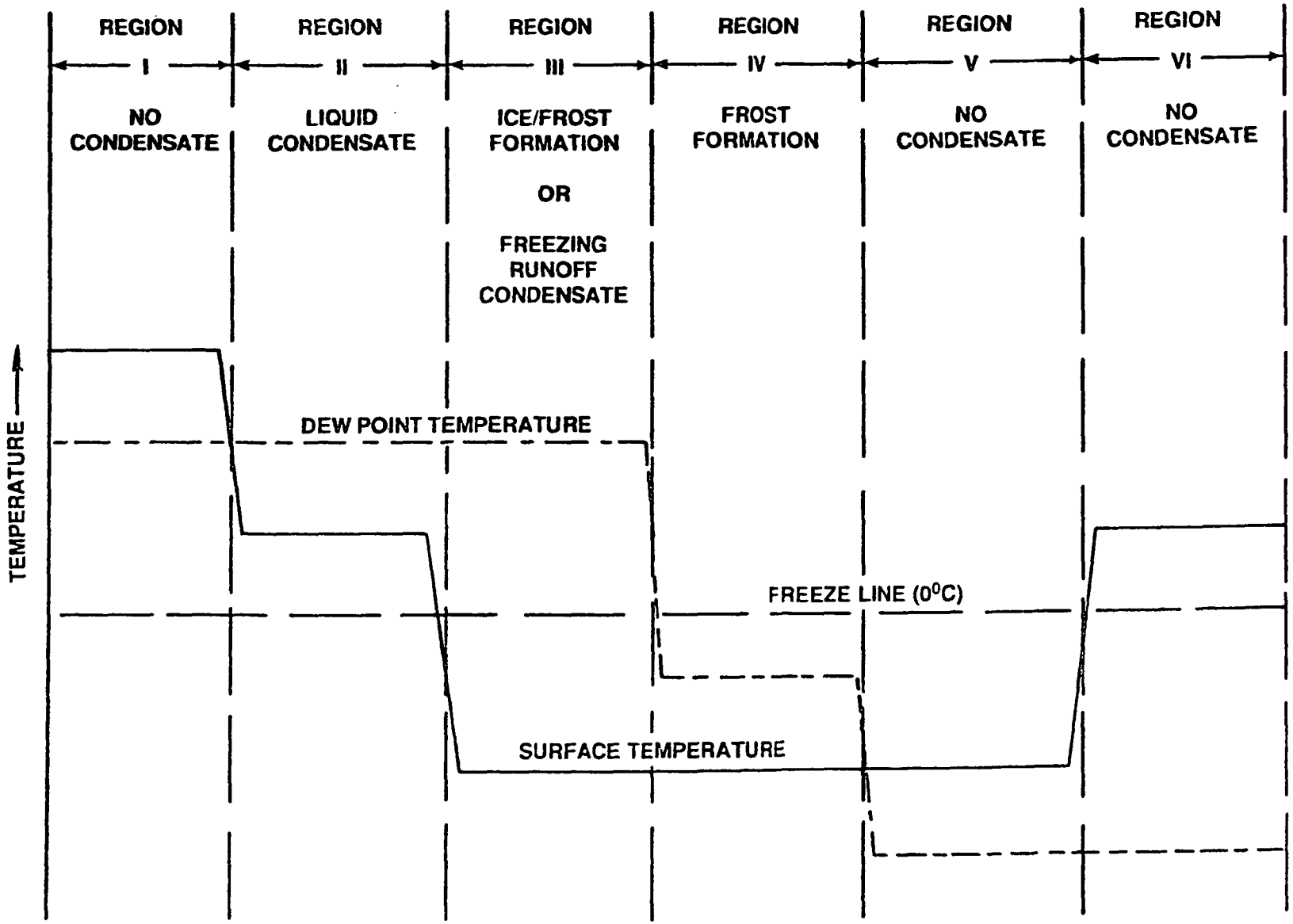
Figure 1. ET TPS Predicted Surface Temperatures and Ice/Condensate

STS – 26R	TEST: WCDDT (Scrub - LH2 Leak, LOX Pumps)															DATE: 7/28/88			T–0 TIME: 0700 DATE 7/28/88					
ORBITER	ET	SRB	MLP	PAD	LO_2 CHILLDOWN TIME:		FAST FILL TIME:			LH_2 CHILLDOWN TIME:		FAST FILL TIME:												
OV– 103	28	BI029	2	39-B	SLOW FILL TIME:		REPLENISH TIME:			SLOW FILL TIME:		REPLENISH TIME:												
LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM %	DEW PT °F	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
0130	79.2	97	78.3	4	143	II	2.36	69.7	+.0033	-.1498	II	2.36	63.3	+.0050	-.1189	II	1.28	57.8	+.0047	-.1089	II	5.56	69.8	+.0066	-.2569
Average	80.0	95.1	78.5	4.84	128.7			71.2					65.6					60.2					71.2		

EGG/V-340

Figure 1. ET TPS Surface Temperatures and Predicted Ice/Condensate

POSSIBLE ENVIRONMENTAL CONDITIONS



2.3 POST-DRAIN INSPECTION

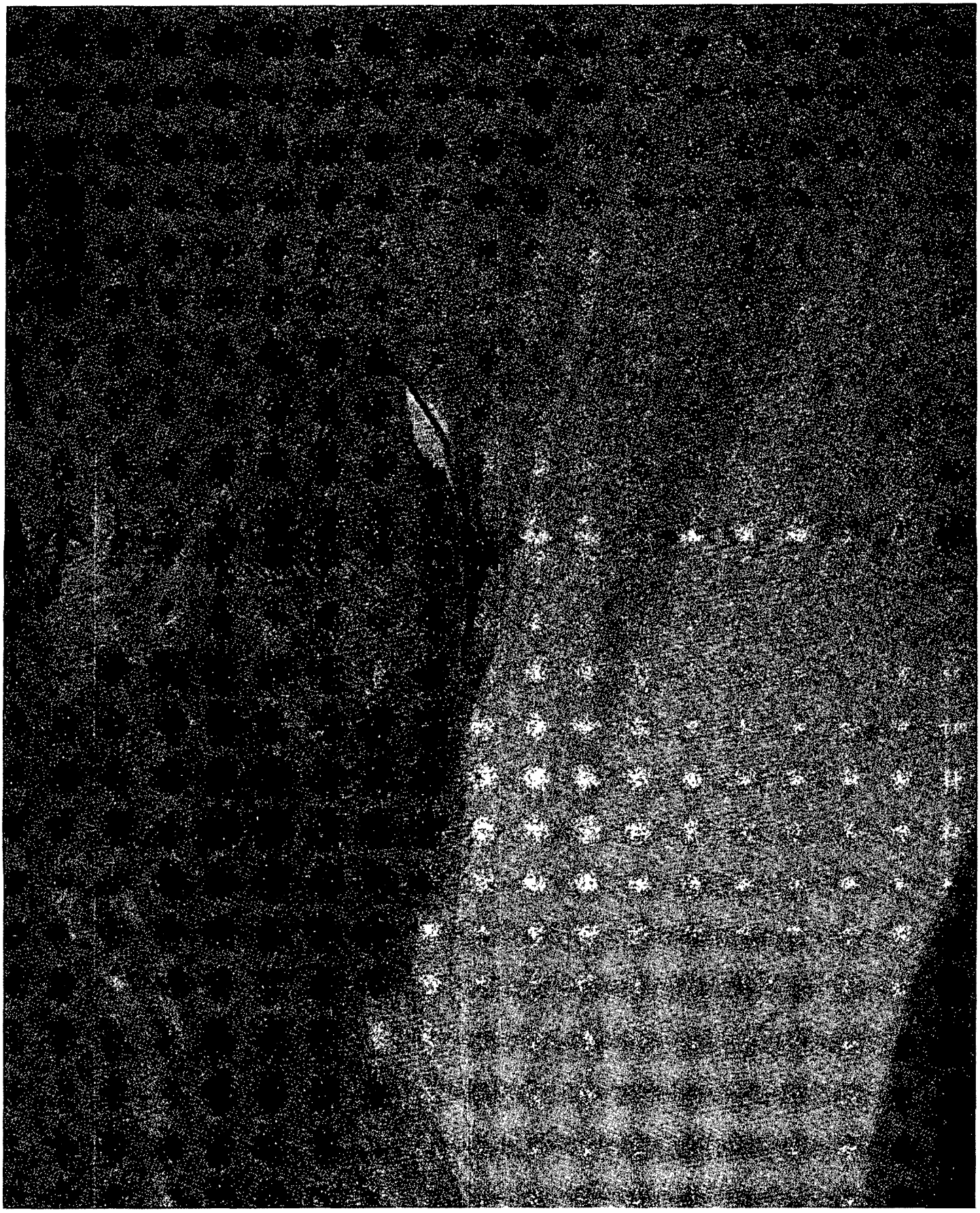
The WCDDT was scrubbed due to an LH2 leak and LOX pump failures. The LH2 tank was filled approximately to the 7 percent level. Filling of the LO2 tank beyond the 0 percent level was not achieved. A post-drain inspection of the vehicle and pad was performed on 28 July 1988.

Some ice, in expected amounts, remained on the ET/ORB umbilical and purge vents, feedline bellows, and recirculation line bellows.

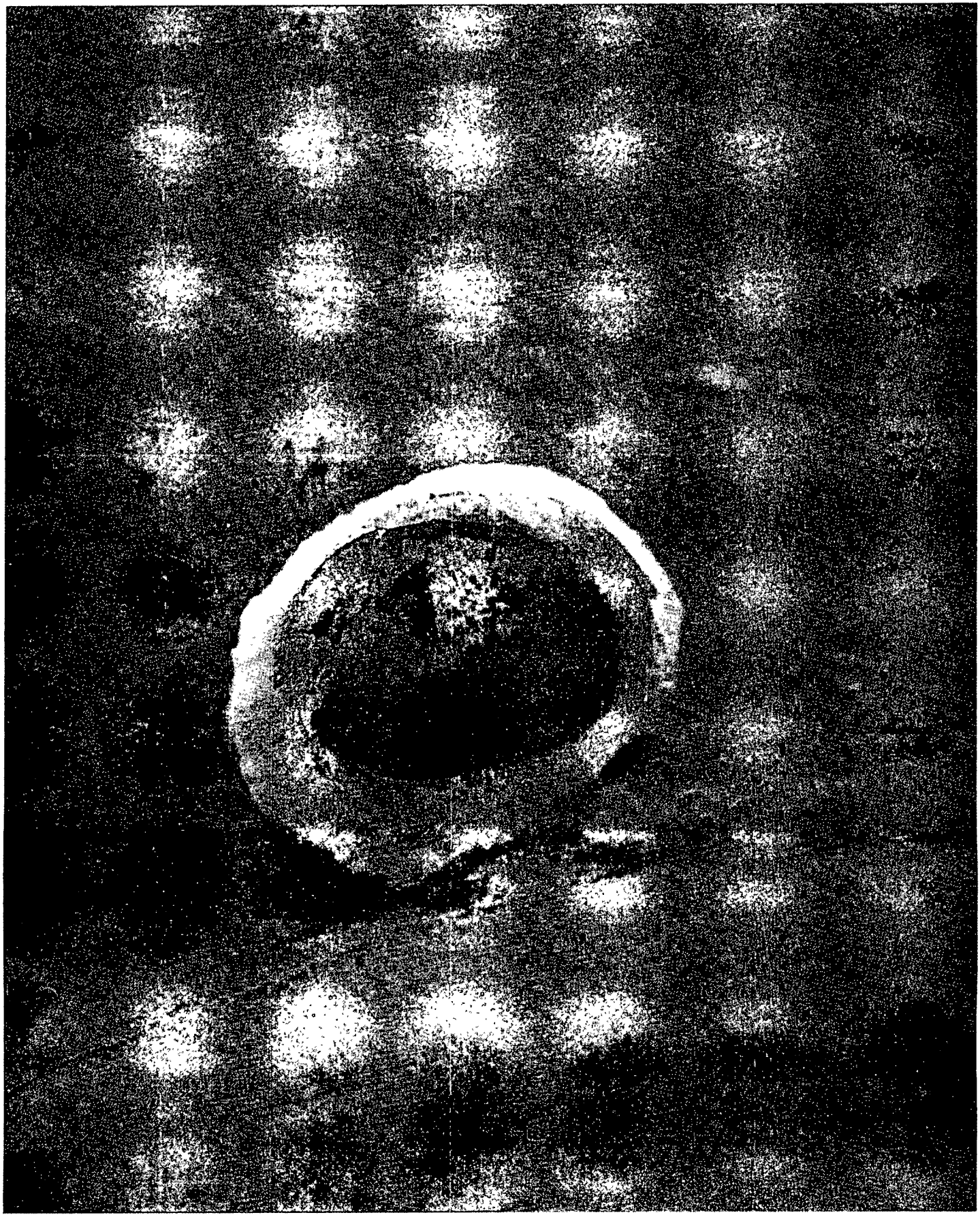
A crack was suspected in the SLA on the LH2 feedline bellows. A hands-on evaluation revealed instead an exposed GX6300 adhesive bondline.

A previous PDL foam repair on the ET LH2 aft dome apex area had a broken bondline for approximately 40 percent of the circumference and the PDL foam was protruding above the adjacent foam about 1/8 inch. An air pocket was the cause of the debond. This area of damaged foam was repaired.

Overall, the External Tank sustained minimal damage and is ready to support another cryo loading.



ET LH2 TANK AFT DOME APEX DIVOT



ET LH2 TANK AFT DOME APEX DIVOT TRIMMED FOR PDL REPAIR

3.0 WET COUNTDOWN DEMONSTRATION TEST (WCDDT)

3.1 PRE-TANKING SSV/PAD DEBRIS INSPECTION

Since the pad was opened for localized controlled work only and the cleanliness of the MLP was maintained, the pre-tanking debris inspection of the pad/MLP and Shuttle vehicle was combined with the ET post drain inspection on 30 July 1988. The vehicle was ready to support another cryo loading/WCDDT.

3.2 ICE/FROST INSPECTION

The Ice/Frost Inspection was performed on 1 August 1988 from 0230 to 0420 hours during the two hour built-in-hold at T-3 hours in the countdown.

Condensate was present on all acreage areas of the tank and dripped steadily from the aft dome. A frost line had formed on another LH2 aft dome apex foam repair. The lower EB fittings were covered with ice/frost out to the strut pin hole while condensate dripped from the outboard section of the fitting. The struts were dry.

Ice/frost was present in all of the LO2 feedline bellows and behind virtually all of the support brackets. A frost ball one inch in diameter had formed on the underside of the +Y ET/SRB cable tray. The LO2 ET/ORB umbilical was generally free of ice except for frost fingers on the purge vents. Ice/frost had accumulated in the LH2 ET/ORB umbilical feedline and recirc line bellows, cavities, purge vents, and on the upper outboard corner of the baggie.

The modifications to the GH2 vent arm worked properly preventing ice/frost build-up on the line. The GUCP was clean. Light frost had formed on the LOX barrel section at the intertank flange.

The wind was generally calm and the GOX cloud drifted downward from the GOX vent ducts but did not envelope the vehicle. The GOX seals were positioned high on the nosecone footprint. The TSM T-0 umbilicals showed no sign of leaks and no facility anomalies were observed.

The Orbiter exhibited no tile problems though two carrier panels on the base heat shield (SSME #1 6 o'clock and SSME #2 2 o'clock) were not installed to allow for later instrumentation work. Frost had formed on the engine mounted heat shield interface at SSME #1 5-7 o'clock and SSME #2 2-4 o'clock.

There were no SRB anomalies.

The Ice Prediction computer program was run from 2130 to 0745 hours and the results tabulated in Figure 2. The program predicted condensate on all TPS acreage.

New infrared sensors were being tested/certified during the WCDDT and FRF. The Wahl Heat Spy, formerly carried by the Ice Team, was replaced with a Mikron 44 Infrared Thermometer to provide spot measurements of vehicle surface temperatures. The Inframetrics Model 600 scanner is the heart of a new Shuttle Thermal Imager (STI) system with the capability to provide surface temperature measurements as well as a variety of thermodynamic functions/processes. The system incorporates two permanent locations at Camera Site #2 and the RSS roof, which are remotely controlled from consoles in Firing Room #2, and a portable unit carried by the Ice Team. Some minor problems with the new systems were encountered and resolved.

An Inframetrics Model 600 scanner was used to image the -Z side of the vehicle and satisfy OMRSD S00J00.126. The results are presented in Figure 3. Temperatures recorded on the SRB frustums and ET ogive are affected somewhat by the increased angle between the imaged surface and the IR scanner location.

The WCDDT summary of ice/frost console observation anomalies includes one ice inspection finding and one post drain finding. Anomaly sequential numbering continues from the initial tanking test.

Anomaly 004 documented a leak from the -Y GOX vent seal. CMEC took a PR to remove and replace the seal.

A frost line on an LH2 aft dome apex foam repair was observed during the ice inspection (Anomaly 005) and accepted per the criteria in NSTS-08303.

Anomaly 006 documented vapors from the LO2 feedline bellows at Station XT-1129 and 1980. The vapor is caused by convective cooled air moving across a cold uninsulated surface and is an explained/predicted condition.

Ice/Frost formation on the ET/ORB LO2 and LH2 umbilical baggies, LH2 feedline and recirculation line bellows, and umbilical purge vents is acceptable per the ice/debris criteria (Anomaly 007).

Vapors emanating from cable tray support area Station XT 1151 are recorded in Anomaly 008. Post drain inspection revealed no damage

Anomaly 009 documented a crack in the foam at the thrust strut to longeron interface, both +Y and -Y sides, during the post drain inspection. This condition was acceptable per NSTS-08303.

STS- 26R	TEST: WCDDT							DATE: 7/31/88	T-0 TIME: 0700 DATE: 8/1/88	
ORBITER: OV- 103	ET: 28	SRB: BI029	MLP: 2	PAD: 39-B	LO_2 CHILLDOWN TIME: SLOW FILL TIME: 22:27	FAST FILL TIME: 22:39 REPLENISH TIME: 01:36	LH_2 CHILLDOWN TIME: SLOW FILL TIME: 23:10	FAST FILL TIME: 00:04 REPLENISH TIME:		

LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
2130	80.7	84	75.7	5	149	II	2.95	69.6	+.0027	-.1695	II	2.95	64.1	+.0045	-.1384	II	1.60	57.2	+.0041	-.1043	II	6.95	69.7	+.0054	-.2995
2145	80.4	85	75.7	3	155	II	1.77	66.7	+.0025	-.1343	II	1.77	58.9	+.0039	-.1094	II	0.96	57.0	+.0042	-.1035	II	4.17	66.0	+.0053	-.1838
2200	80.4	85	75.7	4	156	II	2.36	68.3	+.0027	-.1426	II	2.36	61.9	+.0043	-.1121	II	1.28	57.0	+.0042	-.1035	II	5.56	68.2	+.0055	-.2417
2215	80.5	86	76.2	4	159	II	2.36	68.7	+.0027	-.1444	II	2.36	62.2	+.0044	-.1138	II	1.68	57.3	+.0042	-.1053	II	1.52	57.3	+.0042	-.1053
2230	80.5	84	75.5	3	160	II	1.77	66.6	+.0025	-.1338	II	1.77	58.8	+.0039	-.1089	II	1.26	56.9	+.0041	-.1030	II	1.14	56.9	+.0041	-.1030
2245	80.4	85	75.7	3	157	II	1.77	66.7	+.0025	-.1343	II	1.77	58.9	+.0039	-.1094	II	0.96	57.0	+.0042	-.1035	II	4.17	66.0	+.0053	-.1838
2300	80.4	85	75.7	6	159	II	3.54	70.4	+.0028	-.1948	II	3.54	65.6	+.0047	-.1631	II	2.52	61.3	+.0047	-.1132	II	3.28	60.2	+.0046	-.1035
2315	80.7	86	76.4	5	165	II	2.95	70.1	+.0028	-.1725	II	2.95	64.6	+.0047	-.1412	II	2.10	59.9	+.0046	-.1066	II	1.90	58.8	+.0044	-.1066
2330	80.8	86	76.5	7	166	II	4.13	71.8	+.0029	-.2257	II	4.13	67.5	+.0050	-.1933	II	2.94	63.6	+.0050	-.1355	II	2.66	62.6	+.0049	-.1231
2345	81.2	87	77.2	9	166	II	5.31	73.4	+.0030	-.2837	II	5.31	70.0	+.0053	-.2500	II	3.78	66.6	+.0054	-.1771	II	3.42	65.8	+.0053	-.1611
2400	81.3	85	76.6	7	165	II	4.13	72.1	+.0028	-.2281	II	4.13	67.8	+.0049	-.1956	II	2.94	63.9	+.0050	-.1374	II	2.66	62.9	+.0049	-.1249
0015	81.2	84	76.2	6	162	II	3.54	71.0	+.0027	-.1992	II	3.54	66.2	+.0047	-.1674	II	2.52	62.0	+.0047	-.1167	II	2.28	60.9	+.0046	-.1076
0030	81.1	84	76.1	4	174	II	2.36	68.9	+.0026	-.1455	II	2.36	62.5	+.0043	-.1149	II	1.68	57.7	+.0042	-.1069	II	1.52	57.7	+.0042	-.1069
0045	81.6	84	76.6	4	157	II	2.36	69.5	+.0026	-.1485	II	2.36	63.1	+.0043	-.1178	II	1.28	58.3	+.0042	-.1102	II	5.56	69.3	+.0054	-.2517
0100	80.4	85	75.7	2	172	II	1.18	65.0	+.0023	-.1343	II	1.18	58.4	+.0039	-.1094	II	0.84	57.0	+.0042	-.1035	II	0.76	57.0	+.0042	-.1035

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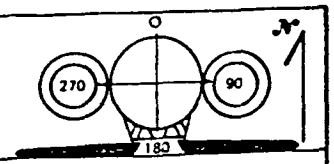
Figure 2. ET TPS Predicted Surface Temperatures and Ice/Condensate

STS - 26R	TEST: WCDDT					DATE 7/31/88	T-0 TIME: 0700 DATE: 8/1/88
ORBITER	ET	SRB	MLP	PAD	LO_2 CHILLDOWN TIME:	FAST FILL TIME: 22:39	LH_2 CHILLDOWN TIME:	FAST FILL TIME: 00:04
OV- 103	28	BI029	2	39-B	SLOW FILL TIME 22:27	REPLENISH TIME: 01:36	SLOW FILL TIME 23:10	REPLENISH TIME:



	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
LOCAL TIME	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL. KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN.HR	ICE RATE IN/HR
0115	80.1	86	75.8	1	158	II	0.59	64.9	+.0024 -.1335		II	0.59	58.2	+.0039	-.1087	II	0.42	56.8	+.0042	-.1027	II	0.38	56.8	+.0042	-.1027
0130	79.6	88	75.9	0	161	II	0.00	64.7	+.0024	-.1326	II	0.00	58.0	+.0040	-.1027	II	0.00	56.6	+.0043	-.1018	II	0.00	56.6	+.0043	-.1018
0145	80.0	87	76.0	0	124	II	0.00	64.9	+.0024	-.1340	II	0.00	58.3	+.0039	-.1091	II	0.00	56.9	+.0042	-.1032	II	0.00	56.9	+.0042	-.1032
0200	79.6	88	75.9	2	70	II	1.18	64.7	+.0024	-.1326	II	1.18	58.0	+.0040	-.1077	II	1.10	56.6	+.0043	-.1018	II	2.44	60.7	+.0048	-.1086
0215	79.2	92	76.8	0	42	II	0.00	64.9	+.0026	-.1345	II	0.00	58.3	+.0041	-.1095	II	0.00	56.9	+.0045	-.1035	II	0.00	56.9	+.0045	-.1035
0230	78.8	92	76.4	0	347	II	0.00	64.4	+.0026	-.1318	II	0.00	57.8	+.0041	-.1069	II	0.00	56.4	+.0044	-.1009	II	0.00	56.4	+.0044	-.1009
0245	79.3	90	76.3	2	331	II	1.18	64.7	+.0025	-.1329	II	1.18	58.0	+.0040	-.1080	II	0.92	56.6	+.0044	-.1020	II	2.46	60.9	+.0050	-.1100
0300	78.3	92	75.9	1	290	II	0.59	63.8	+.0025	-.1286	II	0.59	57.1	+.0041	-.1037	II	0.43	55.7	+.0044	-.0977	II	1.21	55.7	+.0044	-.0977
0315	78.2	93	76.1	0	336	II	0.00	63.9	+.0026	-.1290	II	0.00	57.2	+.0041	-.1041	II	0.00	55.8	+.0044	-.0981	II	0.00	55.8	+.0044	-.0981
0330	78.4	92	76.0	0	11	II	0.00	64.0	+.0025	-.1292	II	0.00	57.3	+.0041	-.1043	II	0.00	55.9	+.0044	-.0983	II	0.00	55.9	+.0044	-.0983
0345	78.1	94	76.3	1	150	II	0.59	64.0	+.0026	-.1294	II	0.59	57.3	+.0042	-.1045	II	0.32	55.9	+.0045	-.0985	II	1.39	55.9	+.0045	-.0985
0400	78.7	93	76.6	2	155	II	1.18	64.5	+.0026	-.1323	II	1.18	57.8	+.0041	-.1073	II	0.64	56.4	+.0045	-.1013	II	2.78	62.1	+.0053	-.1240
0415	78.8	95	77.3	1	147	II	0.59	65.0	+.0027	-.1351	II	0.59	58.3	+.0043	-.1101	II	0.32	56.9	+.0046	-.1041	II	1.39	56.9	+.0046	-.1041
0430	79.0	96	77.8	3	152	II	1.77	67.5	+.0030	-.1375	II	1.77	59.7	+.0045	-.1125	II	0.96	57.4	+.0046	-.1065	II	4.17	67.1	+.0062	-.1918
0445	78.5	96	77.3	2	151	II	1.18	64.8	+.0027	-.1342	II	1.18	58.1	+.0043	-.1093	II	0.64	56.7	+.0043	-.1093	II	2.78	62.6	+.0055	-.1264

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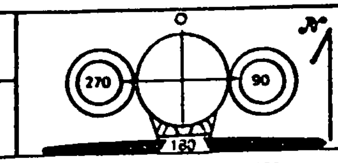
Figure 2. ET TPS Predicted Surface Temperatures and Ice/Condensate

STS-26R	TEST: WCDDT				DATE: 7/31/88	T-0 TIME: 0700 DATE: 8/1/88
ORBITER OV-103	ET 28	SRB BI029	MLP 2	PAD 39B	LO_2 CHILLDOWN TIME: FAST FILL TIME: SLOW FILL TIME: REPLENISH TIME:	LH_2 CHILLDOWN TIME: FAST FILL TIME: SLOW FILL TIME: REPLENISH TIME:



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM %	DEW PT °F	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
0500	78.4	97	77.5	3	153	II	1.77	67.0	+.0030	-.1346	II	1.77	59.1	+.0045	-.1096	II	0.96	56.8	+.0046	-.1035	II	4.17	66.6	+.0062	-.1884
0515	78.6	97	77.7	4	140	II	2.36	69.0	+.0033	-.1461	II	2.36	62.5	+.0050	-.1153	II	1.28	57.0	+.0047	-.1049	II	5.56	69.1	+.0066	-.2504
0530	78.6	97	77.7	3	139	II	1.77	67.2	+.0030	-.1360	II	1.77	59.4	+.0045	-.1109	II	0.96	57.0	+.0045	-.1109	II	4.17	66.8	+.0062	-.1901
0545	78.6	96	77.4	5	130	II	2.95	70.0	+.0034	-.1722	II	2.95	64.5	+.0052	-.1407	II	1.60	56.9	+.0046	-.1038	II	6.95	70.3	+.0067	-.3071
0600	78.8	97	77.9	3	142	II	1.77	67.4	+.0031	-.1373	II	1.77	59.7	+.0045	-.1123	II	0.96	57.3	+.0047	-.1062	II	4.17	67.1	+.0062	-.1918
0615	78.7	96	77.5	3	147	II	1.77	67.1	+.0030	-.1355	II	1.77	57.0	+.0044	-.1105	II	0.96	57.0	+.0046	-.1045	II	4.17	66.7	+.0061	-.1892
0630	78.5	96	77.3	0	149	II	0.0	64.8	+.0027	-.1342	II	0.0	58.1	+.0043	-.1092	II	0.0	56.7	+.0046	-.1032	II	0.0	56.7	+.0046	-.1032
0645	78.5	96	77.3	0	154	II	0.0	64.8	+.0027	-.1342	II	0.0	58.1	+.0043	-.1092	II	0.0	56.7	+.0046	-.1032	II	0.0	56.7	+.0046	-.1032
0700	78.8	97	77.9	1	154	II	0.59	65.3	+.0028	-.1373	II	0.59	58.7	+.0044	-.1123	II	0.32	57.3	+.0047	-.1062	II	1.39	57.3	+.0047	-.1062
0715	79.2	97	78.3	3	168	II	1.77	67.9	+.0031	-.1400	II	1.77	60.2	+.0045	-.1150	II	1.26	57.8	+.0047	-.1089	II	1.14	57.8	+.0047	-.1089
0730	79.7	97	78.8	2	165	II	1.18	66.4	+.0028	-.1434	II	1.18	59.8	+.0044	-.1184	II	0.84	58.4	+.0043	-.1123	II	0.76	58.4	+.0048	-.1123
0745	80.5	92	78.1	4	168	II	2.36	70.1	+.0031	-.1519	II	2.36	63.7	+.0048	-.1209	II	1.68	58.5	+.0046	-.1121	II	1.52	58.5	+.0046	-.1121
Average	79.6	90.6	76.7	2.8	SE	II		66.5			II		60.4			II		57.8			II		61.2		

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Figure 2. ET TPS Predicted Surface Temperatures and Ice/Condensate

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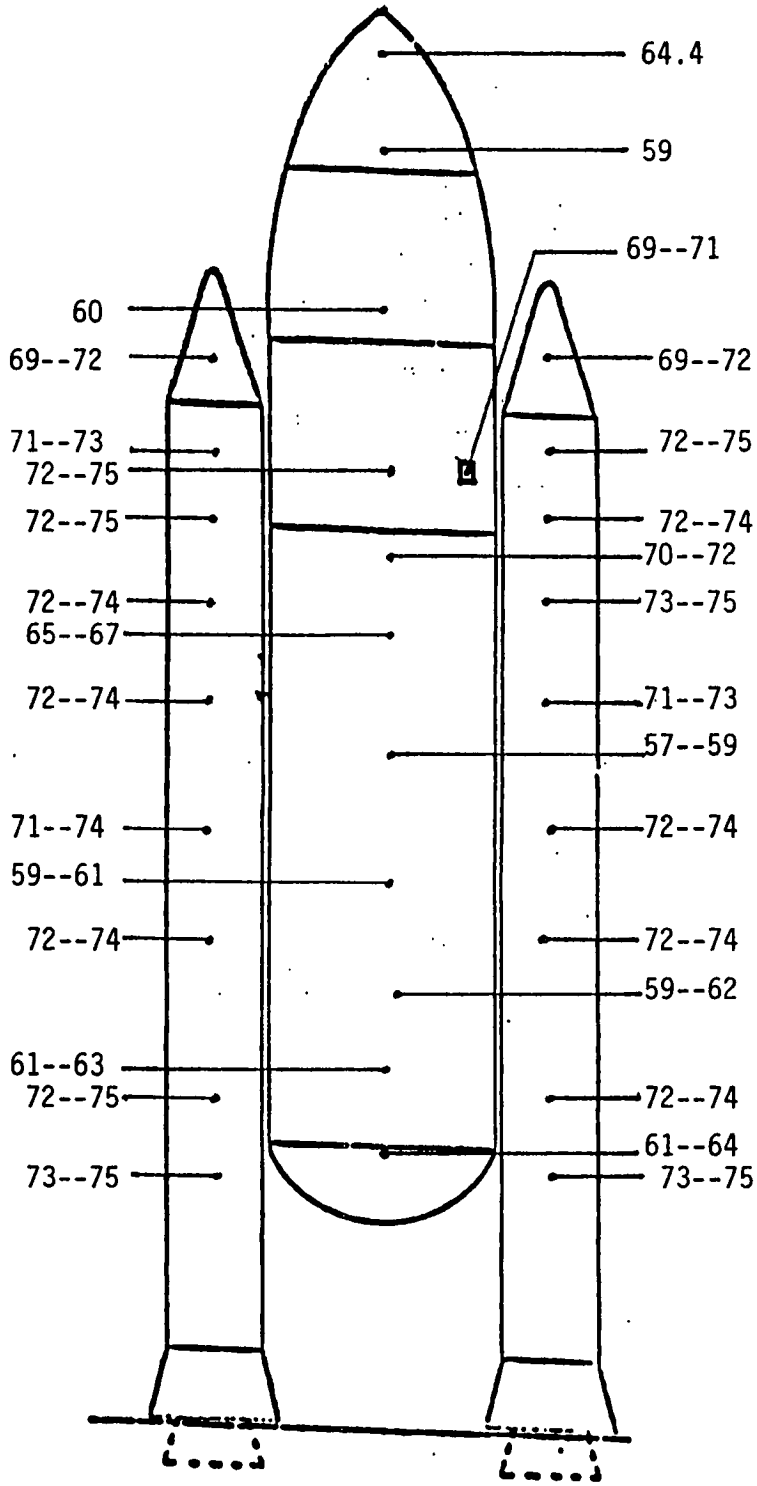
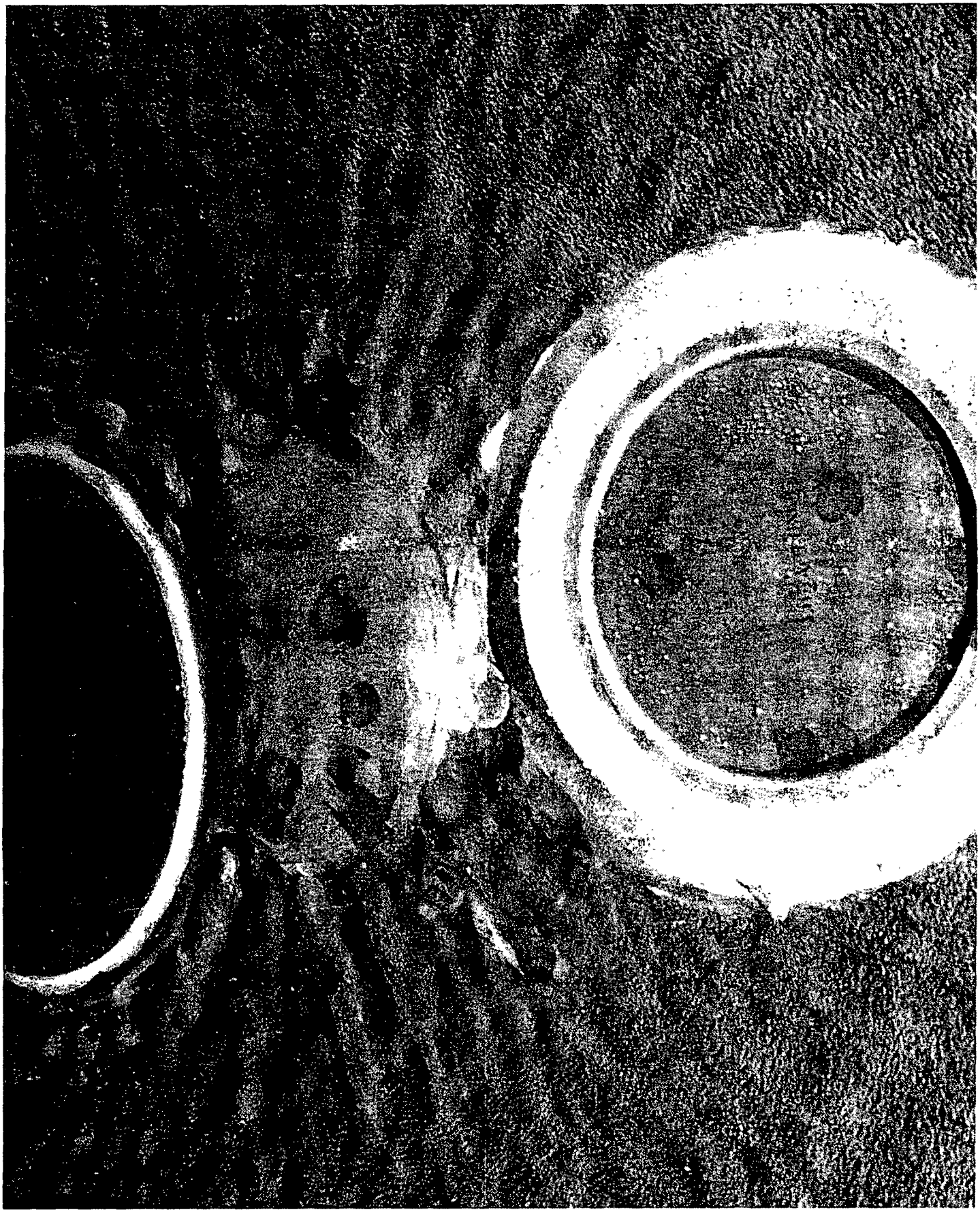


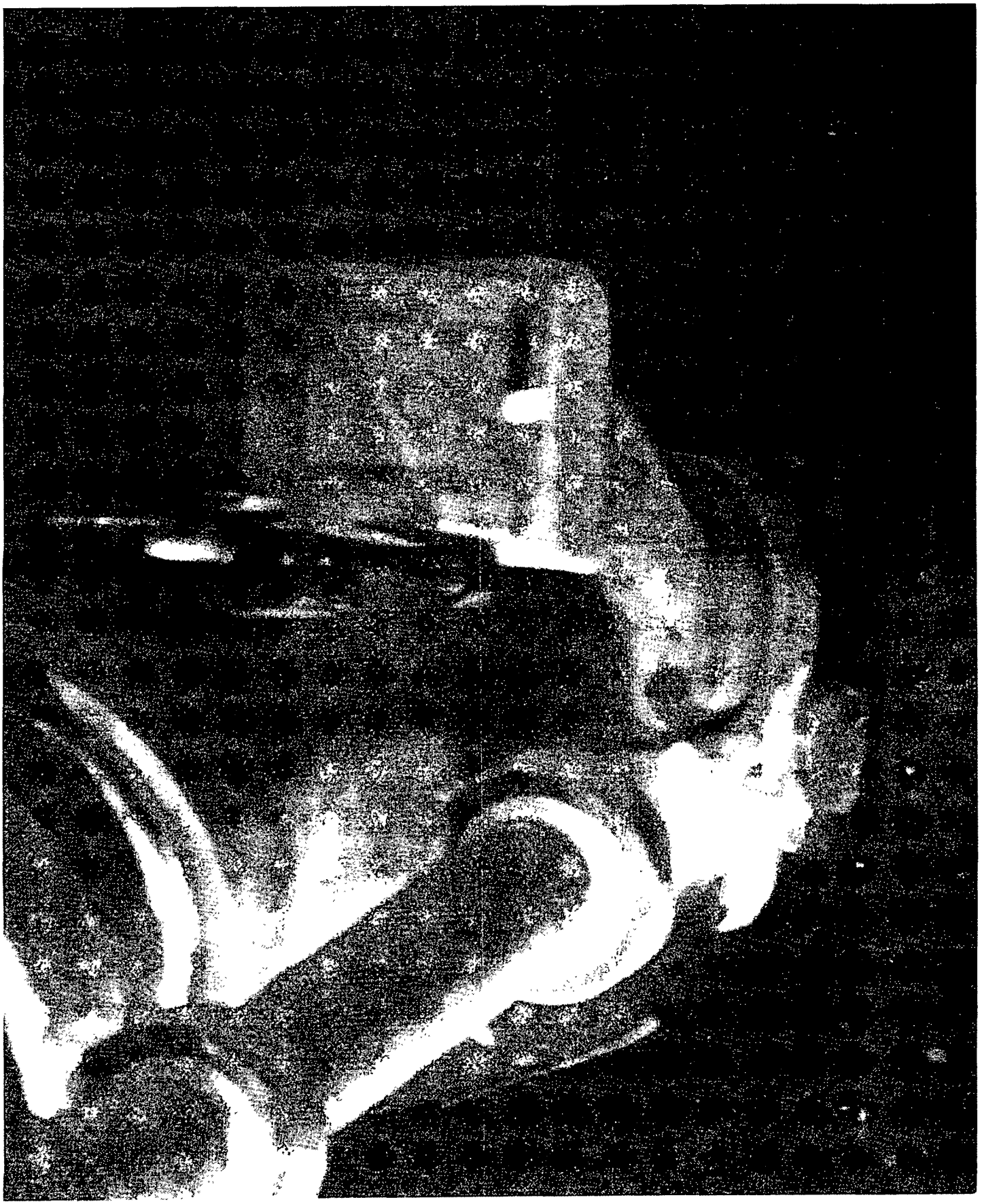
TEMPERATURE IN DEGREES FAHRENHEIT

Figure 3. INFRARED SCAN DATA - SCANNER LOCATED 700 FEET NORTH OF SSV CENTERLINE AT FLAME TRENCH

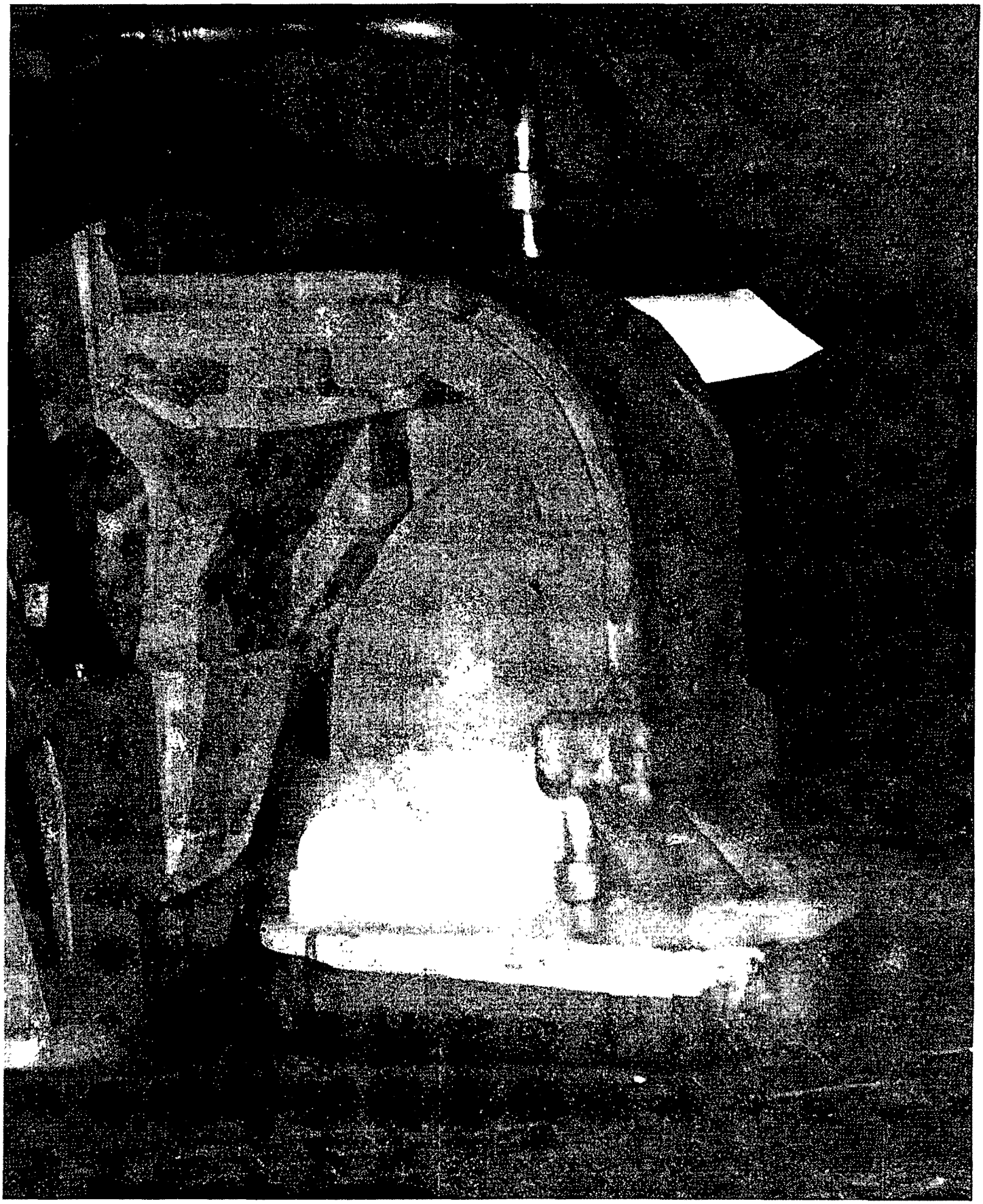


CONDENSATE AND FROST LINES ON LH2 TANK AFT DOME APEX

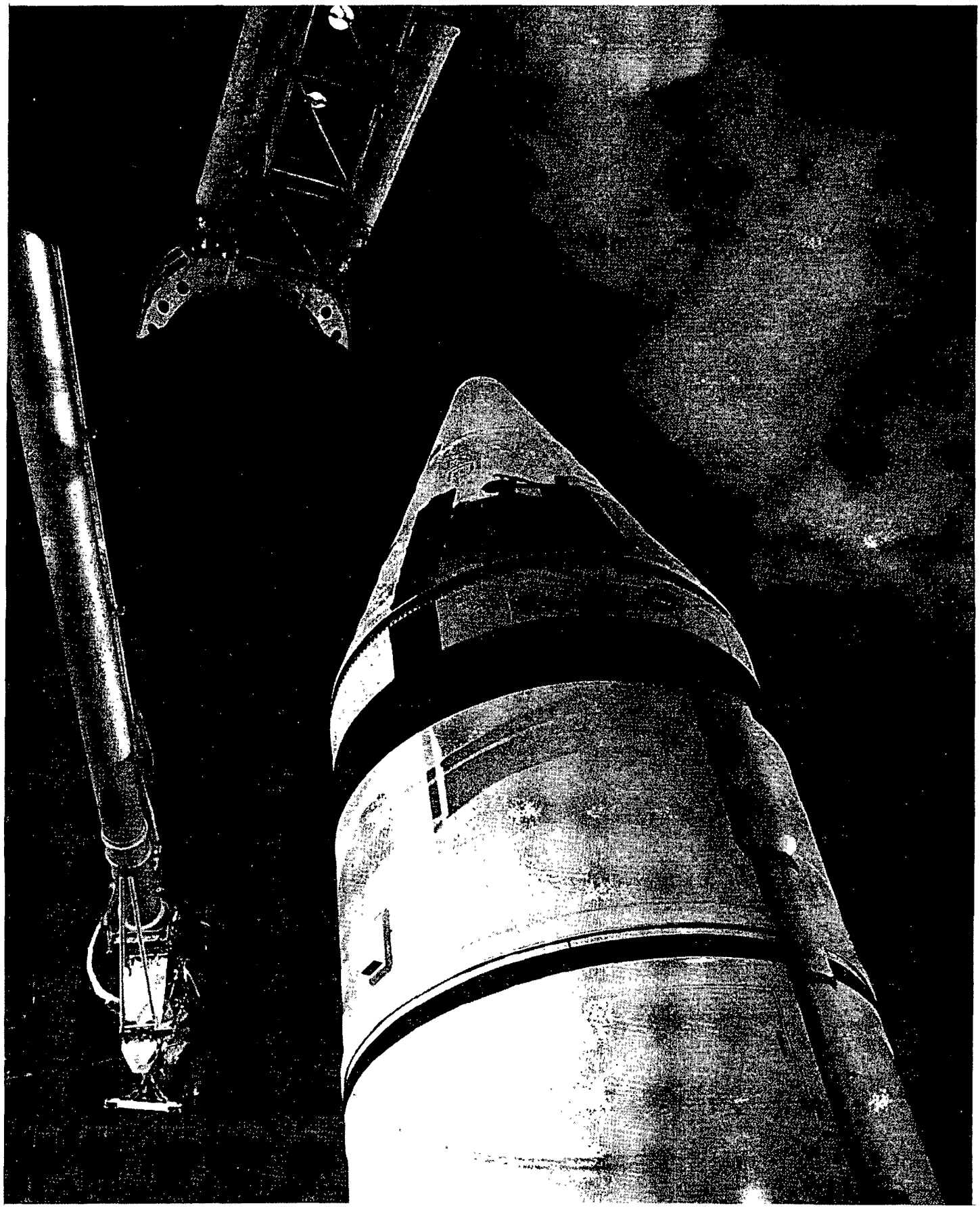
ET/ORB LH2 UMBILICAL. GAS ANALYZERS AND INSTRUMENTATION CABLES INSTALLED FOR FRF ONLY.



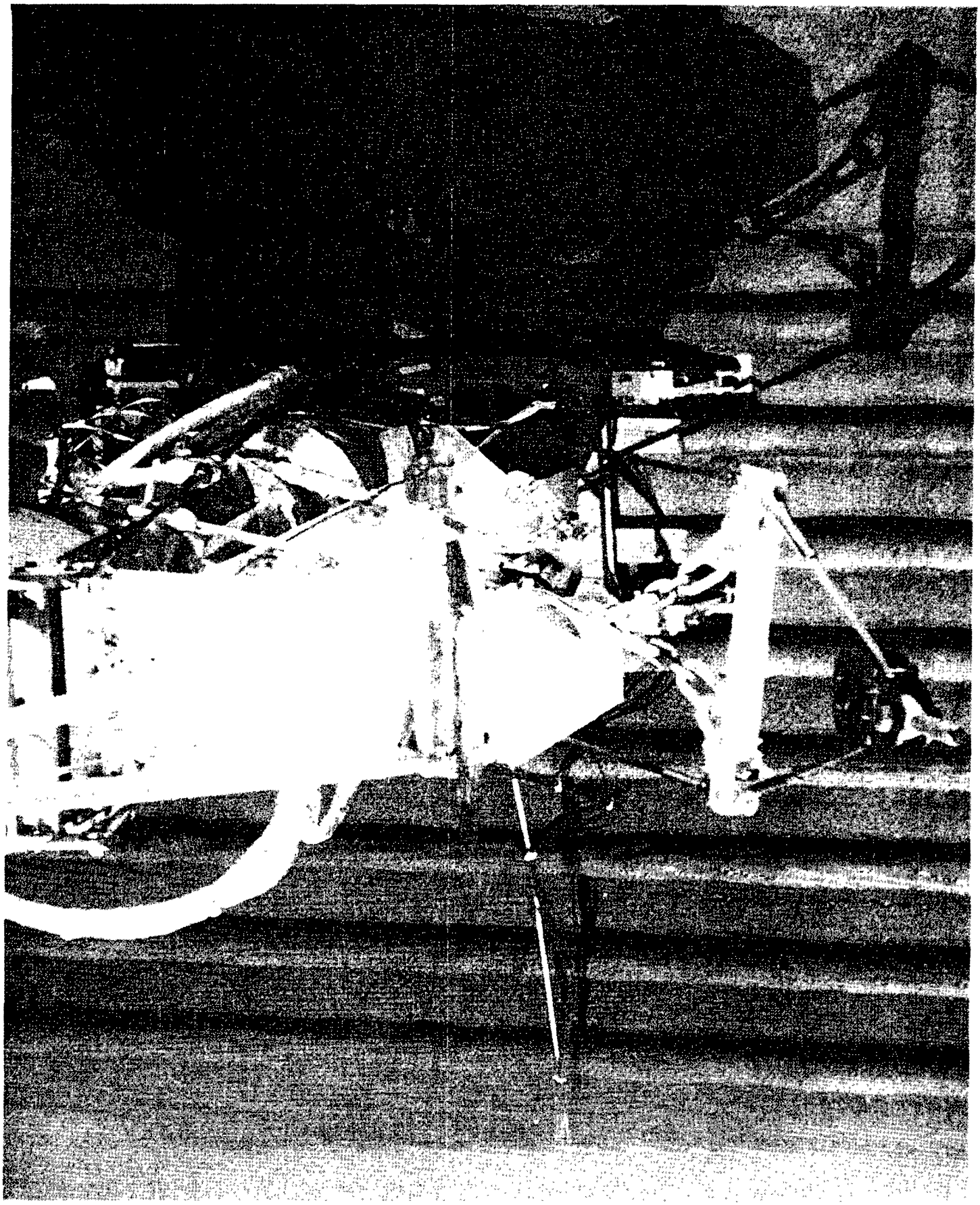
ET/ORB LH2 UMBILICAL. ICE/FROST ACCUMULATION IN FEEDLINE BELLOWS, RECIRCULATION LINE BELLOWS, AND ON GAS ANALYZER.



ET/ORB LO2 UMBILICAL WITH FROST FINGER ON PURGE VENT



GH2 VENT LINE WITH INSULATION MOD TO PREVENT FORMATION OF ICE



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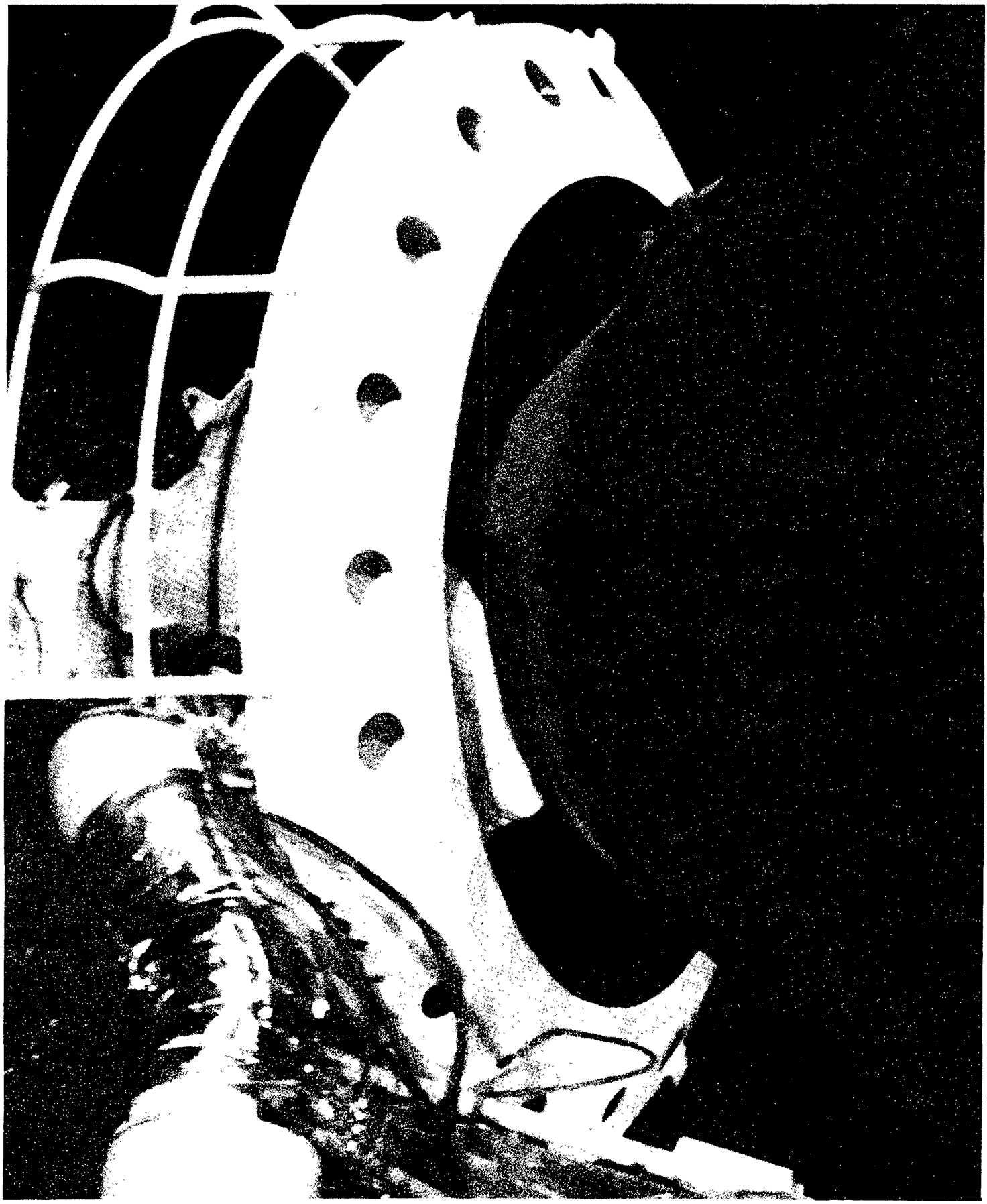
NO ICE/FROST FORMATION ON GUCP OR GH2 VENT LINE. RED FRF CABLES REMOVED BEFORE LAUNCH



DISCREPANT SOUTHWEST SEAL OF GOX VENT HOOD IS POSITIONED HIGH ON FOOTPRINT AREA AND RESULTING LEAK CAUSES SLIGHT EROSION

3.3 POST-DRAIN INSPECTION

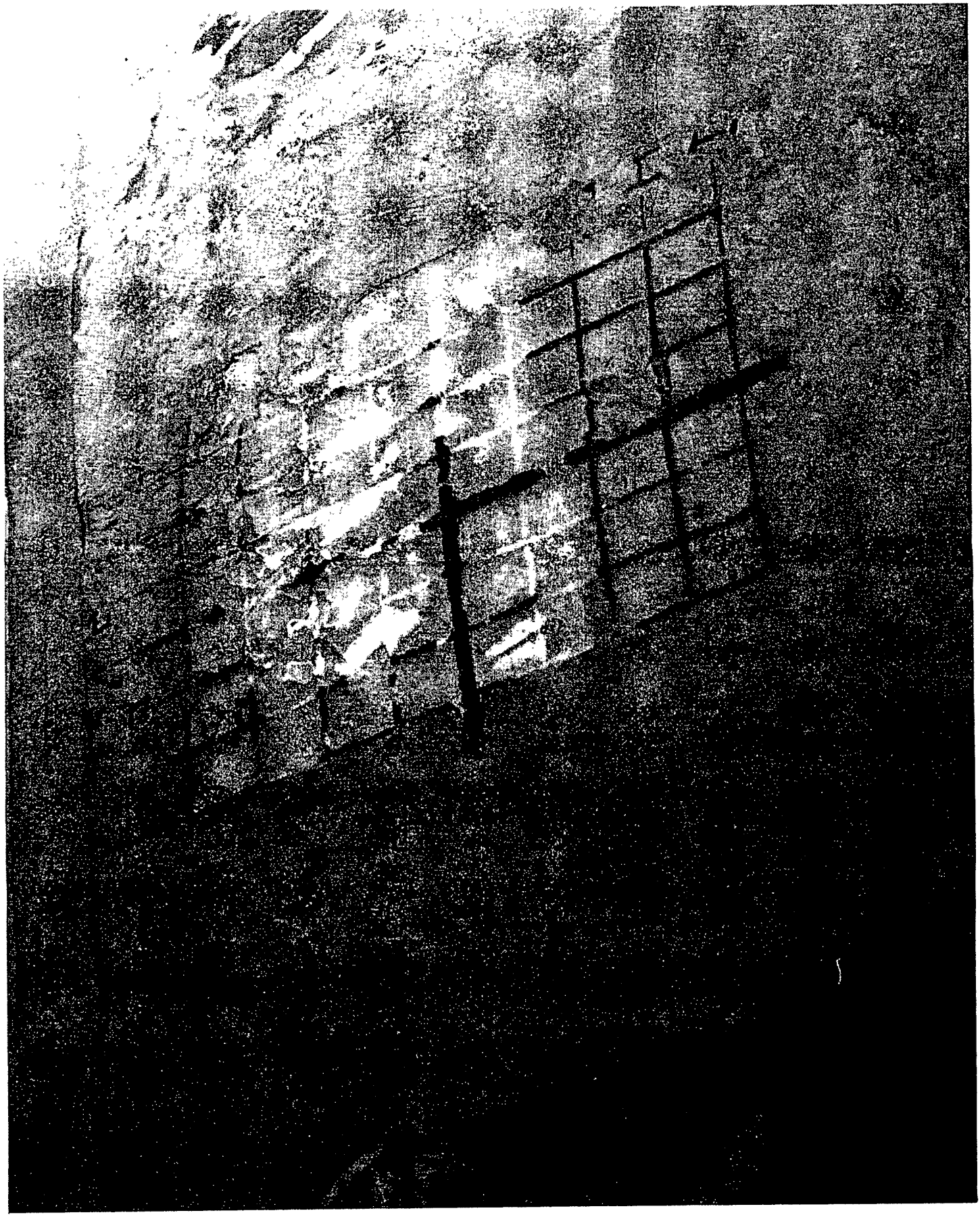
The WCDDT was considered complete with the LOX tank filled 100 percent and the LH2 tank 65 percent. A post-drain inspection of the vehicle and pad was conducted on 1 August 1988. No anomalies were observed on the Orbiter and SRB's.

Some areas of ice/frost, all within the NSTS-08303 acceptance criteria, still remained on the ET/ORB LH2 umbilical, LH2 feedline bellows, and recirculation line bellows.

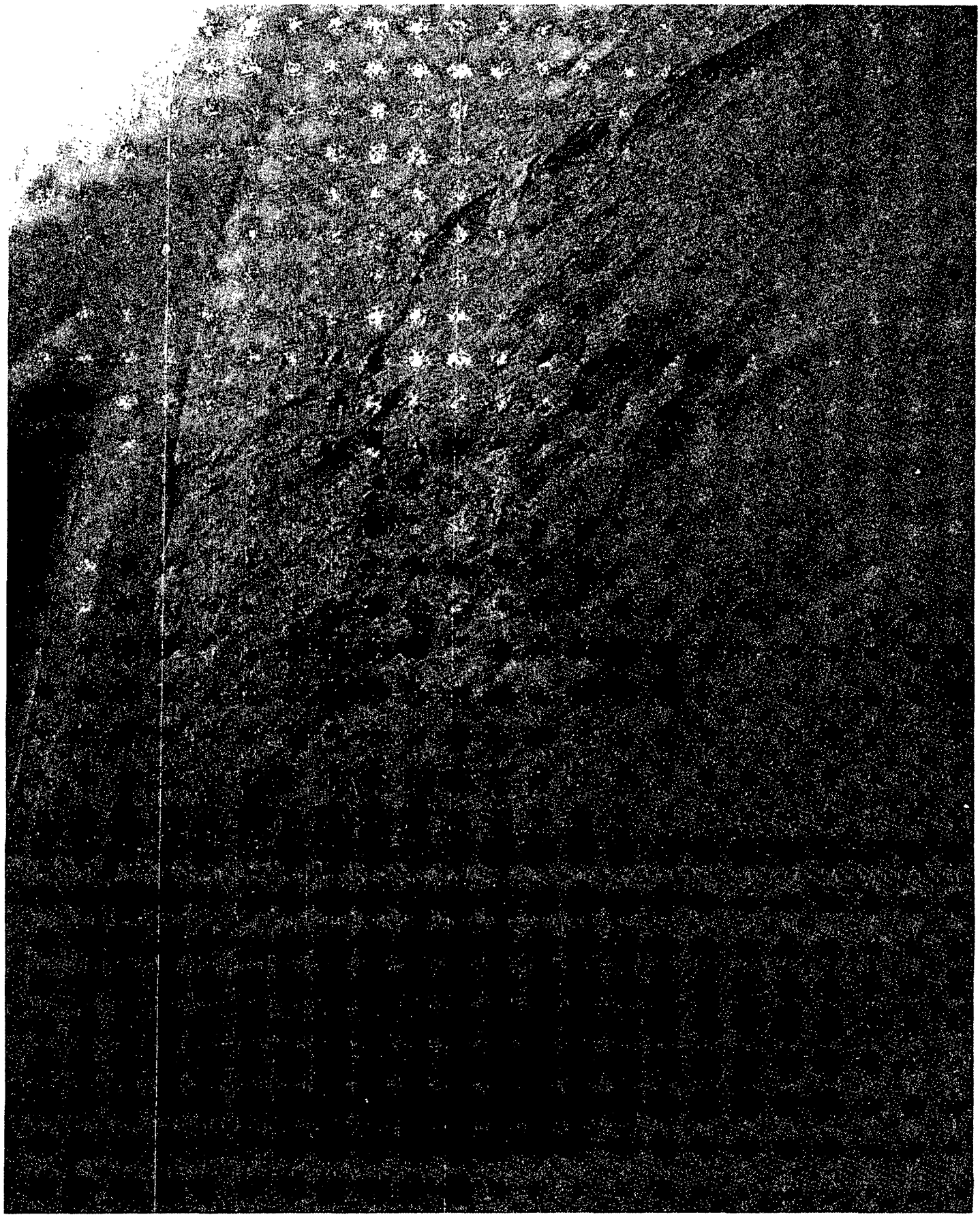
A leaking GOX seal caused slight erosion of the grid area below the -Y louver. The GOX seals were removed and replaced. The -Y footprint foam was dressed up and topcoat applied to both +Y and -Y GOX vent sealing areas.

A crack had formed in the SOFI where the ball-fitting joint of the thrust strut interfaces with the longeron (both +Y/-Y sides). These cracks were considered acceptable per the NSTS-08303 criteria.

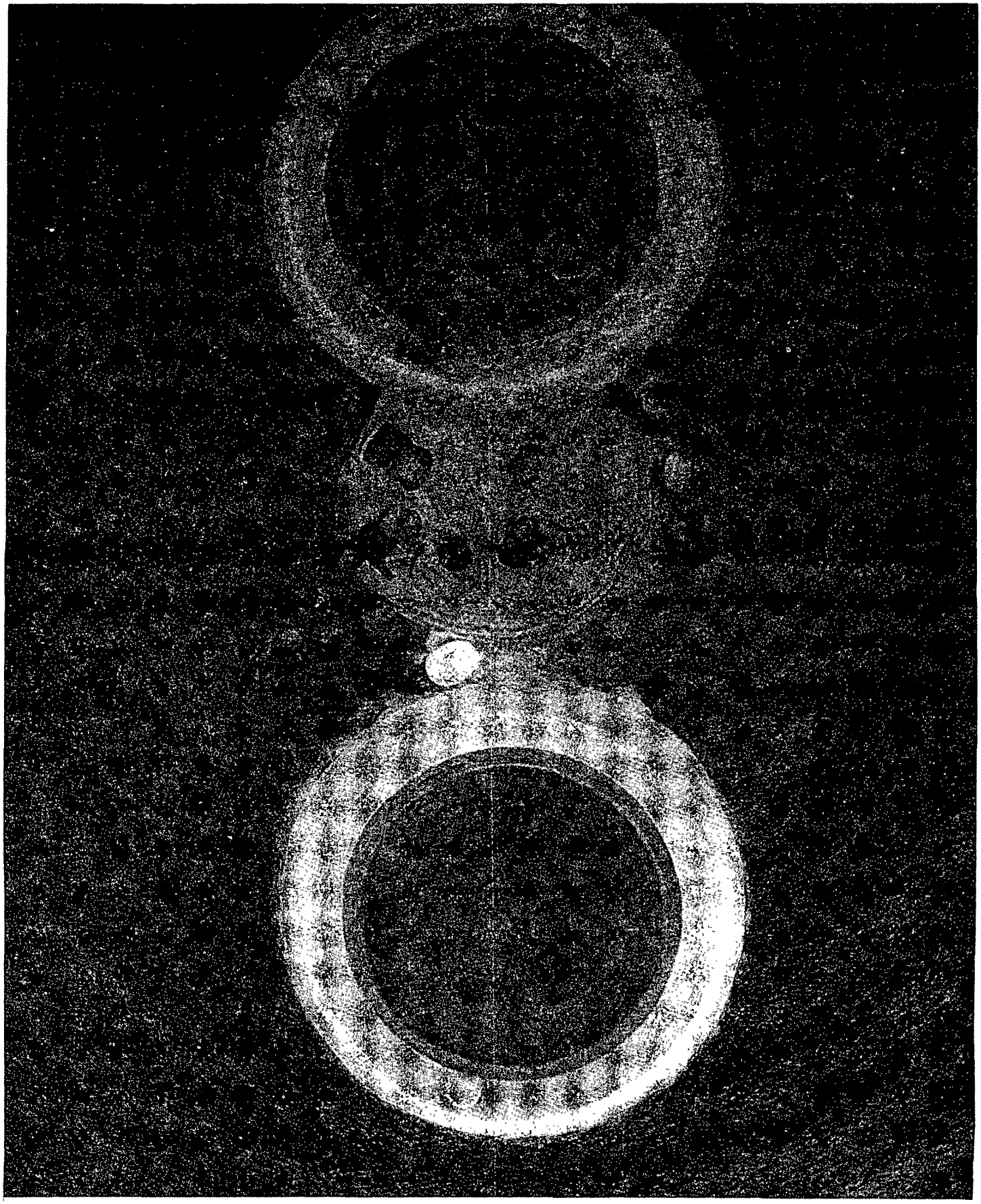
The External Tank was generally in good condition and ready to support FRF cryo loading.



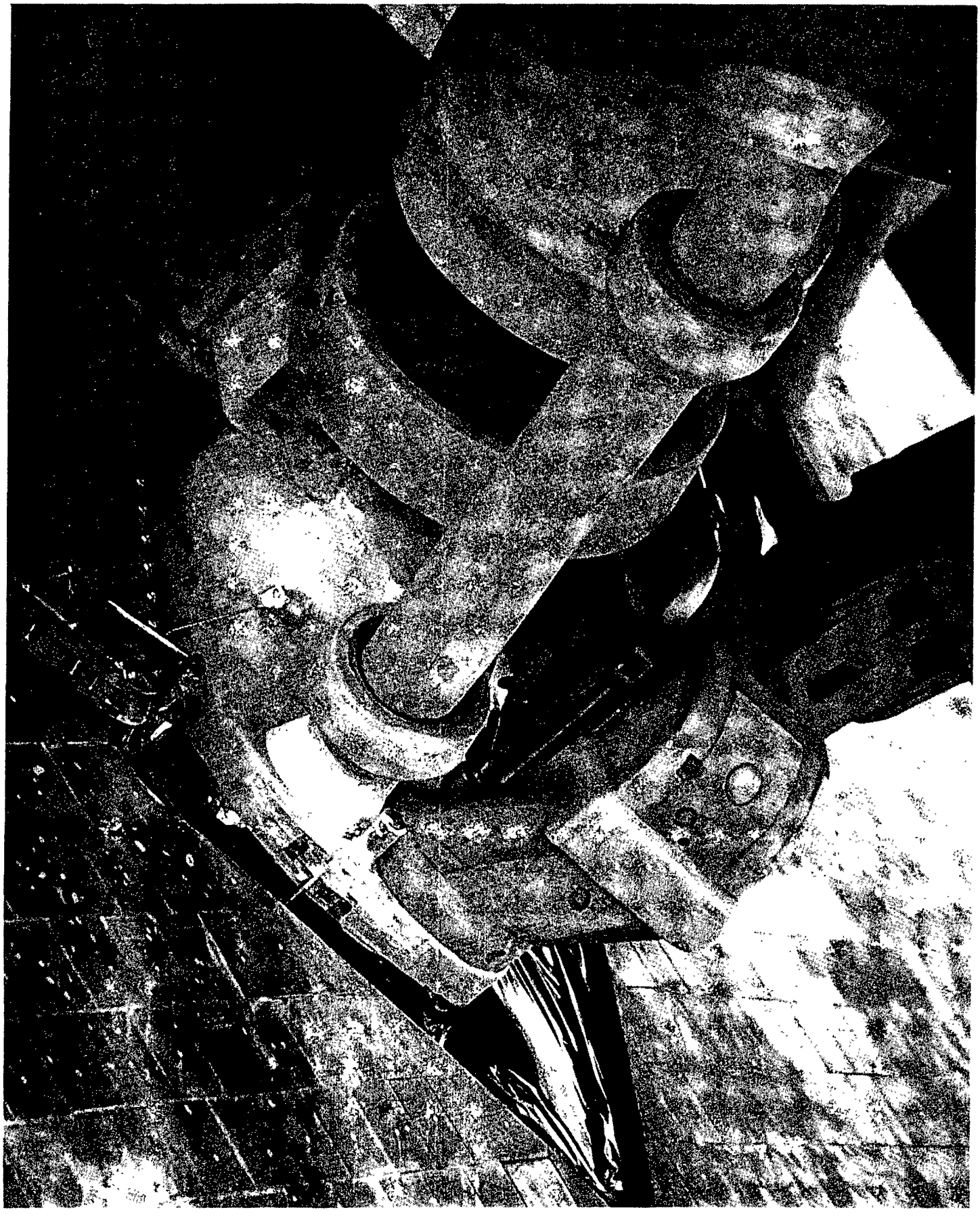
EROSION TO ET NOSECONE TOPCOAT FROM LEAKING GOX SEAL



FOOTPRINT AREA TOPCOAT HAS BEEN LIGHTLY ABRADED TO REMOVE LOOSE PARTICLES. NO TPS REPAIR WAS NECESSARY.



REPAIRS TO DIVOTS ON ET LH2 TANK AFT DOME APEX



GAS ANALYZER INSTALLATION ON ET/ORB LH2 UMBILICAL

4.0 FLIGHT READINESS FIRING (FRF) ABORT (SSME #2 Bleed Valve)

4.1 PRE-TANKING SSV/PAD DEBRIS INSPECTION

A pre-FRF debris inspection of the pad and Shuttle vehicle was conducted on 3 August 1988. Repairs had been made to the ET aft dome apex area divots and the ET/ORB LH2 umbilical baggie. No anomalies were noted on the STS-26R stack. Overall, MLP deck zero level and pad cleanliness was good.

4.2 ICE/FROST INSPECTION

The Ice/Frost Inspection was performed on 4 August 1988 from 0116 to 0300 hours during the two hour built-in-hold at T-3 hours in the countdown.

Condensate was present on most areas of the tank acreage and dripped steadily from the aft dome. Three frost spots had formed on the bond lines of LH2 aft dome apex PDL repairs. The lower EB fittings were covered with ice/frost out to the strut pin holes. Condensate dripped from the outboard part of the fittings and the struts.

The LO2 ET/ORB umbilical was generally clear of ice/frost except for an accumulation on the aft side of the baggie and frost fingers on the purge vents. Ice/frost had formed in the LH2 ET/ORB umbilical feedline and recirculation line bellows, cavities, purge vents, and on the aft and upper outboard sides of the baggie.

Ice/frost was present in all of the LO2 feedline bellows and behind most of the support brackets. Frost balls one inch in diameter were visible on the aft surface of the cable tray ramps and a frost spot had grown on the underside of the +Y ET/SRB cable tray.

No ice/frost formed on the GH2 vent line though some frost was present on the +Z side of the GUCP. The GOX vent ducts were clean and the GOX seals looked normal. Purge gases vented from the TSM T-0 umbilicals, but there were no leaks.

The Orbiter exhibited no tile problems. Some light frost had formed on the SSME engine mounted heat shield interface at the 2-4 o'clock position.

The only SRB discrepancies were pieces of red tape on the IEA's.

The Ice Prediction computer program was run from 2130 to 0815 hours and the results tabulated in Figure 4. The program predicted condensate on all TPS acreage.

The testing and certification of the new infrared equipment, the Mikron 44 Infrared Thermometer and the Shuttle Thermal Imager (STI), continued. An Inframetrics Model 600 scanner was used to image the -Z side of the vehicle and satisfy OMRSD S00J00.126. Results are presented in Figure 5. Temperatures recorded on the SRB frustums and ET ogive are affected somewhat by the increased angle between the imaged surface and the IR scanner location.

The FRF Abort summary of ice/frost console observation anomalies includes three from the ice inspection and three from the post drain walkdown. Anomaly sequential numbering continues from the initial tanking test.

Anomaly 010 documented a 2-inch crack and ice/frost formation in the CPR foam at the +Y thrust strut to longeron interface. This item was evaluated per IPR 26RV-0760 as acceptable per NSTS-08303.

The formation of frost on the +Y thrust strut upper flange on the lower edge of the closeout and in the -Y thrust strut to longeron interface was recorded in Anomaly 011 and found acceptable per the ice/debris criteria.

Ice/frost formation 1-inch in diameter on the -Z axis of the LH2 tank 2 feet below the intertank flange (Anomaly 012) and frost between the stringer roots on the intertank near the -Z LH2 flange were acceptable per NSTS-08303.

Anomaly 013 documented ice formation in the LOX feedline support XT-1871 and Anomaly 014 recorded ice/frost formations on the aft edges of ice/frost ramps XT-1205, 1528, 1787, and 2058. All were acceptable per the ice/debris criteria.

Vapors emanated from cable tray and LOX feedline support areas during LH2 tank drain (Anomaly 015), but post drain inspection revealed no damage.

During the inspection at T-3 hours, the Ice Team noted frost on the LH2 feedline bellows shield drain hole (Anomaly 016) and frost on the aft side of the -Y vertical strut attachment closeout (Anomaly 017). Both were acceptable per NSTS-08303.

Anomaly 018 documented three frost formations, reported by the Ice Team, on the LH2 aft dome apex near the BX-250 closeout. The vendor PDL repair on the -Z side of the +Z siphon cover was visibly loose during the post drain inspection. The area was repaired per PR ET-28-TS-0208.

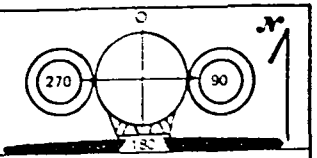
A 4-inch crack in the LOX feedline foam XT-1693 (Anomaly 019) was detected during the post drain inspection and repaired on PR ET-28-TS-0207.

A 4-inch crack on the -Y edge of the LH2 aft dome BX-250 closeout was documented in Anomaly 020 during the post drain inspection. Evaluation per IPR 26RV-0759 revealed no damage.

Anomaly 021 documented suspect debris behind the LOX feedline support bracket XT-1377 during the post drain inspection. IPR 26RV-0761 was upgraded to PR ET-28-TS-0210 and a repair accomplished.

STS – 26R	TEST: FRF (Abort - SSME =2 Bleed Valve)	DATE 8/3/88	T-0 TIME: 0730 DATE: 8/4/88

ORBITER	ET	SRB	MLP	PAD	LO_2	LH_2
OV– 103	28	BI029	2	39B	CHILLDOWN TIME 22:04 FAST FILL TIME 22:41 SLOW FILL TIME 22:29 REPLENISH TIME 00:53	CHILLDOWN TIME 21:52 FAST FILL TIME. 22:30 SLOW FILL TIME 22:00 REPLENISH TIME 00:37

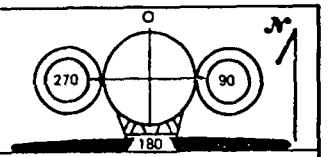


LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL. HUM. %	DEW PT °F	WIND VEL. KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
2130	81	86	76.8	4	130	II	2.36	69.4	+.0027 -.1480		II	2.36	63.0	+.0044 -.1173		II	1.28	58.1	+.0043 -.1092		II	5.56	69.2	-.0056	-.2514
2200	82	84	76.7	2	170	II	1.18	66.4	+.0023 -.1416		II	1.18	59.8	+.0039 -.1167		II	0.84	58.4	+.0042 -.1108		II	0.76	58.4	+.0042	-.1108
2215	82	85	76.9	2	157	II	1.18	66.4	+.0024 -.1422		II	1.18	59.8	+.0040 -.1173		II	0.64	58.5	+.0043 -.1113		II	2.78	63.7	+.0050	-.1322
2230	81	85	76.5	2	139	II	1.18	66.0	+.0024 -.1396		II	1.18	59.3	+.0039 -.1146		II	0.64	58.0	+.0042 -.1087		II	2.78	63.3	+.0049	-.1296
2245	81	86	76.4	3	156	II	1.77	67.3	+.0026 -.1375		II	1.77	59.6	+.0040 -.1125		II	0.96	57.6	+.0042 -.1066		II	4.17	66.6	+.0054	-.1882
2300	81	87	76.8	4	164	II	2.36	69.3	+.0028 -.1475		II	2.36	62.9	+.0045 -.1168		II	1.68	57.9	+.0043 -.1084		II	1.52	57.9	+.0043	-.1084
2315	81	87	76.9	4	179	II	2.36	69.4	+.0028 -.1481		II	2.36	63.0	+.0045 -.1173		II	1.68	58.0	+.0043 -.1091		II	1.52	58.0	+.0043	-.1091
2330	81	87	76.9	3	159	II	1.77	67.7	+.0026 -.1450		II	1.77	60.0	+.0041 -.1150		II	1.26	58.0	+.0043 -.1091		II	1.14	58.0	+.0043	-.1091
2345	81	86	76.3	4	176	II	2.36	68.8	+.0027 -.1450		II	2.36	62.4	+.0044 -.1144		II	1.68	57.4	+.0042 -.1060		II	1.52	57.5	+.0042	-.1060
2400	81	86	76.3	4	168	II	2.36	68.8	+.0027 -.1450		II	2.36	62.4	+.0044 -.1144		II	1.68	57.4	+.0042 -.1060		II	1.52	57.5	+.0042	-.1060
0015	80	89	77.0	4	208	II	2.36	69.2	+.0029 -.1469		II	2.36	62.7	+.0046 -.1162		II	1.28	57.7	+.0044 -.1074		II	5.44	68.9	+.0059	-.2450
0030	81	87	76.8	1	192	II	0.59	65.9	+.0024 -.1393		II	0.59	59.3	+.0040 -.1144		II	0.42	57.9	+.0043 -.1084		II	0.38	57.9	+.0043	-.1084
0045	80	90	76.7	4	196	II	2.36	68.7	+.0029 -.1445		II	2.36	62.2	+.0046 -.1139		II	1.68	57.1	+.0044 -.1046		II	1.52	57.1	+.0044	-.1046
0100	80	89	77.1	3	152	II	1.77	67.6	+.0027 -.1390		II	1.77	59.9	+.0042 -.1140		II	0.96	57.8	+.0044 -.1081		II	4.17	67.0	+.0056	-.1912
0115	80	90	77.4	3	170	II	1.77	67.8	+.0028 -.1402		II	1.77	60.1	+.0042 -.1152		II	1.26	58.0	+.0044 -.1092		II	1.14	58.0	+.0044	-.1092

EGG/V-340

Figure 4. ET TPS Predicted Surface Temperatures and Ice/Condensate

STS – 26R	TEST. FRF (Abort - SSME #2 Bleed Valve)					DATE 8/3/88	T-0 TIME. 0730 DATE 8/4/88
ORBITER	ET	SRB	MLP	PAD	LO_2 CHILLDOWN TIME. 22:04 FAST FILL TIME: 22:41 SLOW FILL TIME 22:29 REPLENISH TIME 00:53	LH_2 CHILLDOWN TIME: 21:52 FAST FILL TIME. 22:30 SLOW FILL TIME 22:00 REPLENISH TIME 00:37	
OV– 103	28	BI029	2	39B			



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
0130	80	91	76.9	2	170	II	1.18	65.2	+.0026	-.1360	II	1.18	58.6	+.0041	-.1110	II	0.84	57.1	+.0044	-.1050	II	0.76	57.2	+.0044	-.1050
0145	79	90	76.3	3	152	II	1.77	66.5	+.0027	-.1329	II	1.77	58.7	+.0041	-.1080	II	0.96	56.6	+.0044	-.1020	II	4.17	66.0	+.0056	-.1838
0200	80	90	76.7	1	165	II	0.59	65.1	+.0025	-.1355	II	0.59	58.5	+.0041	-.1106	II	0.42	57.1	+.0044	-.1046	II	0.38	57.1	+.0044	-.1046
0215	80	88	76.3	1	162	II	0.59	65.1	+.0024	-.1352	II	0.59	58.5	+.0040	-.1103	II	0.42	57.1	+.0043	-.1043	II	0.38	57.1	+.0043	-.1043
0230	80	88	76.3	3	142	II	1.77	66.9	+.0026	-.1352	II	1.77	59.1	+.0041	-.1103	II	0.96	57.1	+.0043	-.1043	II	4.17	66.3	+.0055	-.1860
0245	80	88	75.9	1	145	II	0.59	64.7	+.0024	-.1326	II	0.59	58.0	+.0040	-.1077	II	0.32	56.6	+.0043	-.1018	II	1.39	56.6	+.0043	-.1018
0300	80	89	76.3	0	144	II	0.0	64.8	+.0025	-.1337	II	0.0	58.2	+.0040	-.1088	II	0.0	56.8	+.0043	-.1029	II	0.0	56.8	+.0043	-.1029
0315	80	90	77.0	0	153	II	0.0	65.5	+.0025	-.1375	II	0.0	58.9	+.0041	-.1125	II	0.0	57.5	+.0044	-.1066	II	0.0	57.5	+.0044	-.1066
0330	78	93	76.3	0	260	II	0.0	64.1	+.0026	-.1303	II	0.0	57.4	+.0041	-.1054	II	0.0	56.1	+.0044	-.0994	II	0.0	56.1	+.0044	-.0994
0345	78	93	75.6	1	276	II	0.59	63.3	+.0026	-.1258	II	0.59	56.6	+.0041	-.1009	II	0.43	55.2	+.0044	-.0994	II	1.21	55.2	+.0044	-.0948
0400	78	93	76.3	0	291	II	0.0	64.1	+.0026	-.1303	II	0.0	57.4	+.0041	-.1054	II	0.0	56.1	+.0044	-.0994	II	0.0	56.1	+.0044	-.0994
0415	78	95	76.1	0	300	II	0.0	63.5	+.0026	-.1272	II	0.0	56.8	+.0042	-.1023	II	0.0	55.4	+.0045	-.0963	II	0.0	55.4	+.0045	-.0963
0430	77	95	75.3	2	321	II	1.18	62.6	+.0026	-.1221	II	1.18	55.8	+.0041	-.0972	II	0.92	54.4	+.0044	-.0912	II	2.46	58.9	+.0051	-.1010
0445	77	95	75.4	3	304	II	1.77	64.7	+.0029	-.1228	II	1.77	56.8	+.0042	-.0978	II	1.38	54.5	+.0044	-.0919	II	3.69	63.2	+.0057	-.1527
0500	77	95	75.9	2	346	II	1.18	63.3	+.0029	-.1266	II	1.18	56.6	+.0041	-.1010	II	0.88	55.2	+.0045	-.0950	II	1.98	57.1	+.0047	-.0950

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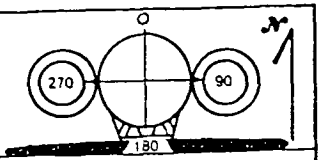
Figure 4. ET TPS Predicted Surface Temperatures and Ice/Condensate

STS – 26R	TEST: FRF (Abort - SSME =2 Bleed Valve)	DATE: 8/3/88	T-0 TIME: 0730 DATE: 8/4/88

ORBITER	ET	SRB	MLP	PAD	LO_2	LH_2
OV-103	28	BI029	2	39B	CHILLDOWN TIME 22:04 FAST FILL TIME: 22:41 SLOW FILL TIME 22:29 REPLENISH TIME 00:53	CHILLDOWN TIME 21:52 FAST FILL TIME: 22:30 SLOW FILL TIME 22:00 REPLENISH TIME 00:37



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
0515	77	96	75.8	0	321	II	0.0	62.9	±.0026	-.1244	II	0.0	56.2	±.0042	-.0995	II	0.0	54.8	±.0045	-.0935	II	0.0	54.8	±.0045	-.0935
0530	77	96	75.8	3	340	II	1.77	65.0	±.0029	-.1244	II	1.77	57.1	±.0043	-.0995	II	1.32	54.8	±.0045	-.0935	II	2.97	61.4	±.0055	-.1249
0545	77	96	75.6	1	019	II	0.59	62.7	±.0026	-.1231	II	0.59	56.0	±.0041	-.0982	II	0.44	54.6	±.0045	-.0922	II	0.99	54.6	±.0045	-.0922
0600	78	94	76.3	2	333	II	1.18	63.9	±.0026	-.1294	II	1.18	57.3	±.0042	-.1045	II	0.92	55.9	±.0045	-.0985	II	2.46	60.3	±.0051	-.1075
0615	78	96	76.4	3	341	II	1.77	65.8	±.0029	-.1283	II	1.77	57.9	±.0043	-.1033	II	1.32	55.6	±.0045	-.0973	II	2.97	62.1	±.0055	-.1289
0630	78	97	76.6	1	044	II	0.59	63.7	±.0027	-.1287	II	0.59	57.0	±.0042	-.1037	II	0.70	55.6	±.0046	-.0977	II	1.21	55.6	±.0046	-.0977
0645	77	97	76.3	1	058	II	0.59	63.4	±.0027	-.1267	II	0.59	56.7	±.0042	-.1017	II	0.70	55.3	±.0045	-.0957	II	1.21	55.3	±.0045	-.0957
0700	78	98	77.1	3	005	II	1.77	66.3	±.0031	-.1310	II	1.77	58.4	±.0045	-.1060	II	1.32	56.1	±.0046	-.1000	II	2.97	62.7	±.0057	-.1321
0715	78	98	77.4	5	014	II	2.95	69.7	±.0035	-.1707	II	2.95	64.2	±.0053	-.1393	II	2.20	59.8	±.0052	-.1019	II	4.95	67.7	±.0065	-.2202
0730	79	96	78.1	3	358	II	1.77	67.8	±.0030	-.1396	II	1.77	60.1	±.0045	-.1145	II	1.32	57.7	±.0047	-.1085	II	2.97	64.3	±.0057	-.1404
0745	79	97	78.0	3	002	II	1.77	67.6	±.0031	-.1380	II	1.77	59.8	±.0045	-.1129	II	1.32	57.4	±.0047	-.1069	II	2.97	64.0	±.0057	-.1390
0800	79	98	78.5	4	357	II	2.36	69.8	±.0034	-.1504	II	2.36	63.4	±.0051	-.1194	II	1.76	58.6	±.0049	-.1093	II	3.96	67.2	±.0063	-.1868
0815	80	96	79.1	3	031	II	1.77	69.0	±.0031	-.1464	II	1.77	61.4	±.0046	-.1214	II	2.10	61.8	±.0052	-.1153	II	3.63	67.4	±.0061	-.1783
Average	79	91	76.6	2.3	005	II		66.0			II		59.2			II		56.9			II		60.3		

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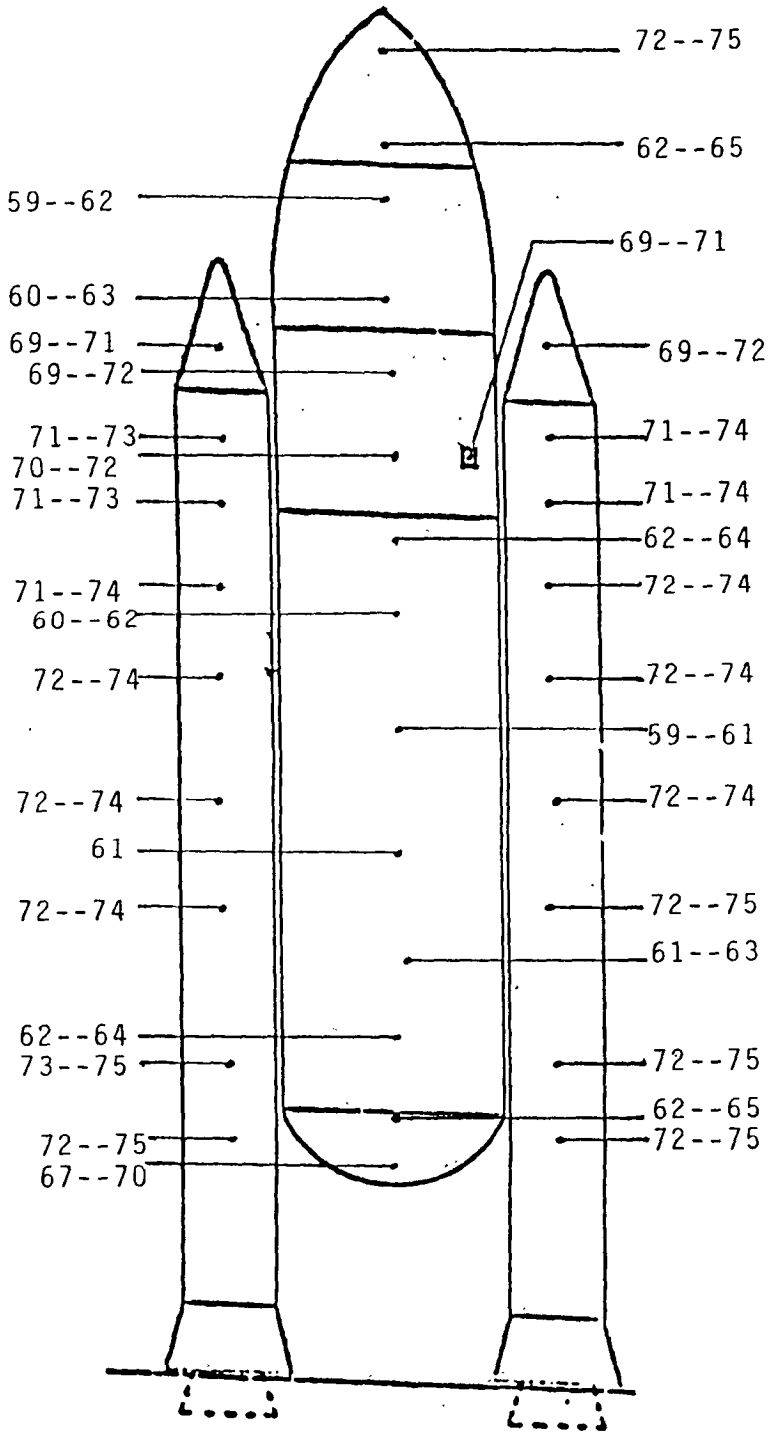
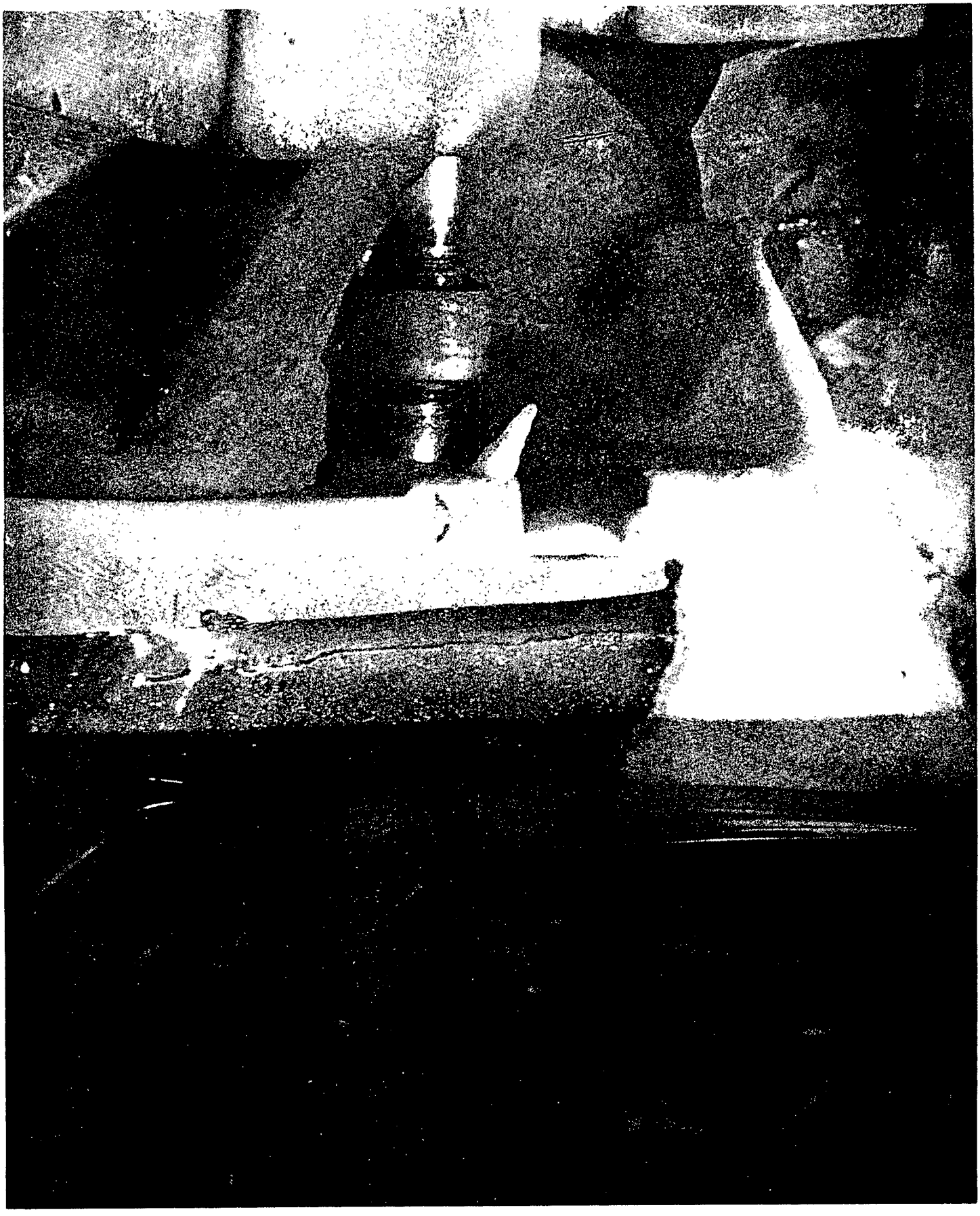
Figure 4. ET TPS Predicted Surface Temperatures and Ice/Condensate



TEMPERATURE IN DEGREES FAHRENHEIT

Figure 5. INFRARED SCANNER DATA - SCANNER LOCATED 700 FEET NORTH OF SSV CENTERLINE AT FLAME TRENCH

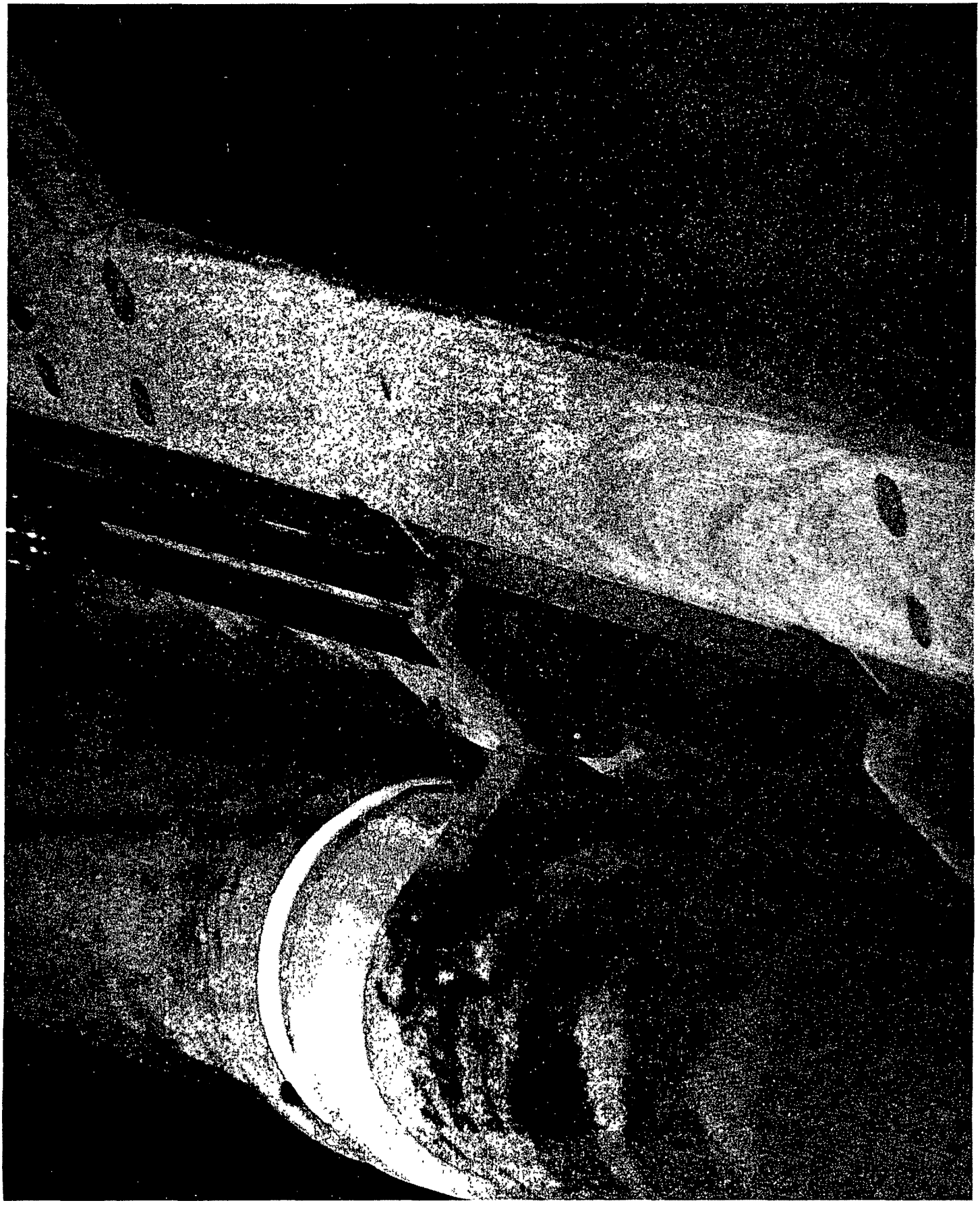
FROST LINES ON ET LH2 TANK AFT DOME APEX VENDOR PDL REPAIRS



ICE/FROST ACCUMULATION ON UPPER OUTBOARD LH2 UMBILICAL BAGGIE

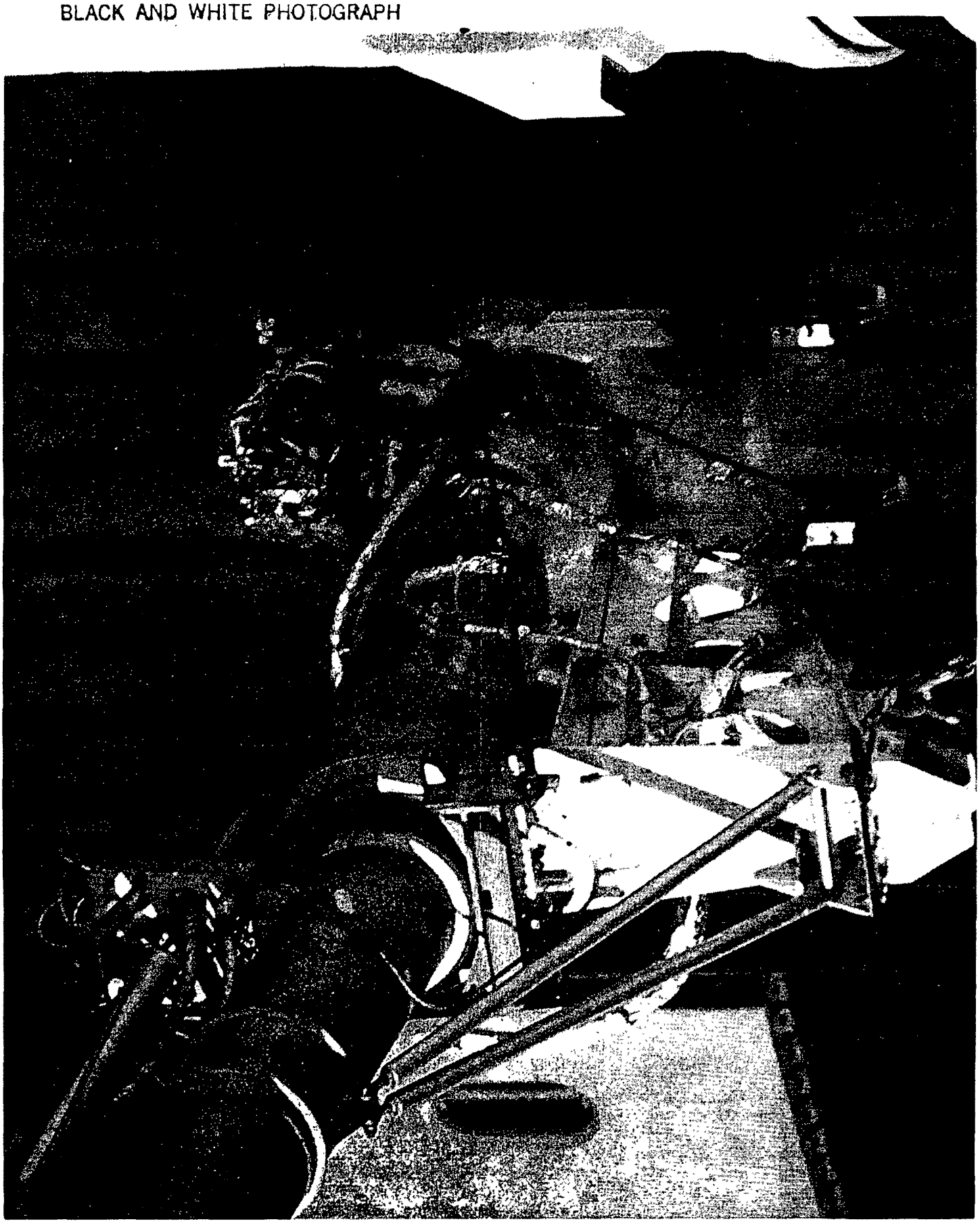
CRACK IN TPS AT THRUST STRUT TO LONGERON INTERFACE

TYPICAL ICE/FROST ACCUMULATION IN ET LO2 FEEDLINE BELLOWS AND SUPPORT BRACKET. CONDENSATE IS ALSO VISIBLE.



TYPICAL ICE/FROST ACCUMULATION IN ET LO2 FEEDLINE BELLOWS AND SUPPORT BRACKET. FROST SPOT ON AFT SIDE OF PRESS LINE RAMP.

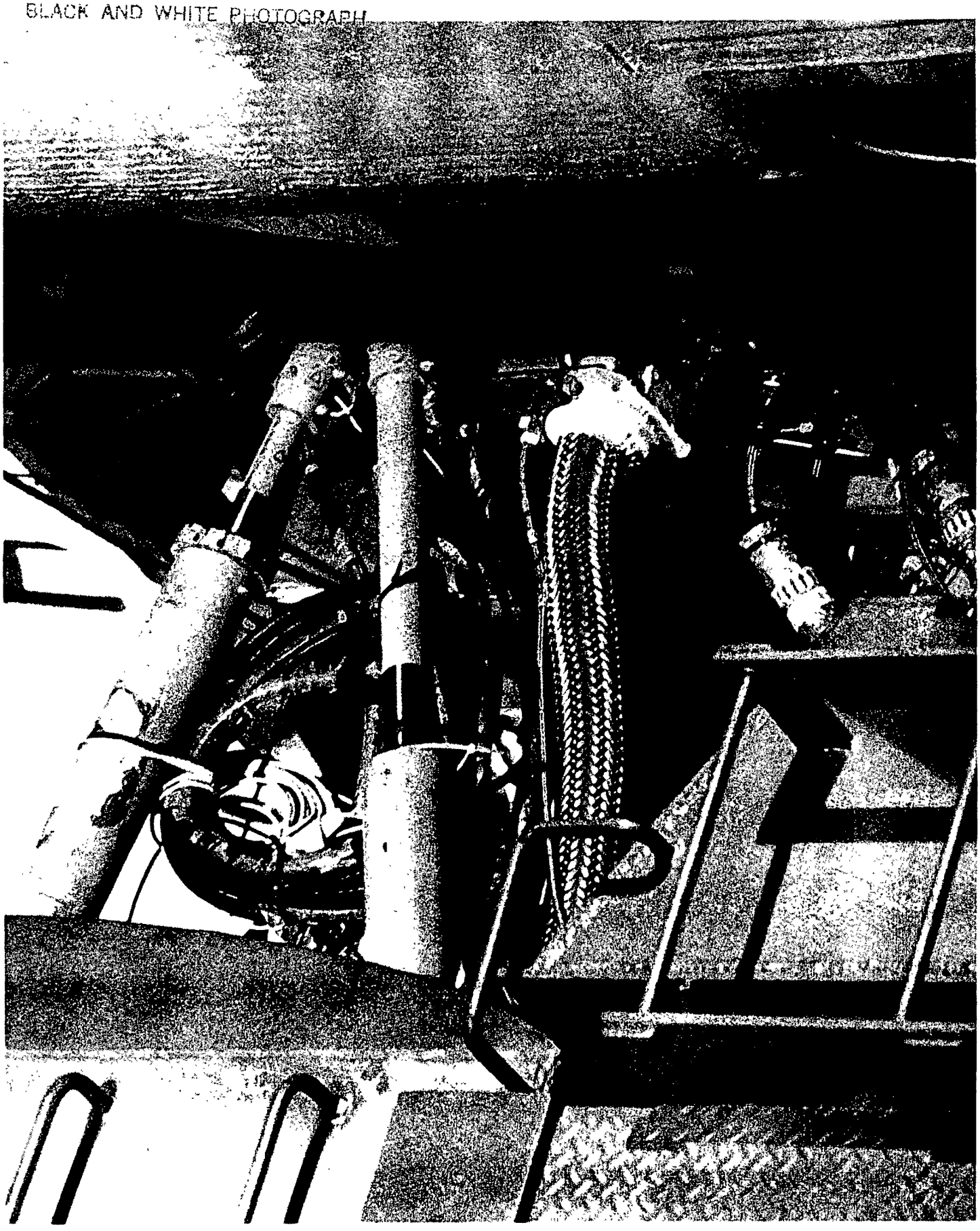
ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



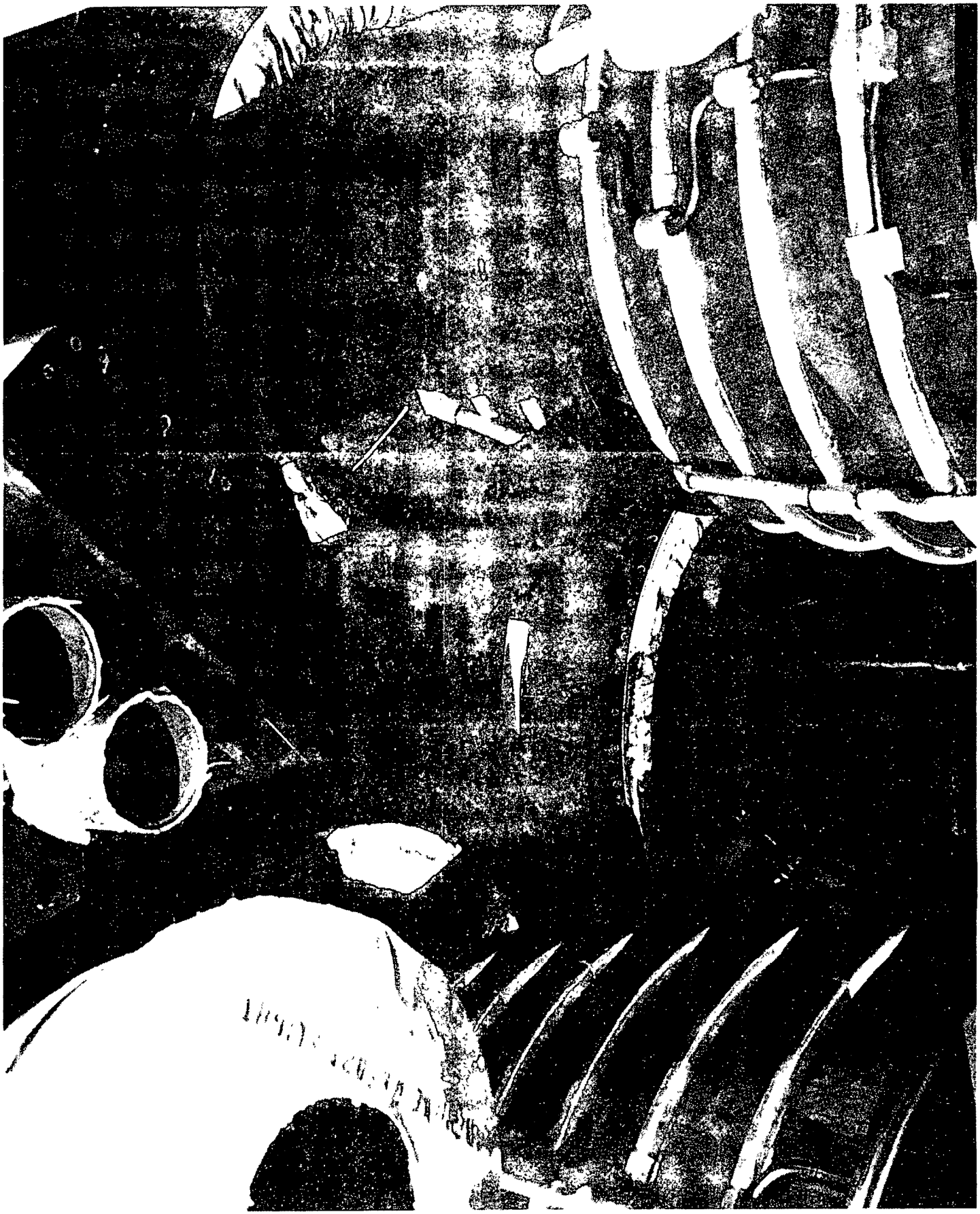
GH2 VENT ARM MODIFICATION PREVENTS ICE/FROST FORMATION ON THE LINE. LIGHT FROST HAS FORMED ON +Z SIDE OF GUCP.

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

SOUTHWEST GOX VENT SEAL IS PROPERLY POSITIONED
OVER ET FOOTPRINT AND DID NOT LEAK



NO LEAK ON ORBITER LH2 T-0 UMBILICAL



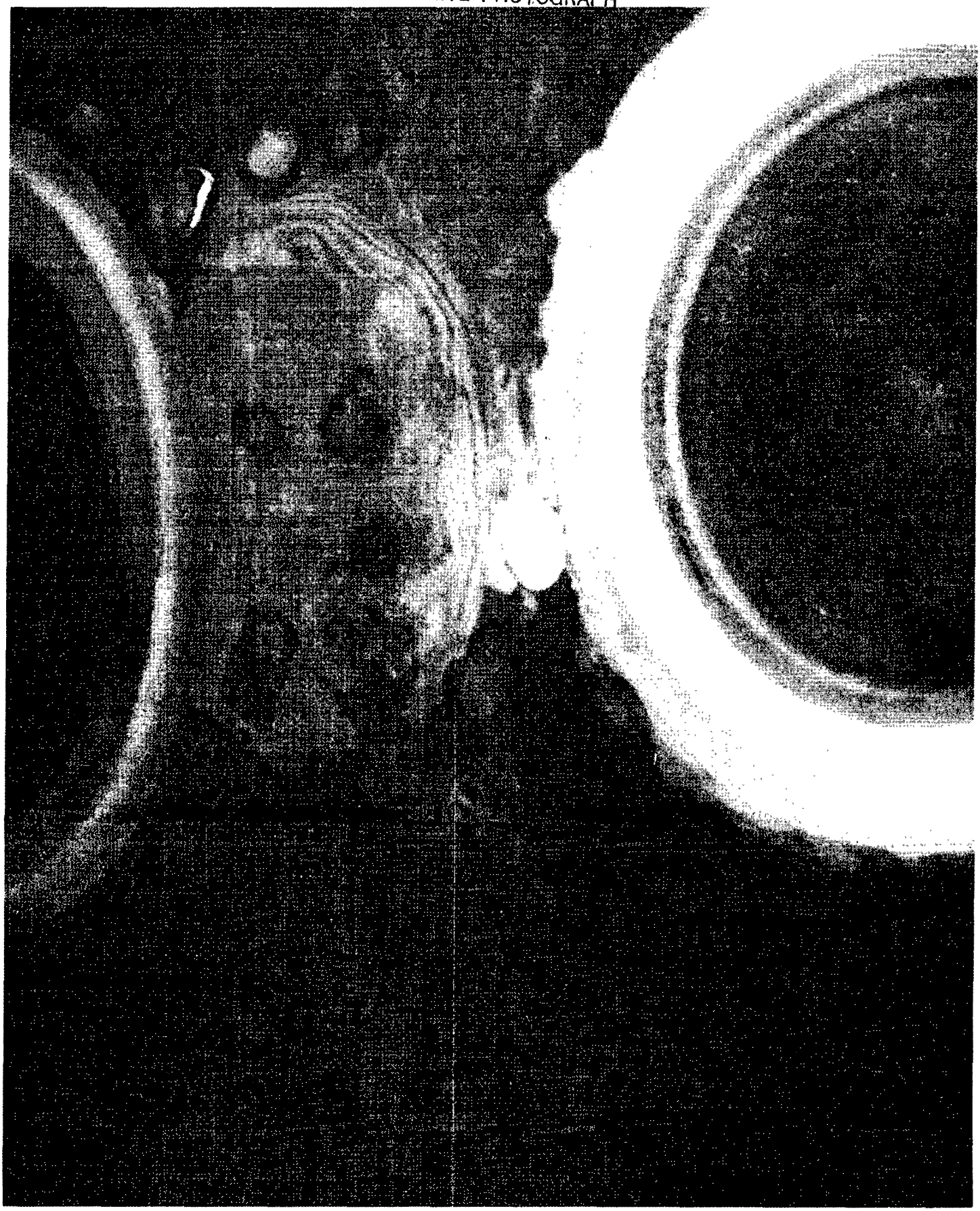
TILE CARRIER PANEL ON ORBITER AFT HEAT SHIELD NOT YET INSTALLED TO ACCOMMODATE FRF INSTRUMENTATION

4.3 POST-DRAIN INSPECTION

The FRF was aborted at T-5 seconds due to a slow bleed valve on SSME #2. A post-drain inspection of the vehicle and pad was performed at approximately T+3 hours on 4 August 1988. The following anomalies were found on the External Tank:

- Two-inch crack in CPR at +Y thrust strut knuckle crotch area
- Debris between LO2 feedline and attaching bracket at Station XT-1377
- Four-inch crack along -Y edge of BX-250 closeout on -Z side of siphon manhole cover, LH2 aft dome
- A second LH2 aft dome PDL vendor repair was loose on -Z side of +Z siphon cover
- A 3 1/2" x 2 3/8" divot on -Y side of LOX Feedline just aft of flange closeout

The above items were no constraint for another cryo loading/FRF. No significant anomalies were noted on the Orbiter, SRB's, or facility.



DIVOT ON ET LH2 TANK AFT DOME APEX

5.0 FLIGHT READINESS FIRING (FRF)

5.1 PRE-FIRING SSV/PAD DEBRIS INSPECTION

The SSME #2 bleed valve was removed and replaced. A pre-firing debris inspection of the pad and Shuttle vehicle was conducted on 9 August 1988. Small amounts of debris were scattered over the MLP deck zero level, but no major pad anomalies or constraints to FRF were found. The Orbiter and SRB's were in proper configuration and ready to support FRF. All previous ET anomalies were approved as no constraint.

5.2 ICE/FROST INSPECTION

The Ice/Frost Inspection was performed on 10 August 1988 during the two hour built-in-hold at T-3 hours in the countdown.

Condensate dripped in a steady stream from the aft dome. Several frost spots had developed on LH2 aft dome apex PDL repair bond lines and one repair area was protruding. The lower EB fittings were covered with ice/frost outboard to the strut pin hole while the rest of the fitting dripped condensate. The struts were dry.

A ring of light frost was visible near the ET XT-2058 ring frame. Ice/frost had formed in all the LO2 feedline bellows and in most of the support brackets. Frost balls one inch in diameter were visible on the aft surface of the cable tray ramps. The +Y thrust strut to longeron interface exhibited a frost spot one inch in diameter along with a 3 inch frost line on a TPS bondline.

The LO2 ET/ORB umbilical was generally clear of ice except for an ice/frost accumulation on the aft side of the baggie and frost fingers on the purge vents. Ice/frost had formed in the LH2 ET/ORB umbilical feedline and recirculation line bellows, cavities, purge vents, and on the forward, aft, and upper outboard sides of the baggie.

Condensate was visible on the intertank flanges. The GH2 vent line was clean but light frost was present on the GUCP +Z side. Small icicles and frost fingers had again formed on the GOX vent ducts. Purge vapors vented from the TSM T-0 umbilicals, but there were no leaks.

The Orbiter exhibited no tile problems. The engine mounted heat shields were generally covered with condensate except for some frost on SSME #1 and #2 6 o'clock positions.

The only SRB discrepancy was red tape on the IEA's.

The Ice Prediction computer program was run from 2230 to 0800 hours and the results tabulated in Figure 6. The program predicted condensate on all the TPS acreage.

The testing and acceptance of the new infrared equipment, the Mikron 44 Infrared Thermometer and the Shuttle Thermal Imager (STI), continued. An Inframetrics Model 600 scanner was used to image the -Z side of the vehicle and satisfy OMRSD S00J00.126. Results are presented in Figure 7. Temperatures recorded on the SRB frustums and ET ogive are affected somewhat by the increased angle between the imaged surface and the IR scanner location.

The FRF summary of ice/frost console observation anomalies consists of nine OTV observations supported by Ice Team findings. Anomaly sequential numbering continues from initial tanking test.

Anomaly 022 documented ice/frost formations on the LH2 aft dome apex closeout - four on previous repair areas and two in depressions in the foam. The repair areas were evaluated in conjunction with PR ET-28-TS-0208.

Anomaly 023 documented ice/frost formations on the aft side of pressline barry mounts and cable tray supports 13 of 15 stations. These areas were inspection during the post drain walkdown and no damage was found.

Small icicles/frost fingers, approx 1 inch in length, formed at the end of the south GOX vent duct and ice/frost build-up around duct circumference (Anomaly 024). This condition was acceptable to the Debris Team for FRF.

Loose ablator at LO2 feedline support XT-1377 remained in place with no ice/frost present (Anomaly 025). IPRRV-0761 required hands-on evaluation after FRF.

Anomaly 026 documented broken foam in the LO2 feedline support bracket XT-1623. The outstanding PR ET-28-TS-0207 required hands-on evaluation after FRF.

Ice/frost accumulation on the ET/ORB umbilicals, bellows, and purge vents (Anomaly 027) were within the accepted data base of the ice/debris criteria.

Anomaly 028 documented cracked foam in the +Y/-Y thrust strut to longeron interfaces, though the foam remained in place and no ice/frost was present. Anomaly 030 documented ice/frost on the GUCP external to the purge canister. Both conditions were acceptable by NSTS-08303.

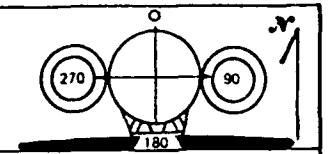
All SSME's showed amounts of ice/frost on the engine mounted heat shields (Anomaly 029) that were acceptable per the ice criteria.

STS- 26R | TEST: Flight Readiness Firing (FRF) | DATE 8/9/88 | T-0 TIME: 0730 DATE: 8/10/88

ORBITER: OV- 103 | ET: 28 | SRB: BI029 | MLP: 2 | PAD: 39B

LO_2 CHILLDOWN TIME: 23:24 FAST FILL TIME 00:01 SLOW FILL TIME: 23:49 REPLENISH TIME 02:36

LH_2 CHILLDOWN TIME: 23:12 FAST FILL TIME: 23:50 SLOW FILL TIME: 23:20 REPLENISH TIME 01:58



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
2230	82	85	77.3	6	135	II	3.54	72.2	±.0028	-.2073	II	3.54	67.4	±.0049	-.1751	II	1.92	60.3	±.0045	-.1140	II	8.34	72.4	±.0056	-.3780
2245	82	84	77.2	7	128	II	4.13	72.8	±.0028	-.2339	II	4.13	68.6	±.0049	-.2012	II	2.24	60.0	±.0046	-.1141	II	9.73	73.1	±.0054	-.4361
2300	82	86	77.6	4	155	II	2.36	70.3	±.0028	-.1529	II	2.36	64.0	±.0045	-.1220	II	1.28	59.1	±.0043	-.1145	II	5.56	70.2	±.0057	-.2598
2315	82	86	77.3	3	149	II	1.77	68.2	±.0026	-.1434	II	1.77	60.7	±.0041	-.1185	II	0.96	56.7	±.0043	-.1125	II	4.17	67.7	±.0055	-.1958
2330	81	86	76.9	4	153	II	2.36	69.5	±.0028	-.1486	II	2.36	63.1	±.0045	-.1179	II	1.28	58.2	±.0043	-.1099	II	5.56	69.4	±.0059	-.2524
2345	81	86	76.7	3	158	II	1.77	67.8	±.0026	-.1408	II	1.77	60.2	±.0041	-.1158	II	1.26	58.2	±.0043	-.1099	II	1.14	58.2	±.0043	-.1099
2400	81	86	77.1	7	143	II	4.13	72.4	±.0029	-.2310	II	4.13	68.2	±.0050	-.1983	II	2.24	61.5	±.0047	-.1112	II	9.73	72.7	±.0057	-.4311
0015	82	86	77.4	3	152	II	1.77	68.4	±.0026	-.1441	II	1.77	60.8	±.0041	-.1192	II	0.96	58.8	±.0043	-.1132	II	4.17	67.8	±.0055	-.1967
0030	81	87	77.3	3	153	II	1.77	68.1	±.0026	-.1426	II	1.77	60.6	±.0041	-.1177	II	0.96	58.5	±.0044	-.1117	II	4.17	67.6	±.0055	-.1952
0045	82	88	77.9	3	146	II	1.77	68.8	±.0027	-.1459	II	1.77	61.2	±.0042	-.1209	II	0.96	59.1	±.0044	-.1149	II	4.17	68.2	±.0057	-.1997
0100	82	88	78.3	5	143	II	2.95	72.0	±.0030	-.1847	II	2.95	66.7	±.0049	-.1529	II	1.60	59.6	±.0045	-.1176	II	6.95	72.2	±.0060	-.3276
0115	82	83	76.6	6	146	II	3.54	71.7	±.0027	-.2037	II	3.54	66.9	±.0047	-.1717	II	1.92	59.8	±.0043	-.1116	II	8.34	71.9	±.0053	-.3708
0130	82	84	76.8	3	148	II	1.77	68.1	±.0025	-.1423	II	1.77	60.4	±.0046	-.1174	II	0.96	58.5	±.0042	-.1115	II	4.17	67.4	±.0053	-.1937
0145	82	89	78.6	8	114	II	4.72	74.3	±.0032	-.2700	II	4.72	70.6	±.0055	-.2363	II	2.56	64.4	±.0052	-.1299	II	11.12	74.7	±.0061	-.5139
0200	80	93	77.5	4	151	II	2.36	69.3	±.0031	-.1475	II	2.36	62.8	±.0048	-.1167	II	1.28	57.6	±.0045	-.1072	II	5.56	69.3	±.0062	-.2521

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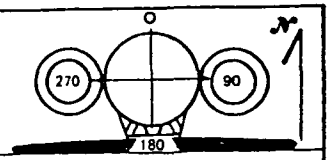
Figure 6. ET TPS Predicted Surface Temperatures and Ice/Condensate

STS- 26R	TEST: Flight Readiness Firing (FRF)	DATE 8/9/88	T-0 TIME: 0730 DATE: 8/10/88

ORBITER	ET	SRB	MLP	PAD	LO_2	LH_2
OV- 103	28	BI029	2	39B	CHILLDOWN TIME 23:24 FAST FILL TIME. 00:01 SLOW FILL TIME. 23:49 REPLENISH TIME: 02:36	CHILLDOWN TIME. 23:12 FAST FILL TIME: 23:50 SLOW FILL TIME 23:20 REPLENISH TIME: 01:58



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL. HUM. %	DEW PT °F	WIND VEL. KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
0215	80	92	77.2	6	161	II	3.54	71.2	+.0033	-.2004	II	3.54	66.3	+.0053	-.1683	II	2.52	62.0	+.0052	-.1168	II	2.28	60.9	+.0050	-.1061
0230	80	91	77.3	3	155	II	1.77	67.6	+.0028	-.1386	II	1.77	59.9	+.0043	-.1137	II	0.96	57.7	+.0045	-.1077	II	4.17	67.0	+.0058	-.1915
0245	79	92	76.8	4	166	II	2.36	68.6	+.0030	-.1439	II	2.36	62.1	+.0047	-.1132	II	0.96	56.9	+.0045	-.1035	II	1.52	56.9	+.0045	-.1035
0300	80	90	77.4	2	153	II	1.18	66.0	+.0025	-.1402	II	1.18	59.4	+.0041	-.1152	II	0.64	58.0	+.0044	-.1092	II	2.78	63.5	+.0052	-.1311
0315	80	92	78.0	5	165	II	2.95	71.2	+.0032	-.1793	II	2.95	65.7	+.0051	-.1476	II	2.10	61.0	+.0049	-.1115	II	1.90	59.8	+.0048	-.1115
0330	80	91	77.3	3	150	II	1.77	67.6	+.0028	-.1386	II	1.77	59.9	+.0043	-.1137	II	0.96	57.7	+.0045	-.1077	II	4.17	67.0	+.0058	-.1915
0345	80	92	77.4	1	157	II	0.59	65.6	+.0026	-.1384	II	0.59	59.0	+.0042	-.1135	II	0.32	57.6	+.0045	-.1075	II	1.39	57.6	+.0045	-.1075
0400	80	93	77.9	2	164	II	1.18	66.0	+.0026	-.1409	II	1.18	59.4	+.0042	-.-159	II	0.84	58.1	+.0046	-.1099	II	0.76	58.1	+.0046	-.1099
0415	81	92	78.4	3	170	II	1.77	68.7	+.0029	-.1452	II	1.77	61.1	+.0044	-.1202	II	1.26	58.9	+.0046	-.1142	II	1.14	58.9	+.0046	-.1142
0430	80	93	78.3	3	174	II	1.77	68.5	+.0029	-.1437	II	1.77	60.8	+.0044	-.1186	II	1.26	58.6	+.0046	-.1126	II	1.14	58.6	+.0046	-.1126
0445	80	93	78.6	1	230	II	0.59	66.9	+.0027	-.1457	II	0.59	60.3	+.0043	-.1207	II	0.32	59.0	+.0046	-.1146	II	1.36	59.0	+.0046	-.1146
0500	79	95	77.3	3	250	II	1.77	67.0	+.0030	-.1351	II	1.77	59.2	+.0044	-.1101	II	1.29	56.9	+.0046	-.1041	II	3.63	65.4	+.0059	-.1648
0515	80	96	78.3	0	245	II	0.0	66.0	+.0027	-.1409	II	0.0	59.4	+.0044	-.1159	II	0.0	58.0	+.0047	-.1098	II	0.0	58.0	+.0047	-.1098
0530	80	95	78.5	0	211	II	0.0	66.4	+.0027	-.1432	II	0.0	59.8	+.0043	-.1182	II	0.0	58.4	+.0047	-.1121	II	0.0	58.4	+.0047	-.1121
0545	79	96	78.0	1	269	II	0.59	65.6	+.0027	-.1389	II	0.59	59.0	+.0043	-.1139	II	0.43	57.6	+.0047	-.1078	II	1.21	57.6	+.0047	-.1018

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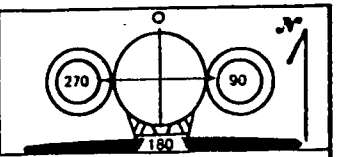
Figure 6. ET TPS Predicted Surface Temperatures and Ice/Condensate

STS- 26R	TEST: Flight Readiness Firing (FRF)					DATE: 8/9/88	T-0 TIME: 0730 DATE: 8/10/88
ORBITER	ET	SRB	MLP	PAD	LO_2 CHILLDOWN TIME: 23:24 FAST FILL TIME: 00:01 SLOW FILL TIME: 23:49 REPLENISH TIME: 02:36	LH_2 CHILLDOWN TIME: 23:12 FAST FILL TIME: 23:50 SLOW FILL TIME: 23:20 REPLENISH TIME: 01:58	
OV- 103	28	BI029	2	39B			



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
0600	79	96	78.1	2	254	II	1.18	65.7	±.0027	±.1396	II	1.18	59.1	±.0043	±.1145	II	0.86	57.7	±.0047	±.1085	II	2.42	62.1	±.0053	±.1151
0615	78	97	77.5	0	252	II	0.0	64.8	±.0027	±.1346	II	0.0	58.2	±.0043	±.1096	II	0.0	56.8	±.0046	±.1035	II	0.0	56.8	±.0046	±.1035
0630	79	97	77.6	0	254	II	0.0	64.9	±.0027	±.1353	II	0.0	58.3	±.0043	±.1103	II	0.0	56.9	±.0046	±.1042	II	0.0	56.9	±.0046	±.1042
0645	79	97	77.9	2	310	II	1.18	65.3	±.0028	±.1373	II	1.18	58.7	±.0044	±.1123	II	0.92	57.3	±.0047	±.1062	II	2.46	61.9	±.0054	±.1150
0700	77	98	76.4	4	291	II	2.36	67.3	±.0033	±.1375	II	2.36	60.6	±.0049	±.1070	II	1.72	55.5	±.0046	±.0954	II	4.84	66.4	±.0063	±.2060
0715	78	98	77.1	2	273	II	1.18	64.2	±.0027	±.1310	II	1.18	57.5	±.0043	±.1060	II	0.86	56.1	±.0046	±.1000	II	2.42	60.5	±.0053	±.1077
0730	79	97	78.4	0	333	II	0.0	65.9	±.0028	±.1407	II	0.0	59.3	±.0044	±.1156	II	0.0	57.9	±.0047	±.1096	II	0.0	57.9	±.0047	±.1096
0745	79	96	78.2	1	316	II	0.59	65.8	±.0027	±.1403	II	0.59	59.2	±.0043	±.1152	II	0.46	57.9	±.0047	±.1092	II	1.23	57.9	±.0047	±.1092
0800	79	97	77.9	3	327	II	1.77	67.4	±.0031	±.1373	II	1.77	59.7	±.0045	±.1123	II	1.38	57.3	±.0047	±.1062	II	3.69	66.0	±.0060	±.1706
AVG.	79	91	75.6	3.1	S	II		68.2			II		61.6			II		58.6			II		64.0		

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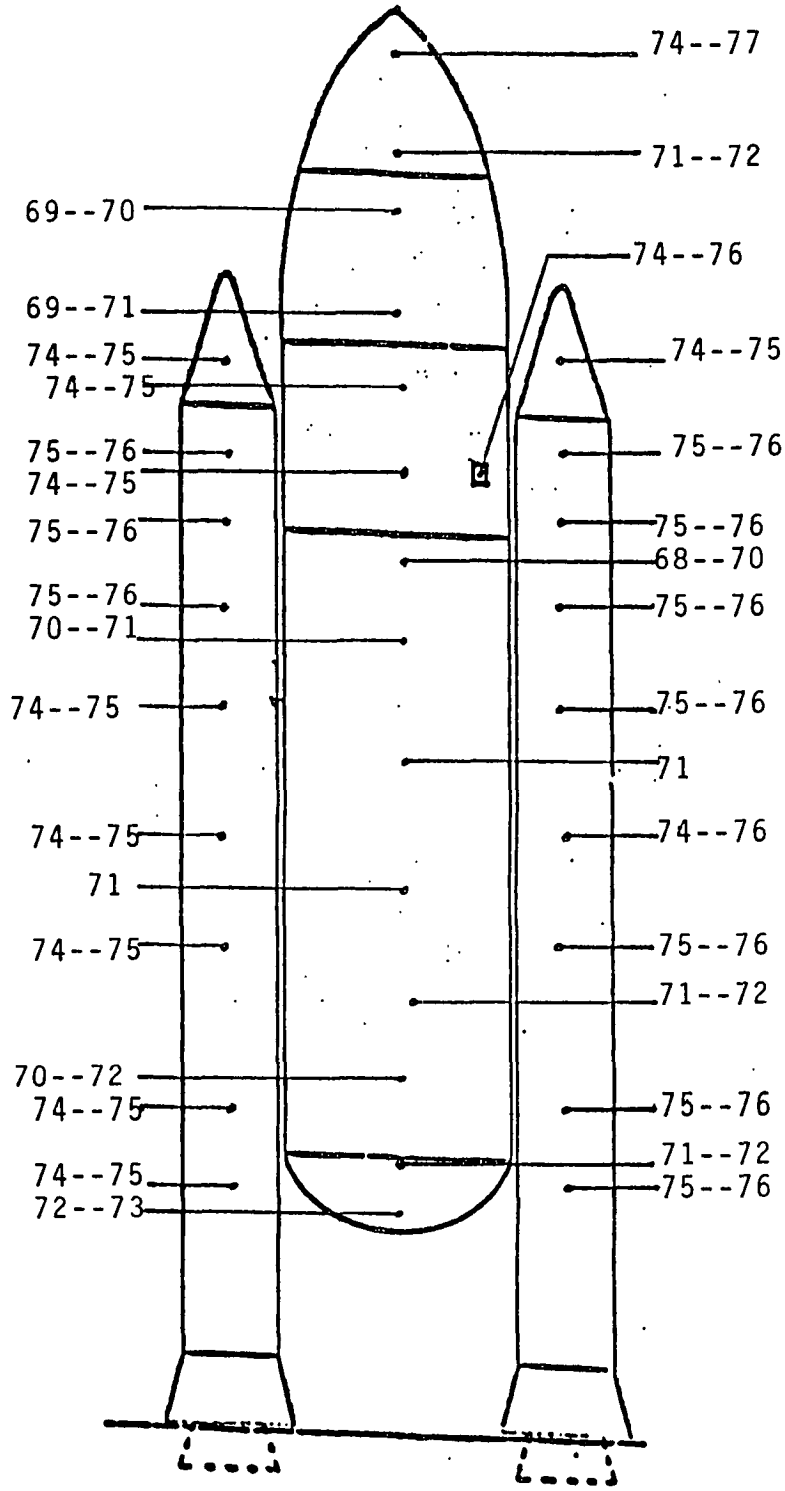
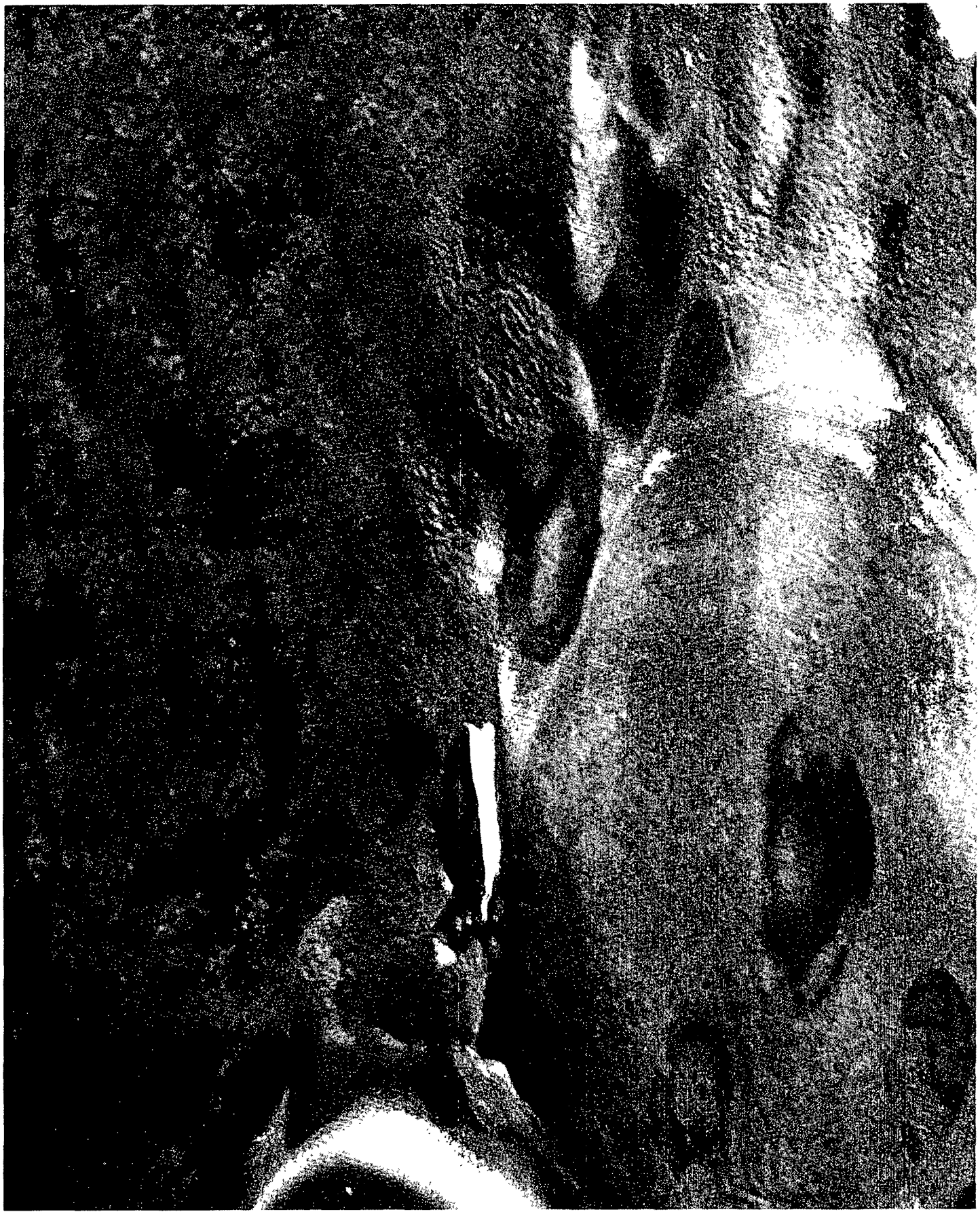
Figure 6. ET TPS Predicted Surface Temperatures and Ice/Condensate

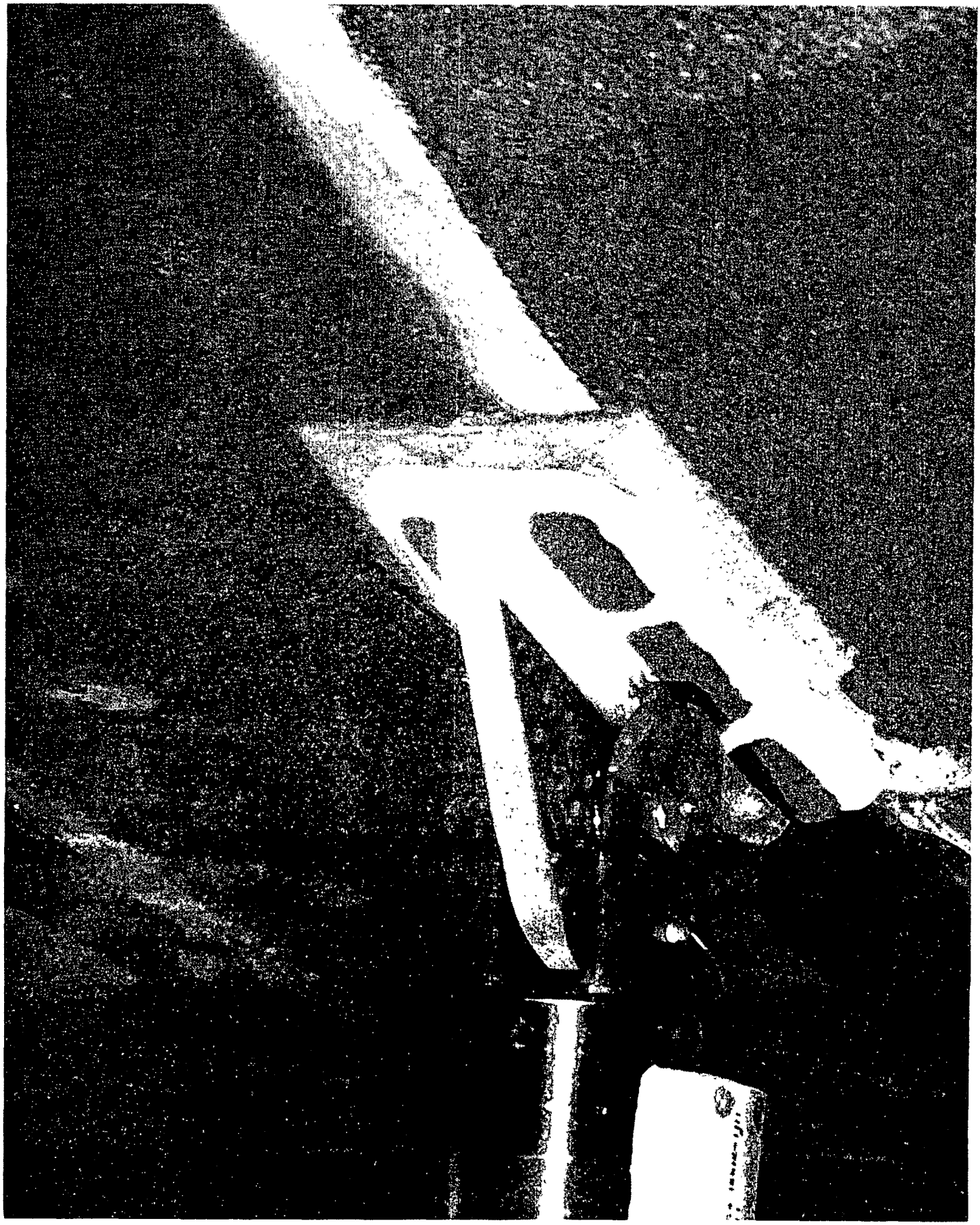


TEMPERATURE IN DEGREES FAHRENHEIT

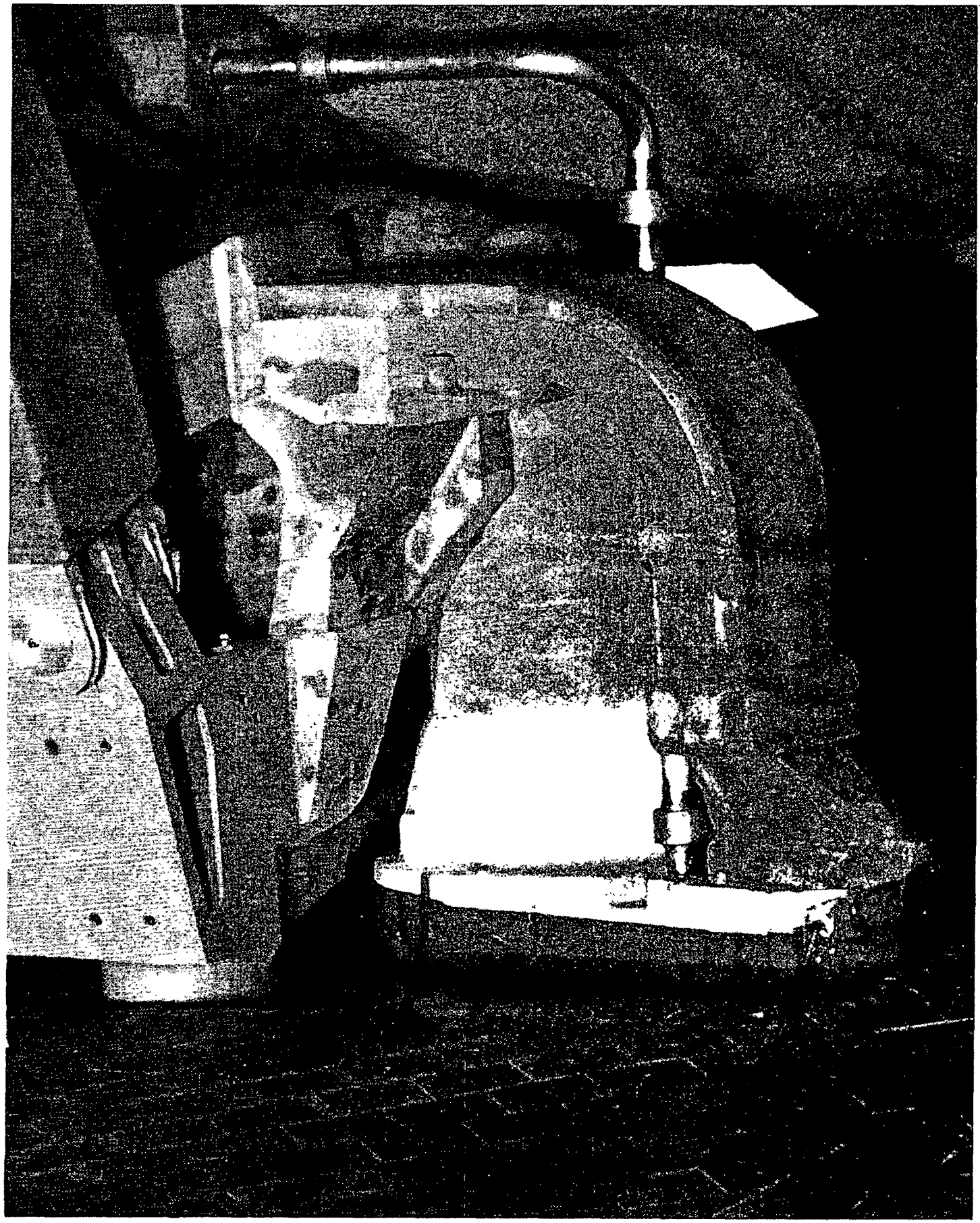
Figure 7. INFRARED SCAN DATA - SCANNER LOCATED 700 FEET NORTH OF SSV CENTERLINE AT FLAME TRENCH



DIVOT ON ET LH2 TANK AFT DOME APEX



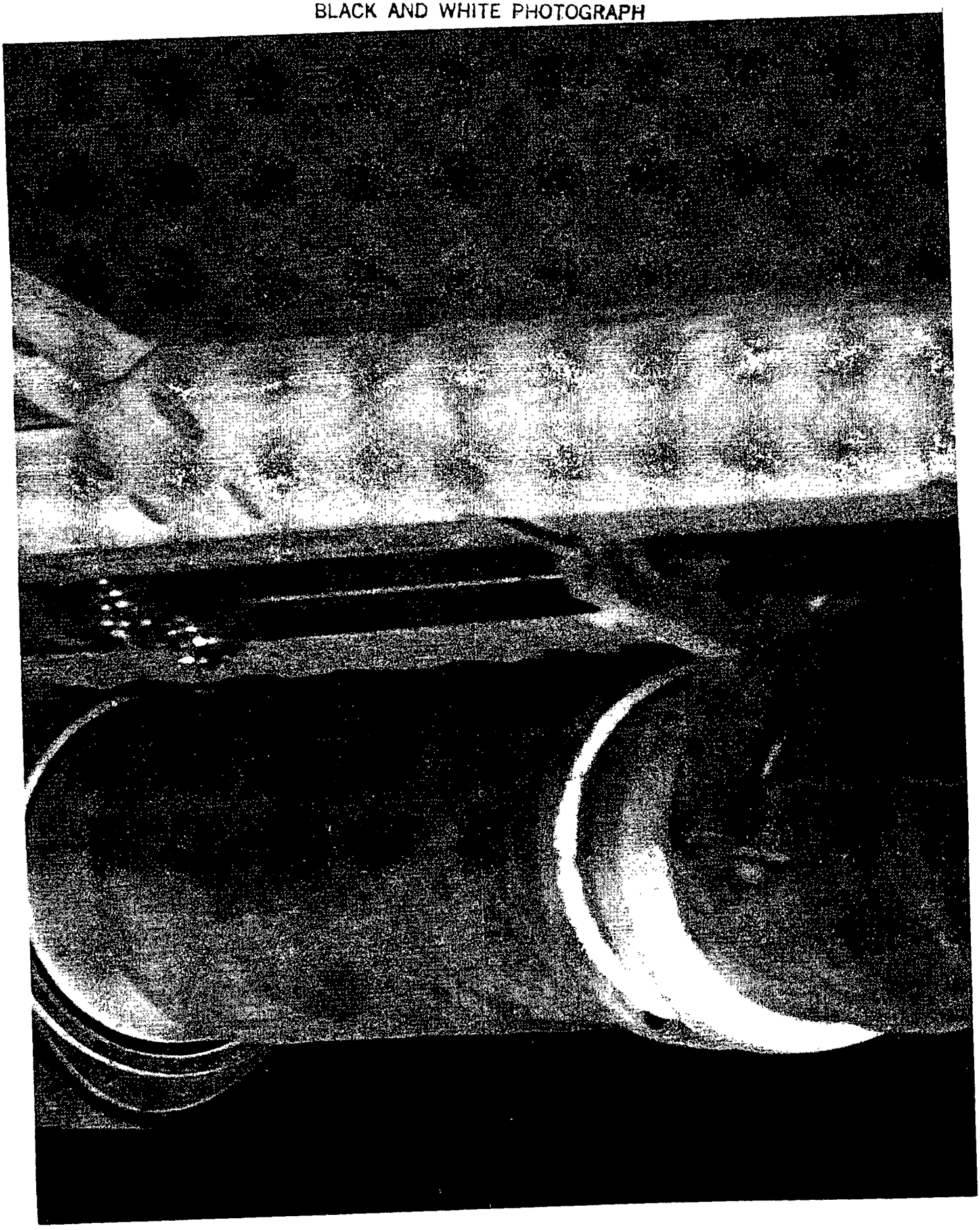
ICE/FROST ACCUMULATION ON EB FITTING TO STRUT PIN HOLE.
CONDENSATE IS PRESENT ON OUTBOARD SECTION OF EB FITTING.



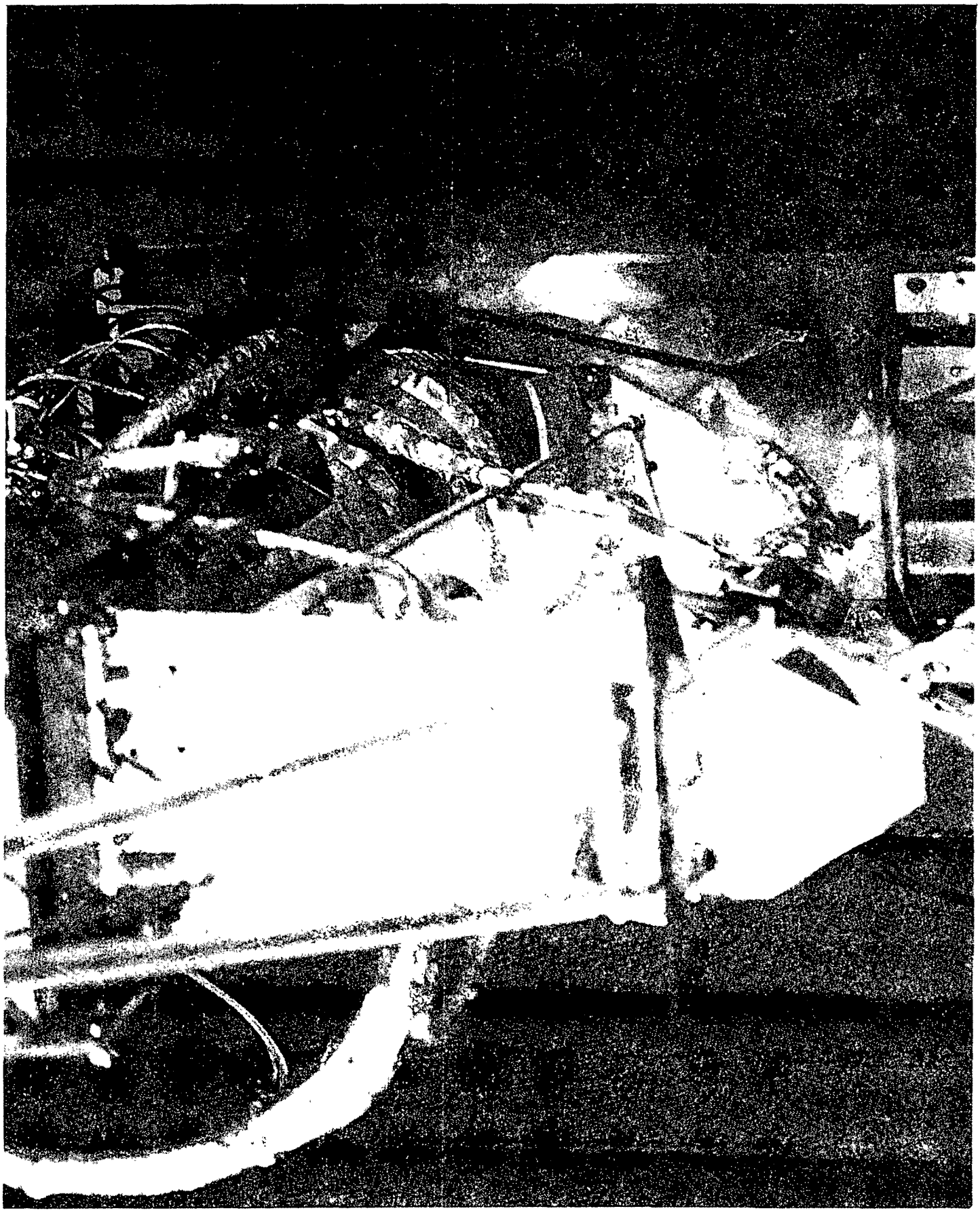
ET/ORB LO2 UMBILICAL WITH FROST FINGER ON PURGE VENT.

ICE/FRST ACCUMULATION ON LH2 UMBILICAL BAGGIE. GAS ANALYZERS AND INSTRUMENTATION AND CABLES HAVE BEEN INSTALLED FOR FRF.

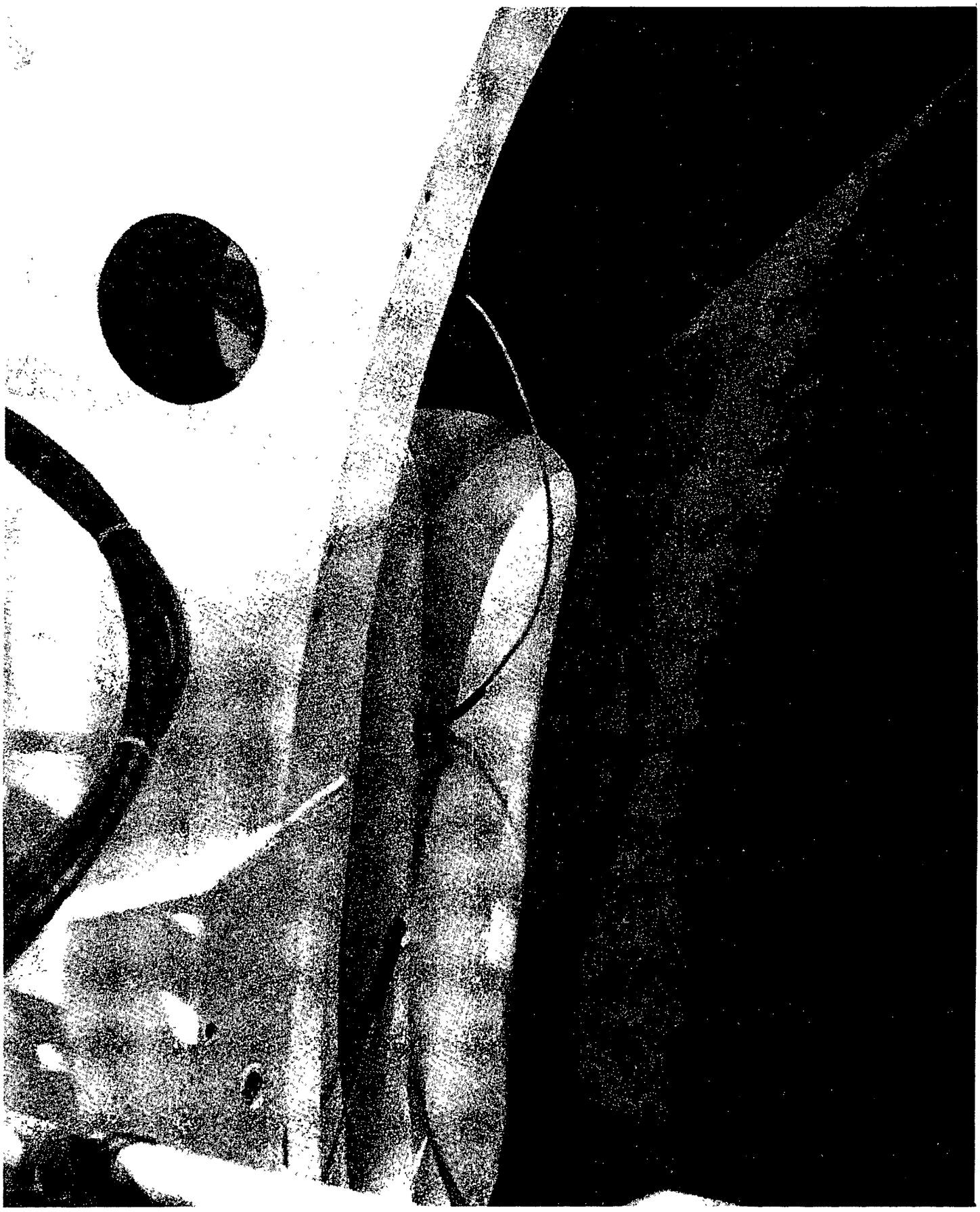
ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



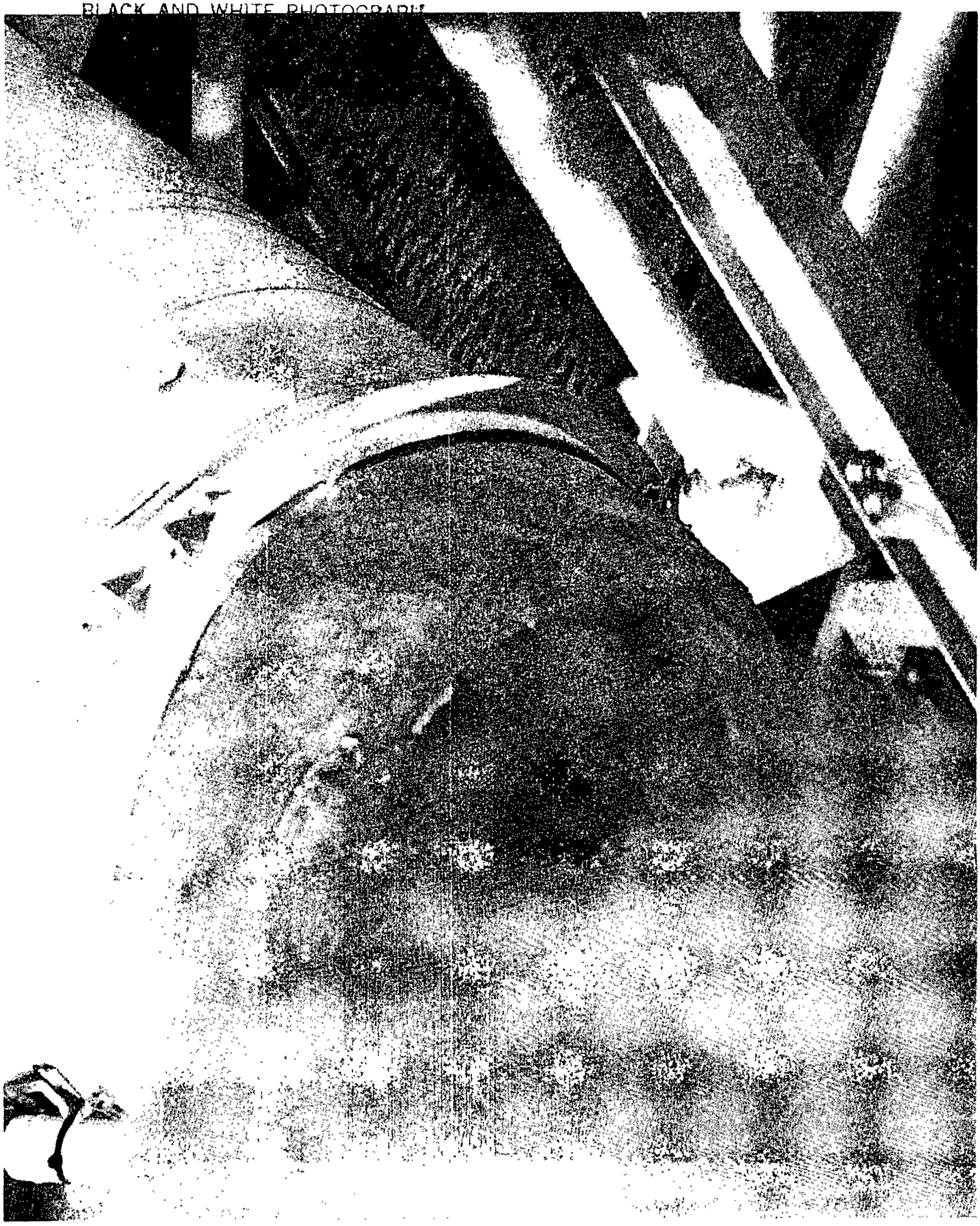
ICE/FROST ACCUMULATION IN LO2 FEEDLINE BELLOWS/SUPPORT BRACKET



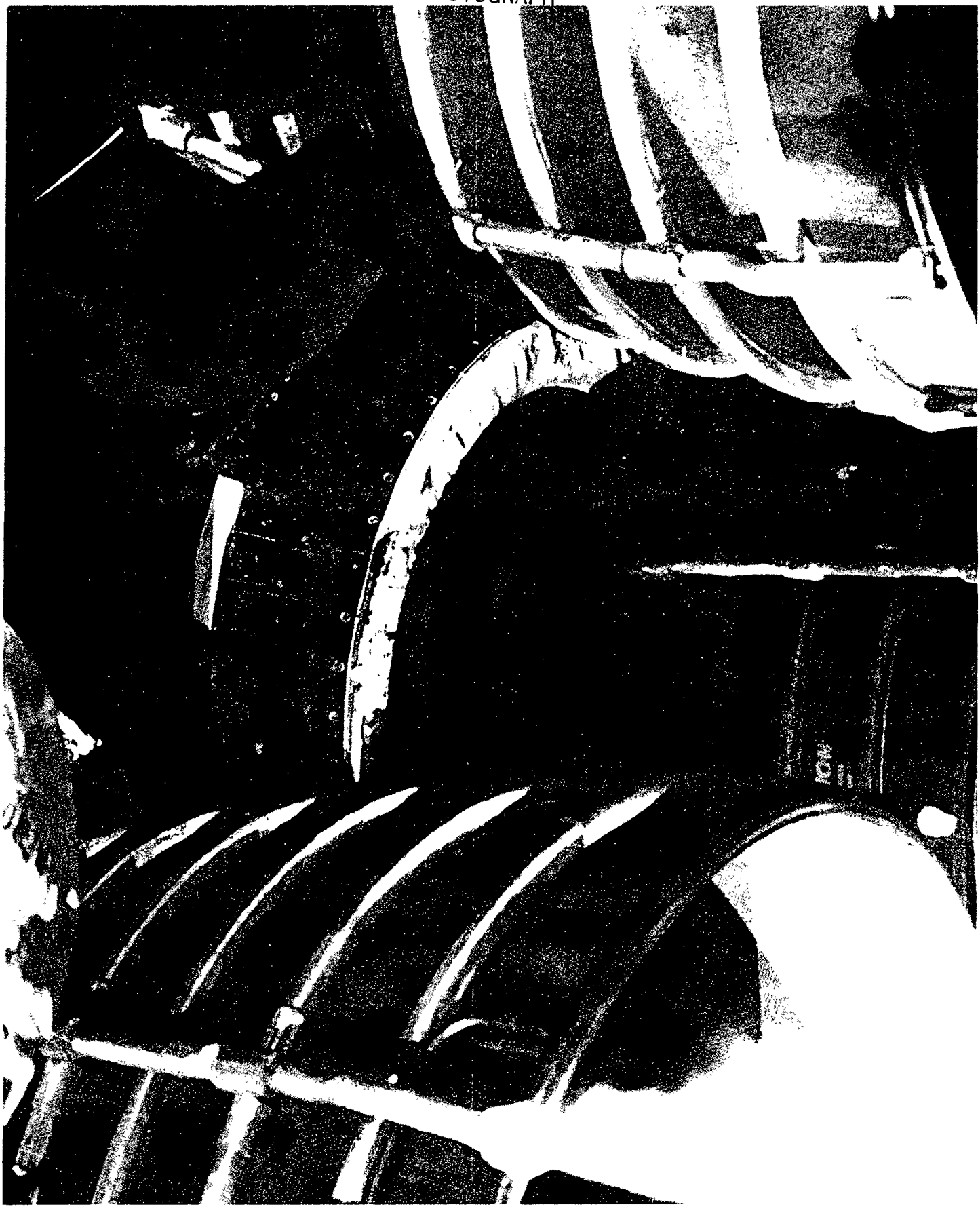
LIGHT FROST ACCUMULATION ON +Z SIDE OF GUCP



GOX VENT SEAL HAS BEEN REPLACED AND REPOSITIONED



SMALL ICICLES AND FROST FINGERS ON GOX VENT EXHAUST DUCT



FROST ACCUMULATION ON SSME#2 ENGINE MOUNTED HEAT SHIELD. TILE CARRIER PANEL REMOVED TO ACCOMMODATE FRF INSTRUMENTATION.

5.3 POST-DRAIN INSPECTION

The vehicle and pad were inspected approximately 5 hours after a successful Flight Readiness Firing on 10 August 1988. The following items were observed:

External Tank

- Expected amounts of ice/frost remained in the LH2 feedline/recirculation line bellows, as well as the LOX purge vents
- The loose PDL foam on the LH2 aft dome was still attached
- All ET anomalies previously documented were unchanged and will be investigated in more detail during a hands-on evaluation
- Topcoat was missing on -Y nosecone, footprint area

ORBITER

- Approximately 40 tile damage locations were observed on the orbiter base heat shield, base of OMS pods, RCS stingers, upper body flap, and speed brake. The largest damage size was approximately 5" x 1/2" and the average size was less than 1/2" in diameter. This damage pattern has been observed for each FRF and is considered to be caused by water spray impact and/or acoustic/vibration loading on the TPS
- Insulation on the hatband and steerhorn pipes on the exterior of the SSME #2 nozzle bell was loose in some areas and missing in others

SRB

- A hole in the instafoam on RH SRM below the ETA ring

A hands-on inspection of the External Tank was performed on 13 August 1988 to evaluate previously documented items in more detail. The following conditions were found:

- The debris between the LO2 feedline and attach bracket at Station XT-1377 (documented after FRF abort) was loose foam. The LO2 feedline boomerang brackets at XT - 1123, 1623, and 1871 also contained loose foam

- The 3-1/4" x 2-3/8" divot on -Y side of LO2 Feedline XT-1623 was investigated for a suspected leak at the ECO leak check port, but no leak was found during mass spec evaluation. The divot was caused by an air pocket

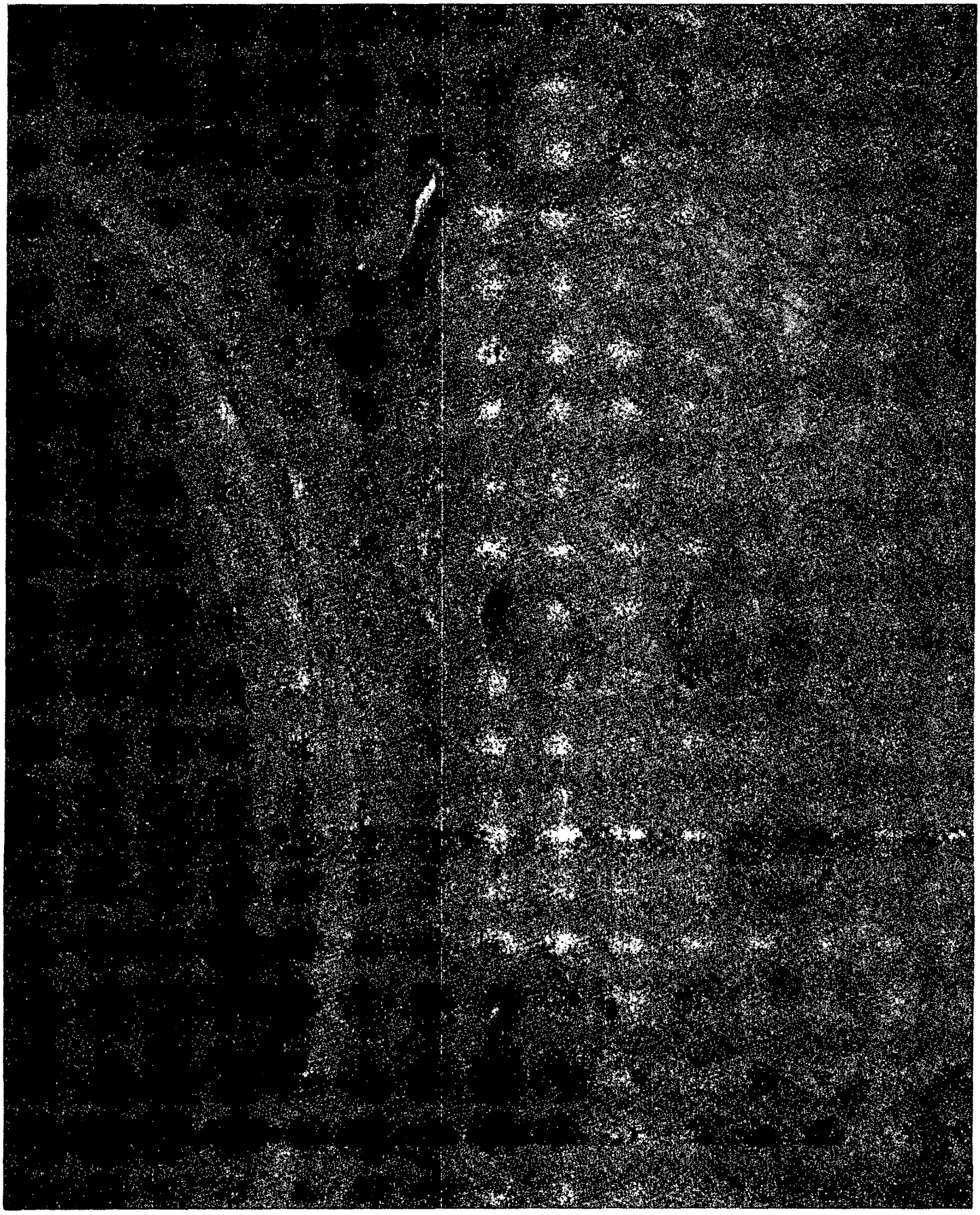
- The 2-inch crack previously observed on X/Y thrust strut knuckle crotch area was found to be acceptable for flight

- The 4-inch crack along -Y edge of BX-250 closeout on -Z side of siphon manhole (LH2 aft dome) was found to be a bondline and not in violation of the acceptance criteria

- Topcoat was missing from the alignment grid on -Y nose cone footprint area

- The second loose LH2 aft dome PDL repair was removed. Three other PDL repairs were included in the same rework job and were also removed.

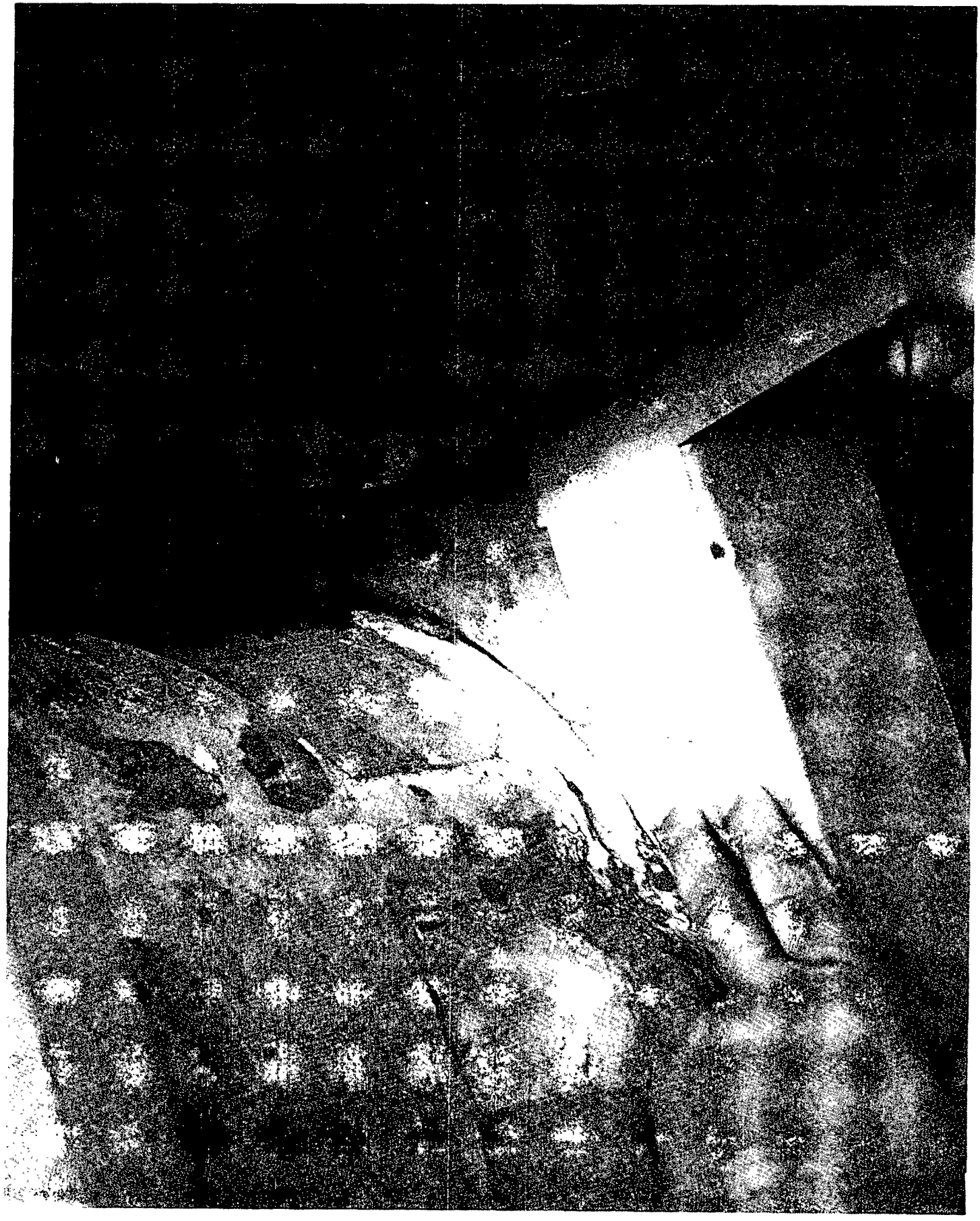
All of the above ET anomalies were repaired to an acceptable condition and the External Tank is ready to support cryo loading for STS-26R launch.



DIVOT ON ET LH2 TANK AFT DOME APEX

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH

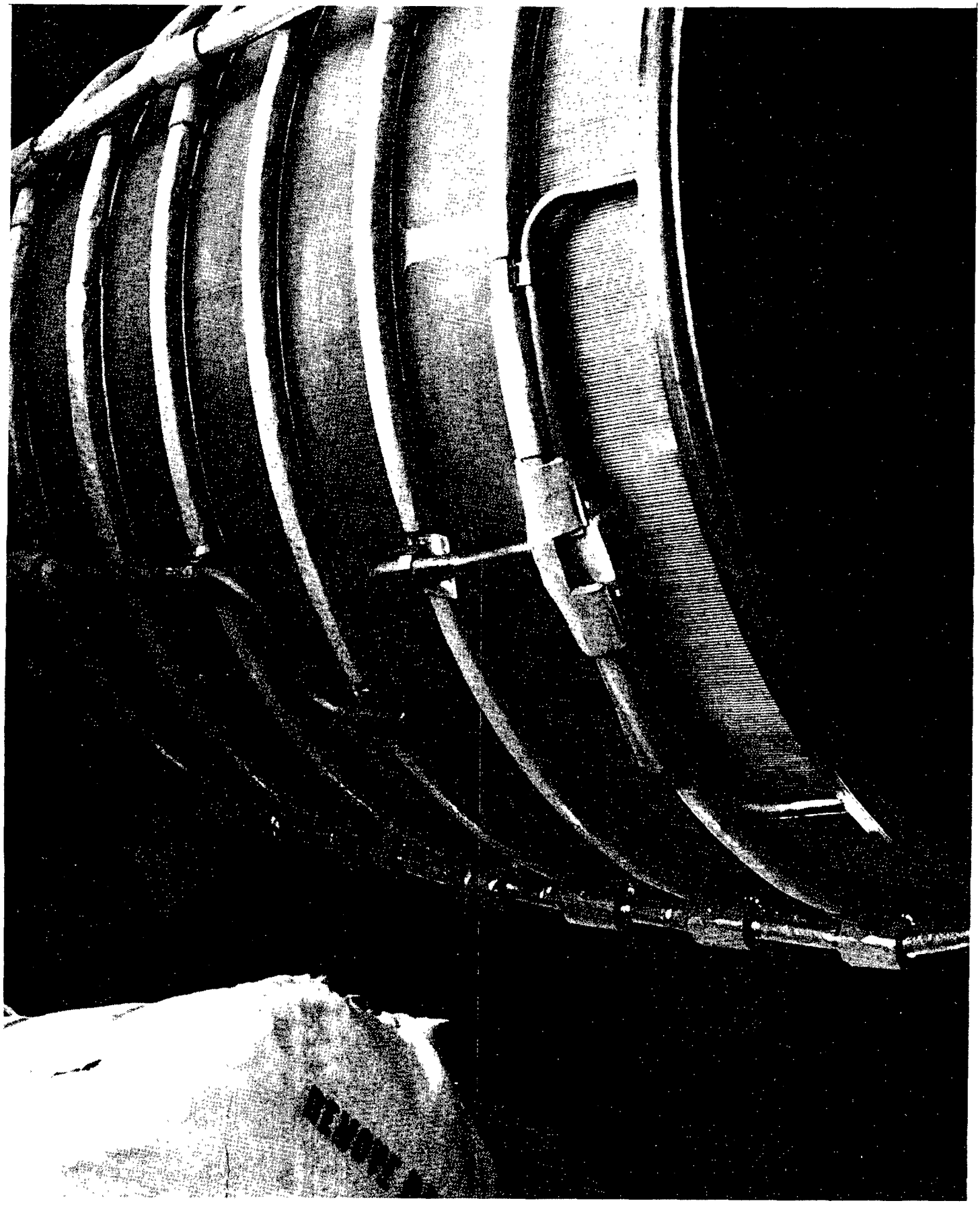
AIR POCKET WAS ENTRAPPED DURING REPAIR AND PDL FOAM
DID NOT ADHERE TO SLA SUBSTRATE OR ISOCHEM BONDLINE



TYPICAL LO2 FEEDLINE DAMAGE FROM MULTIPLE
CRYO LOAD AND DRAINBACK OPERATIONS

DAMAGED FOAM HAS BEEN REMOVED FROM LO2 FEEDLINE/SUPPORT BRACKET

LO2 FEEDLINE ACREAGE DIVOT XT-1629 CAUSED BY ENTRAPPED AIR



LOOSE FOIL THERMAL INSULATION BLANKET ON SSME #1 NOZZLE

5.4 FRF FILM SUMMARY/PROBLEM REPORTS

No significant vehicle damage or safety-of-flight concerns were observed that would affect launch.

Flame is visible under base heat shield approximately 5.5 seconds after SSME shutdown. Flame recirculates on -Z side of SSME #1 nozzle and travels about two feet up the nozzle exterior surface (E-3, 76, 77).

Foil thermal insulation blankets on SSME #1 steerhorn detaches partially at ignition (E-19 and 20).

Acoustics/vibration from SSME ignition cause numerous "dings" in the base heat shield tiles. Ice/frost falls from Orbiter T-0 umbilicals and ET-ORB LO2 and LH2 umbilicals.

Lights for film item E-22 internal to the LH2 TSM are activated at T-20 seconds causing light to be visible on the Orbiter T-0 umbilical area. Light is turned off, by command, at T+60 seconds (OTV 163).

Upper sections/corners of radiation shield exhibit unusual amount of flexure. This phenomenon did not occur on previous FRF's E-31.

Transparent purge barrier on LH2 TSM T-0 opening comes loose and flaps around T-0 umbilical area after SSME ignition (OTV 163).

Firex water activated under SSME's reaches OMS pod and Orbiter LH2 T-0 umbilical. Firex water north of radiation shield reaches ET/ORB LH2 umbilical. Rust colored water is visible for a few seconds, but is soon washed off vehicle (OTV 109, 163).

Maximum ET 'twang' of 33.276 inches from CZR metric data compares fairly well with 34 inch estimation in E-79 comments and 31.898 inches calculated on an engineering analyzer.

No PR's or IPR's were generated as a result of the FRF film and video data review.

5.5 FRF FILM AND VIDEO DATA REVIEW

FILM ITEMS

E-1	Camera is located on the NE corner of the MLP deck
400 FPS	and views the lower ET, SRB's, and Orbiter.
16mm	
Focus :	OK
F. O. V.:	Need to show more MLP deck
Exposure:	OK
Comments:	1. Several film defects were noted.
	2. A dragonfly passes through the left of the frame a few seconds after ignition.
	3. No anomalies noted.

E-2	Camera is located on the SE corner of the MLP deck
400 FPS	and views Orbiter SSME and OMS engine nozzles.
16mm	
Focus :	OK
F. O. V.:	OK
Exposure:	OK
Comments:	1. Film ends prior to last visible exhaust flame. Film needs to run longer.
	2. RCS paper covers rupture at ignition.
	3. A GH2 plume is visible during engine shutdown. The plume lasts 0.75 sec for SSME #1 and 0.5 seconds for SSME #2.

E-X2	Camera is located on the MLP deck and views the RH
400 FPS	SRB joint heater umbilical.
16mm	
Focus :	
F. O. V.:	
Exposure:	
Comments:	********** CAMERA FAILED **********

E-X3
400 FPS
16mm
Focus :
F. O. V.:
Exposure:

Camera is located on the MLP deck and views the LH SRB joint heater umbilical.

Cannot be determined
OK
Underexposed

Comments:

1. No anomalies noted.

E-3
400 FPS
16mm
Focus :
F. O. V.:
Exposure:

Camera is located on the SW corner of the MLP deck and views Orbiter SSME and OMS engine nozzles.

OK
Needs to be oriented more to the left
OK

Comments:

1. Film appears to be dirty.
2. RCS paper covers rupture at ignition.
3. A thin white object (approx. 2" x 3") falls through FOV approx. 8 sec after ignition. Object is visible for eight frames and falls on +Z side of Orbiter wing along plane of TSM.
4. At least 1 small dark object falls through the right side of the frame at the same time as the large white object.
5. Flame is visible under aft heat shield approx. 5.5 seconds after SSME shutdown.
6. Flame recirculates on -Z side of SSME #1 nozzle and travels approx. 2 ft up the nozzle exterior
7. Light from LH2 TSM internal camera is reflected on the Orbiter.
8. The OMS engine covers appear to be loose.

E-4
400 FPS
16mm
Focus :
F. O. V.:
Exposure:

Camera is located on the NW corner of the MLP deck and views lower ET, SRB's, and Orbiter.

OK
OK for FRF, should be slightly left for launch
More exposure for FRF, OK for launch

Comments:

1. No anomalies noted.

E-5 400 FPS 16mm	Camera is located on the east side of the MLP deck and views the Orbiter RH wing, body flap, and lower ET/SRB.
Focus : F. O. V.: Exposure:	OK Lower 1/8 frame Underexposed
Comments:	1. Film was wound on reel backwards. 2. A shiny object, possibly sheet ice from LOX T-0 umbilical, falls from umbilical area approx one second after SSME ignition. 3. A second similar object, possibly sheet ice from LOX T-0 umbilical, falls at approx 1.25 seconds. 4. Elevon movement was minimal.

E-6 200 FPS 16mm	Camera is located on the east side of the MLP deck and views the RH lower Orbiter wing, body flap, and ET/Orbiter umbilical area.
Focus : F. O. V.: Exposure:	OK OK underexposed
Comments:	1. SSME ignition causes some elevon movement. 2. Dust shakes off Orbiter wing upper surface. 3. One debris particle falls from the +Z side of the Orbiter wing.

E-15 400 FPS 16mm	Camera is located on the MLP deck and views the RH SRB skirt, sound suppression water troughs, and RH lower Orbiter body flap.
Focus : F. O. V.: Exposure:	OK OK Underexposed for FRF, OK for launch
Comments:	1. Film wound on reel backwards. 2. No anomalies noted.

E-16
400 FPS
16mm

Camera is located on the MLP deck and views the LH SRB skirt, sound suppression water troughs, and LH lower Orbiter body flap.

Focus :
F. O. V.:
Exposure:

OK
OK
Underexposed for FRF, OK for launch

Comments:

1. Film wound on reel backwards.

2. No anomalies noted.

E-17
400 FPS
16mm

Camera is located on the MLP deck and views the TSM LO2 T-0 umbilical.

Focus :
F. O. V.:
Exposure:

OK
OK
Underexposed

Comments:

1. RCS paper covers rupture at ignition

2. Ice falls from SSME nozzle.

3. Ice falls from LO2 T-0 umbilical.

4. A ding in a base heat shield tile occurs early in the engine run.

5. Three dings are located next to the SSME #3 thermal barrier.

6. Several dings are observed on the inboard edge of the OMS stinger.

E-18F

********** CAMERA FAILED **********

E-19
400 FPS
16mm

Camera is located on the SE side of the MLP deck and views the SSME/OMS nozzles and Orbiter aft heat shield area.

Focus :
F. O. V.:
Exposure:

OK
Too far right, showing too much LO2 TSM
OK

Comments:

1. RCS paper covers rupture at ignition.

2. At ignition, a loose foil thermal insulation blanket flaps near the SSME #1 steerhorn (approx. 2 o'clock).

3. Flakes of ice/frost fall from the LOX T-0 umbilical at ignition.

4. A small flake of black tile on the starboard OMS stinger aft wall falls off at ignition.

5. A jet of hydrogen comes from SSME #1 and #2 after shutdown.

E-20
400 FPS
16mm

Camera is located on the SW side of the MLP deck and views the SSME/OMS nozzles and Orbiter aft heat shield area.

Focus :
F. O. V.:
Exposure:

OK
Too far left, showing too much LH2 TSM
OK

Comments:

1. Film started too early and ended too soon.

2. Several tile gap fillers on the aft heat shield are shaken loose by SSME ignition acoustics/ vibration.

3. RCS paper covers rupture at ignition.

4. Foil thermal insulation blankets on the SSME #1 steerhorn (approx. 10 o'clock) detach partially at ignition.

5. Acoustical vibration effects on OMS engine covers are apparent. Covers appear loose.

6. Tile flakes fall from the aft heat shield.

7. A jet of hydrogen comes from SSME #1 and #2 at shutdown.

E-21
200 FPS
16mm

Camera is located inside the LO2 TSM and views the disconnection of the T-0 umbilical.

Focus :
F. O. V.:
Exposure:

OK
Lower 1/8 frame
Open up 2/3 f-stop

Comments:

1. SSME shutdown occurs during 5th oscillation of vehicle.

2. Vapor/water is visible for 3300 frames after cutoff.

E-22
200 FPS
16mm
Focus :
F. O. V.:
Exposure:

Camera is located inside the LH2 TSM and views the disconnection of the T-0 umbilical.

Comments: ********** CAMERA FAILED **********

E-23
400 FPS
16mm
Focus : OK
F. O. V.: Too far right
Exposure: OK

Camera is located on the MLP deck and views the +Y OMS engine nozzle.

Comments:

1. RCS paper covers rupture at ignition.
2. Five base heat shield tiles are chipped between LH OMS engine and SSME #1 and #3.
3. Post-shutdown burning is visible.
4. Ice falls from the LO2 umbilical.
5. Vehicle rotation during SSME run is noticeable.

E-24
400 FPS
16mm
Focus : OK
F. O. V.: Too high
Exposure: OK

Camera is located on the MLP deck and views the -Y OMS engine nozzle.

Comments:

1. Film leader is too long. Film only showed engine startup.
2. RCS paper covers rupture at ignition.
3. Unknown object passes near camera.
4. Pieces of tape come off the -Y OMS engine nozzle cover.
5. A tile in the base heat shield at a location 6 o'clock from the OMS nozzle is chipped.
6. No visible indication that firex water contacts the aft heat shield.

E-31 100 FPS 16mm	Camera is located on the FSS 95 foot level and views the LH Orbiter wing, body flap, and ET/Orbiter LH2 umbilical area.
Focus : F. O. V.: Exposure:	OK OK Underexposed
Comments:	1. Upper sections of the radiation shield exhibit unusual amount of flexure. This phenomenon was not observed on previous FRFs. 2. Five pieces of ice fall from the ET LH2 umbilical area. 3. Some movement of the Orbiter aero-control surfaces is attributed to SSME ignition. 4. Debris from the upper forward side of the Orbiter body flap comes loose. (RTV or gap filler?)

E-33 400 FPS 16mm	Camera is located on the FSS 235 foot level and views the ET GH2 vent line and GUCP.
Focus : F. O. V.: Exposure:	OK OK Underexposed
Comments:	1. Some frost has formed on the GUCP in the area of the quick disconnect but external to the new purge shield. 2. Vehicle "twang" motion is noticeable.

E-34 400 FPS 16mm	Camera is located on FSS at 255 foot level and views upper Orbiter tile surfaces.
Focus : F. O. V.: Exposure:	OK Needs to be shifted left to better view GUCP Underexposed
Comments:	1. No anomalies noted.

E-35 400 FPS 16mm Focus : F. O. V.: Exposure:	Camera is located on the FSS 255 foot level and views the mid-Orbiter/ET/SRB area. OK OK Underexposed
Comments:	1. Light from the LH2 TSM internal umbilical camera reflect on the side of the Orbiter. 2. No anomalies noted.

E-36 400 FPS 16mm Focus : F. O. V.: Exposure:	Camera is located on the FSS 255 foot level and views lower Orbiter, ET, SRB's, and water trough. OK OK Underexposed
Comments:	1. Light from the LH2 TSM internal umbilical camera reflects on the side of the Orbiter. 2. Post-shutdown burning is visible above the deluge water. 3. Loose thermal curtain tape appears on the LH SRB systems tunnel. 4. Reflected energy is noticeable in SRB flame holes. 5. An orange glow is visible in the SSME exhaust cloud south of the MLP deck. 6. Water deluge is visible in the SRB flame trench through both RH and LH SRB flame holes due to the absence of the secondary water troughs. (FRF configuration only).

E-37F FPS mm	Camera provides a view of the ET with a fixed target on the FSS centered in the frame to measure ET tip deflection from ignition through cutoff.
Focus : F. O. V.: Exposure:	OK OK Underexposed
Comments:	1. GUCP target is obstructed by hand rail prior to SSME ignition.

E-40
400 FPS
16mm

Camera is located on the FSS 255 foot level east side and views the ET ogive, SRB nosecone, and tiled surfaces of Orbiter passing through frame.

Focus : OK
F. O. V.: OK
Exposure: Underexposed

Comments:

1. An OTV camera obscures the FOV of this camera.
2. Five vehicle "twang" motion cycles occur prior to SSME shutdown.

E-43
200 FPS
16mm

Camera is located on pad surface and views beneath the MLP to show sound suppression water system.

Focus : OK
F. O. V.: OK
Exposure: Underexposed

Comments:

1. Several pieces of debris, and one bird, fly through the general area at SSME start/cutoff.
2. Plume dynamics are visible.
3. Initiation of water deluge produces small water geyser at north end of flame trench.
4. Ice falls from the MLP Side 1 LO2 line when water deluge is initiated.
5. Flame is evident beneath the MLP for approx. 23 seconds after SSME startup.

E-50
400 FPS
16mm

Camera is located at camera site 1 at NE pad perimeter. Overall view of GH2 vent line including hinge and ET interface during disconnect and retract.

Focus : OK
F. O. V.: OK
Exposure: Underexposed

Comments:

1. Vehicle "twang" motion is noticeable.
2. No anomalies noted.

E-60
100 FPS
35mm

Camera is located on north pad perimeter at camera site 1 and views the entire launch vehicle, FSS, and MLP zero level.

Focus : OK
F. O. V.: Too high, should show top of the pad
Exposure: OK

Comments:

1. Hydrogen burning is visible under the MLP.

E-61
100 FPS
35mm

Camera is located at camera site 2 on the S pad perimeter and views the launch vehicle, FSS, and MLP.

Focus : OK
F. O. V.: Should be moved slightly lower to show top of pad
Exposure: Underexposed

Comments:

1. Hydrogen burning is visible under the MLP from SSME startup until shutdown.

2. Ice falls from the cryogenic line on MLP Side 2

E-62
100 FPS
35mm

Camera is located on the SE pad perimeter at camera site 3 and views the ET, MLP, SRB, and and pad surface.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments:

1. Hydrogen burning is visible under the MLP.

2. Ice falls from the cryo line on MLP Side 2.

E-63
100 FPS
35mm

Camera is located on SW side of pad perimeter and views entire launch vehicle, FSS, and MLP

Focus : OK
F. O. V.: OK
Exposure: OK

Comments:

1. Hydrogen burning is visible under the MLP.

2. No evidence of hydrogen burning is observed in the exhaust cloud after SSME shutdown.

3. Ice/debris falls from the LO2 cryogenic line and MLP side 1 skid.

E-64 100 FPS 35mm	Camera is located on NW pad perimeter at camera site 6 and views entire launch vehicle, FSS, and MLP, with ground level at bottom of frame.
Focus : F. O. V.: Exposure:	OK Too high, should show top of pad not top of MLP OK
Comments:	1. SSME startup and run is not visible since FOV is too high.

E-76 100 FPS 35mm	Camera is located on SE pad perimeter at camera site 3 and views SSME engines #1 and #3 and the +Y OMS engine nozzle.
Focus : F. O. V.: Exposure:	OK Too tight, should show from top of Orbiter tail to top of MLP deck OK
Comments:	1. Broken tiles are visible at engine startup. 2. Ice falls from the LO2 TSM T-0 umbilical. 3. Hydrogen burning is visible during SSME shutdown.

E-77 200 FPS 35mm	Camera is located on SW pad perimeter at camera site 4 and views SSME engines #1 and #2 and the -Y OMS engine nozzle.
Focus : F. O. V.: Exposure:	OK Too tight, should show from top of Orbiter tail to top of MLP deck OK
Comments:	1. Broken tiles are visible at SSME startup. 2. Very little ice falls from the LH2 TSM T-0 umbilical. 3. Hydrogen burning is observed during SSME shutdown.

E-79
100 FPS
16mm
Focus :
F. O. V.:
Exposure:

Camera is located on east pad perimeter at camera site 2 and views the ET nosecone.

Soft
Should be moved more to the right
Underexposed

Comments:

1. First vehicle "twang" motion to the north goes beyond zero mark on the scale to approx. -8". The second and third north movements go to approx. -10".

2. A total of 21 vehicle oscillations are visible.

3. The ET tip moves approx. 34" with the first "twang" motion.

4. SSME shutdown occurs during the fifth "twang" cycle.

5. The maximum travel from the zero mark on the scale is approx. 34".

VIDEO ITEMS

OTV 134
B/W

Views MLP side 1 (south) LH2 skid.

Comments:

1. SSME startup is detectable by glare reflection and camera shake.

2. Post-shutdown steam and vapors are visible.

3. No MLP anomalies.

4. No hydrogen fire visible on B/W.

OTV 135
B/W

Views base of FSS

Comments:

1. No anomalies noted.

OTV 143
B/W

Views east side of launch vehicle and pad from camera site 2.

Comments:

1. View is too distant to discern small detail.
2. Some water deluge spray and SSME exhaust exits through SRB flame trench.
3. SSME plume dispersion exhibits effects of high heat and/or hydrogen fire. Effects are most noticeable to left side of RSS.

OTV 111
B/W IR

Views GUCP and GH2 vent line with new Insight IR camera.

Comments:

1. Good view of vehicle "twang".
2. No thermal changes evident.

OTV 119
B/W IR

Views LH2 umbilical with new Insight IR camera.

Comments:

1. Vehicle "twang" and umbilical purge vapors are visible.
2. IR camera is overdriven.
3. Firex water reaches umbilical area from MLP deck. Some water gets past crossbeam.
4. After firex water cutoff, umbilical purge vapors are again visible.

OTV 130
B/W IR

Views SSMEs and Orbiter aft end from SE pad apron with new Insight IR camera.

Comments:

1. Although infrared signature of ignitors (ROFI) is visible, SSME firing appears to overdrive IR camera.
2. No other anomalies noted.

OTV 149
B/W

Views LO2 T-0 umbilical

Comments:

1. Good view of T-0 umbilical movement in spite of camera shake.
2. Two chunks of ice/frost drop from umbilical at SSME shutdown.
3. Firex water reaches umbilical area.

OTV 172
B/W IR

Views SSMEs with new Insight IR camera from SW corner of MLP deck.

Comments:

1. GO2 venting and ignitors (ROFI) visible, but IR camera is overdriven when SSMEs start up.

OTV 160
Color M-II

Views ET nosecone and NE louver from water tower.

Comments:

1. Considerable camera shake.
2. Frost develops on louver from GO2, but no ice balls are visible.
3. Large ET excursions from "twang" are visible.
4. GO2 vent hood is repositioned over nosecone before ET movement subsides.

OTV 161
Color M-II

Views ET nosecone and SW louver from FSS.

Comments:

1. Some camera shake.
2. Frost develops on louver from GO2, but no ice balls are visible.
3. Large ET excursions from "twang" are obvious.
4. Hood repositioning on nosecone is blocked from view by GO2 vent duct.

OTV 163
Color M-II

Views ET/Orbiter umbilical and Orbiter T-0 umbilical from FSS.

Comments:

1. Lights for film item E-22 internal to the LH2 TSM are activated at T-20 seconds causing light to be visible on the Orbiter T-0 umbilical area. Light is turned off, by planned command, at T+60 seconds.

2. Transparent purge barrier from LH2 TSM opening comes loose and flaps around T-0 umbilical area after SSME startup.

3. Purge vapors from ET/Orbiter LH2 umbilical are drawn under the body flap due to SSME aspiration.

4. At SSME cut-off, a chunk of ice falls from the ET/Orbiter umbilical and shatters on MLP deck north of radiation shield.

5. Firex water activated under SSMEs reaches OMS pod and Orbiter LH2 T-0 umbilical. Firex water north of radiation shield reaches ET/Orbiter LH2 umbilical. Rust colored water is visible for a few seconds.

OTV 170
Color M-II

Views entire launch vehicle from SE direction.

Comments:

1. No anomalies during SSME firing.

2. OAA extended immediately after SSME shutdown.

3. Good view of GO2 vent hood repositioned over nosecone. ET continues to move under hood.

4. Ice cascades from cryo lines on sides of MLP.

5. No visible hydrogen fire is seen in SSME flame trench south of MLP.

6. Rust colored Firex water is sprayed on aft end of the Orbiter.

OTV 171
Color M-II

Views SSMEs from SW direction.

Comments:

1. Normal SSME startup.
2. Paper covers rupture on RCS stingers at SSME ignition.
3. Particles of ice/frost drop from both T-0 umbilicals.
4. Traces of burning hydrogen are visible a few seconds after SSME shutdown, but nothing extensive enough to activate fire sensors is seen.
5. Firex system sprays rust colored water for a few seconds.

TV-2
Color M-II

Views entire launch vehicle from camera site 7 east of Pad B.

Comments:

1. No hydrogen fire is visible in flame trench after SSME shutdown.

TV-3
Color M-II

Views entire launch vehicle from camera site 9 north of Pad B.

Comments:

1. Some water deluge spray is visible in the SRB flame trench.
2. Flames from SSME firing are visible under the MLP.

TV-4
Color M-II

Views Orbiter aft end from Pad A beach tracker site.

Comments:

1. Water deluge covers pad surface.
2. Ice/frost drops from cryo lines on sides of MLP.
3. No fire is visible in flame trench after SSME shutdown.
4. Firex water spray is rust colored for a few seconds.

C-2

TV-6
Color M-II

Views entire launch vehicle from DLTR-3 site directly south of Pad B.

Comments:

1. View is quickly obscured by SSME plume.

TV-7
Color M-II

Views entire launch vehicle from camera site 2 east of pad.

Comments:

1. Smoke rises from Xenon light diesel generators.
2. After SSME shutdown, exhaust plume disperses and rises as if driven by high heat source or hydrogen fire.

TV-16
Color M-II

View from helicopter orbiting east of pad.

Comments:

1. Overall view of SSME plume.

OTV 109
B/W M-II

Views ET/Orbiter LH2 umbilical area from the 95 foot level of the FSS.

Comments:

1. Purge vapors drawn downward by SSME aspiration.
2. Chunk of ice breaks loose at SSME shutdown.
3. Firex water reaches past ET/Orbiter umbilical and crossbeam.
4. Butcher paper hydrogen fire detectors are still intact.

OTV 150
B/W M-II

Views Orbiter LH2 T-0 umbilical from SW MLP deck.

Comments:

1. Considerable camera shake and vehicle movement.
2. Purge helium vapors are visible.
3. Firex water spray reaches umbilical.

OTV 151
B/W M-II

Views RH OMS pod and APU exhaust ports.

Comments:

1. No visible sign of APU exhaust.
2. Firex water spray reaches leading edge of OMS pod.

OTV 154
B/W M-II

Views ET/Orbiter LO2 umbilical and Orbiter RH wing

Comments:

1. Ice/frost cascades from umbilical at SSME startup.
2. Orbiter aero-control surface movement is visible.
3. Firex water obscures SSME #3 and ET/Orbiter LO2 umbilical.

OTV 155
B/W M-II

Views RH SRB and underside of Orbiter RH wing.

Comments:

1. Ice/frost falls from ET/Orbiter umbilical.
2. Firex water spray is directed at ET/Orbiter LO2 umbilical.

OTV 156
B/W M-II

Views LH SRB and underside of Orbiter LH wing.

Comments:

1. Ice/frost falls from ET/Orbiter umbilical.
2. Frost falls from GUCP.
3. Firex water spray directed at ET/Orbiter umbilicals.

OTV 149
B/W M-II

Views Orbiter LO2 T-0 umbilical from MLP deck.

Comments:

1. Considerable camera shake and vehicle movement is obvious.
2. Chunks of ice/frost drop from umbilical at SSME shutdown.

OTV 101
B/W M-II

Views aft end of Orbiter from FSS 255 foot level.

Comments:

1. Good view of vehicle "twang" movement.
2. OAA extended after SSME cutoff.
3. Transparent purge barrier from LH2 TSM opening comes loose, flaps around T-0 umbilical area, reflects light from inside TSM. Interior light is visible on Orbiter T-0 umbilical area.
4. Firex water spray envelopes aft end of Orbiter.

OTV 103
B/W M-II

Views GUCP and GH2 vent line.

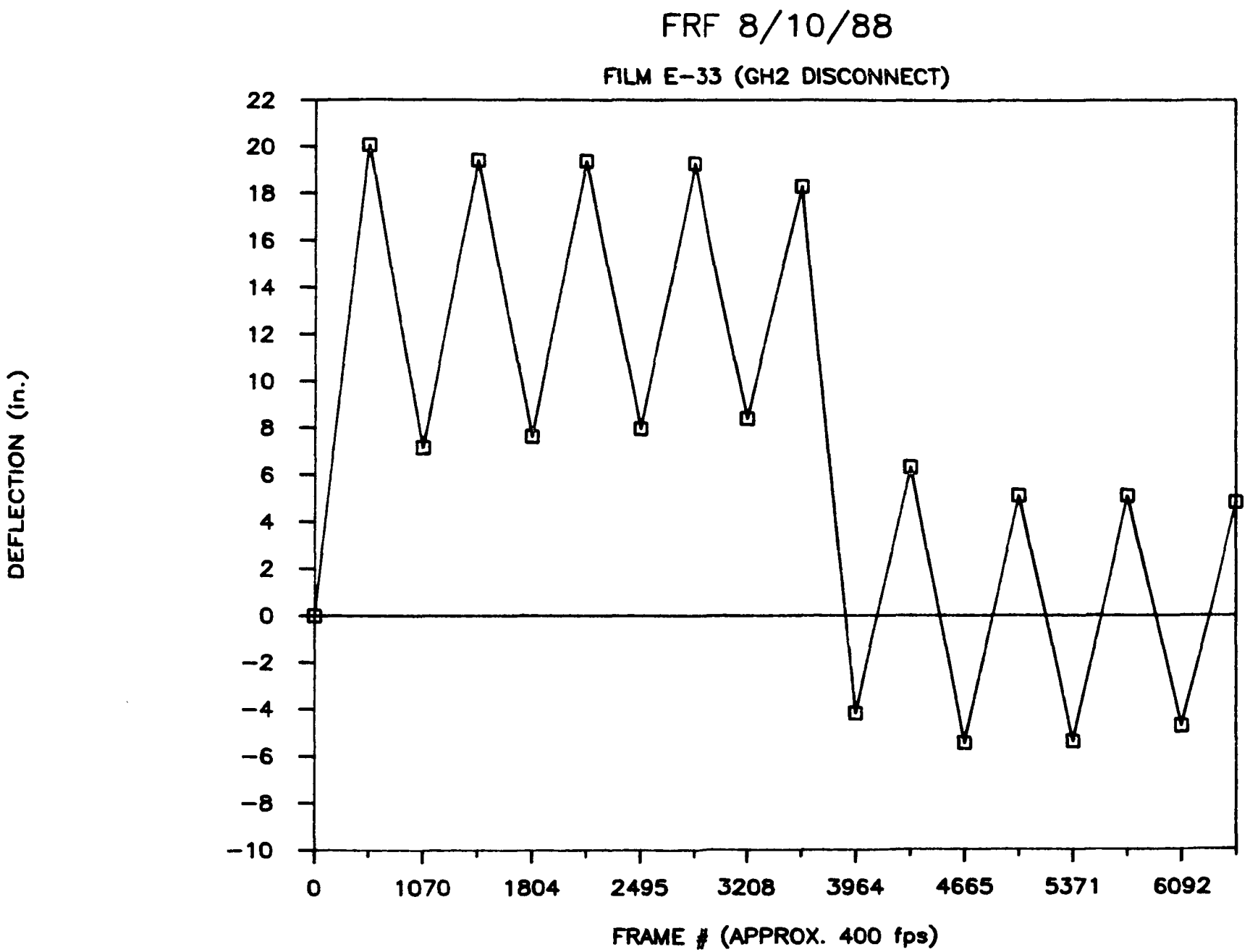
Comments:

1. Purge vapors are visible.
2. No ice/frost on GH2 vent line due to recent modification.
3. Good view of vehicle "twang" motion. Moves through 5 cycles before SSME cutoff.

GUCP DEFLECTION FROM FILM E-33
STS-26R FRF 8/10/88

FRAME NUMBER	DEFLECTION (IN.)	FRAME NUMBER	DEFLECTION (IN.)
714	20.064	3964	-4.202
1070	7 .155	4288	6.320
1415	19.415	4665	-5.459
1804	7.628	5028	5.113
2160	19.575	5371	-5.383
2495	7.965	5724	5.088
2849	19.263	6092	-4.725
3208	8.395	6452	4.793
3541	18.309	EOF	

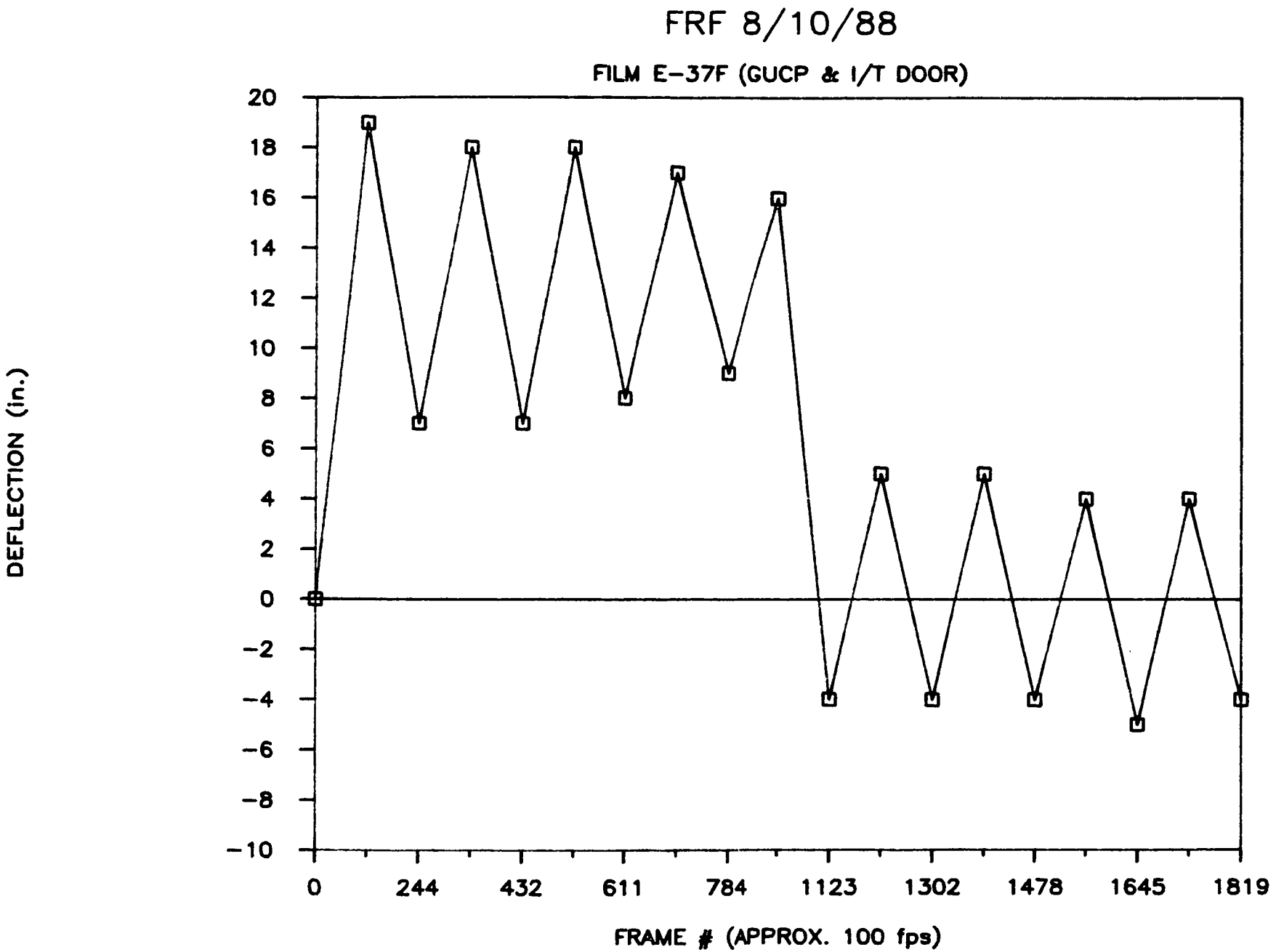
FRAME SPEED APPROX. 400 fps


FRF 8/10/88
FILM E-33 (GH2 DISCONNECT)
DEFLECTION (in.)
22
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
0
1070
1804
2495
3208
3964
4665
5371
6092
FRAME # (APPROX. 400 fps)

GUCP DEFLECTION FROM FILM E-37F
STS-26R FRF 8/10/88

FRAME NUMBER	DEFLECTION (IN.)	FRAME NUMBER	DEFLECTION (IN.)
160	19	1123	-4
244	7	1220	5
339	18	1302	-4
432	7	1387	5
518	18	1478	-4
611	8	1515	4
691	17	1645	-5
784	9	1740	4
863	16	1819	-4

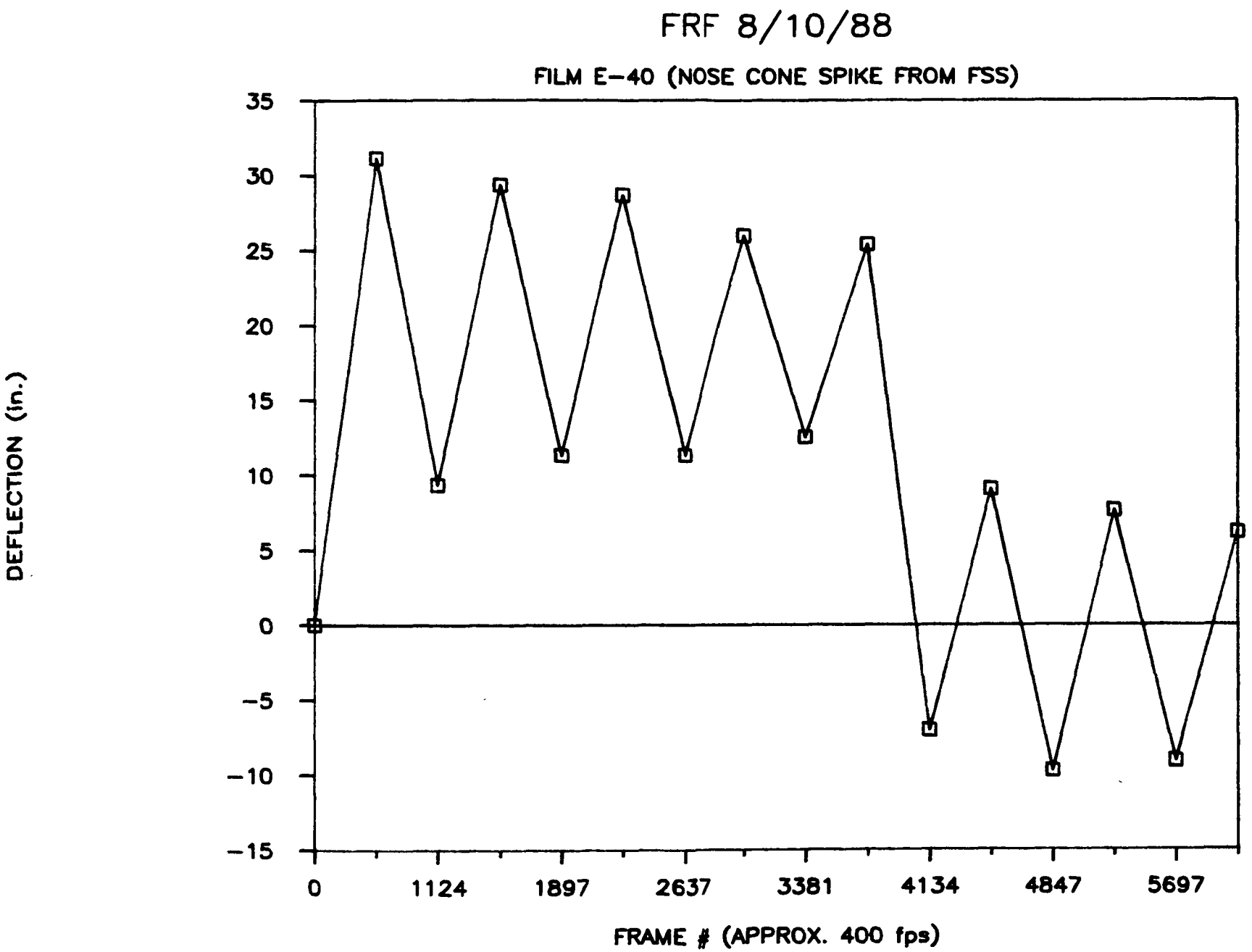
FRAME SPEED APPROX. 100 fps


FRF 8/10/88
FILM E-37F (GUCP & I/T DOOR)
DEFLECTION (in.)
20
18
16
14
12
10
8
6
4
2
0
-2
-4
-6
-8
-10
0
244
432
611
784
1123
1302
1478
1645
1819
FRAME # (APPROX. 100 fps)

ET TIP DEFLECTION FROM FILM E-40
STS-26R FRF 8/10/88

FRAME NUMBER	DEFLECTION (IN.)	FRAME NUMBER	DEFLECTION (IN.)
711	31.119	3749	25.418
1124	9.345	4134	-7.009
1495	29.343	4525	9.065
1897	11.307	4847	-9.719
2298	28.689	5262	7.663
2637	11.307	5697	-9.065
3037	25.979	6006	6.168
3381	12.552	EOF	

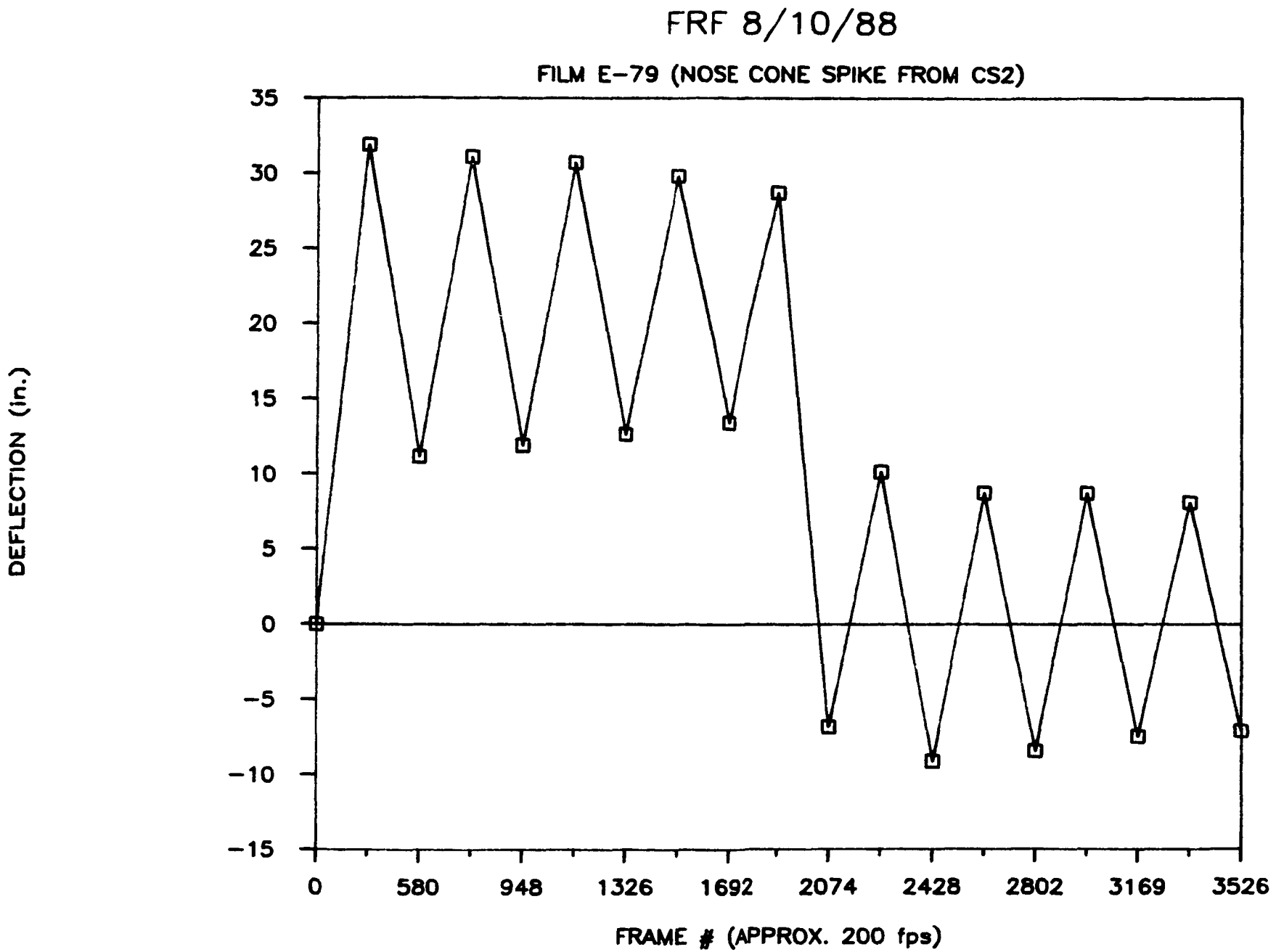
FRAME SPEED APPROX. 400 fps


FRF 8/10/88
FILM E-40 (NOSE CONE SPIKE FROM FSS)
DEFLECTION (in.)
35
30
25
20
15
10
5
0
-5
-10
-15
0
1124
1897
2637
3381
4134
4847
5697
FRAME # (APPROX. 400 fps)

ET TIP DEFLECTION FROM FILM E-79
STS-26R FRF 8/10/88

FRAME NUMBER	DEFLECTION (IN.)	FRAME NUMBER	DEFLECTION (IN.)
377	31.898	2074	-6.820
580	11.146	2248	10.125
764	31.088	2428	-9.121
948	11.923	2623	8.732
1131	30.699	2802	-8.424
1326	12.636	2990	8.716
1508	29.808	3169	-7.468
1692	13.397	3360	8.100
1863	28.706	3526	-7.114

FRAME SPEED APPROX. 200 fps


FRF 8/10/88
FILM E-79 (NOSE CONE SPIKE FROM CS2)
DEFLECTION (in.)
35
30
25
20
15
10
5
0
-5
-10
-15
0
580
948
1326
1692
2074
2428
2802
3169
3526
FRAME # (APPROX. 200 fps)

6.0 PRE-TEST BRIEFING

The Ice/Frost/Debris Team briefing for launch activities was conducted on 28 September 1988 at 0900 hours with representatives present from:

C. Stevenson	NASA - KSC	Chief, ET/SRB Mech Sys Lead, Ice/Debris Team
G. Katnik	NASA - KSC	ET Mech/TPS, Ice/Debris Assessment, STI
R. Speece	NASA - KSC	ET Processing, Ice Assess
B. Bowen	NASA - KSC	ET Processing, "SURFICE"
S. Higginbotham	NASA - KSC	STI, Debris Assessment
R. Stevens	NASA - KSC	SRB Stacking, Disassembly
Z. Byrns	NASA - JSC	Level II Integration
F. Huneidi	NASA - MSFC	TPS & Ice Assessment
D. Andrews	NASA - MSFC	Debris Assessment
R. Seale	LSOC - SPC	ET Processing, Ice Assess
J. Cawby	LSOC - SPC	ET Processing, Ice Assess
C. Gray	MMC - MAF	ET TPS & Materials Design
R. Huber	MMC - MAF	ET TPS Testing/Certif
J. McClymonds	RI - Downey	Support LVL II Integration
L. Zook	USBI - PSE	SRB Processing
G. Woods	NASA - SSC	STI Checkout
G. Meeks	NASA - SSC	STI Installation

6.1 PRE-LAUNCH SSV/PAD DEBRIS INSPECTION

The pre-launch debris inspection of the pad and Shuttle vehicle was conducted on 28 September 1988 from 1000 - 1300 hours. The detailed walkdown of Launch Pad 39B and MLP-2 also included the primary flight elements OV-103 Discovery (7th flight), ET-28 (LWT-21), and BIO-29. Documentary photographs were taken of facility anomalies, potential sources of vehicle damaging debris, and new vehicle configurations.

Bolts were not torqued in 8"x8" deck plates located west of the LH SRB and east of the RH SRB. The deck plate on the east side of the MLP below the sound suppression water pipe contained two 1-inch loose bolts while one 1-inch bolt on the northeast raised deck area needed to be tightened. Eight loose bolts were discovered on a camera control box for camera E-14 adjacent to holddown post #8.

The hazard-proof electrical boxes in all four corners of the MLP had loose covers.

Hand rails around the south holddown posts (#1, 2, 5, and 6) could not be removed and were cut off leaving a 6-inch piece of aluminum in each post hole. Since the possibility of vibration or heat from SRB ignition could dislodge these pieces, their removal was mandatory.

Teflon tape used for FRF instrumentation was attached to the RH SRB joint heater umbilical.

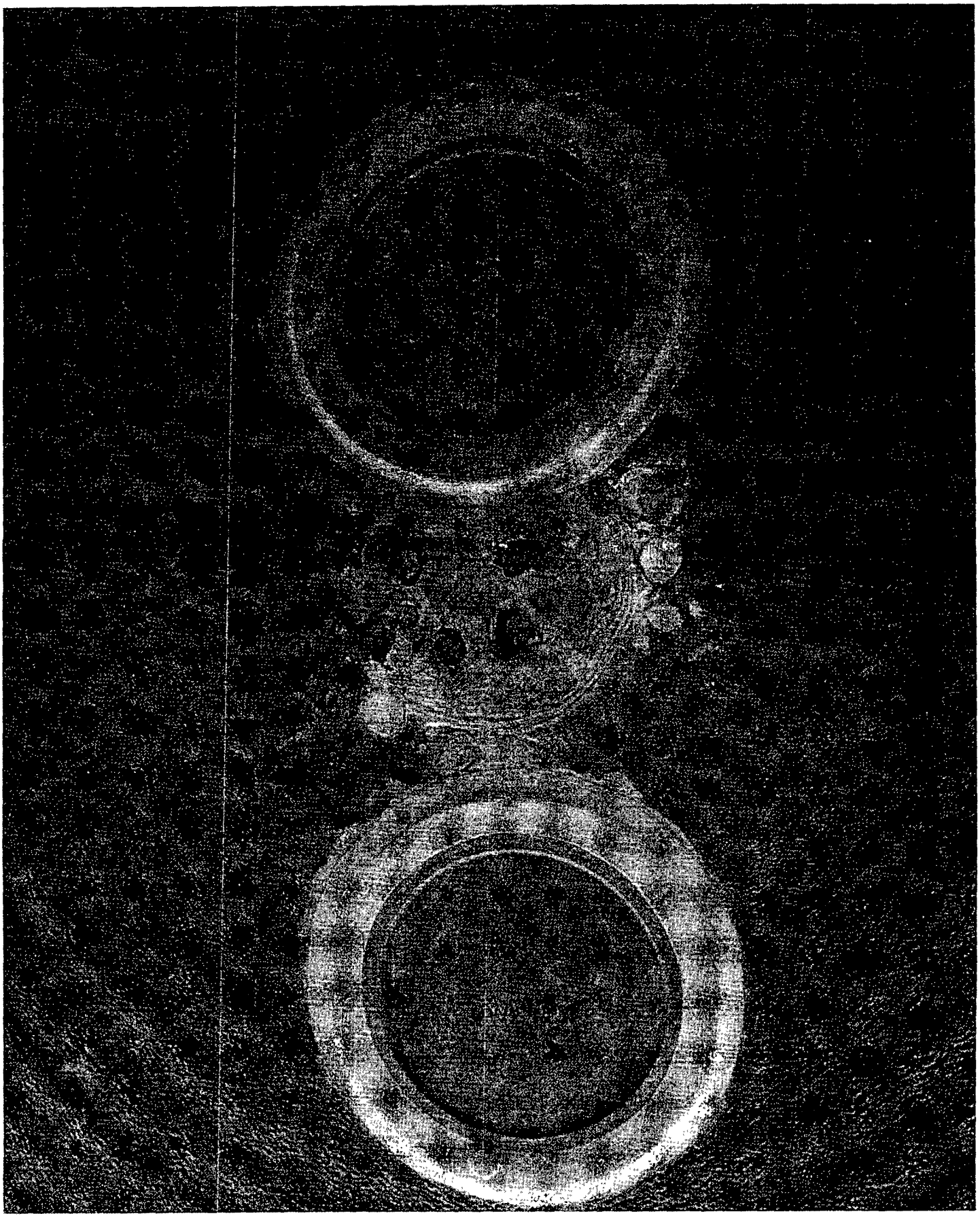
Small pieces of trash were present on the MLP deck particularly in the southwest MLP gutter, the raised deck areas, and under the heat shield around the SSME exhaust hole.

The inspection included an examination of the new configuration changes to the SRB. Joint heater umbilicals were added under the aft skirts. The holddown post shoes feature chamfered edges to protect the firing cables. Redesigned debris covers contain plungers to plug the holes in the aft skirt feet to prevent debris from dropping out during ascent. In addition, springs were redesigned in the doghouse blast covers to ensure proper closure.

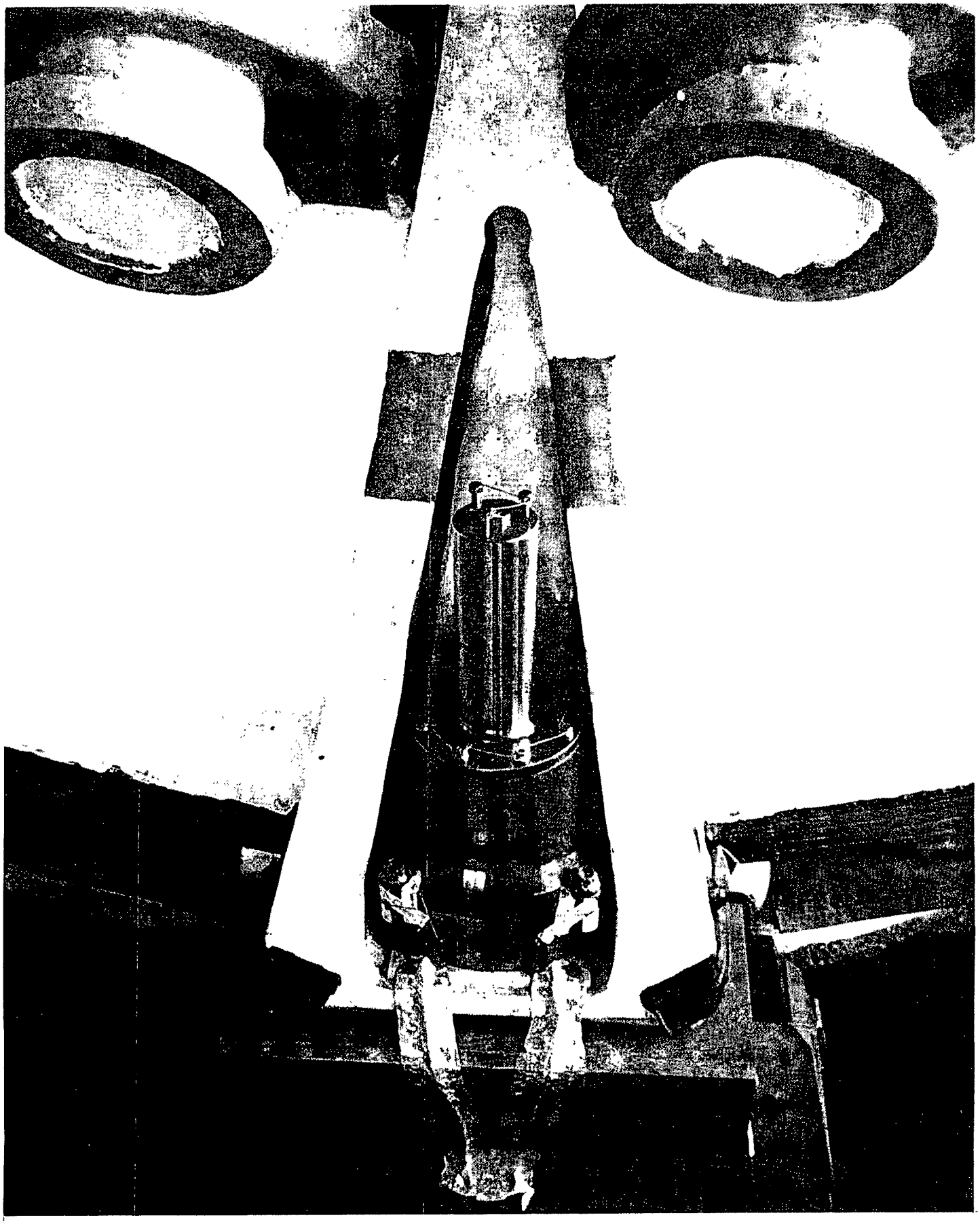
A few minor SRB discrepancies were noted. A piece of thermal blanket tape was loose on the LH SRB +Z side. Two pieces of masking tape were attached to the LH SRB BSM's. Excessive amounts of RTV had been applied to the strain gage belly bands around the bases of all holddown posts.

Although the cleanup of the MLP deck and pad surface was still in progress at the time of the inspection, overall cleanliness was considered good. Launch pad managers were briefed on the facility discrepancies listed above for resolution prior to

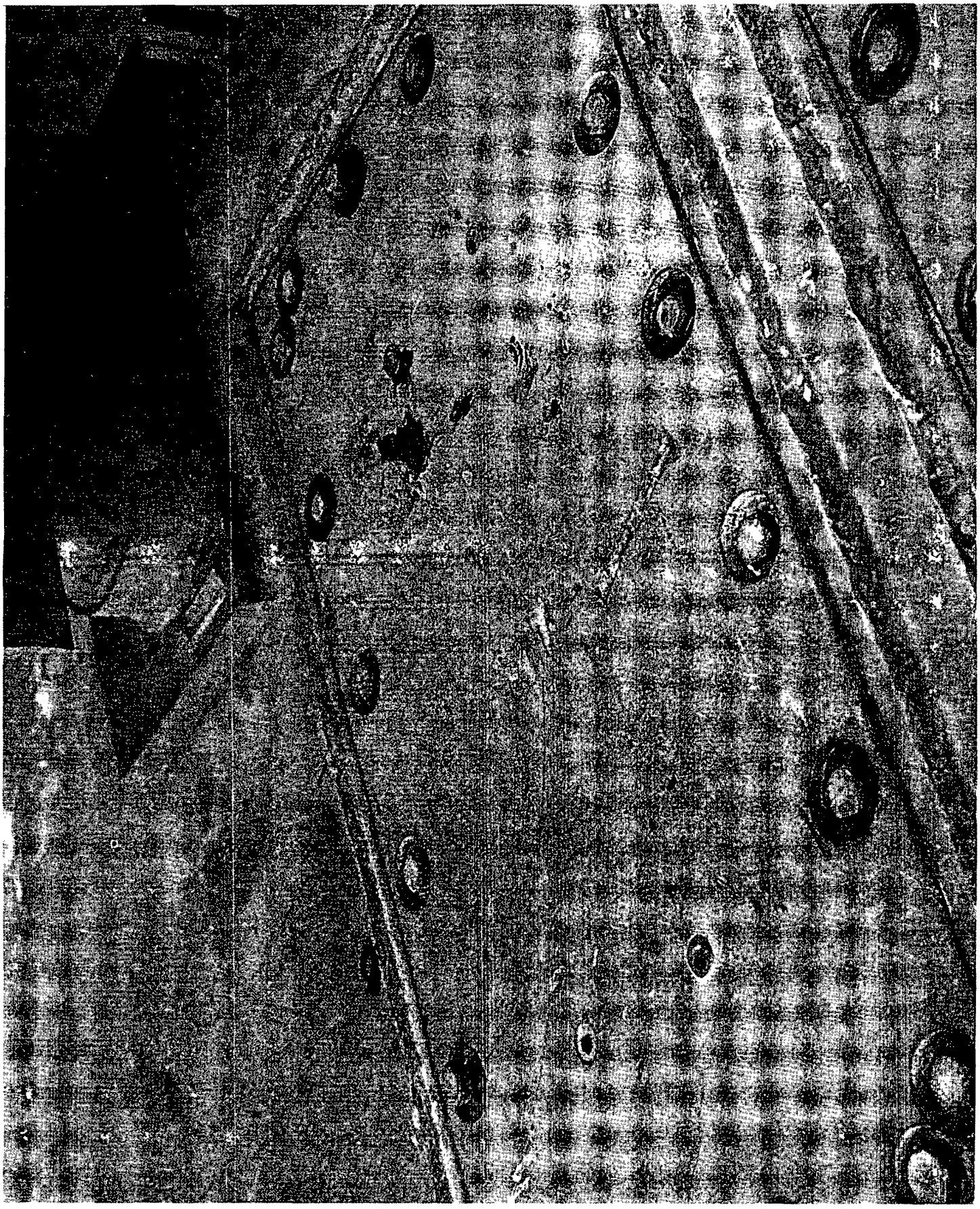
vehicle tanking. No PR's were required for the SRB discrepancies though Engineering is reviewing the procedures for applying RTV.



PDL REPAIRS TO DIVOTS ON ET LH2 TANK AFT DOME APEX



REDESIGNED HDP DEBRIS CONTAINER WITH INTERNAL PLUNGER TO PLUG HOLE IN AFT SKIRT FOOT. CHAMFERED SHOE PROTECTS FIRING CABLES



LOOSE ONE-INCH DECK PLATE BOLTS ON EAST SIDE OF MLP

7.0 ICE/FROST INSPECTION

The Ice/Frost Inspection of the cryoloaded vehicle was performed on 29 September 1988 from 0500 - 0730 hours during the two hour built-in-hold at T-3 hours in the countdown. There was one violation to NSTS-08303 and it was documented by IPR 26RV-0945 "S"-Shaped Ice/Frost Line 10 Inches in Length Near +Y ET/SRB Lower Attach Fitting. Ambient weather conditions at the time of the inspection were:

Temperature:	71 F
Relative Humidity:	77 %
Wind Speed:	3 MPH
Wind Direction:	325 Degrees

7.1 ORBITER OBSERVATIONS

No Orbiter tile anomalies were observed. The surface temperatures of the SSME engine mounted heat shields averaged 65 F. Some ice/frost was present at the engine to heat shield interface of SSME #1 5-7 o'clock and SSME #2 2-3 o'clock positions.

7.2 SRB OBSERVATIONS

Infrared scanners recorded LH SRB surface temperatures between 71 to 75 degrees F while temperatures on the RH SRB ranged from 72 to 75 degrees F. An average temperature of 82 degrees F was recorded for the SRB field joints. The predicted Propellant Mean Bulk Temperature (PMBT) supplied by MTI was 80 degrees F. No anomalies were observed.

7.3 ET OBSERVATIONS

Steady condensate was present on the LOX tank, Intertank, and LH2 tank. The IR scanners showed a surface temperature of 64 to 68 degrees F on the LOX tank, an average of 73 degrees F on the Intertank, and a range of 59 - 64 degrees F on the LH2 tank.

Ice/Frost covered the lower EB fittings outboard to the strut pin hole with condensate dripping from the rest of the fitting. The EB struts were dry.

Frost had accumulated on the +Y longeron closeout and near the +Z axis at approx XT-1600. Both are acceptable per the criteria given in NSTS-08303.

Normal icing conditions were observed on the LOX feedline and pressurization line barrymounts with small frost balls forming on the aft surface of the ramps. Ice/frost was present in all the LO2 feedline bellows and support brackets.

The LO2 ET/ORB umbilical was generally free of ice except for an accumulation of ice/frost on the aft side of the baggie and frost fingers on the purge vents. Ice/frost had formed in the LH2 ET/ORB umbilical feedline and recirculation line bellows, purge vents, cavities, and almost the entire circumference of the baggie.

The tumble valve cover was intact and not protruding.

The Ice Prediction computer program was run from 0045 to 1137 hours and the results tabulated in Figure 8. The program predicted condensate on all TPS acreage.

After the checkout and validation of the Mikron 44 Infrared Thermometer and the Shuttle Thermal Imager (STI) system during WCDDT and FRF, the Ice Team utilized this new equipment to obtain surface temperature measurements in the overall thermal assessment of the vehicle. The measurements, presented in Figure 9, are a summary of data from the Mikron 44, the STI portable system, and the STI sensors located Camera Site #2 and RSS roof.

A total of seven Ice/Frost anomalies were written for STS-26R launch - six from FR-2 console observations and one from the Ice Inspection on the pad. Anomaly 001 documented vapors flowing from the LOX feedline bellows at Stations XT 1129 and 1980. Similar vapors occurred during WCDDT and FRF, but no leaks were found during post drain inspection. These vapors were caused by convective air movement over the cold surfaces of the bellows. Anomaly 002 documented purge gas vapors from the LH2 ET/ORB umbilical purge vents - an explained condition.

Ice/frost accumulation on feedline support boomerang brackets (XT 1123, 1377, 1623, 1871) was documented in Anomaly 003. All locations had been repaired with PDL after FRF and the ice build-up was acceptable per the launch criteria.

An "S"-shaped ice/frost line (Anomaly 004) approx 10 inches in length formed on the aft dome acreage aft of the EB-8 fitting at 120 degrees. No crack or offset was visible and this line had not been present during FRF. The anomaly was dispositioned on IPR 26RV-0945 as a frost line resulting from a heat short formed by a tight crack that does not extend to substrate. The crack was caused by predictable non-deleterious structural deflections from loads induced at FRF. Consequently, it was considered acceptable for flight.

Anomaly 005 documented a frost formation on the +Y thrust strut to longeron interface while Anomaly 006 recorded "froth" on the -Z LH2 aft manhole cover. Both were acceptable for flight per the launch criteria.

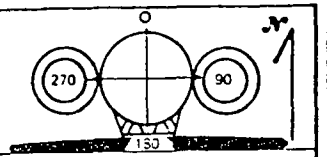
Frost formed at a foam repair on the LH2 tank acreage -Z axis Station XT 1600 (Anomaly 007), but was accepted for launch.

During post flight photographic review, Anomaly 008 was written against the butcher paper from area #6 (LH2 tie-bolt closeout). Butcher paper was not in place for launch and was most probably removed during FRF instrumentation removal.

7.4 FACILITY OBSERVATIONS

All debris concerns previously identified had been resolved prior to cryoloading and no new items were noted. No leaks were observed on either LO2 or LH2 T-0 umbilical. The modification to the GH2 vent line prevented any ice from forming but some frost, which was expected, had accumulated on the GUCP. Visual and infrared observations of the GOX seals confirmed no leakage. Small frost fingers had formed on the GOX vent ducts.

STS – 26R	TEST: LAUNCH (S0007)								DATE 9/29/88	T-0 TIME 11:37:00 DATE 9/29/88	
ORBITER OV– 103	ET 28	SRB BIO 29	MLP 2	PAD 39 B	LO_2 CHILLDOWN TIME 02:08 SLOW FILL TIME 02:33	FAST FILL TIME 02:46 REPLENISH TIME 04:48	LH_2 CHILLDOWN TIME 01:56 SLOW FILL TIME 02:06	FAST FILL TIME: 02:33 REPLENISH TIME: 04:38			



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 553 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL. HUM. %	DEW PT °F	WIND VEL. KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
0045	71	74	62.4	6	316	II	3.54	57.2	±.0017	.1140	II	3.54	51.6	±.0032	.0852	II	2.76	47.8	±.0033	.0583	II	7.38	56.7	±.0035	.1815
0115	70	75	62.1	6	320	II	3.54	56.8	±.0018	.1117	II	3.54	51.1	±.0032	.0830	II	2.76	47.3	±.0033	.0564	II	7.38	56.3	±.0036	.1780
0145	71	75	62.7	6	318	II	3.54	57.4	±.0018	.1152	II	3.54	51.8	±.0033	.0864	II	2.76	48.1	±.0034	.0593	II	7.38	56.4	±.0036	.1837
0215	70	76	62.4	7	313	II	4.13	57.7	±.0018	.1284	II	4.13	52.6	±.0034	.0995	II	3.22	49.1	±.0035	.0695	II	8.61	57.4	±.0036	.2108
0230	71	76	63.2	4	321	II	2.36	55.4	±.0018	.0829	II	2.36	48.1	±.0031	.0548	II	1.84	43.5	±.0030	.0420	II	4.92	54.2	±.0038	.1207
0245	71	75	62.7	5	333	II	2.95	56.4	±.0018	.0985	II	2.95	50.1	±.0032	.0701	II	2.30	45.9	±.0032	.0463	II	6.15	55.6	±.0037	.1513
0300	70	76	62.7	5	328	II	2.95	56.2	±.0019	.0975	II	2.95	49.8	±.0032	.0691	II	2.30	45.7	±.0032	.0454	II	6.15	55.4	±.0038	.1498
0315	71	76	63.7	5	324	II	2.95	57.3	±.0018	.1098	II	2.95	51.0	±.0033	.0742	II	2.30	46.9	±.0033	.0498	II	6.15	56.6	±.0038	.1583
0330	70	76	62.3	5	321	II	2.95	55.8	±.0019	.0954	II	2.95	49.4	±.0032	.0670	II	2.30	45.2	±.0032	.0436	II	6.15	55.0	±.0037	.1464
0345	70	76	62.7	4	334	II	2.36	54.9	±.0018	.0806	II	2.36	47.5	±.0030	.0526	II	1.84	42.9	±.0030	.0396	II	4.92	53.6	±.0038	.1171
0400	70	76	62.6	4	331	II	2.36	54.7	±.0018	.0801	II	2.36	47.4	±.0030	.0521	II	1.84	42.8	±.0030	.0391	II	4.92	53.5	±.0038	.1164
0415	71	76	63.2	2	243	II	1.18	52.3	±.0017	.0719	II	1.18	45.0	±.0028	.0475	II	0.64	43.5	±.0030	.0420	II	2.72	48.2	±.0034	.0596
0430	72	77	64.4	1	306	II	0.59	53.5	±.0017	.0772	II	0.59	46.3	±.0029	.0527	II	0.46	44.8	±.0031	.0472	II	1.23	44.8	±.0031	.0472
0445	71	76	63.4	2	310	II	1.18	52.5	±.0017	.0729	II	1.18	45.3	±.0028	.0485	II	0.92	43.8	±.0030	.0430	II	2.46	47.3	±.0030	.0531
0500	72	76	63.9	3	343	II	1.77	54.4	±.0018	.0754	II	1.77	45.9	±.0028	.0509	II	1.32	44.4	±.0031	.0454	II	2.97	50.1	±.0036	.0704

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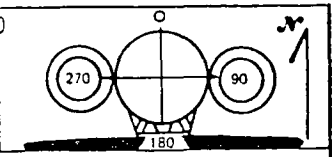
Figure 8. ET TPS Predicted Surface Temperatures and ICe/Condensate

STS - 26R	TEST. LAUNCH (S0007)							DATE 9/29/88	T-0 TIME 11:37:00 DATE 9/29/88
ORBITER	ET	SRB	MLP	PAD	LO_2			LH_2	
OV- 103	28	BI0 29	2	39 B	CHILLDOWN TIME 02:08	FAST FILL TIME 02:45		CHILLDOWN TIME 01:56	FAST FILL TIME 02:33
					SLOW FILL TIME 02:33	REPLENISH TIME 04:39		SLOW FILL TIME 02:04	REPLENISH TIME 03:52

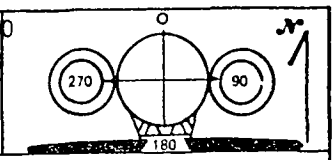


LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL HUM. %	DEW PT °F	WIND VEL KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
0515	71	77	64.0	2	331	II	1.18	53.0	±.0017	-.0747	II	1.18	45.7	±.0029	-.0502	II	0.92	44.2	±.0031	-.0447	II	2.46	47.8	±.0034	-.0549
0530	72	77	64.1	3	343	II	1.77	54.5	±.0018	-.0757	II	1.77	45.9	±.0029	-.0512	II	1.32	44.5	±.0031	-.0457	II	2.97	50.2	±.0036	-.0709
0545	72	77	64.4	4	359	II	2.36	56.7	±.0019	-.0881	II	2.36	49.4	±.0032	-.0598	II	1.76	44.8	±.0031	-.0472	II	3.96	53.5	±.0039	-.1014
0600	71	77	63.5	3	339	II	1.77	53.7	±.0018	-.0723	II	1.77	45.1	±.0028	-.0478	II	1.32	43.6	±.0030	-.0423	II	2.97	49.3	±.0036	-.0672
0615	70	76	62.0	3	325	II	1.77	52.2	±.0017	-.0661	II	1.77	43.6	±.0027	-.0417	II	1.38	42.1	±.0029	-.0363	II	3.69	50.1	±.0036	-.0799
0630	71	76	63.2	1	87	II	0.59	52.3	±.0017	-.0719	II	0.59	45.0	±.0028	-.0475	II	0.55	43.5	±.0030	-.0420	II	1.22	43.5	±.0030	-.0420
0645	71	77	63.8	2	286	II	1.18	52.7	±.0017	-.0737	II	1.18	45.5	±.0028	-.0493	II	0.86	44.0	±.0031	-.0438	II	2.42	47.4	±.0034	-.0528
0700	70	77	63.1	4	322	II	2.36	55.1	±.0019	-.0815	II	2.36	47.7	±.0031	-.0534	II	1.84	43.2	±.0030	-.0404	II	4.92	53.8	±.0039	-.1187
0715	71	72	63.9	3	343	II	1.77	54.1	±.0018	-.0742	II	1.77	45.6	±.0029	-.0497	II	1.32	44.1	±.0031	-.0442	II	2.97	49.8	±.0036	-.0693
0730	71	77	63.4	5	311	II	2.95	56.8	±.0019	-.1002	II	2.95	50.4	±.0033	-.0716	II	2.30	46.3	±.0033	-.0475	II	6.15	56.0	±.0039	-.1542
0745	71	77	63.3	4	314	II	2.36	55.3	±.0019	-.0824	II	2.36	48.0	±.0031	-.0543	II	1.84	43.4	±.0030	-.0413	II	4.92	54.1	±.0039	-.1201
0800	73	78	66.2	2	351	II	1.18	55.3	±.0018	-.0853	II	1.18	48.2	±.0030	-.0607	II	0.88	46.7	±.0033	-.0551	II	1.98	47.8	±.0034	-.0551
0815	74	78	66.8	3	354	II	1.77	57.4	±.0019	-.0884	II	1.77	48.9	±.0031	-.0638	II	1.32	47.5	±.0033	-.0583	II	2.97	53.2	±.0039	-.0843
0830	75	78	68.3	3	6	II	1.77	59.1	±.0020	-.0965	II	1.77	50.8	±.0032	-.0719	II	1.32	49.3	±.0034	-.0663	II	2.97	55.0	±.0040	-.0927
0845	77	77	69.3	3	14	II	1.77	60.5	±.0020	-.1033	II	1.77	52.3	±.0032	-.0786	II	1.32	50.8	±.0035	-.0730	II	2.97	56.4	±.0040	-.0995

EGG/V-340

Figure 8. ET TPS Predicted Surface Temperatures and Ice/Condensate

STS – 26R	TEST. LAUNCH (S0007)					DATE 9/29/88	T-0 TIME 11:37:00 DATE 9/29/88	
ORBITER OV-103	ET 28	SRB BIO 29	MLP 2	PAD 39 B	LO_2 CHILLDOWN TIME 02:08 FAST FILL TIME 02:45 SLOW FILL TIME 02:33 REPLENISH TIME 04:39		LH_2 CHILLDOWN TIME 01:56 FAST FILL TIME 02:33 SLOW FILL TIME 02:04 REPLENISH TIME 03:52	



LOCAL TIME	CONDITIONS					LO_2 TANK STA 370 TO 540					LO_2 TANK STA 550 TO 852					LH_2 TANK STA 1130 TO 1380					LH_2 TANK STA 1380 TO 2058				
	TEMP. °F	REL. HUM. %	DEW PT °F	WIND VEL. KNTS	WIND DIR DEG	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR	REGION	LOCAL VEL KNTS	SOFI TEMP °F	COND RATE IN/HR	ICE RATE IN/HR
0900	79	74	70.7	5	59	II	2.95	65.6	±.0020	±.1457	II	2.95	59.8	±.0036	±.1157	II	3.50	60.3	±.0041	±.1305	II	6.05	64.6	±.0041	±.2229
0915	81	68	69.9	5	71	II	2.95	65.8	±.0016	±.1466	II	2.95	60.1	±.0032	±.1167	II	2.75	58.2	±.0035	±.1036	II	6.10	64.7	±.0035	±.2249
0930	81	65	68.8	6	67	II	3.54	65.8	±.0012	±.1636	II	3.54	60.7	±.0030	±.1334	II	4.20	61.2	±.0033	±.1512	II	7.26	64.9	±.0029	±.2566
0945	82	64	69.0	5	57	II	2.95	65.5	±.0013	±.1452	II	2.95	59.8	±.0030	±.1154	II	3.50	60.3	±.0033	±.1299	II	6.05	64.4	±.0030	±.2202
1000	82	61	67.7	6	79	II	3.54	65.6	±.0009	±.1623	II	3.54	60.6	±.0027	±.1323	II	3.30	59.0	±.0033	±.1184	II	7.32	64.7	±.0023	±.2557
1015	83	60	68.1	6	59	II	3.54	66.2	±.0008	±.1663	II	3.54	61.2	±.0026	±.1362	II	4.20	61.7	±.0029	±.1524	II	7.26	65.3	±.0022	±.2599
1030	83	58	67.7	5	74	II	2.95	65.4	±.0008	±.1443	II	2.95	59.7	±.0025	±.1147	II	2.75	58.0	±.0028	±.1021	II	6.10	64.1	±.0022	±.2192
1045	84	59	68.4	6	75	II	3.54	66.8	±.0007	±.1697	II	3.54	61.8	±.0026	±.1395	II	3.30	60.3	±.0029	±.1254	II	7.32	65.8	±.0020	±.2671
1100	83	58	67.7	5	60	I	2.95	65.4	±.0008	±.1443	II	2.95	59.7	±.0025	±.1147	II	3.50	60.1	±.0028	±.1290	II	6.05	64.1	±.0023	±.2175
1115	84	58	68.0	7	61	II	4.13	67.2	±.0004	±.1899	II	4.13	62.7	±.0024	±.1593	II	4.90	63.1	±.0025	±.1811	II	8.47	66.4	±.0015	±.3040
1130	84	56	67.4	7	46	II	4.13	67.0	±.0002	±.1883	II	4.13	62.5	±.0022	±.1574	II	4.90	62.9	±.0023	±.1794	II	8.47	66.1	±.0012	±.3010
1137	84	57	68.1	7	42	II	4.13	67.5	±.0003	±.1920	II	4.13	63.1	±.0023	±.1614	II	4.90	63.5	±.0024	±.1834	II	8.47	66.7	±.0013	±.3073
AVG.	73	70	64	4.2	NE*	II		57.7			II		51.7			II		49.7			II		55.9		
	* NORTH PRIOR TO 0900, EAST AFTER 0900																								

EGG/V-340

Figure 8. ET TPS Predicted Surface Temperatures and Ice/Condensate

FIGURE 9. **INFRA-RED SCANNER SSV SUMMARY DATA**

NOTE: All surface temperature measurements were taken with emissivity = 1.0 and are in degrees F.

TIME: 0500 - 0700
DATE: 9/29/88
VEH STS-26R

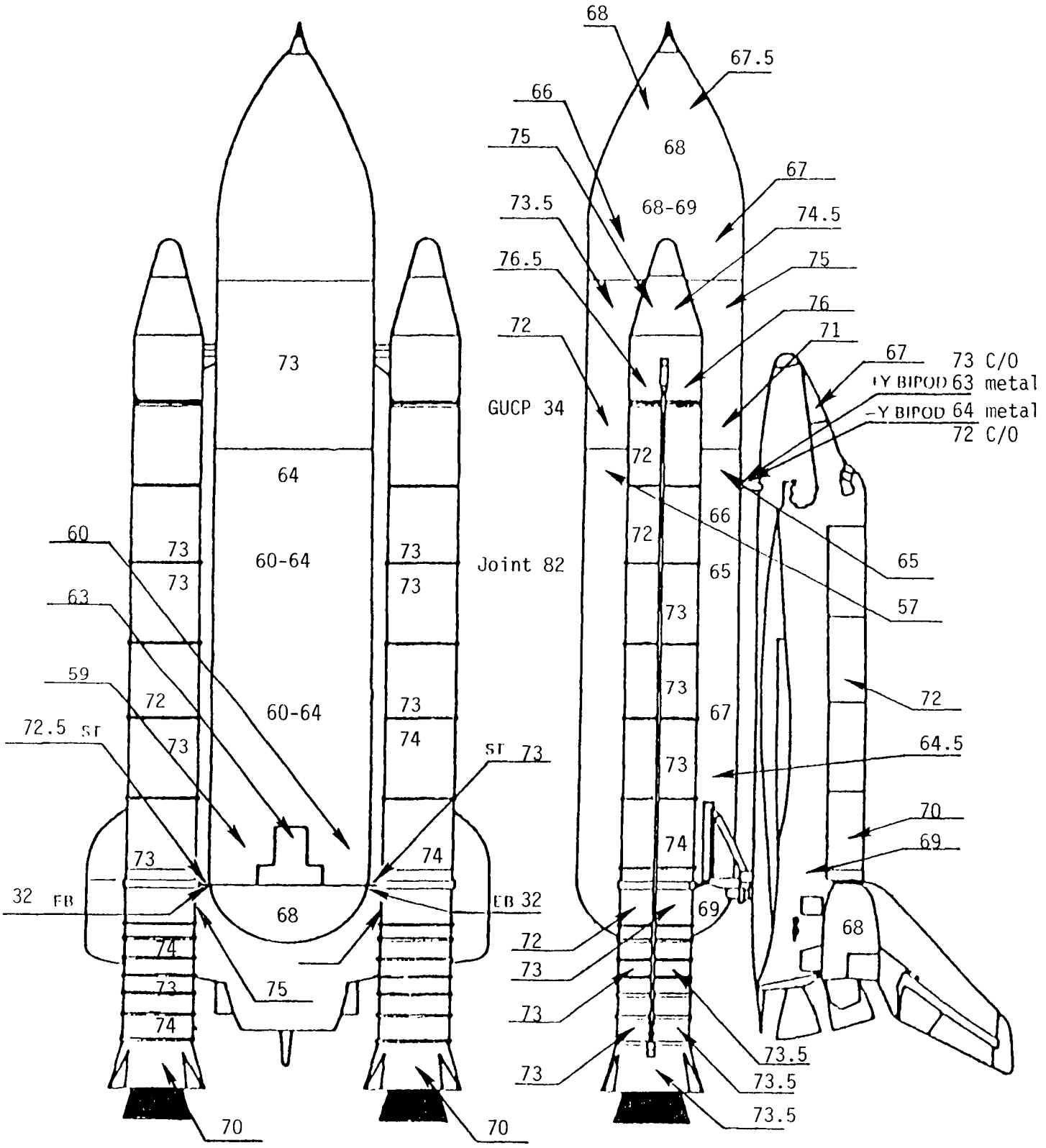
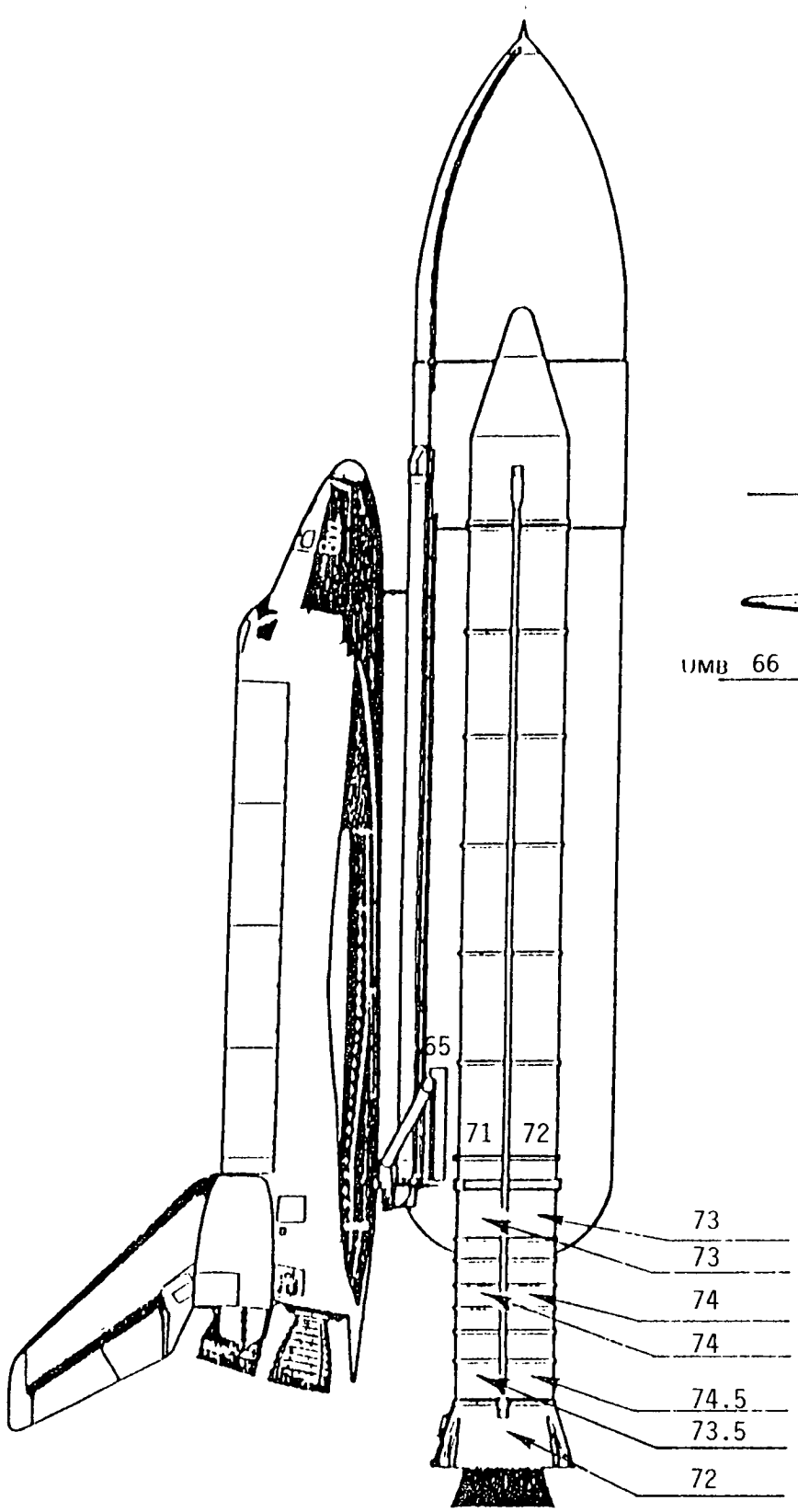
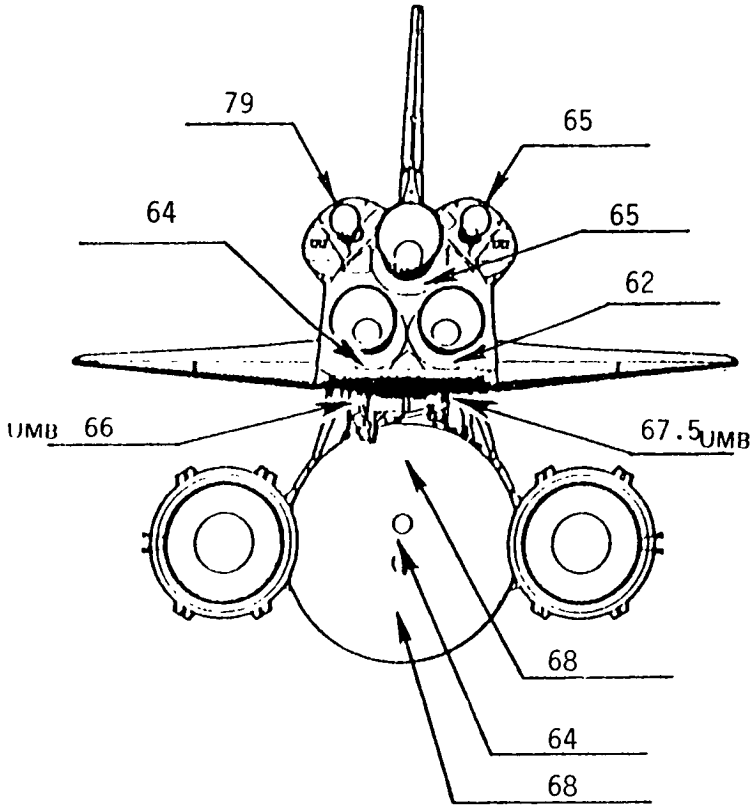


FIGURE 9. INFRA-RED SCANNER SSV SUMMARY DATA

TIME: 0500 - 0700
DATE: 9/29/88
VEH. STS- 26R

NOTE: All surface temperature measurements were taken with emissivity = 1.0 and are in degrees F.





MLP DECK 73 °F
SKY 45° 37.5 °F

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OF POOR QUALITY

EGG/V -343D

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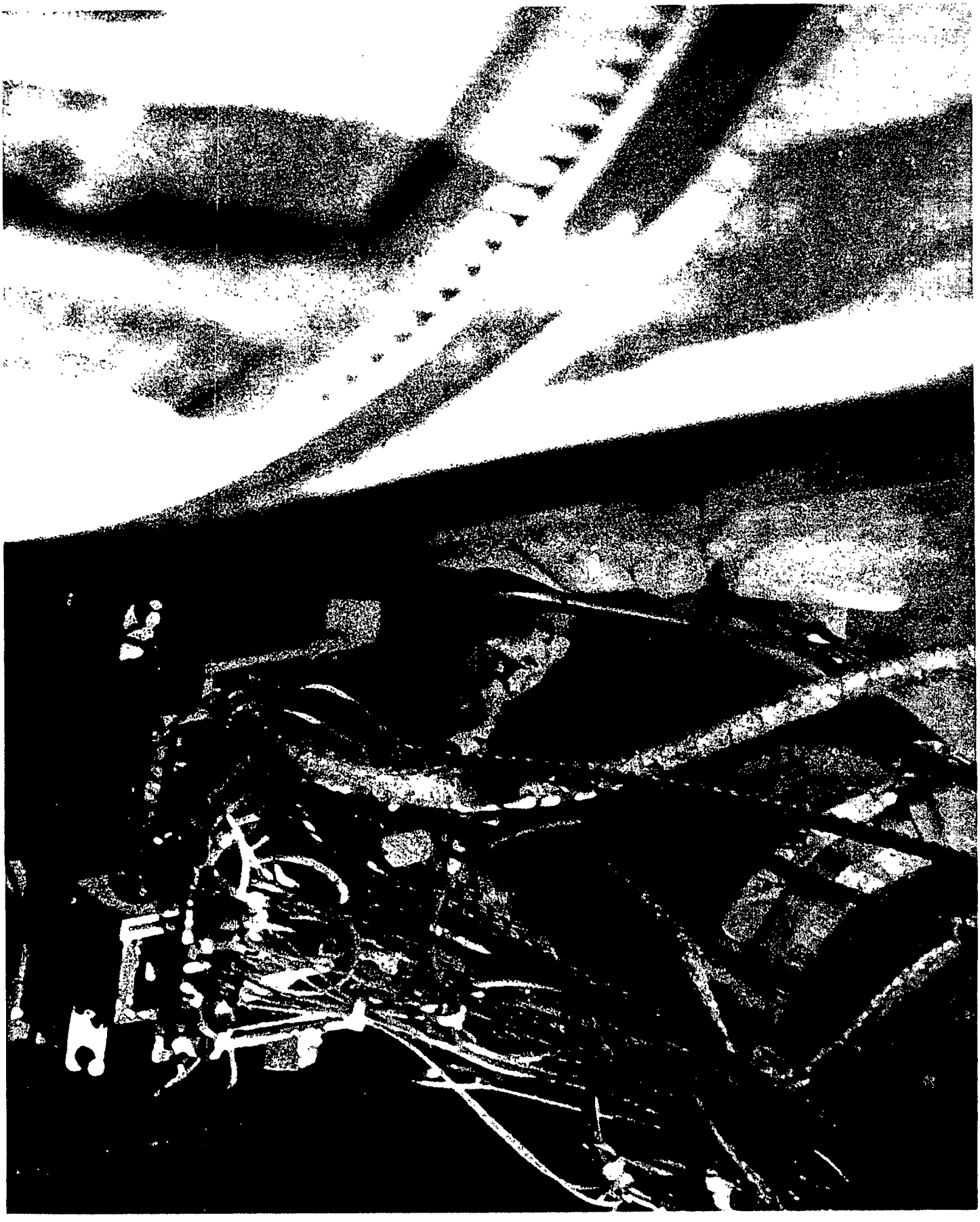
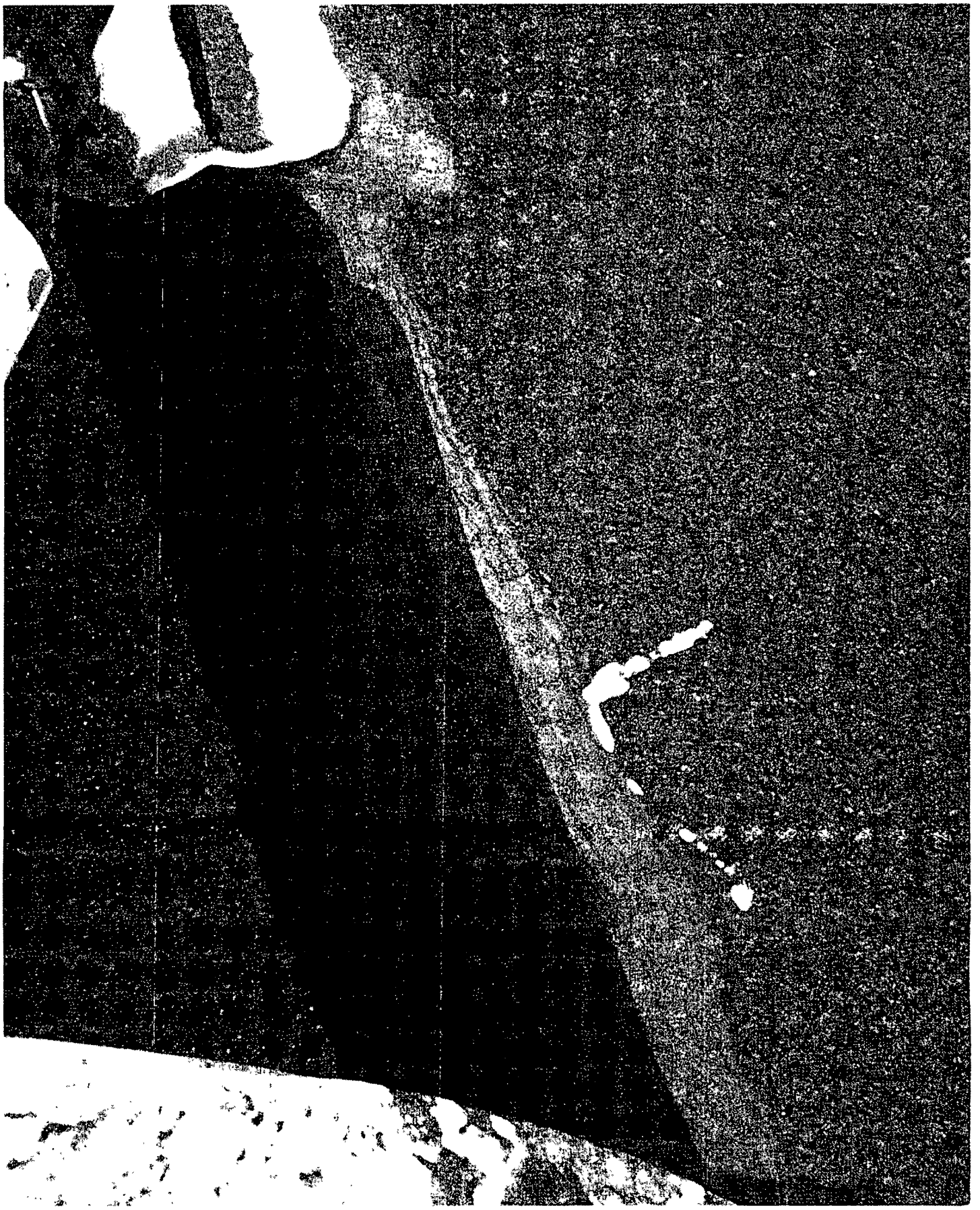
FROST LINES APPEAR ON LH2 TANK AFT DOME VENDOR REPAIRS.
CONDENSATE DRIPS FROM MANHOLE COVERS AND AFT DOME APEX.

ICE/FROST ACCUMULATION ON ET/ORB LH2 UMBILICAL BAGGIE, UMBILICAL SEP BOLT CLOSEOUT, AND THREE PURGE VENTS

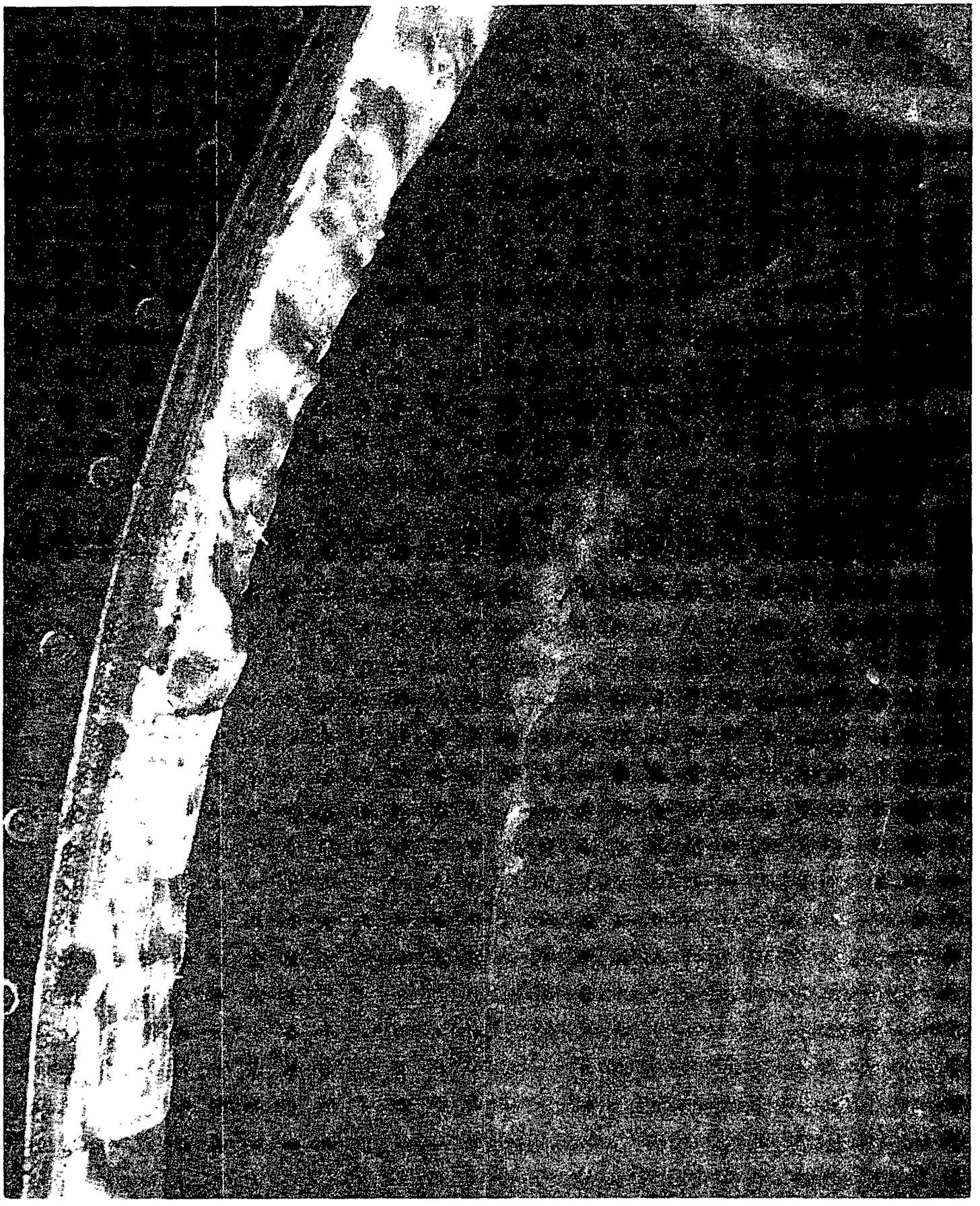
ICE/FROST ACCUMULATION IN LO2 FEEDLINE SUPPORT BRACKET



LIGHT FROST ACCUMULATION ON +Z SIDE OF GUCP

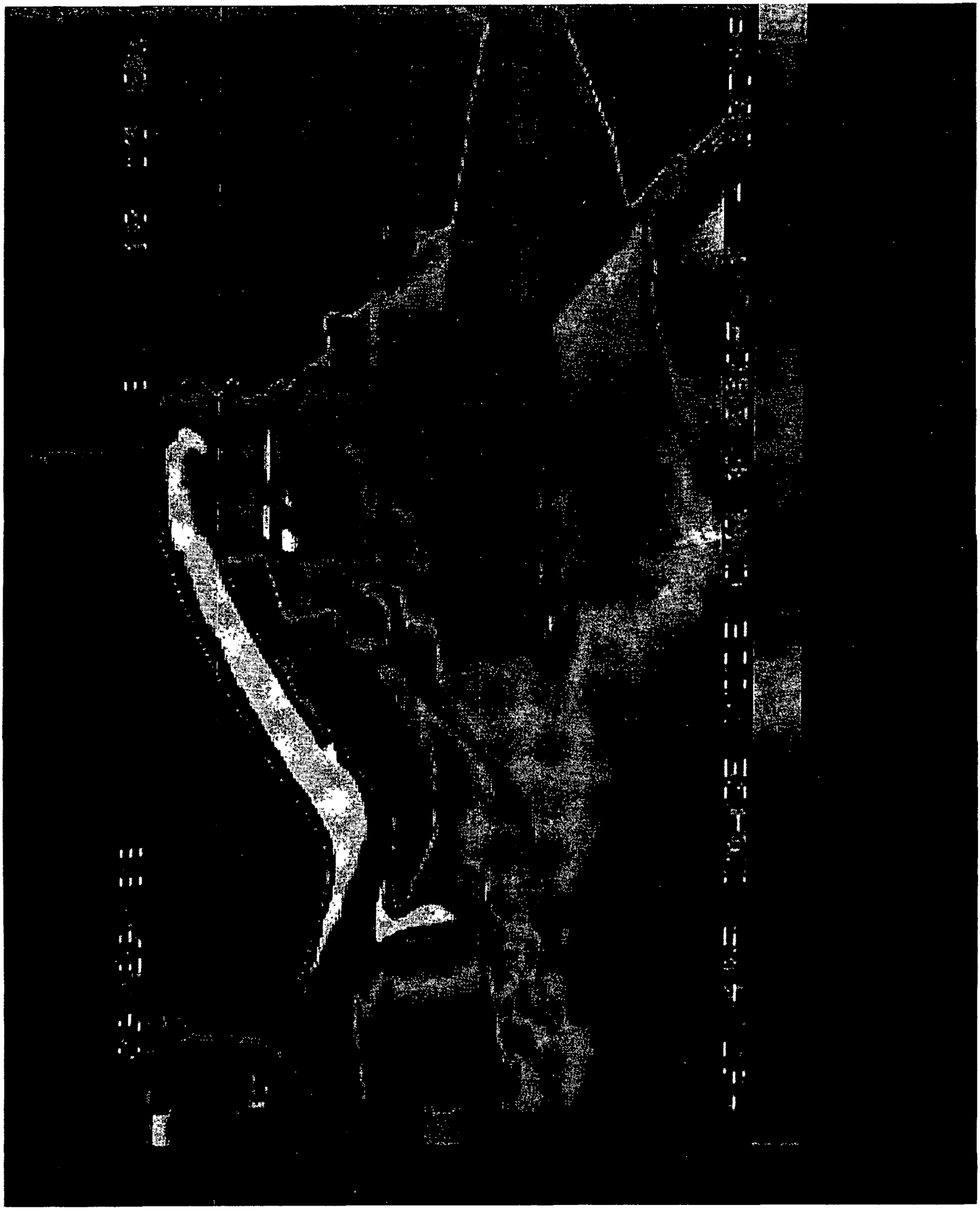


"S"-SHAPED FROST LINE JUST AFT OF 2058
RING NEAR EB-7 AFT LOWER ATTACH POINT



FROST ACCUMULATION ON SSME ENGINE MOUNTED HEAT SHIELD

SMALL ICICLES AND FROST FINGERS ON GOX VENT EXHAUST DUCT



NEW SHUTTLE THERMAL IMAGER COMPUTER COLORIZED INFRARED IMAGE OF GOX HOOD AND ET OGIVE FROM RSS ROOF UNIT

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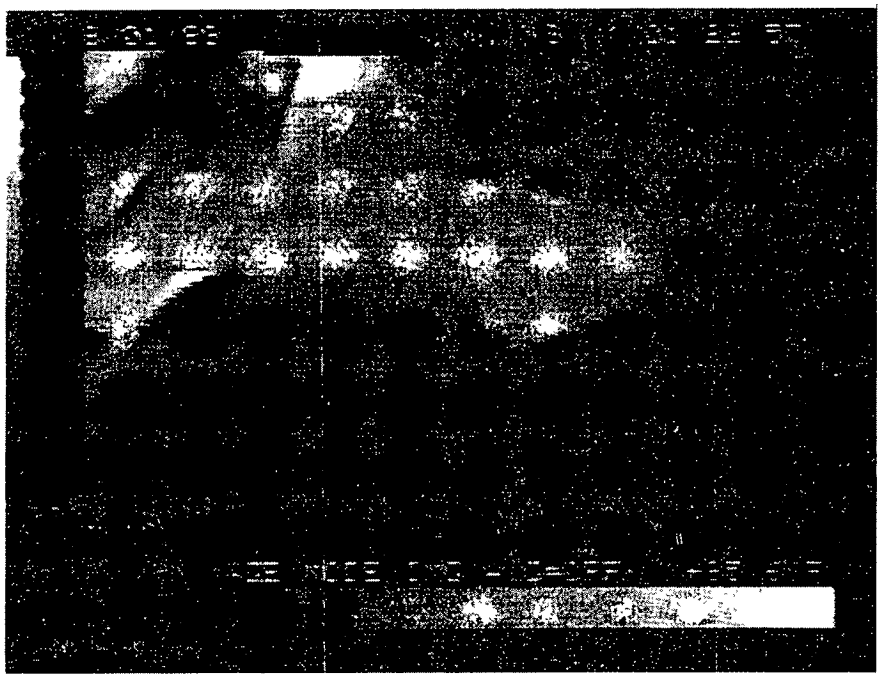
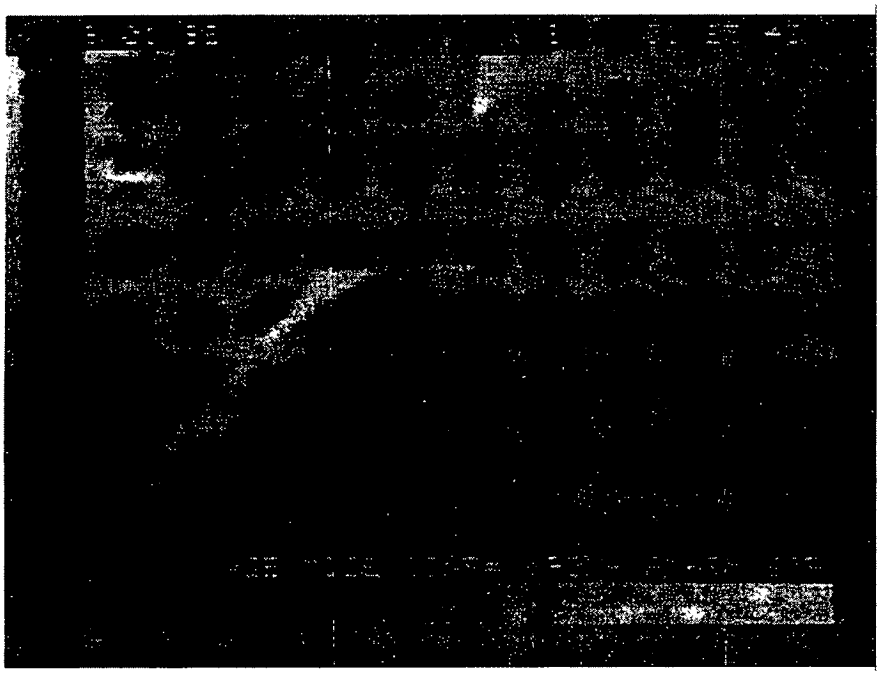
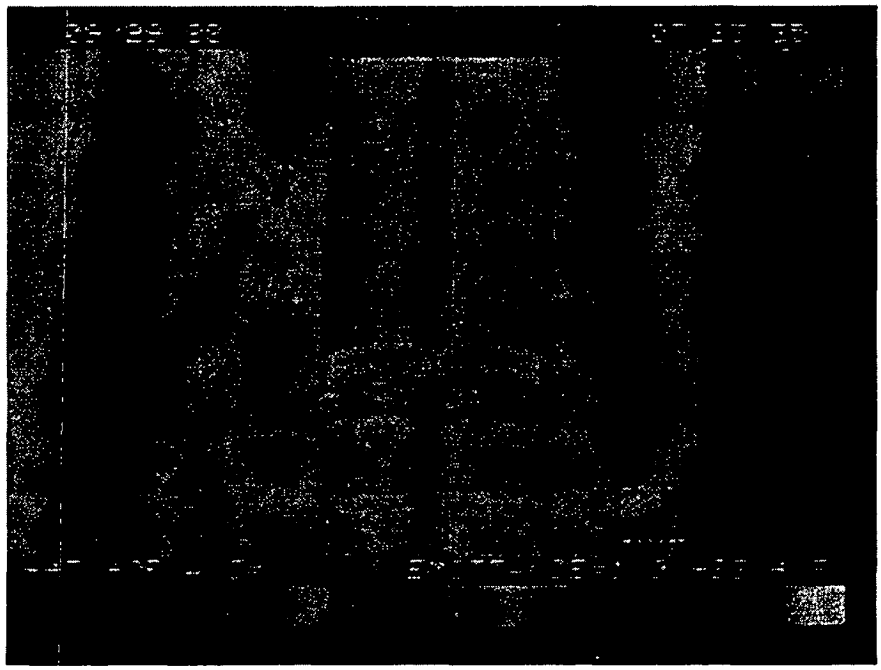




GOX SEAL LEAK DETECTED AND IMAGED BY SHUTTLE THERMAL IMAGER ON RSS ROOF DURING WCDDT



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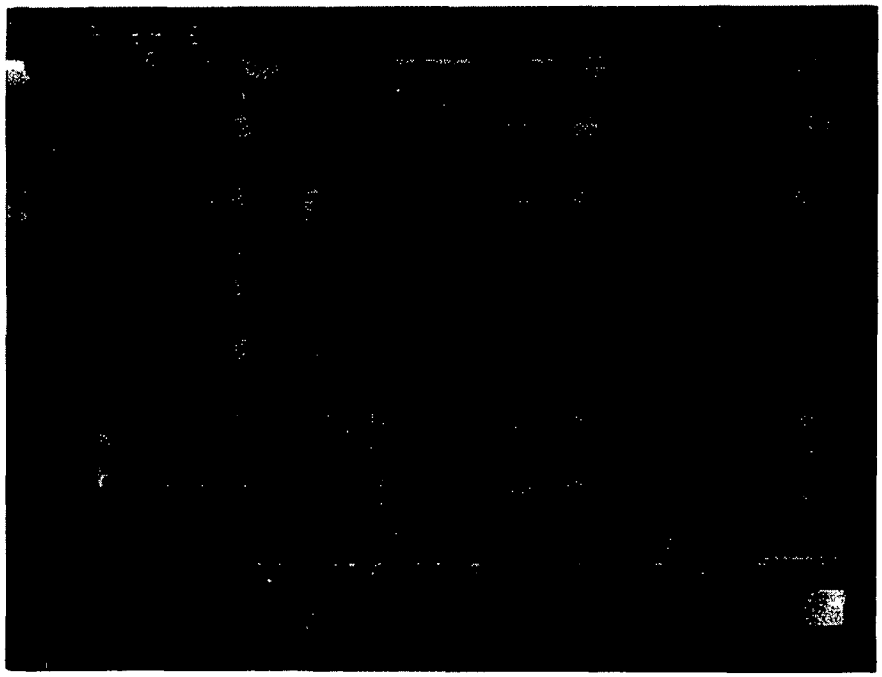
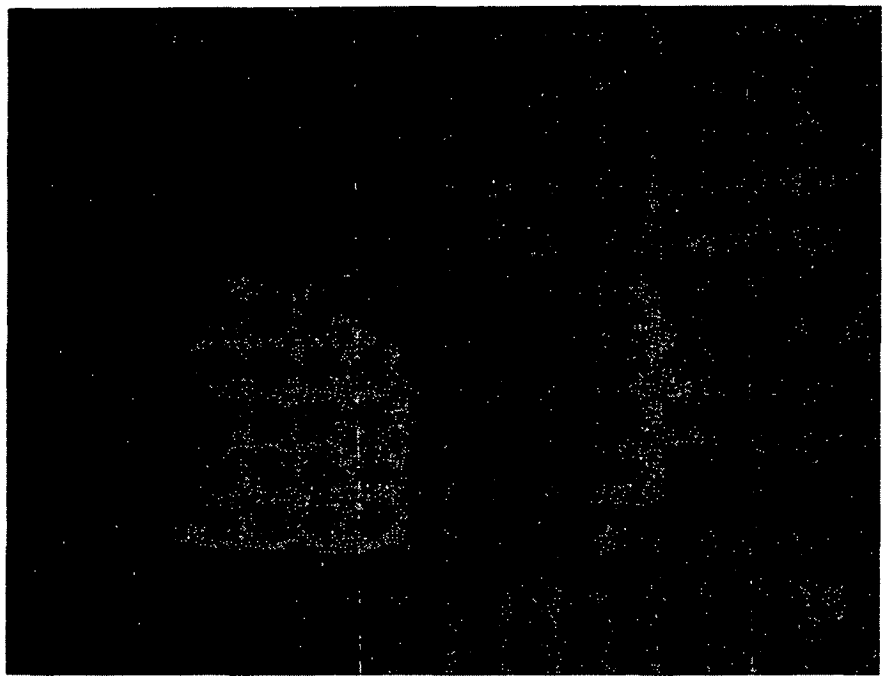
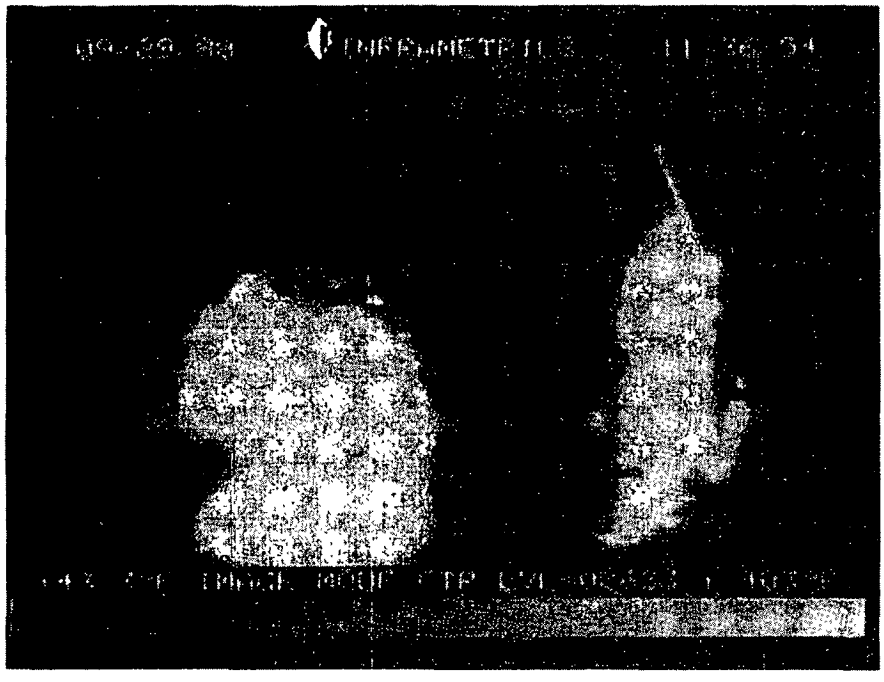
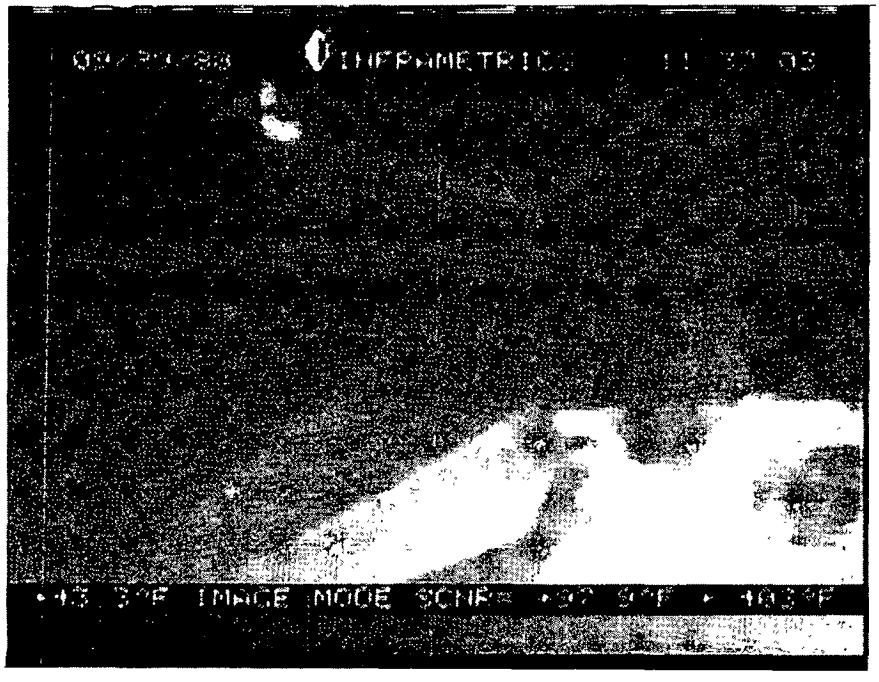


COMPUTER COLORIZED THERMAL IMAGE OF CRYOLOADED ET LH2 TANK AND SRB JOINT HEATER FROM SCANNER AT CAMERA SITE 2





COMPUTER COLORIZED AND HIGHER RESOLUTION B&W THERMAL IMAGES
OF SSME IGNITION EFFECT ON AFT END OF ORBITER



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THERMAL IMAGES OF ORBITER AFT END JUST BEFORE TOWER CLEAR. VERTICAL STABILIZER AND BASE HEAT SHIELD HEATED BY SSME PLUME.

8.0 POST LAUNCH PAD DEBRIS INSPECTION

The post launch inspection of the pad and surrounding area began on 29 September 1988 from Launch + 4 to 8 hours. The MLP, FSS, pad apron, and acreage areas were inspected. No flight hardware or TPS materials were found with the exception of the usual SRB throat plug material (foam and RTV). Water trough material from the SRB exhaust holes were scattered through the fields and on the pad surfaces, but in lesser amounts than on previous launches.

SRB holddown post erosion was negligible for this launch though most of the excessive RTV on the holddown post belly bands had either blown away or melted and dripped. South holddown post shim material was intact and no shrapnel from the aft skirt debris containers was found. All of the new doghouse blast covers on the north holddown posts were in the closed position, exhibited no apparent damage, and did not appear to be missing any parts. The SRB aft skirt purge lines were in place and undamaged. The new SRB joint heater umbilicals showed no damage after separation.

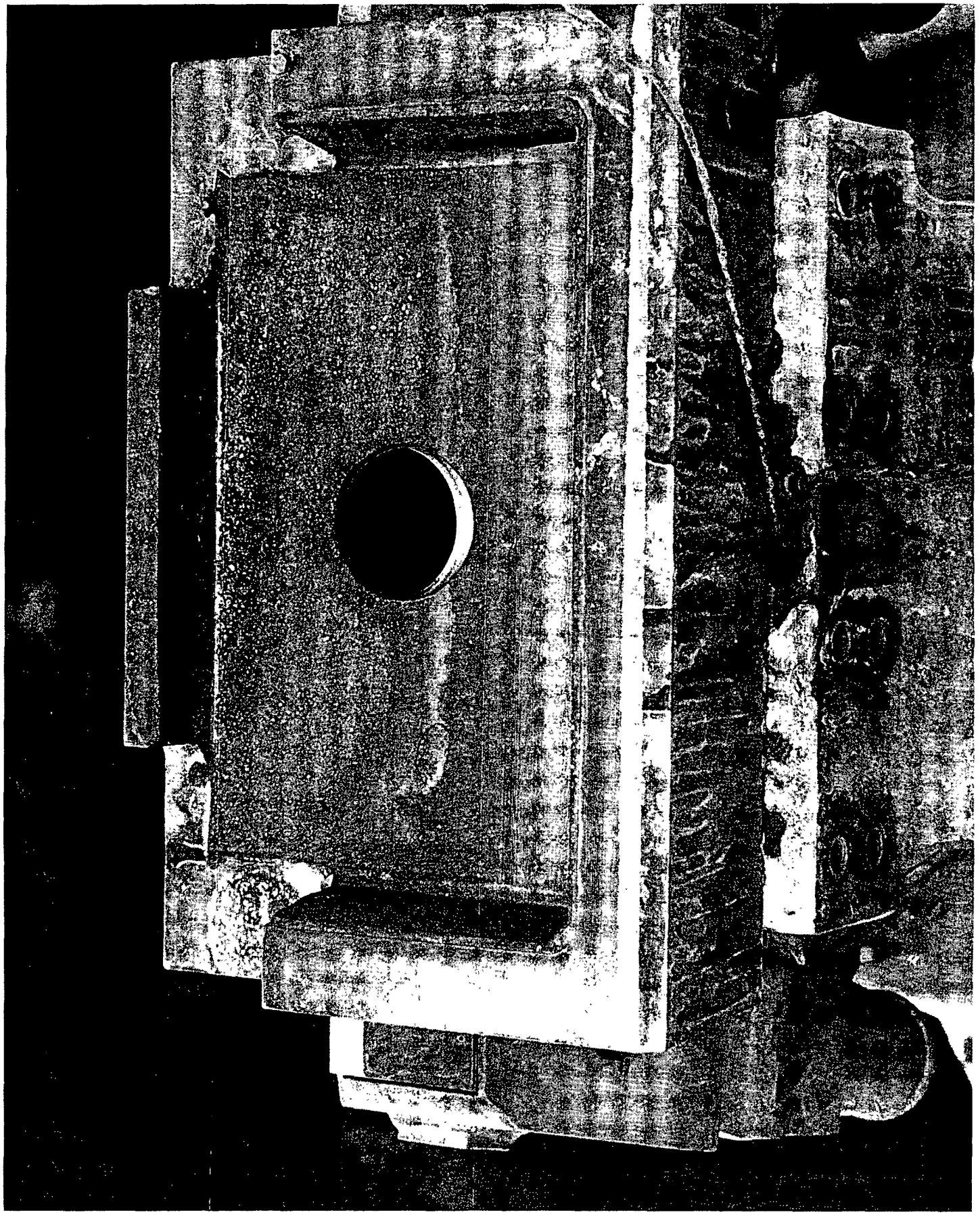
Facility swing arms and TSM's also showed no signs of damage. The GH2 vent arm and Orbiter Access Arm both latched in place. Some electrical cables were torn loose from the top of the GH2 vent arm, but the Ground Umbilical Carrier Plate was not damaged.

A greater amount of facility hardware was loose or detached than is normally observed. These include several large cable tray covers from the FSS/RSS (largest 10'x2'), a large ventilator cover (3'x3'x1') found in the field east of the pad, and a piece of facility sheet metal (3'x2') wedged between SRB holddown post #2 and the sidewall of the RH SRB exhaust hole.

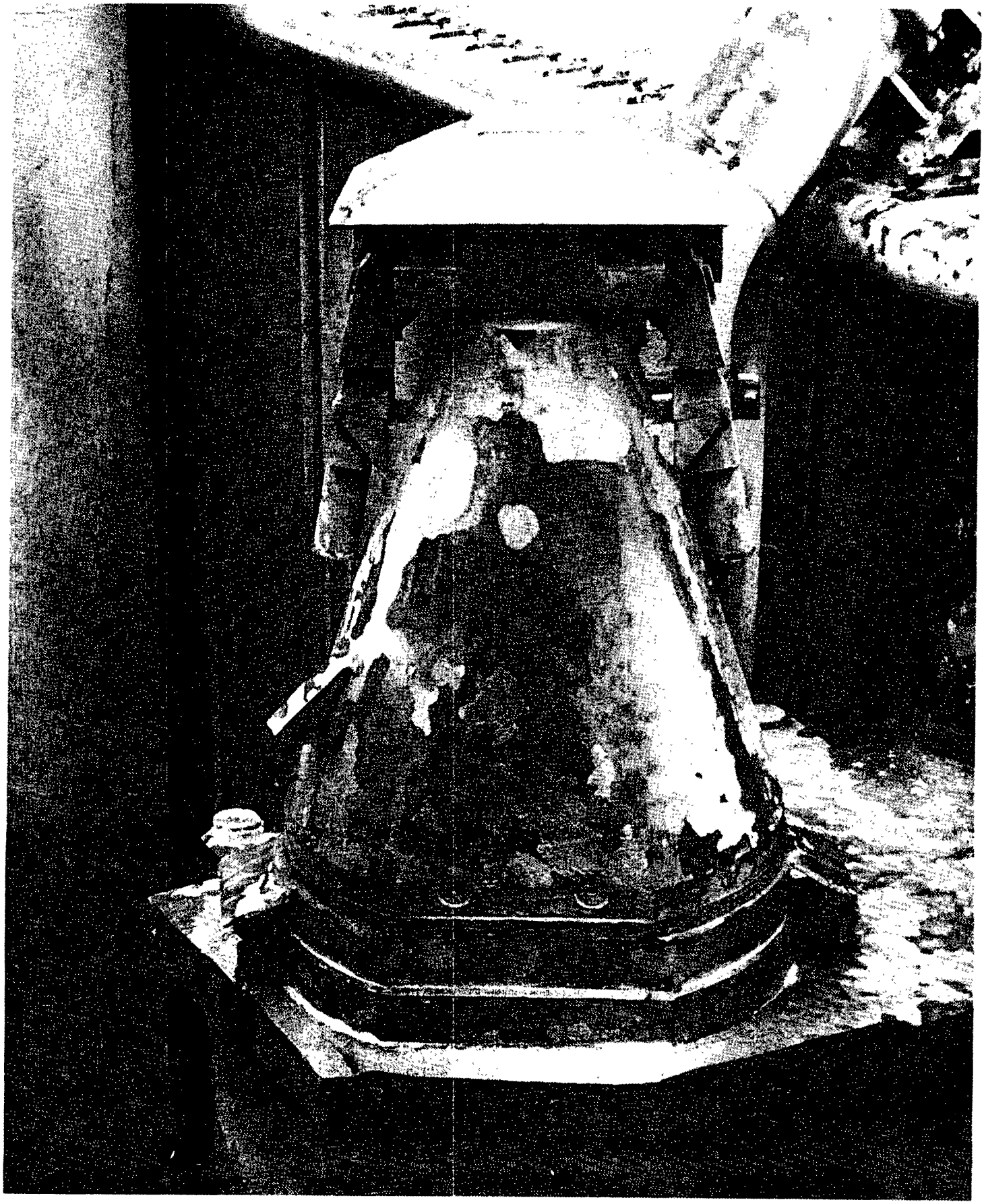
Three emergency egress baskets were in the landing zone and were apparently released during launch. (Subsequent film review showed the release did not occur between T-0 and tower clear). The thermal protection blanket for basket #7 was on the ground west of the pad. A large truck trailer approximately 500 west of the pad tipped over laterally about 20 degrees.

The new Shuttle Thermal Imager (STI) infrared cameras located at Camera Site #2 and on the roof of the RSS did not sustain any launch damage and were operational after launch. The housing of the unit on the RSS roof was coated with SRB residue.

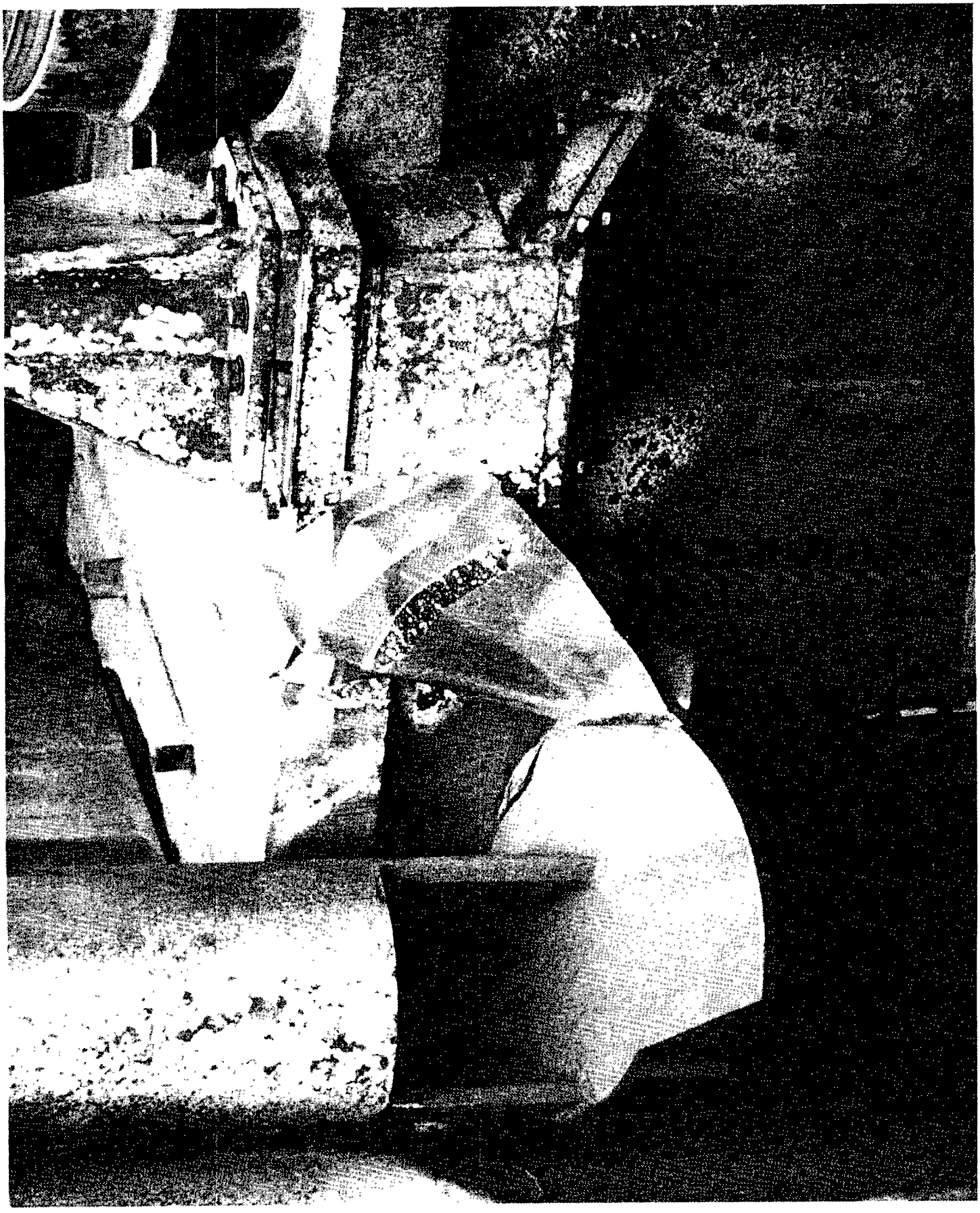
The debris inspection was expanded on 30 September 1988 to include areas outside the pad fence and east of the pad along the vehicle's flight path along with the railroad tracks, beach road, and the beach from the north KSC fence south to Pad A. No flight hardware or TPS material from the launch vehicle were found.



NO POST LAUNCH DAMAGE TO SOUTH HOLDDOWN POST SHOE. SHIM AND SIDEWALL MATERIAL IS INTACT.



NORTH HOLDDOWN POST SUSTAINED MINIMAL DAMAGE.
DOGHOUSE BLAST COVER CLOSED NOMINALLY.



FACILITY SHEET METAL COVER FOUND WEDGED BETWEEN RH SRB GN2 PURGE STANCHION AND WATER DELUGE DEFLECTOR PLATE

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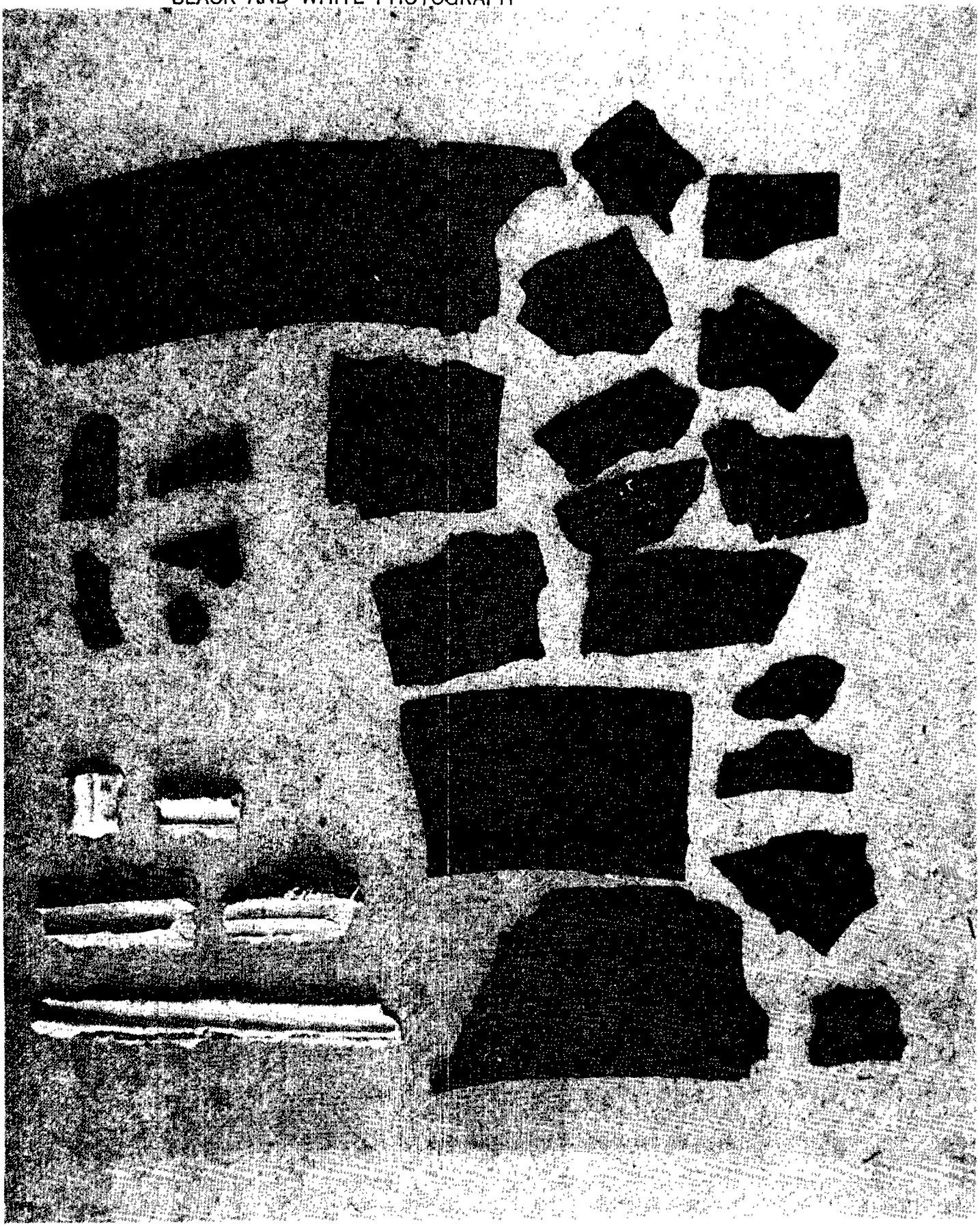

SAMPLES OF RED/BLACK SRB THROAT PLUG
MATERIAL AND WHITE FACILITY RTV

9.0 LAUNCH FILM SUMMARY/PROBLEM REPORT DISPOSITION

A total of 118 film and video data items, which included 41 videos, 54 16mm films, 14 35mm films, and 9 70mm films, were reviewed starting at Launch + 1 day.

No major vehicle damage or lost flight hardware were observed that would have affected the mission. However, one small tile from the base heat shield near the LH OMS pod broke loose at SSME ignition.

Flashes in the Main Engine plume occur soon after tower clear and continue through most of the ascent. Brightest/largest flashes are visible at T+13 seconds (Item E-52, 202. Ref photograph, page 137-A). Subsequent analysis revealed the flashes to be expanding pockets of unburned hydrogen that originated from SSME #1 and are probably related to the failure of the main combustion chamber.

Debris struck the Orbiter RH wing lower surface at T+52.2 seconds. The actual piece of debris is not discernible (Items E-201, E-215, ET-206, ET-207), but the impact and resulting shower of particles into the airstream is visible for 5 frames (Ref photograph, page 137-B). Location of the impact was outboard of the main landing gear door hinge line and forward of the elevon hinge line. Flashes in the SSME exhaust plume, reflections off the Orbiter tiles, and aerodynamic shock waves occur in this same general time frame, but are clearly not associated with the debris impact. Post landing inspection of the Orbiter revealed a damage crater measuring 18"x6"x1.5" that coincides with the impact location observed in the films. Depth and position of the damage crater make cork from the forward RH SRB the leading candidate for the debris. Subsequent inspection of the recovered RH SRB confirmed cork was missing from this area.

Shortly after completion of the roll program, a debris particle is noted passing over the Orbiter RH wing and continuing aft without impacting the vehicle. This particle, approximately 12" x 12" in size, appears to originate from the RH FWD ET/SRB attach point area.

The SRB plume recirculation effect is recorded on Items E-204, TV-13, ET-206, and ET-208 (Ref photograph, page 137-C). This is an expected phenomenon and occurs on every flight.

SSME startup was normal, but pockets of free hydrogen were ignited by the ROFI's and drifted upward before SSME #3 plume was stabilized. Shown in Item E-19.

Several tiles on the Orbiter base heat shield sustained minor damage due to SSME ignition acoustics/vibration. A wedge-shaped (5"x3"x1.5" by 1" thick) piece of tile breaks off the tile-covered LH OMS pod mounting bracket located at the 4 O'clock position to the OMS nozzle on the base heat shield (Item E-24. Ref photograph, page 137-D).

Several film items document loose thermal curtain tape that comes loose at SRB ignition. A 10"x6" piece of instafoam separates from the RH SRB Aft Skirt at liftoff. Four to five fragments drop from the hole in the HDP #1 foot and is an indication that the plunger in the debris container failed. One to two fragments also fall from the hole in HDP #3 foot (Ref photograph, page 137-E).

Many film and video items record various amounts of flying debris. This debris is SRB throat plug material and shredded water troughs - an expected occurrence.

There were no major facility anomalies and no swing arms or other pad structures contacted the vehicle during liftoff. Although 3 emergency egress slidewire baskets were found in the bunker landing zone, Items E-63 and 64 confirm the basket release did not occur during the time frame T-0 through tower clear. Large pieces of debris, visible in Items E-34, 35, 40, and 41, are cable tray covers from the FSS/RSS. They enter the camera field-of-view after the vehicle has cleared the tower.

No PR's or IPR's were generated as a result of the launch film and video data review.

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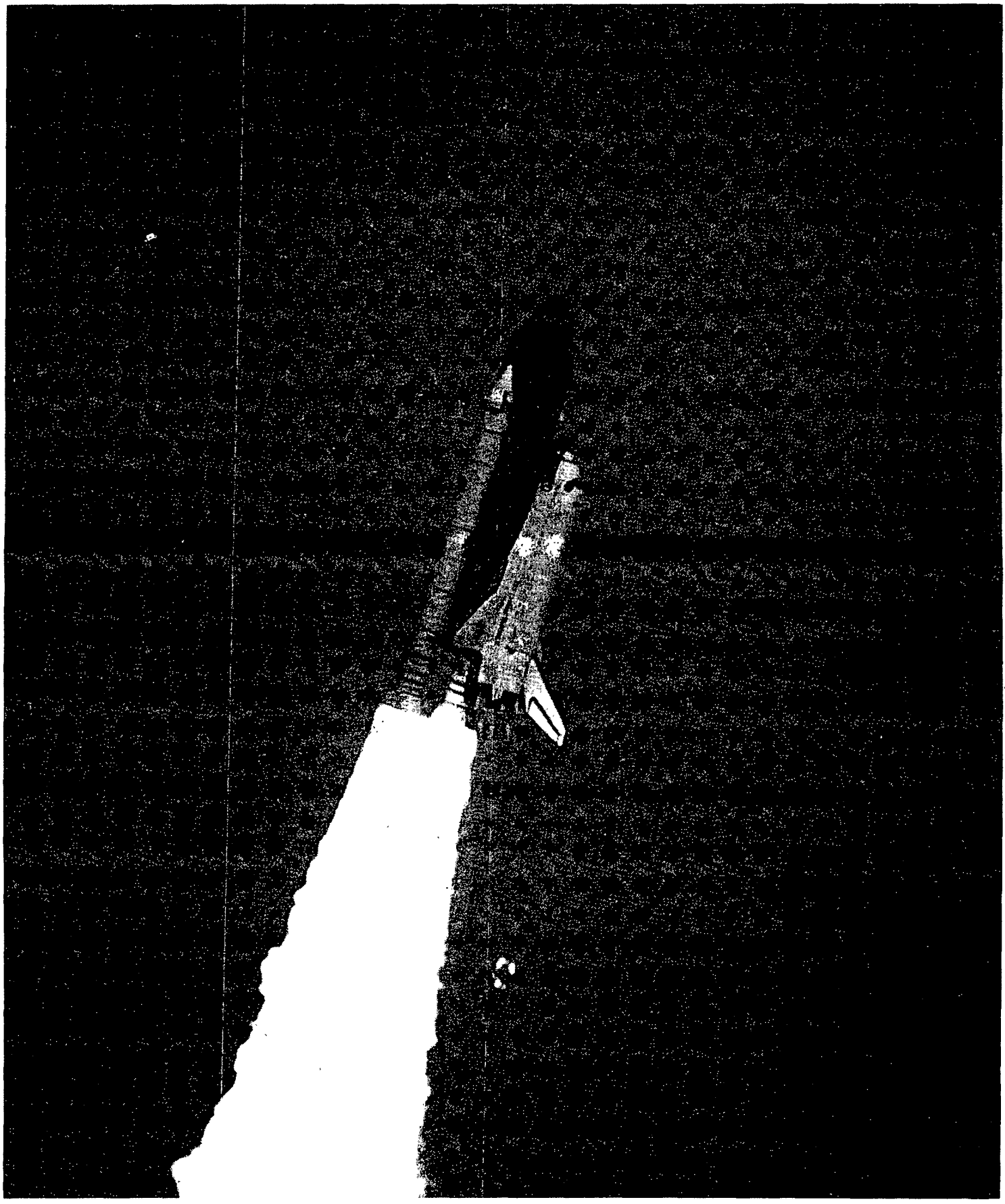
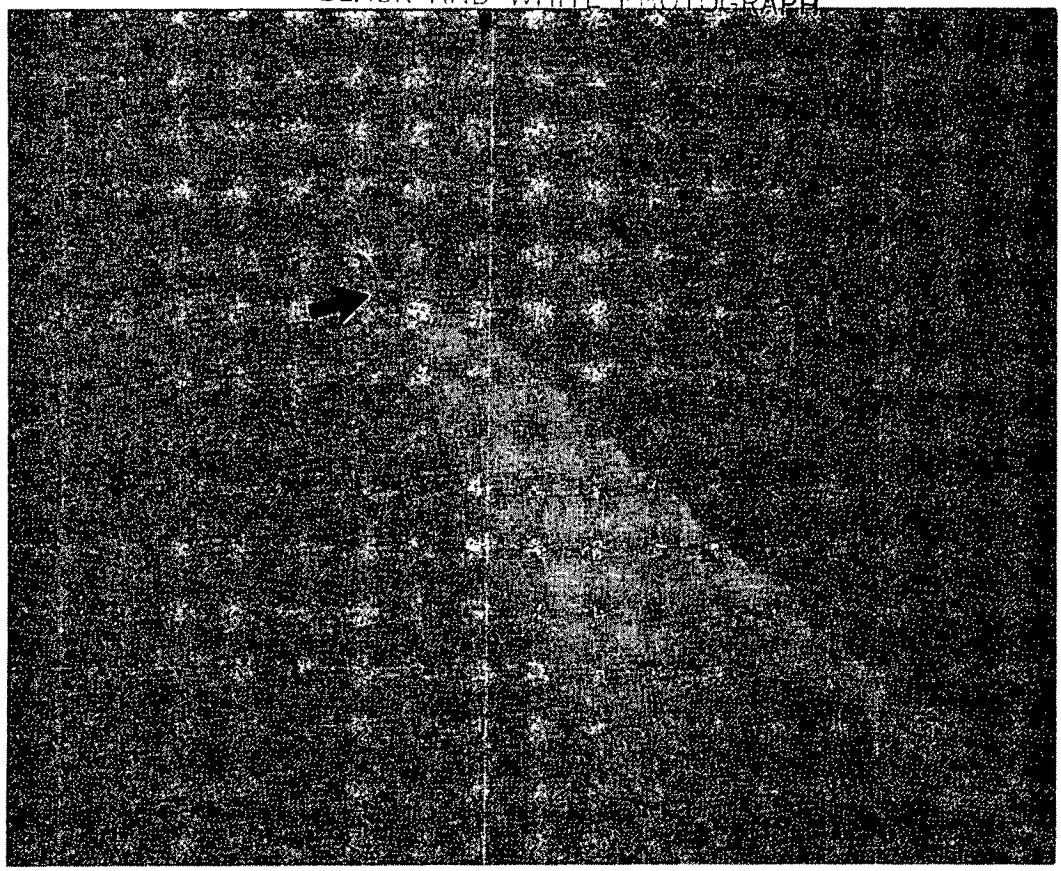
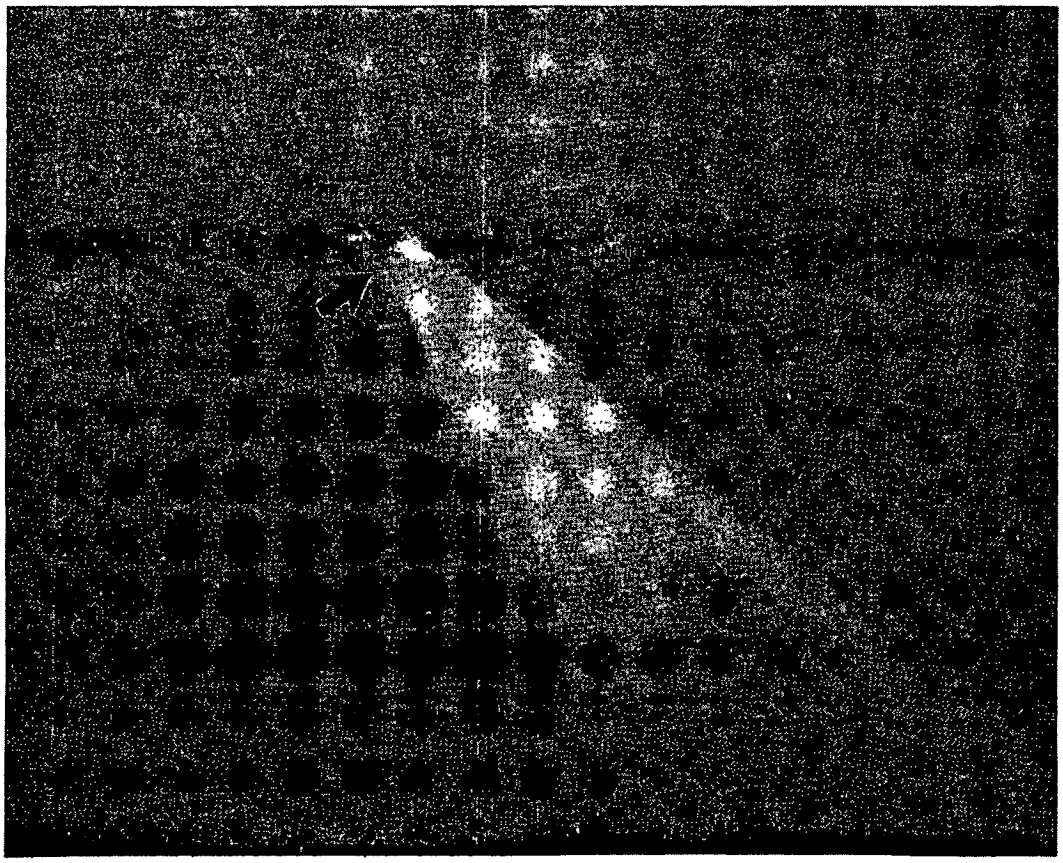
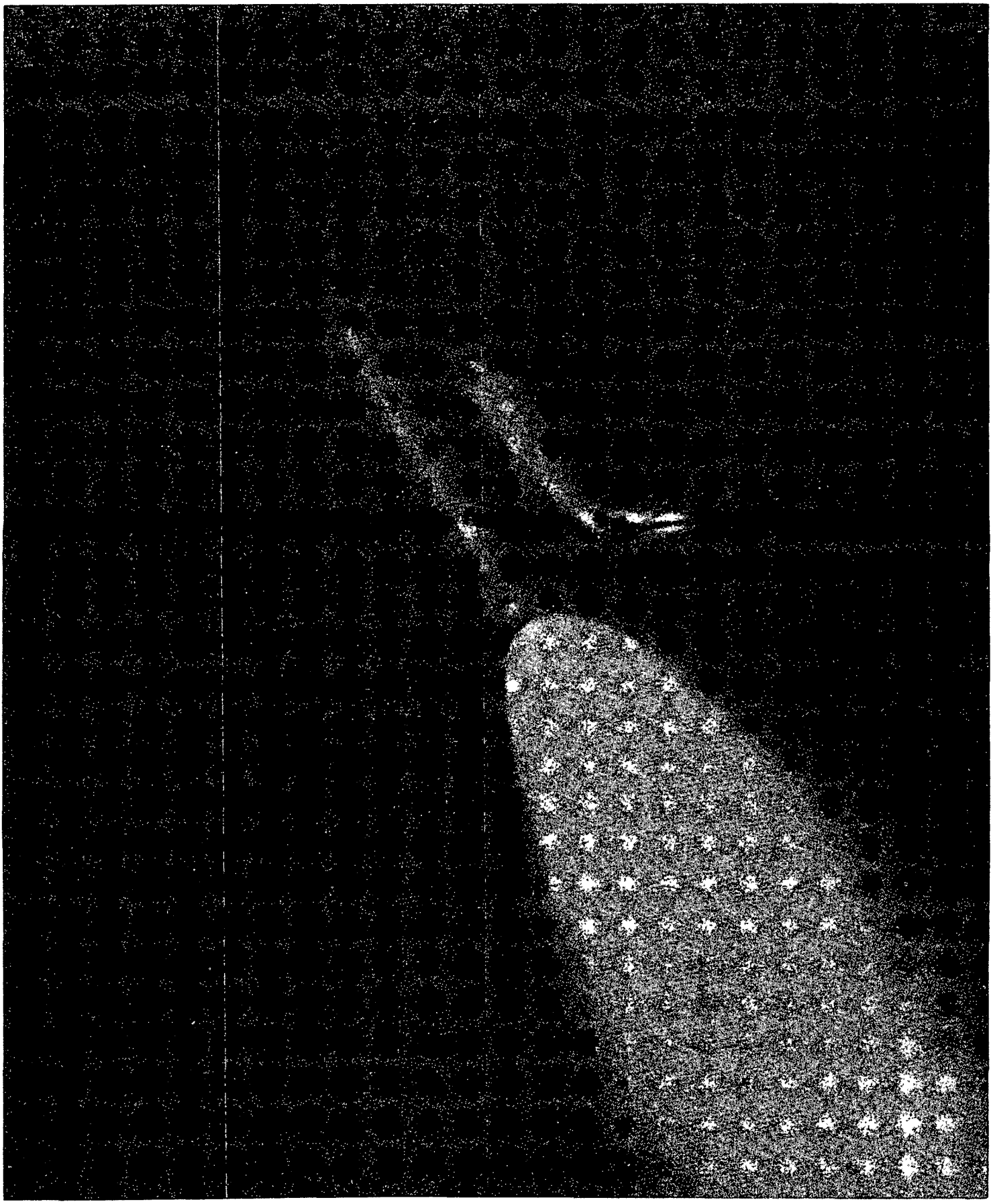


FLASH OF VAPORIZING HYDROGEN IN SSME #1 PLUME AT T+13 SECONDS CAUSED BY MAIN COMBUSTION CHAMBER FAILURE
137-A

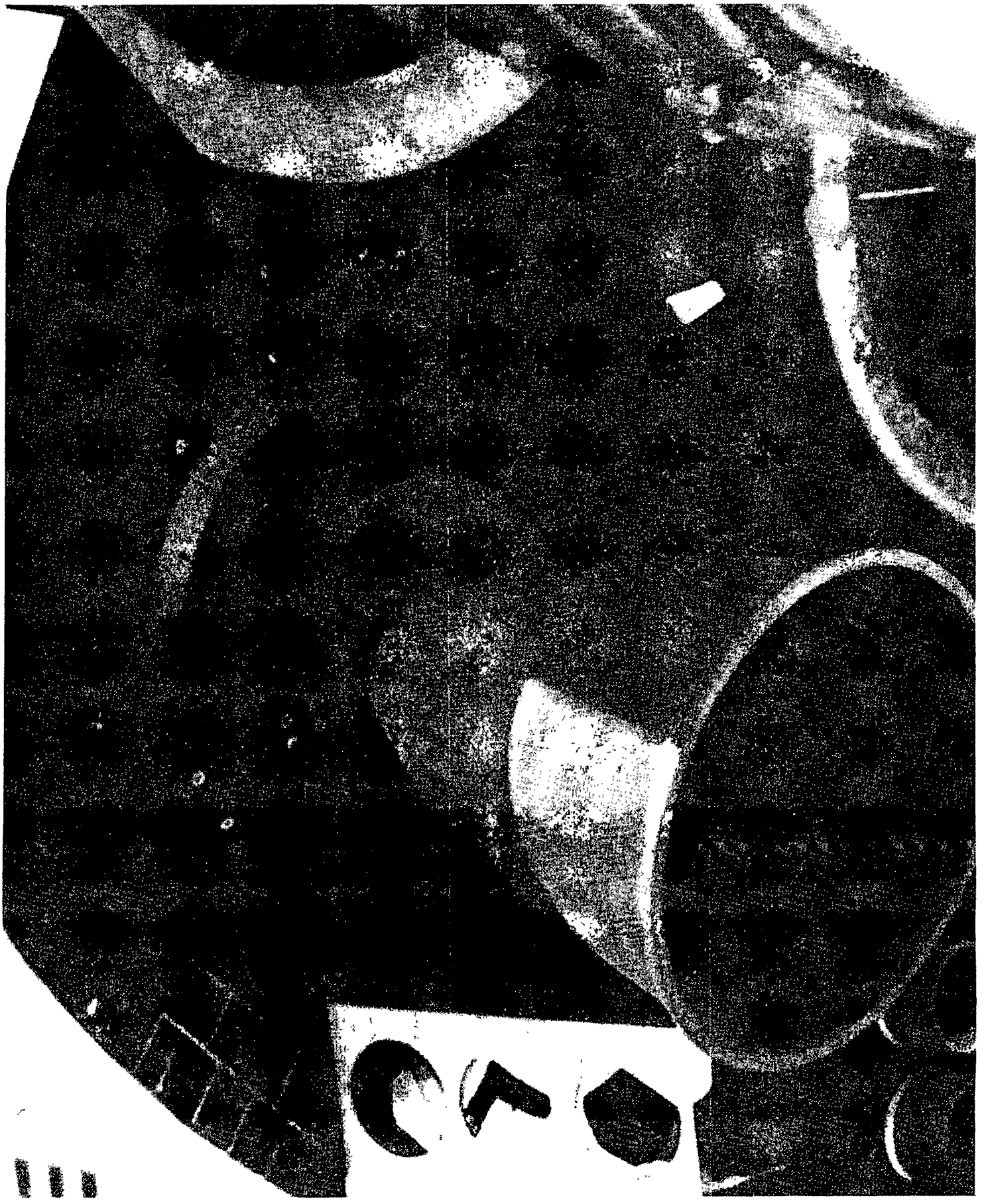




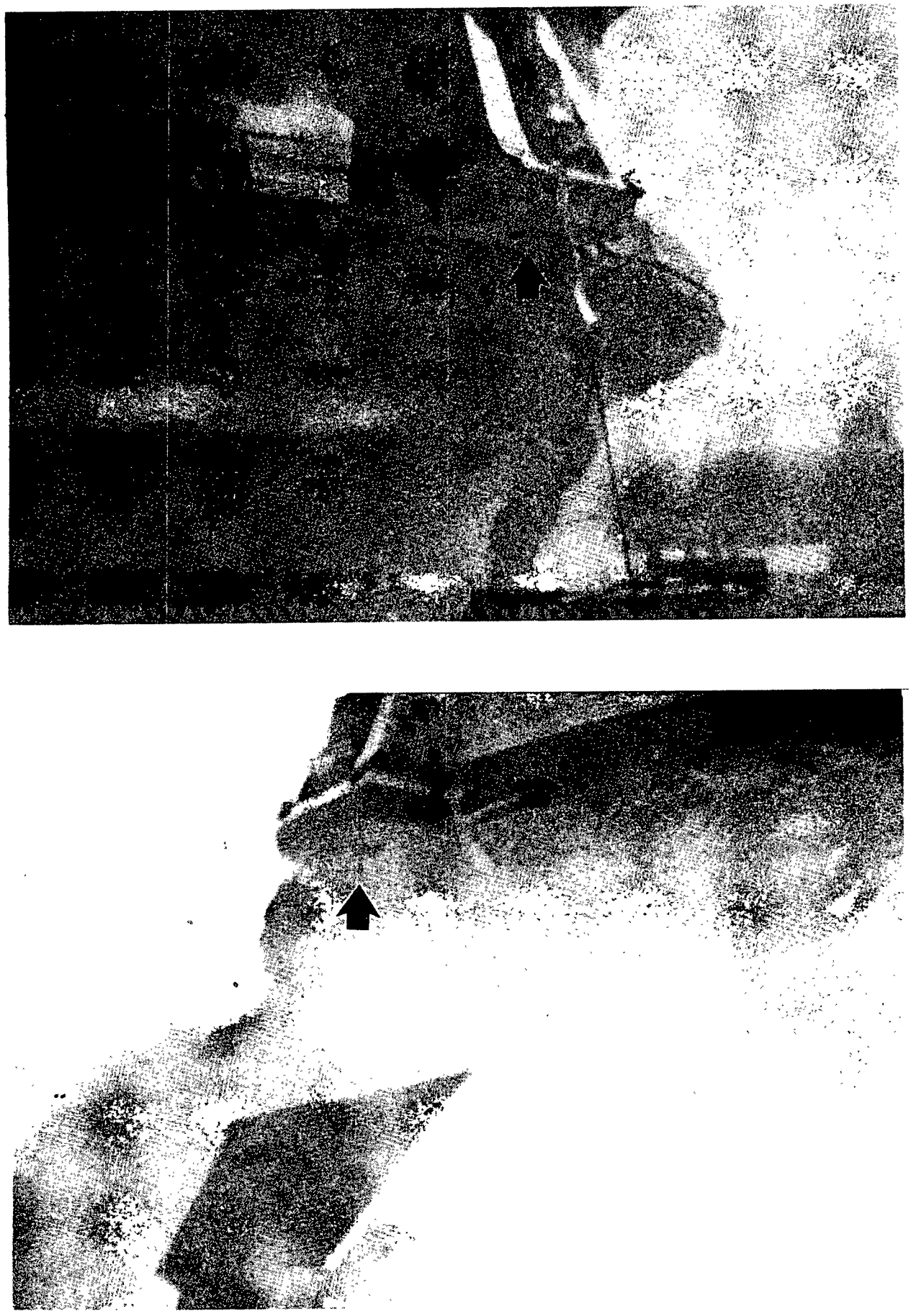
DEBRIS IMPACT ON RH LOWER ORBITER WING AT T+52.2 SECONDS



SRB PLUME RECIRCULATION EFFECT
(TYPICALLY OBSERVED FROM APPROX. T+90 TO T+115 SECONDS)
137-C



TILE FRAGMENT FALLING FROM LH OMS POD
MOUNTING BRACKET SHORTLY BEFORE T-0
137-D



FRANGIBLE NUT FRAGMENTS FALLING FROM SRB AFT SKIRT FOOT AT T-0

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ON ORBIT PHOTO OF ET AFTER SEPARATION FROM ORBITER
NO ET ANOMALIES VISIBLE
137-F

9.1 LAUNCH FILM AND VIDEO DATA REVIEW

FILM ITEMS

EX1
400 FPS
16mm

Camera is located on MLP deck south of SRB exhaust duct and looks north to view SRB Heater Umbilical during ignition and disconnect at liftoff.

Focus : OK
F. O. V.: CAMERA SHOWS HOLD DOWN POST NUMBER 1.
Exposure: OK

Comments: FOUR OR FIVE FRAGMENTS COME OUT OF HOLD DOWN POST. THE LARGEST IS 1"x1". TWO PIECES OF INSTAFOAM, 10"x6" AND 2"x1", ARE SEPARATED FROM THE AFT SKIRT NEAR THE RIGHT HAND SIDE OF THE HOLDDOWN POST AT LIFTOFF. LEFT HAND FIRING CABLE STRETCHES ABOUT TWO FEET BEFORE BREAKING. THREE PIECES OF THERMAL CURTAIN TAPE COME LOOSE. THREE PIECES OF DEBRIS FALL ON LEFT HAND SIDE, POSSIBLY ICE FROM UMBILICALS.

E-1
400 FPS
16mm

Camera is located on the NE corner of the MLP deck and views the lower ET, SRB's, and Orbiter.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO SRB IGNITION

Comments: TWO PIECES OF THERMAL CURTAIN TAPE COME LOOSE FROM RH SRB. ICE FALLS FROM LH2 UMBILICAL. SRB WATER TROUGH MATERIAL MOVES FROM LEFT TO RIGHT ACROSS FRAME.

E-2
400 FPS
16mm

Camera is located on the SE corner of the MLP deck and views Orbiter SSME and OMS engine nozzles.

Focus : SOFT-FOCUS IN FOREGROUND
F. O. V.: OK
Exposure: OK

Comments: FOUR PIECES OF THERMAL CURTAIN TAPE COME LOOSE ON RH SRB. NO DEBRIS COMES FROM SRB EXHAUST HOLES. RCS STINGER PAPER COVER RUPTURES AND COMES OFF. RH SRB ETA AND STIFFENER RINGS EJECT WATER JUST AFTER LIFTOFF. SOME ICE FALLS FROM THE AREA OF THE LOX T-0 UMBILICAL. ENGINE START-UP SEQUENCE IS NORMAL. LH2 TSM DOOR CLOSURE IS NOMINAL.

EX2 Camera is located on the MLP deck west side of RH
400 FPS SRB flame duct and looks east to view SRB Heater
16mm Umbilical during ignition and liftoff.

Focus : OK
F. O. V.: TIGHT, COULD BE EXPANDED
Exposure: UNDEREXPOSED

Comments: THREE PIECES OF THERMAL CURTAIN TAPE COME LOOSE AT IGNITION. SEVERAL PIECES OF THROAT PLUG MATERIAL CROSS FIELD OF VIEW. NOMINAL UMBILICAL SEPARATION. WATER SPRAY ORIGINATES FROM WATER TROUGH AREA.

EX3 Camera is located on the MLP deck east side of LH
400 FPS SRB flame duct and looks west to view SRB Heater
16mm Umbilical during ignition and launch.

Focus : GOOD
F. O. V.: TIGHT, COULD BE EXPANDED
Exposure: OK

Comments: FOUR PIECES OF THERMAL CURTAIN TAPE COME LOOSE AT IGNITION. WATER SPRAY ORIGINATES FROM WATER TROUGH AREA. NOMINAL UMBILICAL SEPARATION. SEVERAL PIECES OF INSTAFOAM VIBRATE LOOSE AT IGNITION.

E-3 Camera is located on the SW corner of the MLP deck
400 FPS and views Orbiter SSME and OMS engine nozzles.
16mm
Focus : OK
F. O. V.: OK
Exposure: OK

Comments: RCS STINGER PAPER COVER RUPTURES AND COMES OFF. ICE FALLS FROM THE LOX T-0 UMBILICAL. LOX TSM T-0 DOOR APPEARS TO HAVE OPERATED NORMALLY. TWO PIECES OF THERMAL CURTAIN TAPE COME LOOSE ON LH SRB AT IGNITION. NO DEBRIS OBSERVED COMING FROM SRB FLAME DUCT. FACILITY DELUGE WATER DROPLETS FALL THROUGH FIELD OF VIEW - SOME LAND ON CAMERA LENS. SSME START-UP SEQUENCE APPEARS NORMAL. ICE DROPS FROM SSME #1 NOZZLE.

EX4 Camera is located on MLP deck south side of LH SRB
400 FPS flame duct and looks north to view LH SRB Heater
16mm Umbilical during ignition and liftoff.

Focus : OK
F. O. V.: CAMERA SHOWS HOLD DOWN POST NUMBER 5.
Exposure: OK

Comments: THREE PIECES OF THERMAL CURTAIN TAPE COME LOOSE AT IGNITION. CAMERA VIBRATES EXCESSIVELY AFTER SSME STARTUP. WATER TROUGH CORD AND DARK DEBRIS COMES FROM FLAME DUCT. BLURRED MATERIAL FALLS FROM ORBITER UMBILICAL, POSSIBLY WATER/ICE/FROST.

E-4 Camera is located on the NW corner of the MLP deck
400 FPS and views lower ET, SRB's, and Orbiter.
16mm
Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO SRB IGNITION

Comments: LOOSE THERMAL CURTAIN TAPE OBSERVED ON BOTH SRB'S - TWO PIECES ON THE RH SRB, THREE PIECES ON THE LH SRB. DEBRIS, INCLUDING WATER TROUGH MATERIAL, ORIGINATES FROM LH SRB FLAME DUCT. NO ORBITER DAMAGE NOTED. ICE FALLS NEAR THE BODY FLAP TO THE MLP DECK PRIOR TO LIFTOFF.

E-5 Camera is located on the east side of the MLP
400 FPS deck and views the Orbiter RH wing, body flap,
16mm and lower ET and SRB's.

Focus : OK
F. O. V.: TOO HIGH. NEED TO SEE ENTIRE ENGINE NOZZLES
Exposure: OK

Comments: FIVE PIECES OF ICE FALL FROM LH2 EO UMBILICAL. VERY SLIGHT MOVEMENT OF THE RH WING AND ELEVON AT T-0. A PARTICLE COMES FROM SCREEN RIGHT AND DISAPPEARS INTO THE SSME FLAME DUCT. THE PARTICLE POSSIBLE ORIGINATES FROM THE SRB HDP #4 AREA. LOOSE THERMAL CURTAIN TAPE VISIBLE ON BOTH SRB'S. A CLOUD OF VAPOR COMES FROM THE LOX T-0 UMBILICAL AREA AT LIFTOFF.

E-6 Camera is located on the east side of the MLP deck
200 FPS and views the lower RH Orbiter wing, body flap, ET
16mm lower feedline, and ET/ORB umbilical area.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: ELEVONS MOVE WITH SSME STARTUP. NUMEROUS PIECES OF ICE FALL FROM INBOARD SIDE OF LO2 ET/ORB UMBILICAL. SMALL PIECE OF DEBRIS PASSES BY ET (MAYBE FROM SRB EXHAUST DUCT) TRAVELING TOWARD BODY FLAP, BUT ANY IMPACT IS NOT VISIBLE. ICE FALLS FROM AREA ABOVE VERTICAL STRUT, POSSIBLY FROM THE LOX FEEDLINE. SEVERAL VENTINGS FROM VERTICAL STRUT DRAIN HOLE NEAR DOG LEG.

E-7 Camera is located on the MLP deck and views the
400 FPS RH SRB northeast holddown post (HDP #4).
16mm
Focus : OK
F. O. V.: OK
Exposure: OK

Comments: HPU EXHAUST IS VISIBLE BEHIND SOUND SUPPRESSION WATER PIPE. THREE PIECES OF THERMAL CURTAIN TAPE COME LOOSE WITH SRB IGNITION. SMALL PIECES OF THROAT PLUG MATERIAL PASS THROUGH FRAME AS VEHICLE RISES. DOGHOUSE BLAST COVER CLOSURE IS NOMINAL. BACK-FLOW OF EXHAUST GASES RISES BETWEEN NOZZLE EXTENSION AND HOLDDOWN POST, CONTACTS INSTAFOAM, AND IS DEFLECTED OUTWARD. WATER TROUGH MATERIAL AND DEBRIS FLY PAST CAMERA AS NOZZLE EXTENSION CLEARS HOLDDOWN POST.

E-8 Camera is located on the MLP deck and views the
400 FPS RH SRB southeast holddown post (HDP #2).
16mm
Focus : SOFT
F. O. V.: OK
Exposure: OK

Comments: PIECE OF THROAT PLUG MATERIAL ORIGINATES FROM EXHAUST DUCT AND RISES VERTICALLY. FOUR PIECES OF THERMAL CURTAIN TAPE COME LOOSE AT IGNITION. BITS OF WATER TROUGH AND THROAT PLUG MATERIAL FLY THROUGH FRAME AS VEHICLE RISES. GN2 PURGE PIPE SEPARATES CLEANLY. NO DEBRIS DROPS FROM HOLE IN AFT SKIRT FOOT.

E-9 Camera is located on the MLP deck and views the
400 FPS RH SRB southwest holddown post (HDP #1).
16mm
Focus : OK
F. O. V.: OK
Exposure: OK

Comments: TWO PIECES OF THERMAL CURTAIN TAPE COME LOOSE AT IGNITION. TWO PIECES OF DEBRIS COME OUT OF THE SRB FLAME DUCT. TWO HAND SIZED PIECES OF INSTAFOAM BREAK OFF THE AFT SKIRT IN THE REGION OF THE HDP SHOE. ONE PIECE OF SHRAPNEL FALLS FROM THE HOLE IN THE AFT SKIRT FOOT. CAMERA VIBRATES EXCESSIVELY DUE TO SSME IGNITION.

E-10 Camera is located on the MLP deck and views the
400 FPS RH SRB northwest holddown post (HDP #3).
16mm
Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO LAUNCH

Comments: SMALL PIECES OF DEBRIS TRAVEL UPWARD AT IGNITION. ONE OR TWO PIECES OF DEBRIS DROP FROM HOLE IN AFT SKIRT FOOT. THERMAL CURTAIN TAPE IS INTACT. DOGHOUSE BLAST COVER CLOSURE IS NOMINAL. BITS OF WATER TROUGH AND THROAT PLUG MATERIAL FLY THROUGH FRAME AS VEHICLE RISES.

E-11 Camera is located on the MLP deck and views the
400 FPS LH SRB northeast holddown post (HDP #7).
16mm
Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO IGNITION

Comments: WHITE TAG ON WATER TROUGH MOVES AFTER SSME IGNITION. PIECE OF DEBRIS ON MLP DECK TRAVELS IN DIRECTION OF MAIN ENGINES. TARGET DROPS OFF OF HOLDDOWN POST AND THREE PIECES OF THERMAL CURTAIN TAPE COME LOOSE AT SRB IGNITION. WHITE TIE-DOWN FOR WATER TROUGH IS VISIBLE NEXT TO HOLDDOWN POST. BACKFLOW OF EXHAUST GASES AND BLACK SMOKE RISE BETWEEN NOZZLE EXTENSION AND HOLDDOWN POST AND ARE DEFLECTED BY AFT SKIRT INSTAFOAM. DOGHOUSE BLAST COVER CLOSURE IS NOMINAL. HDP FIRING CABLE IS DRAWN THREE FEET UPWARD BY RISING VEHICLE BEFORE BREAKING. WATER TROUGH MATERIAL CONTINUES TO FLY THROUGH FRAME AFTER NOZZLE EXTENSION CLEARS HDP.

E-12 Camera is located on the MLP deck and views the
400 FPS LH SRB southeast holddown post (HDP #5).
16mm
Focus : OK
F. O. V.: OK
Exposure: OK

Comments: THE CAMERA VIBRATES EXCESSIVELY DURING SSME START-UP. THREE PIECES OF THERMAL CURTAIN TAPE ARE LOOSE. FOUR PIECES OF DEBRIS ARE EJECTED FROM THE SRB FLAME DUCT.

E-13 Camera is located on the MLP deck and views the
400 FPS LH SRB southwest holddown post (HDP #6).
16mm
Focus : OK
F. O. V.: OK

Exposure: OK

Comments: FOUR PIECES OF THERMAL CURTAIN TAPE COME LOOSE AT SRB IGNITION. ONE HDP FIRING CABLE BREAKS ALMOST IMMEDIATELY, THE OTHER IS DRAWN UPWARD BY THE RISING VEHICLE BEFORE BREAKING. A PIECE OF THROAT PLUG MATERIAL IS DRAWN TOWARD SSME'S. NO DEBRIS IS OBSERVED DROPPING FROM HOLE IN AFT SKIRT FOOT. OTHER SMALL PIECES OF DEBRIS PASS THROUGH FRAME AS VEHICLE RISES.

E-14 Camera is located on the MLP deck and views the
400 FPS LH SRB northwest holddown post (HDP #8).
16mm
Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO IGNITION

Comments: THERMAL CURTAIN TAPE IS INTACT. BACKFLOW OF EXHAUST GASES AND GRAY SMOKE RISE BETWEEN NOZZLE EXTENSION AND HOLDDOWN POST AND ARE DEFLECTED BY AFT SKIRT INSTAFOAM. DOGHOUSE BLAST COVER CLOSURE IS NOMINAL. THROAT PLUG MATERIAL, WATER TROUGH, AND DEBRIS PASS THROUGH FRAME AS VEHICLE RISES.

E-15 Camera is located on the MLP deck and views the RH
400 FPS SRB skirt, sound suppression water troughs, and RH
16mm lower Orbiter body flap.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: THREE PIECES OF THERMAL CURTAIN TAPE COME LOOSE AT IGNITION. HPU EXHAUST IS VISIBLE AT 90 DEGREE POSITION. WATER FROM TROUGHS GYSERS 20 FEET AND OBSCURES FIELD OF VIEW MOMENTARILY. DOGHOUSE BLAST COVERS CLOSURE IS NOMINAL. ICE FALLS FROM ET LOX UMBILICAL.

E-16 Camera is located on the MLP deck and views the LH
400 FPS SRB skirt, sound suppression water troughs, and LH
16mm lower Orbiter body flap.
Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: FIVE PIECES OF THERMAL CURTAIN TAPE COME LOOSE AT IGNITION. DOGHOUSE BLAST COVERS CLOSE NORMALLY. WATER FROM TROUGHS GYSERS 20 FEET AND OBSCURES FIELD OF VIEW MOMENTARILY. SRB EXHAUST BACKFLOW RISES BETWEEN RIGHT HAND SIDE OF HOLDDOWN POST #7 AND SIDE OF NOZZLE EXTENSION, IMPINGES UPON THERMAL

BLANKETS, AND IS DEFLECTED OUTWARD. THIS EVENT OCCURS WHEN VEHICLE HAS RISEN THREE FEET ABOVE DOGHOUSE BLAST COVERS AND IS ABOVE THE LEVEL OF THE LOWER EDGE OF THE AFT SKIRT (IPR POSSIBLE). NOZZLE EXTENSION APPEARS TO BE DISCOLORED. DARK GRAY SMOKE RISES AFTER FLAME BETWEEN HOLD POST 7 AND 8 (SEEN IN FILM E-28). TWO SMALL DARK PIECES OF DEBRIS, WHICH APPEAR TO ORIGINATE FROM AREA OF HOLDDOWN POST #7, RISE STRAIGHT UP AND OUT OF VIEW.

E-17 Camera is located on the MLP deck and views the
400 FPS -Z side of the LO2 T-0 Umbilical and TSM.
16mm
Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SPARKS FROM IGNITORS IMPACT TSM. HYDROGEN FIRE RISES TOWARD AFT HEAT SHIELD AND RCS PAPER COVERS RUPTURE WITH SSME IGNITION. ICE/FROST DROPS FROM T-0 UMBILICAL AND SSME #3 DUE TO STARTUP VIBRATION. BODY FLAP MOVEMENT IS ALSO VISIBLE. SSME #3 IS GIMBALLED TO LAUNCH POSITION. T-0 UMBILICAL RETRACTS NORMALLY BUT LEAVES A CLOUD OF GOX NEAR THE VEHICLE.

E-18 Camera is located on the MLP deck and views the
400 FPS -Z side of the LH2 T-0 Umbilical and TSM.
16mm
Focus : OK
F. O. V.: TILTED UP TOO HIGH
Exposure: UNDEREXPOSED

Comments: RCS PAPER COVERS RUPTURE WITH SSME IGNITION. ICE/FROST DROPS FROM T-0 UMBILICAL AND ET/ORB LH2 UMBILICAL DUE TO STARTUP VIBRATION. BODY FLAP MOVEMENT IS ALSO VISIBLE. T-0 UMBILICAL RETRACTS NORMALLY. A TILE ON THE AFT HEAT SHIELD IS CHIPPED DURING SSME IGNITION.

E-19 Camera is located on the SE side of the MLP deck
400 FPS and views the SSME/OMS nozzles and Orbiter aft
16mm heat shield area.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: IGNITORS PRODUCE THIN CLOUDS OF WHITE SMOKE. POCKETS OF FREE HYDROGEN ARE IGNITED BY ROFI'S AND RISE TOWARD AFT HEAT SHIELD BEFORE SSME #3 STARTUP IS COMPLETE. RCS PAPER COVERS RUPTURE AT SSME IGNITION. ICE FALLS FROM T-0 UMBILICAL CON-

TINUOUSLY AFTER SSME START, BUT DISCONNECTION FROM ORBITER IS NORMAL. NO DAMAGED TILES ON AFT HEAT SHIELD WERE VISIBLE AS VEHICLE BEGINS ASCENT.

E-20 Camera is located on the SW side of the MLP deck
400 FPS and views the SSME/OMS nozzles and Orbiter aft
16mm heat shield area.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: RCS STINGER COVER PAPER RUPTURES AND TEARS OFF AT SSME IGNITION. SOUTHWEST IGNITER RUNS THROUGH LIFTOFF. GAS JET COMES FROM SSME #1 AT START UP. MANY PARTICLES OF ICE FALL FROM SSME NOZZLES. A ONE INCH SIZE PARTICLE FALLS FROM AFT HEAT SHIELD AREA. A REFLECTION OF SRB PLUME OCCURS AT 8 O'CLOCK POSITION ON SSME #2 ENGINE MOUNTED HEAT SHIELD (THIS PHENOMENON HAS BEEN NOTED ON PREVIOUS MISSIONS). ICE FALLS FROM LOX TSM T-0 UMBILICAL DURING RETRACTION. TWO ADDITIONAL PIECES OF ICE FALL FROM SSME WHEN VEHICLE HAS REACHED AN ALTITUDE OF APPROXIMATELY 35 FEET. PUFFS OF GASEOUS HYDROGEN AND OXYGEN APPEAR WHEN T-0 UMBILICAL CARRIER PLATES DISCONNECT.

E-21 Camera is located inside the LO2 TSM and views
200 FPS the disconnection of the T-0 umbilical.
16mm
Focus : OK
F. O. V.: OK
Exposure: OVEREXPOSED

Comments: NUMEROUS PIECES OF SMALL DEBRIS MOVE THROUGH FRAME. SEPARATION OF T-0 UMBILICAL AND DOOR CLOSURE IS NOMINAL. ICE HAS FORMED ON T-0 UMBILICAL. RIGHT HAND DISPLACEMENT TARGET IS LOOSE. END OF CABLE IS ALSO LOOSE DURING DOOR CLOSURE.

E-22 Camera is located inside the LH2 TSM and views
200 FPS the disconnection of the T-0 umbilical.
16mm
Focus : OK
F. O. V.: OK
Exposure: OK

Comments: PLASTIC PURGE ENCLOSURE COMES LOOSE AT MAIN ENGINE START. ICE HAS FORMED ON T-0 UMBILICAL. SEPARATION OF T-0 UMBILICAL AND DOOR CLOSURE ARE NOMINAL.

E-23 Camera is located on the MLP deck and views the
400 FPS RH OMS engine nozzle.
16mm
Focus : OK
F. O. V.: OK
Exposure: OK

Comments: SPARKS FROM IGNITER IMPACT OMS NOZZLE, RCS STINGER AND TSM AFTER MAIN ENGINE START UP. ICE FALLS FROM T-0 UMBILICAL. RCS PAPER COVERS RUPTURE. NUMEROUS PIECES OF DEBRIS APPEAR AROUND NOZZLE. TEN SMALL DAMAGE AREAS OCCUR ON TILE AROUND OMS NOZZLE: TWO ON BASE HEAT SHIELD AT NINE O'CLOCK TO THE OMS NOZZLE, ONE ON BHS AT SEVEN O'CLOCK TO OMS NOZZLE, FOUR ON BHS AT FOUR O'CLOCK FROM SSME #1, ONE ON BHS AT ONE O'CLOCK FROM SSME #2, ONE ON INBOARD CORNER OF STINGER SHIELD TOWARD SSME #2, ONE ON CORNER OF STINGER SHIELD NEAR OMS NOZZLE.

E-24 Camera is located on the MLP deck and views the
400 FPS LH OMS engine nozzle.
16mm
Focus : OK
F. O. V.: SHOULD BE LOWER
Exposure: UNDEREXPOSED

Comments: SPARKS FROM IGNITER IMPACT OMS NOZZLE. RCS PAPER COVERS RUPTURE. NUMEROUS DEBRIS PARTICLES APPEAR AFTER SSME START. VIBRATION FROM SSME IGNITION CAUSES WEDGE-SHAPED (5"x3"x1.5"BY 1"THICK) PIECE OF TILE TO BREAK OFF OF TILE-COVERED OMS POD LIFTING BRACKET. THIS TILE WAS LOCATED AT THE 4 O'CLOCK POSITION TO THE OMS NOZZLE ON THE AFT HEAT SHIELD. ENGINE VIBRATION ALSO CAUSES A SMALL CHIP TO BREAK FROM ANOTHER TILE ON THE AFT HEAT SHIELD. ICE FROM LH2 UMBILICAL FALLS AFTER VEHICLE CLEARS FRAME. SMALL AREA OF DAMAGE ON BASE HEAT SHIELD TILE AT 12 O'CLOCK FROM SSME #2. NO ANOMALIES ON OMS NOZZLE.

E-25 Camera is located on the east side of the MLP and
400 FPS views between Orbiter and ET/SRB during liftoff.
16mm

Focus : OK
F. O. V.: OK, THOUGH RIGHT SIDE OF FRAME IS VIGNETTED
Exposure: OK

Comments: FOUR PIECES OF ICE FALL FROM LOX ET/ORB UMBILICAL SHORTLY AFTER SSME IGNITION. ELEVEN DEBRIS PARTICLES ARE EJECTED WESTWARD FROM THE RH SRB FLAME DUCT, OF WHICH FOUR PASS NEAR THE ORBITER. TWO PIECES OF THERMAL CURTAIN TAPE COME LOOSE.

E-26 Camera is located on the west side of the MLP and
400 FPS views between Orbiter and ET/SRB during liftoff.
16mm

Focus : OK
F. O. V.: OK, THOUGH RIGHT SIDE OF FRAME IS VIGNETTED
Exposure: OK

Comments: ELEVON MOVEMENT OCCURS WITH ENGINE IGNITION. ICE FALLS FROM BOTH ET/ORB UMBILICALS. TWO PARTICLES ORIGINATE FROM SRB FLAME HOLE AND ARC TOWARDS THE LH2 TSM. EXHAUST PLUME REFLECTS OFF OF AFT HEAT SHIELD AT THE EIGHT O'CLOCK POSITION TO SSME #2. TWO PIECES OF THERMAL CURTAIN TAPE COME LOOSE AT IGNITION. SEVEN PIECES OF ICE FALL FROM THE GH2 VENT ARM. SOME OF THESE FALL BETWEEN THE SRB AND ET WHILE SOME FALL OUTBOARD OF SRB.

E-27 Camera is located on the MLP deck and views RH SRB
400 FPS northwest holddown post (HDP #3) blast cover.
16mm
Focus : OK
F. O. V.: OK
Exposure: OK

Comments: LOOSE THERMAL CURTAIN TAPE IS VISIBLE ON BOTH SRB'S. HDP 3 & 4 DOGHOUSE BLAST COVERS CLOSE NOMINALLY. A BAT OR SMALL BIRD IS DRAWN BY ASPIRATION INTO SRB FLAME DUCT JUST AFTER LIFT-OFF. MANY DEBRIS PARTICLES, PROBABLY THROAT PLUG MATERIAL, APPEAR IN THE WATER TROUGH AREA. TWO LARGE PIECES OF RTV FROM HDP #4 MOVE AT HIGH RATE OF SPEED IN A NORTHWEST DIRECTION.

E-28 Camera is located on MLP deck and views LH SRB
400 FPS northeast holddown post (HDP #7) blast cover.
16mm
Focus : OK
F. O. V.: OK
Exposure: OK

Comments: THREE PIECES OF THERMAL CURTAIN TAPE COME LOOSE AT IGNITION. HDP DOGHOUSE BLAST COVERS CLOSE NOMINALLY. LARGE AMOUNT OF DEBRIS PARTICLES, PROBABLY THROAT PLUG MATERIAL, EXITS THE SRB FLAME DUCT IN A NORTHERLY DIRECTION. GRAY SMOKE FOLLOWED BY NUMEROUS LUMINOUS PARTICLES IMPINGE ON THE AFT SKIRT HDP#8 FOOT AFTER APPROXIMATELY TWO FEET OF VEHICLE RISE. (SRB NOZZLE EXTENSION HAS DISCOLORED OR MOTTLED APPEARANCE).

E-30 Camera is located on the FSS 135 foot level and
400 FPS views LH SRB and sound suppression water troughs.
16mm

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: NUMEROUS SMALL, THIN PIECES OF DEBRIS TRAVEL IN ALL DIRECTIONS. WATER FROM FSS DELUGE FALLS NORTH TO SOUTH. FLAME/EXHAUST BACKFLOW RISES UP BETWEEN HOLD DOWN POST 7 AND 8 AND SRB NOZZLE EXTENSION AND IS DEFLECTED OUTWARD BY AFT SKIRT. FLAME IS FOLLOWED BY UNUSUAL GRAY SMOKE. THIS PHENOMENON IS NOT VISIBLE AT HOLDDOWN POST 5 AND 6. NUMEROUS WHITE PIECES OF DEBRIS FALL NEAR FSS.

E-31 Camera is located on the FSS 95 foot level and
100 FPS views the LH Orbiter wing, body flap, and
16mm ET/Orbiter LH2 umbilical area.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: ICE FALLS FROM LH2 UMBILICAL. ELEVONS MOVE SLIGHTLY WITH ENGINE IGNITION. TWO THERMAL CURTAIN TAPES LOOSE ON LH SRB. SMALL WHITE DEBRIS OBJECT, POSSIBLY ICE FROM GUCP, DROPS BELOW ELEVON.

E-33 Camera is located on the FSS 235 foot level and
400 FPS views the ET GH2 vent line and GUCP.
16mm
Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: ICE FROM GUCP BEGINS TO FALL WITH ENGINE START UP. ICE FALLS BETWEEN ET AND SRB. SOME ICE STAYS WITH GUCP AFTER SEPARATION. NOMINAL SEPARATION OF GUCP. GOOD VIEW OF TWANG.

E-34 Camera is located on FSS at 255 foot level and
400 FPS views upper Orbiter tile surfaces.
16mm
Focus : OK
F. O. V.: OK
Exposure: OK

Comments: FORWARD RCS PAPER COVERS ARE INTACT. ET BUTCHER PAPER STILL ATTACHED AS VEHICLE PASSES THROUGH FRAME. FACILITY DELUGE WATER PARTIALLY OBSCURES VIEW. WATER VAPOR FALLS FROM RH SRB STIFFENER RINGS. NO ORBITER TPS DAMAGE VISIBLE. THREE OBJECTS WHICH SEEM TO BE THIN SHEET METAL (MIGHT BE CABLE TRAY COVERS FROM FSS) WERE SEEN AT FRAME 3425 TO 3710. A DARK RIGID OBJECT APPEARED AT FRAME 3000.

E-35 Camera is located on the FSS 255 foot level and
400 FPS views the mid-Orbiter/ET/SRB area.
16mm
Focus : SOFT FOCUS
F. O. V.: OK
Exposure: OK

Comments: THERMAL CURTAIN TAPE COMES LOOSE ON LH SRB. ONE DEBRIS PARTICLE PASSES THROUGH FIELD OF VIEW NEAR CAMERA AT ABOUT T-0. FACILITY WATER DELUGE PARTIALLY OBSCURES VIEW. NO ORBITER TPS ANOMALIES. THREE OBJECTS APPEARED AT FRAME 3359 TO 3707. THESE OBJECTS SEEM TO BE THIN SHEET METAL (MIGHT BE CABLE TRAY COVERS FROM FSS). VEHICLE HAS ALREADY CLEARED THE TOWER AT THIS TIME.

E-36 Camera is located on the FSS 255 foot level and
400 FPS views lower Orbiter, ET, SRB's, and water trough.
16mm
Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: VIEW OBSCURED BY FACILITY WATER DELUGE. THERMAL CURTAIN TAPE COMES LOOSE ON LH SRB. FLASH OF FIRE VISIBLE ABOVE DELUGE WATER IN SSME FLAME DUCT AT SSME IGNITION. NO ORBITER TPS ANOMALIES VISIBLE. DEBRIS OBJECTS PREVIOUSLY OBSERVED IN E-34 AND E-35 ARE NOT RECORDED IN THIS FILM ITEM DUE TO THE DOWNWARD TILT OF THE CAMERA F.O.V.

E-39 Camera is located on the FSS 185 foot level and
400 FPS views GH2 vent line latchback.
16mm
Focus : OK
F. O. V.: OK
Exposure: OK

Comments: WATER DELUGE MOSTLY OBSCURES VIEW. GH2 VENT LINE IS PROPERLY CAPTURED AND LATCHED.

E-40
400 FPS
16mm

Camera is located on the FSS 255 foot level and views the ET ogive, SRB nosecone, and Orbiter tiled surfaces.

Focus : OK
F. O. V.: FIELD OF VIEW TOO WIDE. NEED MEDIUM ZOOM LENS
Exposure: UNDEREXPOSED

Comments: ET H2 FIRE DETECTION SYSTEM STILL IN PLACE AS VEHICLE PASSES THROUGH FRAME. FACILITY WATER DELUGE PARTIALLY OBSCURES VIEW. NO ORBITER ANOMALIES ARE VISIBLE. DEBRIS OBJECT VIEWED IN FRAME 3130 COMES FROM ABOVE AND BEHIND CAMERA. THIS OBJECT IS ALSO VISIBLE IN FILMS 34 AND 35. NUMEROUS FLAT, THIN DEBRIS OBJECTS OF VARIOUS SHAPES AND SIZES APPEAR IN THE FIELD OF VIEW TRAVELING IN ALL DIRECTIONS. SOME OF THIS DEBRIS SEEMS TO ORIGINATE FROM THE FSS 255 FOOT LEVEL OR ABOVE AND APPEARS TO BE NONMETALLIC.

E-41
400 FPS
16mm

Camera is located on the FSS 255 foot level and views the GH2 vent line during rotation. Also shows clearance between structure and SRB aft skirt.

Focus : SOFT FOCUS
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: GH2 VENT ARM RETRACTION APPEARS NOMINAL. TWO PIECES OF THERMAL CURTAIN TAPE COME LOOSE ON LH SRB. ONE PIECE OF BLACK FACILITY DEBRIS, CLOSE TO CAMERA, FALLS WHILE VEHICLE LEAVES FIELD OF VIEW. WHITE DEBRIS, POSSIBLY FIBER GLASS CLOTH FOUND ON CRAWLER WAY DURING POST-LAUNCH WALK DOWN, MOVES THROUGH FRAME. THREE LARGE METALLIC DEBRIS OBJECTS, TWO LARGE PIECES OF FOAM (NOT ET FOAM), AND NUMEROUS SMALL PIECES OF DEBRIS ENTER FIELD OF VIEW AFTER VEHICLE HAS CLEARED THE TOWER.

E-42
400 FPS
16mm

Camera is located on the FSS 185 foot level and views the GH2 vent line drop, deceleration, and latchback.

Focus : OBSCURED BY WATER
F. O. V.: TOO TIGHT
Exposure: UNDEREXPOSED

Comments: VIEW IS OBSCURED BY WATER. GH2 VENT ARM RELEASE AND LATCHBACK APPEAR NOMINAL. NUMEROUS FACILITY DEBRIS OBJECTS ENTER FIELD OF VIEW AFTER VEHICLE CLEARS THE TOWER.

E-43 Camera is located on pad surface and views sound
200 FPS suppression water flow distribution beneath MLP.
16mm
Focus : OK
F. O. V.: OK
Exposure: OK

Comments: NUMEROUS SMALL PIECES OF THROAT PLUG MATERIAL AND OTHER DEBRIS MOVE GENERALLY SOUTH THROUGH THE FLAME TRENCH AND AWAY FROM THE VEHICLE. WATER FLOW PATTERN IS EVENLY DISTRIBUTED.

E-44 Camera is located on the FSS 155 foot level and
400 FPS views the LH OMS pod leading edge tiles during
16mm ignition and liftoff.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: NO DAMAGE TO TILES ON LEADING EDGE OF OMS POD. ICE FALLS FROM LH2 T-0 UMBILICAL.

E-45 Camera is located on the FSS 185 foot level ET I/T
400 FPS access arm structure and views the outboard side &
16mm bottom of Orbiter Access Arm for flame impingement

Focus : OK
F. O. V.: OK
Exposure: BRIGHT AFTER IGNITION

Comments: SMOKE WITH NO FLAME IMPINGES ON THE ORBITER ACCESS ARM SURFACES. NO OAA ANOMALIES SEEN BEFORE VIEW IS OBSCURED BY WATER AND SMOKE.

E-46 Camera is located on the FSS 115 foot level and
200 FPS views the outboard side of the weather protection
16mm door during ignition and liftoff.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: ALTHOUGH VIEW IS QUICKLY OBSCURED BY SMOKE AND WATER, NO DAMAGE OR DEBRIS CONCERNS WERE VISIBLE ON WEATHER PROTECTION DOOR.

E-47
200 FPS
16mm

Camera is located on the FSS 115 foot level and views the valves/hydraulic lines on the interior side of the weather protection door.

Focus : SOFT
F. O. V.: OK
Exposure: OK

Comments: NO DAMAGE OR DEBRIS CONCERNS ON WEATHER PROTECTION DOOR.

E-48
400 FPS
16mm

Camera is located on the FSS 215 foot level (ET Intertank access arm structure) and views the GH2 vent line during GUCP disconnection, rotation,and latchback.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED, NO DETAIL OF GUCP IS VISIBLE

Comments: GUCP DISCONNECT IS NOT VISIBLE, BUT GH2 VENT LINE ROTATION IS NORMAL. GH2 VENT LINE AND ACCESS ARM STRUCTURE DO NOT CONTACT LEFT SRB. THREE PIECES OF THERMAL CURTAIN TAPE HAD COME LOOSE BEFORE AFT SKIRT ENTERS FRAME. WATER VAPOR FALLS FROM ET AFT DOME AREA.

E-50
400 FPS
16mm

Camera is located at camera site 1 at NE pad perimeter and views entire GH2 vent line and GUCP during rotation and latchback.

Focus : SOFT
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: WATER DELUGE SPRAY FALLS FROM INTERTANK ACCESS ARM STRUCTURE. DETAIL OF GUCP DISCONNECT IS NOT VISIBLE, BUT GH2 VENT LINE ROTATION AND LATCHBACK IS NOMINAL. ICE DROPS FROM GUCP WHEN CONTACT IS MADE WITH LATCH MECHANISM.

E-52
96 FPS
35mm

Camera is located at camera site 2 on the east pad perimeter. Remote tracking of lower one-third of launch vehicle from ignition to 1200 feet.

Focus : EXCELLENT
F. O. V.: O.K.
Exposure: O.K.

Comments: WATER VAPORIZES NEAR AFT DOME AND STIFFENER RINGS. ICE FALLS FROM BOTH ET/ORB UMBILICALS, MAIN ENGINE OVERBOARD VENTS AND ENGINE MOUNTED HEAT SHIELD. SHORTLY AFTER COMPLETION OF THE ROLL PROGRAM A PIECE OF FLIGHT HARDWARE DEBRIS, APPROXIMATELY 12" X 12" IN SIZE, PASSES OVER THE RH WING AND CONTINUES AFT WITHOUT IMPACTING THE ORBITER. THIS DEBRIS ORIGINATES FROM THE RH FWD ET/SRB ATTACH POINT AREA. VAPOR CONTRAILS COME OFF WINGTIPS AFTER TOWER CLEAR. FLASHES IN THE MAIN ENGINE PLUME OCCUR SOON AFTER TOWER CLEAR AND CONTINUE THROUGH MOST OF THE ASCENT. LARGEST/BRIGHTEST FLASHES ARE VISIBLE AT T+13 SECONDS. SUBSEQUENT ANALYSIS REVEALED THE FLASHES TO BE EXPANDING POCKETS OF UNBURNED HYDROGEN THAT ORIGINATED FROM SSME #1 AND ARE PROBABLY RELATED TO THE FAILURE OF THE MAIN COMBUSTION CHAMBER.

E-53
96 FPS
35mm

Camera is located at camera site 2 on the east pad perimeter. Remote tracking of middle one-third of launch vehicle from ignition to 1200 feet.

Focus : EXCELLENT
F. O. V.: O.K.
Exposure: O.K.

Comments: VAPOR VAPORIZES NEAR AFT DOME AND STIFFENER RINGS. ICE FALLS FROM BOTH ET/ORB UMBILICALS, MAIN ENGINE OVERBOARD VENTS, AND ENGINE MOUNTED HEAT SHIELD. FLASHES ARE VISIBLE IN SSME EXHAUST PLUME. VAPOR CONTRAILS COME OFF WINGTIPS AFTER TOWER CLEAR. THERMAL CURTAIN TAPE IS VISIBLE ON RH SRB AFTER LIFTOFF.

E-54
96 FPS
35mm

Camera is located at camera site 2 on the east pad perimeter. Remote tracking of upper one-third of launch vehicle from ignition to 1200 feet.

Focus : EXCELLENT
F. O. V.: OK
Exposure: OK

Comments: GOOD VIEW OF VEHICLE TWANG AT SSME IGNITION. ICE FALLS FROM ET/ORB AND T-0 UMBILICALS. WATER VAPOR IS PRESENT ON ET LH2 AFT DOME. ICE PARTICLES FALL FROM SSME'S. CONTRAILS FORM ON AFT EDGE OF ORBITER WING AS VEHICLE CLEARS TOWER. DEBRIS PARTICLE CLOSE TO CAMERA ENTERS AND LEAVES FIELD OF VIEW TWICE.

E-57
96 FPS
35mm

Camera is located at camera site 6 on the NW pad perimeter. Remote tracking coverage of lower one-third of vehicle from ignition to 1200 feet.

Focus : O.K.

F. O. V.: O.K.
Exposure: UNDEREXPOSED AT LAUNCH

Comments: ICE FALLS FROM LH2 CROSS COUNTRY LINE ON NORTH SIDE OF MLP AT T-0, MOVES UPWARD AND IN NORTHERLY DIRECTION. NO ANOMALIES SEEN ON THE LH ORB WING TILES THROUGH TOWER CLEAR. WATER FROM SRB STIFFENER RINGS AND CONDENSATE FROM ET LH2 AFT DOME VAPORIZE SHORTLY AFTER LAUNCH. ICE PARTICLES FALL FROM ET/ORB AND T-0 UMBILICAL AREAS.

E-58
96 FPS
35mm

Camera is located at camera site 6 on the NW pad perimeter. Remote tracking coverage of center one-third of vehicle from ignition to 1200 feet.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: WATER FROM SRB STIFFENER RINGS AND ET AFT DOME VAPORIZES SOON AFTER LAUNCH. SOME ICE PARTICLES FALL FROM ET/ORB UMBILICALS. NO TILE ANOMALIES ARE OBSERVED ON ORBITER LH WING THROUGH TOWER CLEAR.

E-59
96 FPS
35mm

Camera is located at camera site 6 on the NW pad perimeter. Remote tracking coverage of upper one-third of vehicle from ignition to 1200 feet.

Focus : EXCELLENT
F. O. V.: OK
Exposure: OK

Comments: WATER FROM SRB STIFFENER RINGS AND ET LH2 AFT DOME VAPORIZES AT LIFTOFF. ICE/DEBRIS PARTICLES FALL FROM UMBILICALS AS VEHICLE CLEARS TOWER. NO ANOMALIES NOTED. VIEW IS PARTIALLY OBSCURED BY SUN.

E-60
96 FPS
35mm

Camera is located on north pad perimeter at camera site 1 and views the entire launch vehicle, FSS, and MLP zero level.

Focus : EXCELLENT
F. O. V.: OK
Exposure: OK

Comments: FLAME APPEARS UNDER MLP AT SSME IGNITION. GH2 VENT ARM RETRACTION AND LATCHBACK IS NOMINAL. LOOSE THERMAL CURTAIN TAPE ON RH SRB. SRB ASPIRATION DRAWS SRB EXHAUST SMOKE BACK TOWARDS VEHICLE. WATER/VAPOR FALLS FROM SRB AFT SKIRTS.

DEBRIS EXITS EXHAUST SMOKE AFTER VEHICLE CLEARS TOWER. MULTIPLE SHOCK WAVE REFLECTIONS AGAINST EXHAUST SMOKE ARE VISIBLE AS VEHICLE BEGINS ASCENT FROM MLP.

E-61
96 FPS
35mm

Camera is located at camera site 2 on the east pad perimeter and views the launch vehicle, FSS, and MLP.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: FLAME APPEARS UNDER MLP AT SSME IGNITION. LOOSE THERMAL CURTAIN TAPE ON RH SRB. SRB ASPIRATION DRAWS EXHAUST SMOKE BACK TOWARDS VEHICLE.WATER VAPOR FALLS FROM SRB AFT SKIRT.

E-62
96 FPS
35mm

Camera is located on the SE pad perimeter at camera site 3 and views entire vehicle, FSS, and MLP.

Focus : EXCELLENT
F. O. V.: OK
Exposure: OK

Comments: DEBRIS IN LOWER STRUCTURE/MLP RISES INTO SRB PLUME. WATER VAPOR PRONOUNCED ON SRB STIFFENER RINGS. PAD AND MLP DEBRIS MOVES IN ALL DIRECTIONS AS VEHICLE CLEARS TOWER.

E-63
96 FPS
35mm

Camera is located on SW side of pad perimeter at camera site 4 and views entire launch vehicle,FSS, and MLP.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: LOOSE THERMAL CURTAIN TAPE ON BOTH SRB'S. WATER FROM STIFFENER RINGS VAPORIZES SOON AFTER LAUNCH. SEVERAL MEDIUM SIZED DEBRIS OBJECTS FROM FACILITY/MLP TRAVEL IN SOUTHERN DIRECTION. EMERGENCY EGRESS BASKETS DID NOT RELEASE DURING THE TIME PERIOD FROM T-0 UNTIL TOWER CLEAR. SHORTLY AFTER THE VEHICLE CLEARED THE TOWER, SMOKE OBSCURED THE FSS 195 FOOT LEVEL AND PREVENTED AN EXACT DETERMINATION OF BASKET RELEASE.

E-64
96 FPS
35mm

Camera is located on NW pad perimeter at camera site 6 and views entire launch vehicle, FSS, and MLP.

Focus : SOFT
F. O. V.: OK
Exposure: OK

Comments: FACILITY WATER DELUGE SPRAYS AND ENVELOPES GH2 VENT ARM. WATER FROM STIFFENER RINGS VAPORIZES AFTER LIFTOFF. SLIDE WIRE BASKETS HAVE NOT RELEASED IN THIS FILM. SEVERAL PIECES OF DEBRIS EXIT EXHAUST PLUME AFTER VEHICLE CLEARS TOWER.

E-65
100 FPS
16mm

Camera is located on east pad perimeter at camera site 2 and views ET LO2 feedline, ET intertank, and RH SRB as vehicle passes through the frame.

Focus : OK
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: NO FEEDLINE ANOMALIES OCCUR DURING VEHICLE TWANG. ICE DROPS FROM ET/ORB UMBILICALS AS VEHICLE PASSES THROUGH FRAME. A FACILITY ELECTRICAL CABLE IS VISIBLE AFTER THE VEHICLE HAS CLEARED THE TOWER.

E-76
400 FPS
35mm

Camera is located on SE pad perimeter at camera site 3 and views SSME engines #1 and #3 and the RH OMS engine nozzle.

Focus : OK
F. O. V.: OK
Exposure: OK

Comments: NO VISIBLE EXHAUST FROM APU'S. CLEAN LH SRB NOZZLE, EXCEPT FOR FIVE LOOSE PIECES OF THERMAL CURTAIN TAPE. ICE FALLS FROM LO2 T-0 UMBILICAL, BUT RETRACTION IS NORMAL. SEVERAL PIECES OF DEBRIS TRAVEL IN VARIOUS DIRECTIONS DURING VEHICLE ASCENT.

E-77
96 FPS
35mm

Camera is located on SW pad perimeter at camera site 4 and views SSME engines #1 and #2 and the LH OMS engine nozzle.

Focus : OK
F. O. V.: TOO HIGH (BOTTOM OF MLP SHOULD BE SEEN)
Exposure: OK

Comments: THREE PIECES OF THERMAL CURTAIN TAPE COME LOOSE ON RH SRB AT IGNITION. SEVERAL DEBRIS OBJECTS TRAVEL UPWARD AND A LARGE PIECE OF DEBRIS MOVING DOWNWARD APPEAR OUT OF THE EXHAUST SMOKE AFTER THE VEHICLE CLEARS THE TOWER.

E-78 Camera is located on SE pad perimeter at camera
400 FPS site 3 and views RH OMS Pod leading edge.
16mm
Focus : SOFTFOCUS
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: NO VISIBLE EXHAUST FROM APU'S. FOUR PIECES OF LOOSE THERMAL CURTAIN TAPE COME LOOSE AT IGNITION. NO VISIBLE DAMAGE TO RH OMS POD LEADING EDGE. TWO SMALL PIECES OF INSTAFOAM FALL FROM LH SRB. TWO PIECES OF DEBRIS, POSSIBLY ICE/FROST, DROP FROM THE SSME #3 NOZZLE.

E-79 Camera is located on east pad perimeter at
100 FPS camera site 2 and views the ET nosecone, louver,
16mm and ogive.

Focus : SOFTFOCUS
F. O. V.: OK
Exposure: UNDEREXPOSED PRIOR TO IGNITION

Comments: FROST HAS FORMED ALONG THE LOWER EDGE (STAT 371) OF +Y VENT LOUVER. TWANG IS APPROXIMATELY 34 INCHES.

E-201 UCS-10 IFLOT tracking of entire launch vehicle
30 FPS from ignition and early flight through LOV.
70mm
Focus : OK
F. O. V.: OK, BUT COULD USE LONGER LENS
Exposure: OK, SLIGHTLY INFLUENCED BY SUN ANGLE

Comments: FLASHES IN SSME EXHAUST PLUME OCCUR EARLY IN FLIGHT. OVERCAST CONDITIONS OBSCURE SOME PORTIONS OF ASCENT. DEBRIS STRIKES ORBITER WING AT APPROX T+52 SECONDS. ACTUAL PIECE OF DEBRIS IS NOT DISCERNIBLE, BUT IMPACT AND RESULTING SHOWER OF PARTICLES IS VISIBLE FOR 5 FRAMES. LOCATION OF IMPACT APPEARS TO BE OUTBOARD OF MAIN LANDING GEAR DOOR AND FORWARD OF THE ELEVON HINGE LINE.

E-202 UCS-15 IFLOT tracking of entire launch vehicle
30 FPS from ignition and early flight through LOV.
70mm
Focus : OK
F. O. V.: OK
Exposure: OK

Comments: THE BRIGHT SPOT ON THE ET OGIVE IS REFLECTION OF THE SUN ON THE PRESSURIZATION LINE. FLASHES IN THE MAIN ENGINE PLUME OCCUR SOON AFTER TOWER CLEAR AND CONTINUE THROUGH MOST OF THE ASCENT. LARGEST/BRIGHTEST FLASHES ARE VISIBLE AT T+13 SECONDS. SUBSEQUENT ANALYSIS REVEALED THE FLASHES TO BE EXPANDING POCKETS OF UNBURNED HYDROGEN THAT ORIGINATED FROM SSME #1 AND ARE PROBABLY RELATED TO THE FAILURE OF THE MAIN COMBUSTION CHAMBER. NUMEROUS PARTICLES OF ICE FALL FROM THE ET/ORB UMBILICALS AND SSME NOZZLES. AERODYNAMIC SHOCK WAVES FORM AT T+56 SECONDS. SRB SEPARATION IS NOMINAL.

E-203
30 FPS
70mm
Focus : OK
F. O. V.: OK
Exposure: OK

UCS-6 IFLOT tracking of SRB and SRB exhaust plume from first acquisition to LOV. Exposed for flame.

Comments: THERMAL CURTAINS ON BOTH SRB'S ARE INTACT AND NO DIVOTS ARE VISIBLE IN THE INSTAFOAM UNDER THE AFT SKIRT AND STIFFENER RINGS. HOWEVER, INSTAFOAM AROUND HDP #8 AFT SKIRT FOOT IS CHARRED. PARTICLES FALLING FROM THE VEHICLE EARLY IN FLIGHT ARE PROBABLY PIECES OF ICE FROM THE ET/ORB UMBILICALS AND SSME NOZZLES. AERODYNAMIC SHOCK WAVES OCCUR AT T+56 SECONDS.

E-204
48 FPS
35mm

PAFB IGOR tracking of entire launch vehicle from acquisition to LOV. Tracks ET/ORB during and after SRB separation.

Focus : SOFT
F. O. V.: OK
Exposure: OK

Comments: DETAILED VIEW OF RECIRCULATION EFFECT AND ET AFT DOME CHARRING. NO LEAK FROM LH2 UMBILICAL IS VISIBLE.

E-205
30 FPS
70mm

MIGOR Shiloh site tracking of entire launch vehicle from acquisition to LOV. Tracks ET/ORB during and after SRB separation.

Focus : SOFT - MOSTLY ATMOSPHERIC EFFECTS
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: IN SPITE OF SOME ATMOSPHERIC EFFECTS, THIS SITE IS AN IMPROVEMENT OVER THE OLD PONCE INLET SITE. NO DEBRIS OR FLIGHT HARDWARE IS OBSERVED FALLING FROM VEHICLE. SSME AND SRB EXHAUST PLUMES APPEAR NORMAL BUT OBSCURE BOOSTER SEPARATION. BOTH SRB's EXHIBIT SLIGHT DARKENING OF AFT BOOSTER SEGMENTS.

E-206
40 FPS
70mm

Melbourne Beach ROTI tracking of entire launch vehicle from acquisition to SRB separation. At separation, camera tracks south SRB to LOV.

Focus : SOFT - ATMOSPHERIC EFFECTS
F. O. V.: OK
Exposure: OK

Comments: SRB SEPARATION IS NOMINAL THOUGH SMOKE FROM BSM'S ENGULFS/OBSCURES ORBITER. CHARRED NCFI ON AFT DOME AND OGIVE SCAR ARE VISIBLE ON EXTERNAL TANK. NUMEROUS PIECES OF BURNING SOLID PROPELLANT FALL OUT OF SRB PLUMES AFTER SEPARATION AND TAILOFF.

E-207
40 FPS
70mm

UCS-10 MIGOR tracking of entire launch vehicle from acquisition to SRB separation. At separation, camera will track north SRB to LOV.

Focus : OK
F. O. V.: OK
Exposure: SLIGHTLY UNDEREXPOSED

Comments: STRONG REFLECTION OF SUNLIGHT OFF OF ORBITER UNDER-SIDE. WEAKER REFLECTIONS FROM SRB EXHAUST PLUME OCCUR ON UNDER-SIDE OF OMS POD AND SRB IEA. GOOD VIEW OF SRB TAILOFF AND BSM FIRING. SRB SEPARATION IS SOMEWHAT OBSCURED BY EXHAUST PLUMES. BOTH SEPARATED SRB's EXHIBIT SLIGHTLY DARKENED AFT BOOSTER SEGMENTS. A FEW PIECES OF BURNING SOLID PROPELLANT EXIT LEFT SRB AND ARE VISIBLE AS BRIGHT PINPOINTS OF LIGHT. OVERCAST CONDITIONS PREVENTED CONTINUED TRACKING OF SEPARATED BOOSTERS.

E-209
30 FPS
70mm

UCS-13 IFLOT intermediate tracking of entire launch vehicle from acquisition to LOV.

Focus : OK, BUT OVERALL IMAGE IS GRAINY
F. O. V.: OK
Exposure: VEHICLE ITSELF IS SLIGHTLY UNDEREXPOSED

Comments: IMAGE IS TOO SMALL TO DETECT ANY DEBRIS OR TILE DAMAGE CONCERNS. VEHICLE IS OBSCURED FROM TIME TO TIME BY CLOUDS. GLOW FROM PROPULSION PLUMES ILLUMINATES ET AFT DOME, SRB AFT BOOSTERS

AND IEA'S, AND UNDERSIDE OF ET/ORB UMBILICALS. TRAJECTORY OR VEHICLE CAUSES SRB PLUME TO OBSCURE SEPARATION, BUT SEPARATED BOOSTERS APPEAR LATER.

E-210 UCS-26 IFLOT intermediate tracking of entire launch vehicle from acquisition to LOV.
30 FPS
70mm
Focus : OK
F. O. V.: BORESIGHT NOT CORRECT - LATE ACQUISITION
Exposure: OK

Comments: RESOLUTION IMPROVES WITH ALTITUDE. NO ANOMALIES NOTED.

E-214 UCS-15 IFLOT close-in tracking of entire launch vehicle during ignition, liftoff, and early portion of flight through LOV.
32 FPS
16mm

Focus : SOFT FOCUS
F. O. V.: OK
Exposure: SLIGHTLY UNDEREXPOSED

Comments: WATER SPILLS FROM STIFFENER RINGS EARLY IN FLIGHT AND VAPORIZES. SIXTEEN PLUS BRIGHT FLASHES OCCUR IN SSME PLUME, POSSIBLY DUE TO HYDROGEN RICH MIXTURE. INTERACTION BETWEEN SSME AND SRB PLUMES IN THE FORM OF TURBULENT BOUNDARY LAYERS IS VISIBLE.

E-215 UCS-10 IFLOT close-in tracking of entire launch vehicle during ignition, liftoff, and early portion of flight through LOV.
32 FPS
16mm

Focus : SOFT
F. O. V.: OK
Exposure: UNDEREXPOSED

Comments: SUN GLARE PROHIBITS FINE DETAIL FROM BEING DISCERNIBLE.

E-216 UCS-6 IFLOT tracking of base of SRB exhaust plume from first acquisition to LOV. Exposed for flame.
48 FPS
70mm
Focus : OK
F. O. V.: OK
Exposure: OK

Comments: NO PLUME ANOMALIES.

E-217 IFLOT Beach Site tracking of Orbiter from liftoff
30 FPS through early flight.
70mm
Focus :
F. O. V.:
Exposure:

Comments: CAMERA FAILURE - NO FILM PRODUCT

VIDEO ITEMS

OTV 134 Views MLP side 1 (south) LH2 skid.
B/W

Comments: CAMERA WAS POINTED TOWARD PAD GATE AND VIEW WAS OF CRAWLERWAY. NO USEFUL LAUNCH DATA.

OTV 135 Views base of the FSS.
B/W

Comments: CAMERA WAS POINTED SOUTH AND VIEW WAS OF FIRE/RESCUE PERSONNEL ON CRAWLERWAY. NO USEFUL LAUNCH DATA.

OTV 141 Views and tracks vehicle from camera site 2.
B/W

Comments: PROVIDES TRACKING VIEW OF AFT END OF VEHICLE. NO ANOMALIES SEEN.

OTV 143 Views east side of launch vehicle and pad from
B/W camera site 2.

Comments: SSME FLAME/EXHAUST IS NOT AS VISIBLE AS SEEN ON COLOR ITEMS FROM THIS SITE.

OTV 111 Views GUCP and GH2 vent line with new Insight IR
B/W IR camera.

Comments: CAMERA WAS POINTED AT GH2 VENT HAUNCH AREA. CAMERA WAS OVERDRIVEN AND PROVIDED NO USEFUL DATA.

OTV 119 Views LH2 umbilical with new Insight IR camera.
B/W IR

Comments: CAMERA WAS POINTED AT NORTHEAST CORNER MLP 0 LEVEL. CAMERA IS OVERDRIVEN AND YIELDS NO USEFUL DATA.

OTV 130 Views SSMEs and Orbiter aft end from SE pad apron
B/W IR with new Insight IR camera.

Comments: CAMERA WAS POINTED AT THE OPEN RSS PCR AT LAUNCH. DOES NOT PROVIDE ANY USEFUL LAUNCH DATA.

OTV 148 Launch and tracking view from camera site 6.
B/W

Comments: -Z SIDE OF VEHICLE SHOWED NO ANOMALIES UNTIL OBSCURED BY SRB PLUME.

OTV 149 Views LO2 T-0 umbilical.
B/W

Comments: ICE FALLS FROM T-0 UMBILICAL AT ENGINE START-UP. T-0 RETRACTION IS NORMAL. ICE PARTICLE FALLS AFTER T-0 RETRACTION AND VEHICLE RISE IS STARTED.

OTV 172 Views SSMEs with new Insight IR camera from SW
B/W IR corner of MLP deck.

Comments: CAMERA WAS POINTED AT HINGELINE BETWEEN RSS AND FSS. CAMERA IS OVERDRIVEN AND NO USEFUL LAUNCH DATA WAS PROVIDED.

OTV 160 Views ET nosecone and NE louver from water tower.
Color M-II

Comments: NO ANOMALIES OF NOSECONE OR LOUVER. HYDROGEN VENT ARM IS LATCHED.

OTV 161 Views ET nosecone and SW louver from the FSS.
Color M-II

Comments: LIGHT FROST ON LOUVERS. TUMBLE VALVE COVER IS NOT PROTRUDING. NO DEBRIS OBSERVED WHILE VEHICLE IS IN VIEW.

OTV 163 Views ET/Orbiter umbilical and Orbiter T-0
Color M-II umbilical from the FSS.

Comments: ONE PIECE OF DEBRIS FROM LEFT SIDE OF SCREEN TRAVELS BEHIND LH SRB. UMBILICAL ICE FALLS DURING SSME START. DARK CLOUD OF SMOKE FROM BACKFLOW OF LH SRB EXHAUST PLUME RISES OUT OF EXHAUST DUCT.

OTV 170 Views entire launch vehicle from SE direction.
Color M-II

Comments: ICE FALLS FROM LO2 TSM AT T-0. FOUR PIECES OF THERMAL CURTAIN TAPE LOOSE ON LH SRB. WHITE DEBRIS FALLS THROUGH FIELD OF VIEW THAT LOOKS SIMILAR TO FACILITY WEATHER PROTECTION BAG RECOVERED BY POST LAUNCH TEAM. WHITE, FLAT PIECE OF DEBRIS, SQUARE WITH THIN EDGE, FALLS THRU FRAME. ADDITIONAL DEBRIS PASSES THROUGH FRAME IN ALL DIRECTIONS AFTER VEHICLE CLEARS FRAME.

OTV 171 Views overall vehicle from SW direction.
Color M-II

Comments: WATER FALLS ON HAUNCH PRIOR TO T-0. GH2 VENT ARM DISCONNECTS FROM ET AND LATCHES PROPERLY WITH NO REBOUND. AS VEHICLE CLEARS FRAME, DEBRIS TRAVELS OUTWARD FROM PAD SURFACE AND IS OBSCURED BY EXHAUST PLUME. DEBRIS (LARGE AND SMALL PIECE) PASS THROUGH FRAME.

TV-1
Color M-II Views launch from SLF.

Comments: NO ANOMALIES NOTED. PLUME IS SHAPED BY WINDS ALOFT.

TV-2 Views entire launch vehicle from camera site 7
Color M-II east of Pad B.

Comments: SRB EXHAUST PLUME IS INFLUENCED BY WINDS ALOFT. SRB SEPARATION IS VISIBLE.

TV-3 Views entire launch vehicle from camera site 9.
Color M-II

Comments: INITIAL VIEW IS PARTIALLY OBSCURED BY CLOUD. CAMERA MOTION MAKES VIEWING DIFFICULT. SRB SEPARATION IS VISIBLE.

TV-4 Views entire vehicle from IFLOT Beach Site.
Color M-II

Comments: SRB STIFFENER RINGS SHED WATER VAPOR. FLASHES OCCUR IN SSME PLUME. SRB SEPARATION IS VISIBLE.

TV-5 Views launch from VAB roof.
Color M-II

Comments: NO ANOMALIES OBSERVED WHILE VEHICLE IS TRACKED THROUGH LOSS OF VIEW. SRB SEPARATION IS VISIBLE.

TV-6 Views entire launch vehicle from DLTR-3 site
Color M-II directly south of Pad B.

Comments: VEHICLE MOMENTARILY OBSCURED FROM VIEW BY EXHAUST PLUME. GOOD VIEW OF ROLL MANEUVER. FLASHES OCCUR IN SSME PLUME.

TV-7 Views entire launch vehicle from camera site 2
Color M-II east of pad.

Comments: HYDROGEN FLAME IS VERY PRONOUNCED UNDER MLP AT SSME IGNITION.

TV-13 Views launch from Patrick IGOR.
Color M-II

Comments: TRACKING LOCK NOT ACHIEVED DURING EARLY STAGE OF FLIGHT. IMAGE IS GENERALLY SOFT-FOCUSED. RECIRCULATION PHENOMENA AND SRB SEPARATION ARE CLEARLY VISIBLE.

TV-16 View from helicopter orbiting west of pad and VAB.
Color M-II

Comments: NO ANOMALIES NOTED.

TV-18 Views launch and tracks from Malabar ITEC.
Color M-II

Comments: INTERMITTENT TRACKING UNTIL LATE IN FLIGHT. IMAGE IS SOFT-FOCUSED AND HAZY. NO ANOMALIES NOTED DURING SRB SEPARATION, GOOD VIEW OF ET AFTER SEPARATION.

OTV-109 Views ET/Orbiter LH2 umbilical area from the 95
B/W M-II foot level of the FSS.

Comments: HPU EXHAUST DRIFTS ACROSS LOWER FIELD OF VIEW. CONTROL SURFACES MOVE DURING SSME IGNITION.

OTV 150 Views Orbiter LH2 T-0 umbilical from SW MLP deck.
B/W M-II

Comments: ICE FALLS FROM LH2 T-0 UMBILICAL. T-0 RETRACTION IS NORMAL. FIVE PIECES OF ICE FALL PRIOR TO T-0, ANOTHER PARTICLE FALLS AFTER T-0.

OTV 151 Views main engine cluster.
B/W M-II

Comments: SSME IGNITION IS NOMINAL. ICE PARTICLES FALL AT ENGINE STARTUP NEAR LO2 TSM.

OTV 154 Views ET/Orbiter LO2 umbilical and Orbiter RH wing
B/W M-II

Comments: ICE PARTICLES FALL FROM ET/ORB LOX AND LH2 UMBILICALS. PUFF OF VAPOR FROM VERTICAL STRUT DRAIN HOLE. ELEVON MOVES AT ENGINE STARTUP.

OTV 155 Views RH SRB and underside of Orbiter RH wing.
B/W M-II

Comments: ICE DROPS FROM LOX UMBILICAL. NO SRB ANOMALIES VISIBLE.

OTV 156 Views LH SRB and underside of Orbiter LH wing.
B/W M-II

Comments: ICE DROPS FROM LH2 ET/ORB UMBILICAL. FLAME/EXHAUST BACKFLOW IMPINGES ON UNDERSIDE OF LH SRB AFT SKIRT.

OTV 149 Views Orbiter LO2 T-0 umbilical from MLP deck.
B/W M-II

Comments: ICE FALLS FROM T-0 UMBILICAL AT IGNITION.

OTV 101
B/W M-II

Views aft end of Orbiter from the FSS 255 foot level.

Comments: DELUGE WATER FROM INTERTANK ACCESS ARM STRUCTURE PASSES ACROSS ORBITER WING. SSME PLUME IS CONFINED TO EXHAUST HOLE OF MLP. LH2 T-0 RETRACTION IS NORMAL.

OTV 103
B/W M-II

Views GUCP and GH2 vent line.

Comments: ICE PARTICLES FALL FROM CARRIER PLATE PRIOR TO DISCONNECT. DISCONNECT AND FALLAWAY IS NORMAL.

STI
B/W M-II

Infrared view is from camera site 2.

Comments: TEMPERATURE SCALE IS 43 TO 403 DEGREES F. HOT GASES RISE TOWARD AFT HEAT SHIELD AT SSME IGNITION. AFTER ENGINE START-UP AND PLUME IS DEFINED, THERMAL REFLECTION IS VISIBLE ON RUDDER AND VERTICAL STABILIZER. JUST BEFORE T-0, RIGHT HAND OMS NOZZLE IS HEATING UP. AT LIFT-OFF, HEATED AFT HEAT SHIELD IS VISIBLE. RUDDER HAS PICKED UP MORE HEAT BY TOWER CLEAR AND SHOWS A DEFINITE HEAT PATTERN. AFT HEAT SHIELD IS IN EXCESS OF 400 DEGREES AND MAIN ENGINE NOZZLE IS COOL. ET AFT DOME SHOWS INFRARED REFLECTION. VEHICLE TRACKING IS LOST SOON AFTER TOWER CLEAR.

STI
B/W M-II

Infrared view is from RSS roof.

Comments: TEMPERATURE RANGE IS 2 TO 361 DEGREES F. HOT GASES RISE TOWARD AFT HEAT SHIELD. AS EXHAUST PLUMES DEVELOP, ENGINE BELLS REMAIN COOL. VEHICLE TRACKING AFTER LAUNCH WAS NOT POSSIBLE.

ET-204
B/W
U-Matic

PIGOR video tracks launch vehicle from acquisition to LOV and continues to track ORB/ET after SRB separation.

Comments: VEHICLE IS OBSCURED MOST OF THE TIME BY CLOUDS, BUT THE VIEW OF SRB TAILOFF AND SEPARATION IS GOOD. AFT BOOSTERS ARE SLIGHTLY DARKENED COMPARED TO REST OF SRB.

ET-205
B/W
U-Matic

MIGOR at Apollo Beach video tracks launch vehicle from acquisition to LOV and continues to track ORB/ET after SRB separation.

Comments: GOOD IMAGERY OF SRB PLUMES. DEBRIS IMPACT ON RIGHT WING IS NOT VISIBLE BECAUSE VEHICLE PASSES BEHIND CLOUD. EXHAUST PLUME OBSCURES SRB SEPARATION, BUT SEPARATED BOOSTERS BECOME VISIBLE LATER.

ET-206
B/W
U-Matic

ROTI Melbourne Beach video tracks launch vehicle from acquisition to SRB separation, then continues to track south SRB to LOV.

Comments: CLOUDS OBSCURE MUCH OF THE VEHICLE DURING ASCENT - TRACKING PROBLEMS ALSO CONTRIBUTE TO LOSS OF IMAGERY. A FLASH OCCURS AT T+52.5 SECONDS AND APPEARS TO BE INDEPENDENT OF THE SSME AND SRB EXHAUST PLUMES. THIS FLASH MAY COINCIDE WITH THE STREAM OF PARTICLES CAUSED BY A DEBRIS IMPACT TO THE RIGHT WING AT T+52.2 SECONDS (RECORDED IN ITEM ET-207). RECIRCULATION EFFECT OCCURS T+90 TO T+112 SECONDS. EXCELLENT VIEW OF SRB SEPARATION. AFT DOME CHARRING AND OGIVE SEP SCAR ARE ALSO VISIBLE. AFTER SRB SEPARATION, CHUNKS OF BURNING PROPELLANT DROP OUT OF BOOSTER EXHAUST. SOME DISCOLORATION OF THE AFT BOOSTER SEGMENTS IS EVIDENT.

ET-207
B/W
U-Matic

MIGOR at UCS-10 video tracks launch vehicle from acquisition to SRB separation, then continues to track north SRB to LOV.

Comments: WATER VAPOR IS VISIBLE ON ET AFT DOME AND NEAR SRB STIFFENER RINGS. PROPULSION EXHAUST ILLUMINATES ET AFT DOME, SRB IEA'S, AND UNDERSIDE OF OMS PODS. A PIECE OF DEBRIS, UNKNOWN IN ORIGIN OR TYPE, IMPACTS ORBITER RIGHT WING AT T+52.2 SECONDS. IMPACT LOCATION ON WING AND STREAM OF PARTICLES INTO AIRFLOW IS DISCERNIBLE. FLASHES IN THE SSME EXHAUST PLUME, REFLECTIONS OFF THE ORBITER TILES, AND AERODYNAMIC SHOCK WAVES OCCUR IN THIS SAME GENERAL TIME FRAME, BUT ARE CLEARLY NOT ASSOCIATED WITH THE DEBRIS IMPACT. GOOD VIEW OF SRB TAILOFF AND SEPARATION.

ET-208
B/W
U-Matic

ROTI at Cocoa Beach video tracks launch vehicle from acquisition to LOV.

Comments: TRACKING OF VEHICLE OCCURS LATE IN FLIGHT. RECIRCULATION EFFECT IS VISIBLE FROM T+92 TO T+115 SECONDS. SRB SEPARATION IS PARTIALLY OBSCURED BY CLOUDS.

10.0 SRB POST FLIGHT/RETRIEVAL DEBRIS ASSESSMENT

Both Solid Rocket Boosters and frustums were inspected for debris damage and sources at CCAFS Hangar AF on 10/2/88 from 0800 to 1230 hours.

10.1 RH SOLID ROCKET BOOSTER DEBRIS INSPECTION

The RH frustum exhibited 6 debonds and 16 pieces of missing TPS. Metal substrate was visible in some of the small TPS divots. Most of the Hypalon black visibility stripe and some of the white topcoat had blistered and peeled with evidence of charring on the layer underneath. All BSM covers were intact.

The RH FWD Skirt exhibited 4 debonds and 7 divots. There was some blistering and peeling of topcoat. K5NA around the banjo fitting was intact. Both RSS antenna phenolic plates were attached. Separation appeared nominal at the forward attach fitting, but the separation bolt was not present at the time of the inspection.

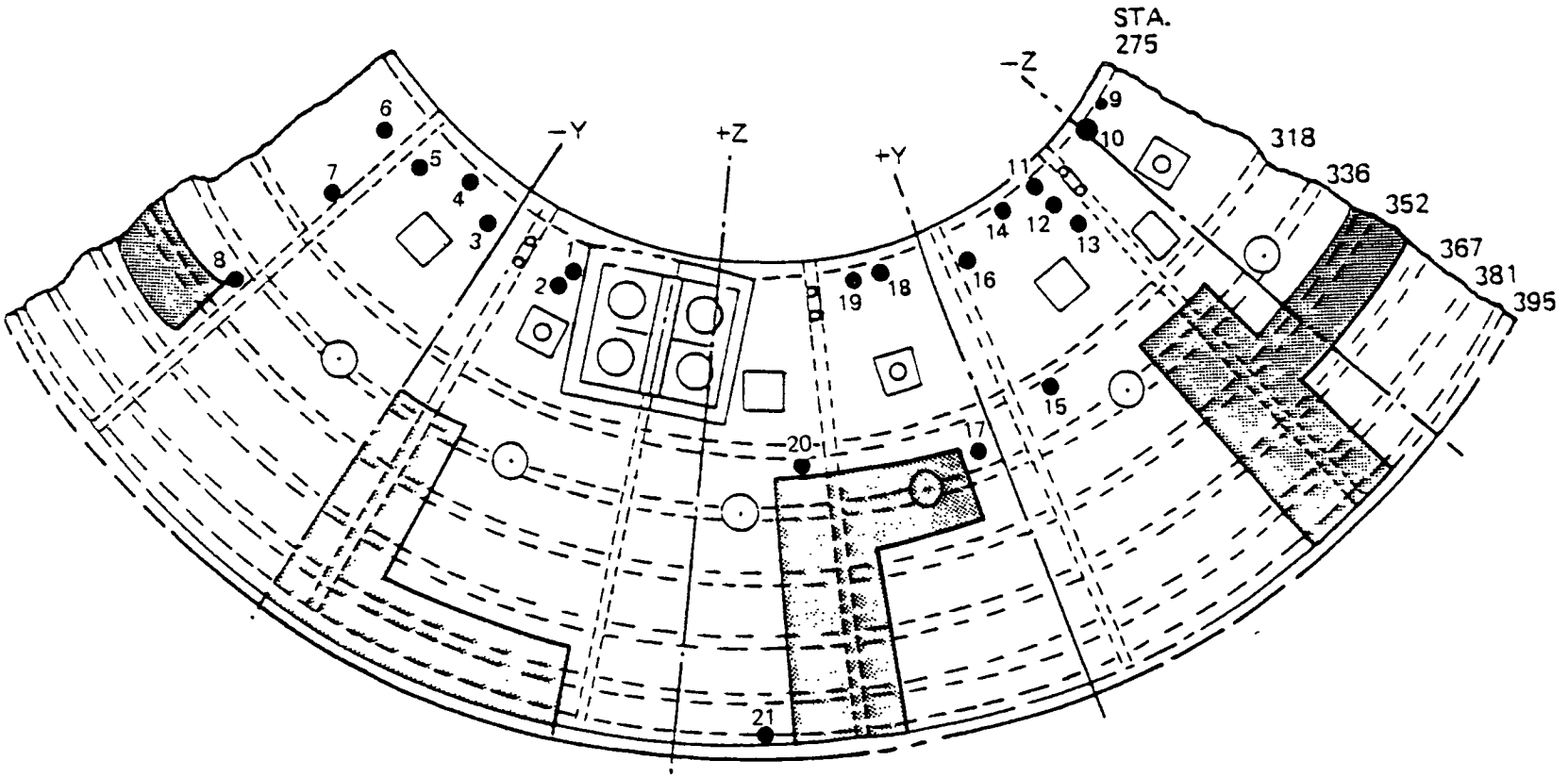
All factory and field joints looked good on the RH SRB. System tunnel covers were in place and closeouts were intact. There were several areas of missing or debonded DFI cork - more so than on the LH SRB. Substrate under debonded areas showed signs of ascent heating. On the FWD Center segment at 140 degrees, DFI cork was missing from three areas each measuring 6"x3". Fore-to-aft scars/scrape marks were visible aft of the missing cork at one of these locations and could be signs of an impact (Ref Figures 10-16).

The ETA ring was damaged by water impact and one cover was missing. The forward face had been subjected to ascent heating and three plug pulls were missing from the aft face. Three stiffener rings had failed at water impact as evidenced by circumferential cracks and missing bolts. This damage occurred at 140 degrees and generally ran 4 to 6 feet in length. Four plug pulls and sections of instafoam were missing from this area. Separation of the aft ET/SRB struts appeared nominal though one upper strut electrical connector shell had broken and some small pieces from fairing closeouts were missing. Milk can was only slightly charred.

All four of the new Aft Skirt debris containers with attaching bolts were intact, but the lockwire had melted or broken on post #1 and #2. The lockwire was intact on post #3 and #4. The #1 and #3 debris plungers failed to seat properly due to interference from pieces of frangible nut. Ten percent of Epon shim #3 was missing to the primed substrate with half of that area showing discoloration. Fifteen percent of the primed substrate, which was also discolored, was visible on shim #4. Both lost approx 20% of the sidewall material. All BSM's were intact with some small TPS and K5NA divots. K5NA was missing from all four BSM nozzles and the adjoining K5NA substrate was

sooted. The TPS on the aft skirt was generally in good condition with the exception of DFI cork divots and some delamination on the phenolic ring.

FIGURE 10. RIGHT SRB FRUSTUM



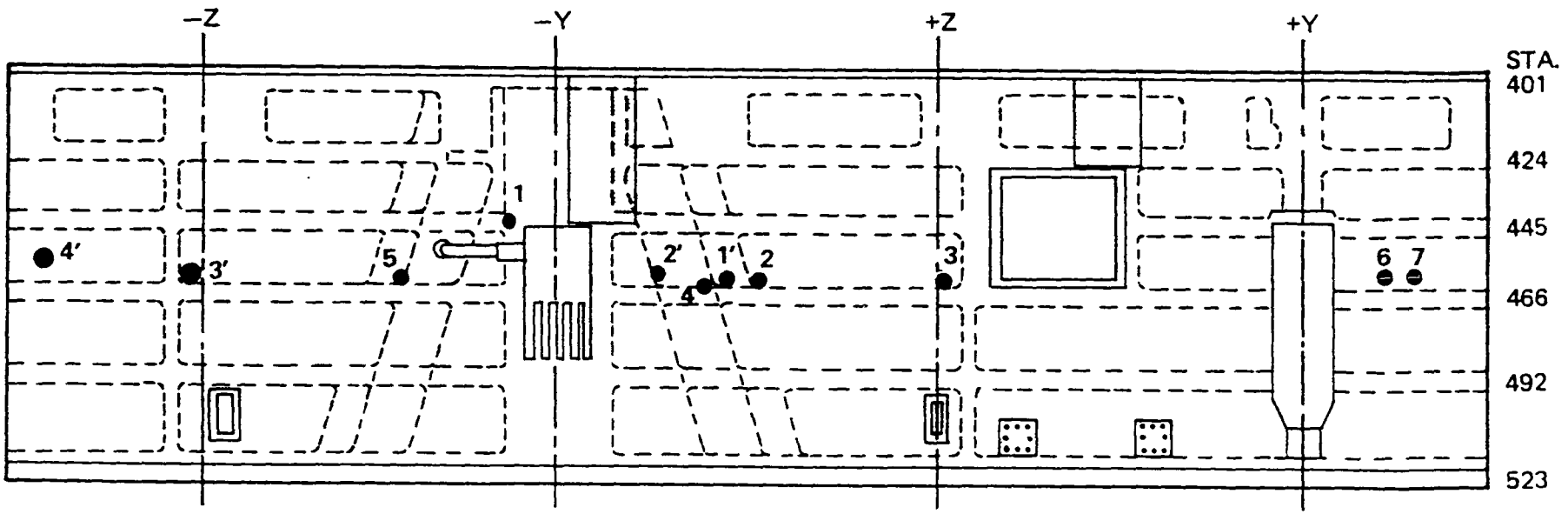
MISSING TPS

1)	4x2	13)	4" DIA
5)	1½x3	14)	3x6
6)	5x4	15)	1½" DIA
7)	1½x1	16)	3" DIA
8)	1½x1	17)	1½" DIA
9)	1½x3	18)	4x8
10)	3½x5	19)	5x8
12)	5x4		

DEBONDS

2)	3" DIA
3)	3" DIA
4)	3" DIA
11)	2" DIA
20)	4"
21)	1" DIA

FIGURE 11. **RIGHT SRB FWD SKIRT**



TPS MISSING

1) 2 x 2
2) 3 x 6
3) 3 x 7
4) 1 x 1.5
5) 1 x 2
6) 2 x 3
7) 2 x 3

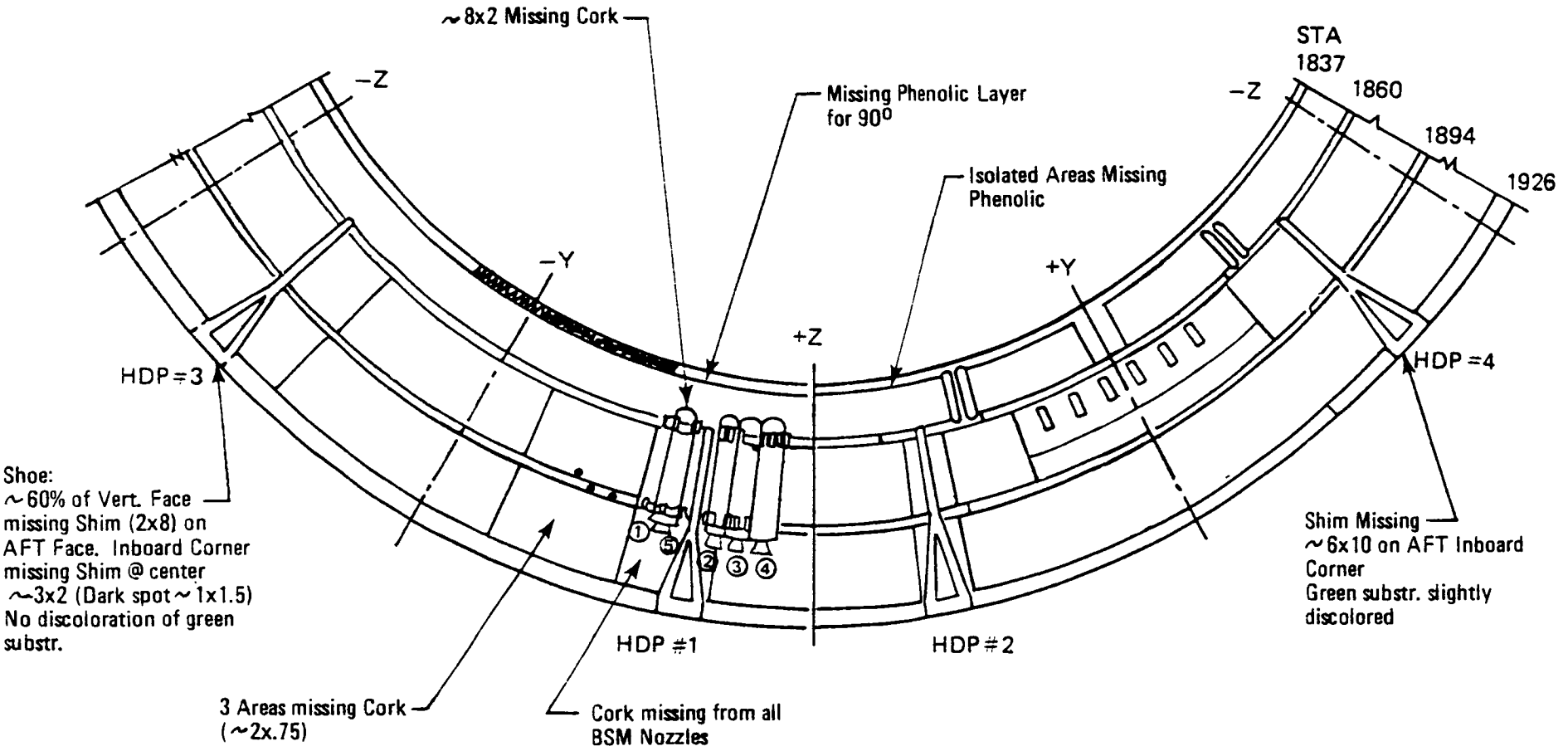
DEBONDS

1') 1 x 1
2') 1 x 1
3') 2 x 1
4') 1 x 1

EGG/V 326A

* HDP 1 Plunger did not function

FIGURE 12. RIGHT SRB AFT SKIRT EXTERIOR TPS



1 - Missing Cork ~3x4 from BSM AFT sides
2 - Missing Cork ~1½x1
3 - Missing 2 areas of Cork (~3x2) on AFT side
4 - Missing Cork ~3x7 on AFT Side
5 - ~5x6 area of missing Cork on BSM Inboard side

EGG/V 326C

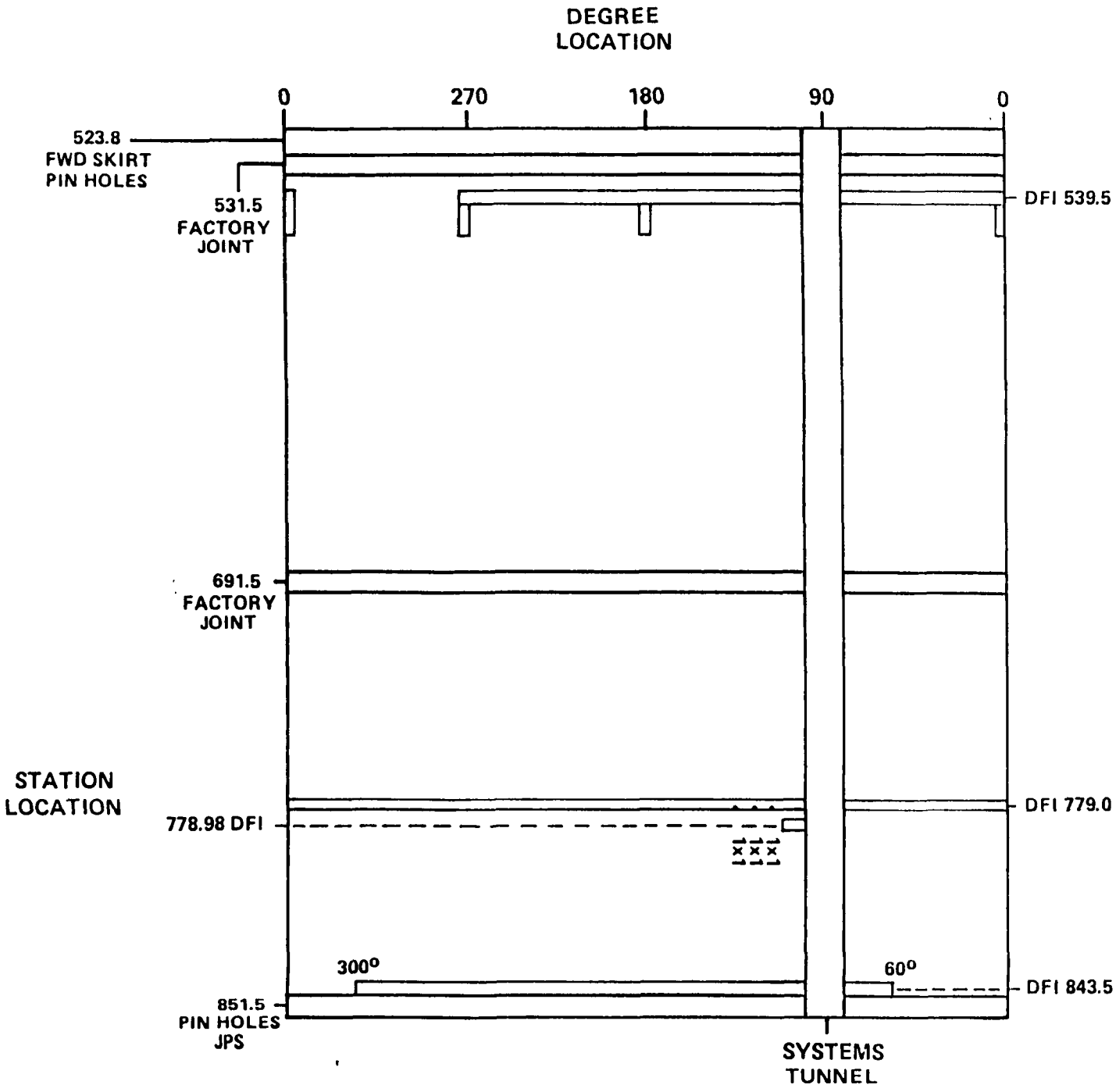


FIGURE 13. **RIGHT FORWARD CASE SEGMENT**

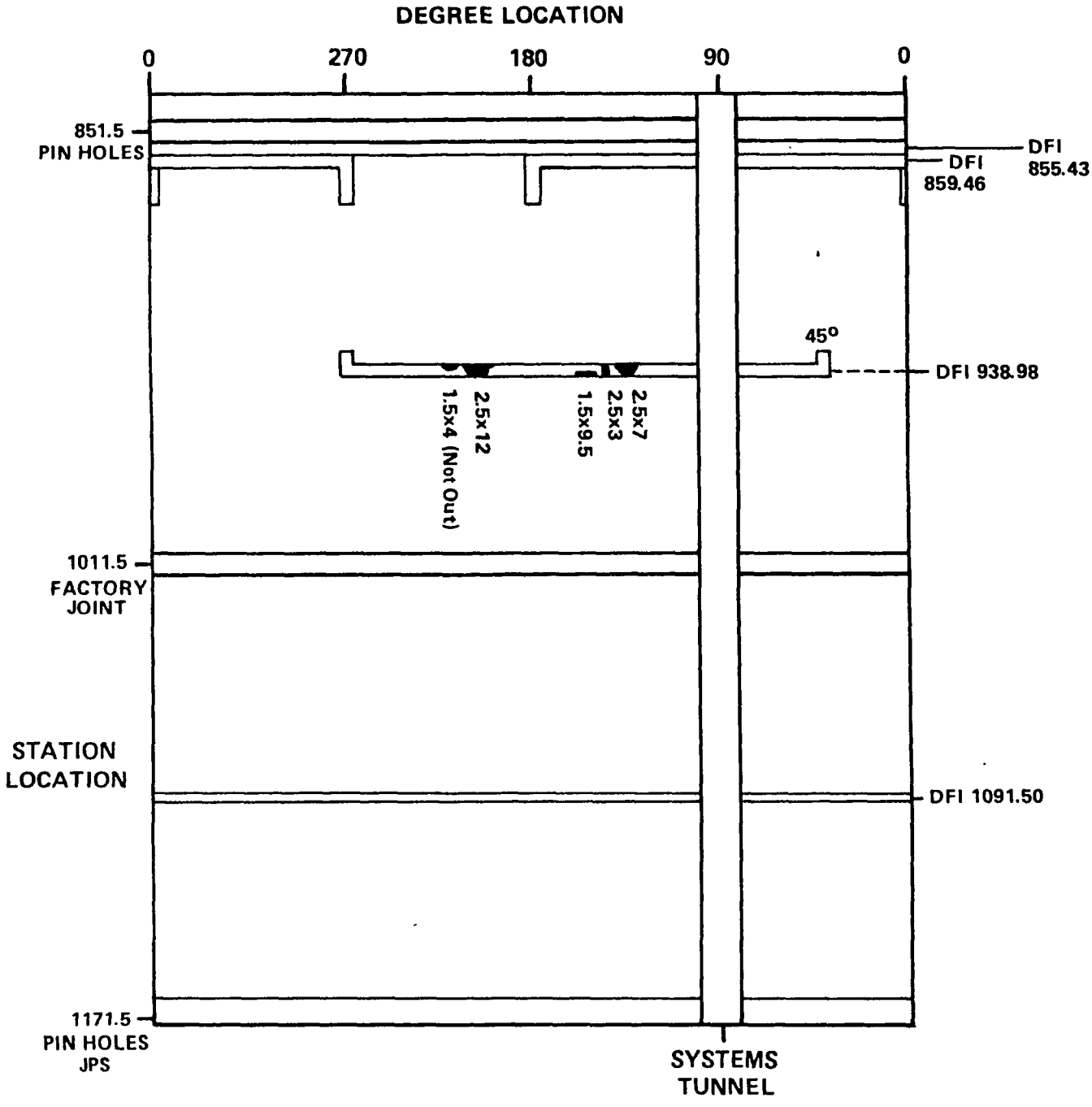


FIGURE 14. RIGHT FORWARD CENTER CASE SEGMENT

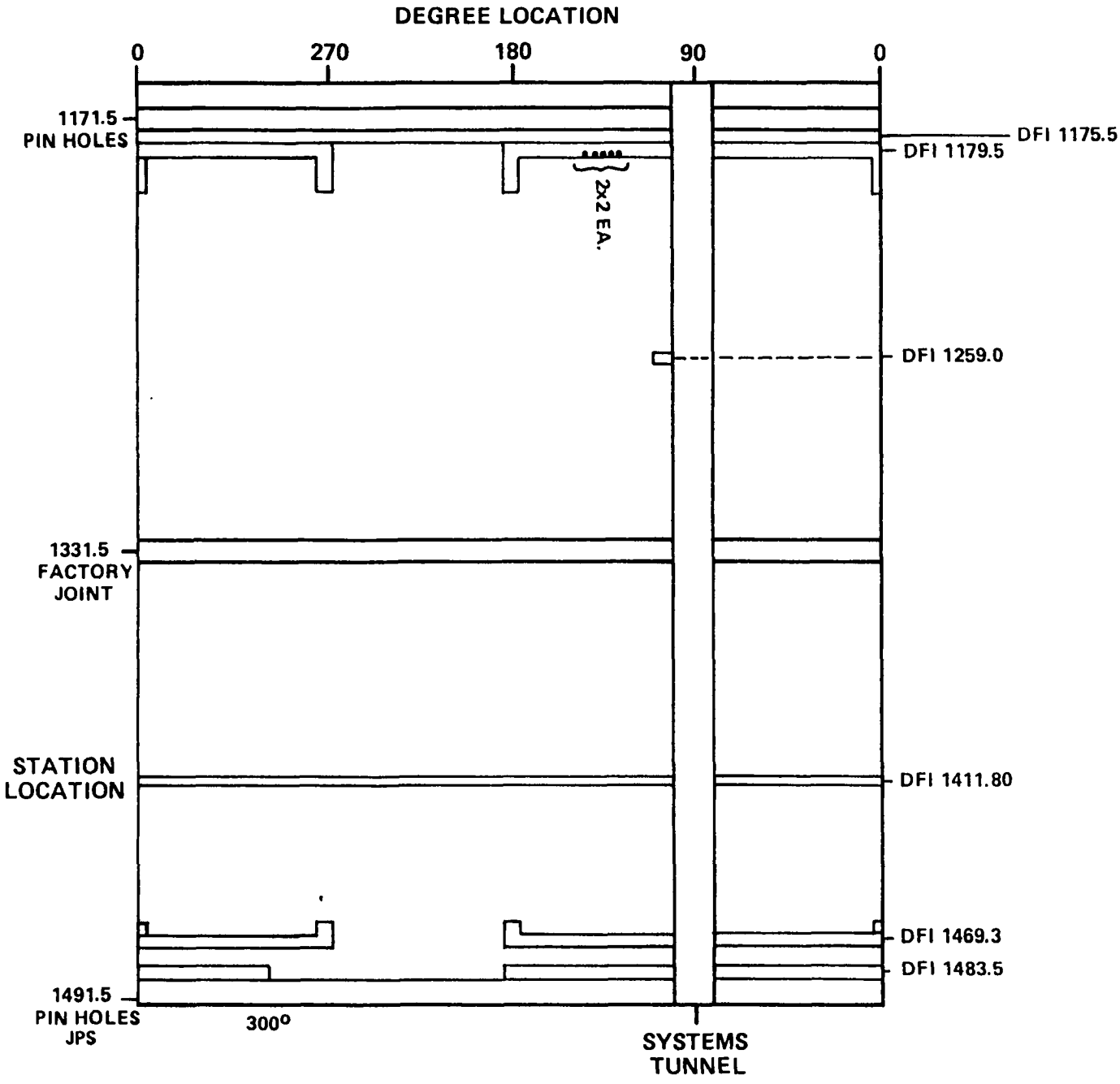


FIGURE 15. **RIGHT AFT CENTER CASE SEGMENT**

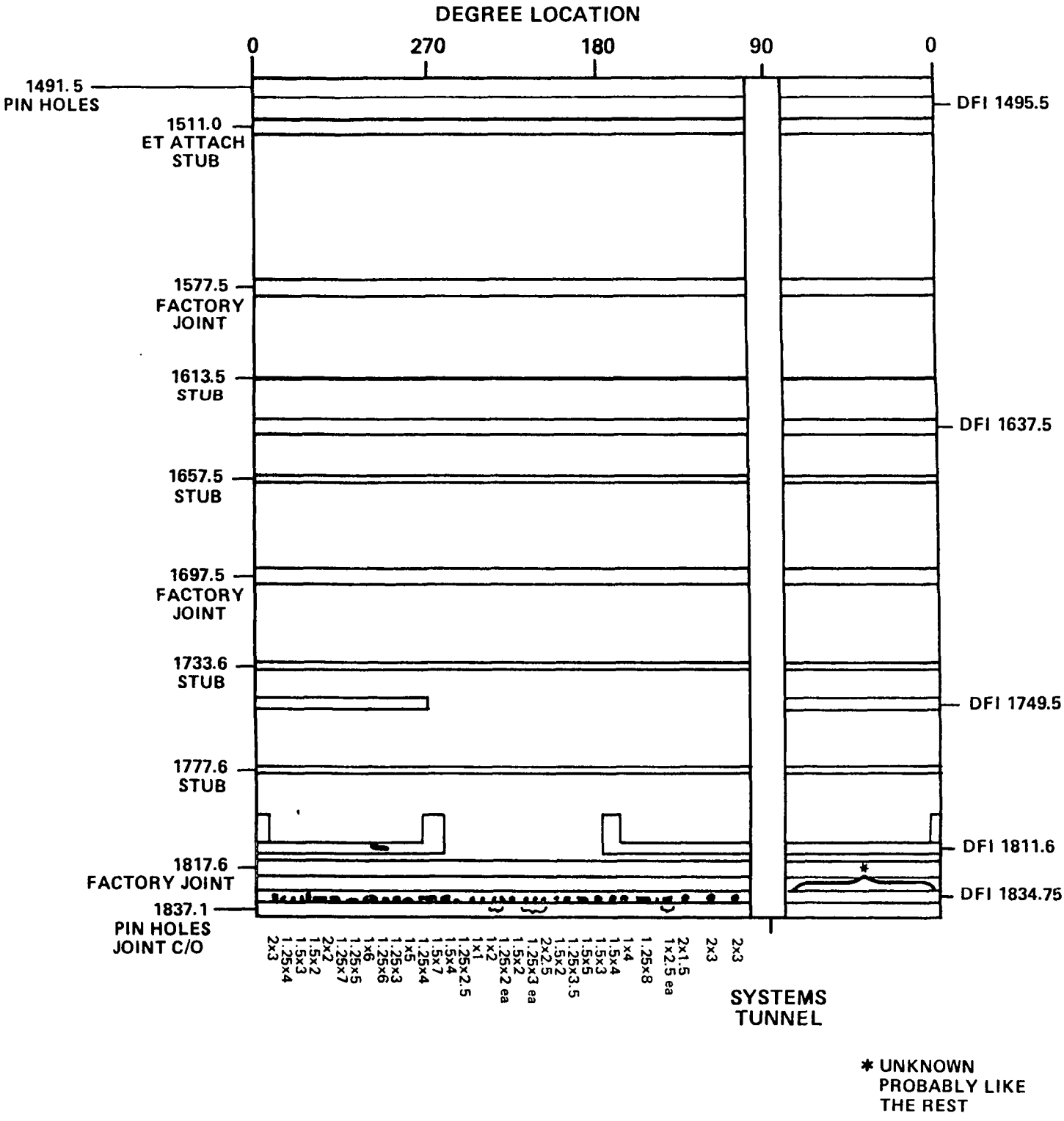


FIGURE 16. **RIGHT AFT CASE SEGMENT**

10.2 LH SOLID ROCKET BOOSTER DEBRIS INSPECTION

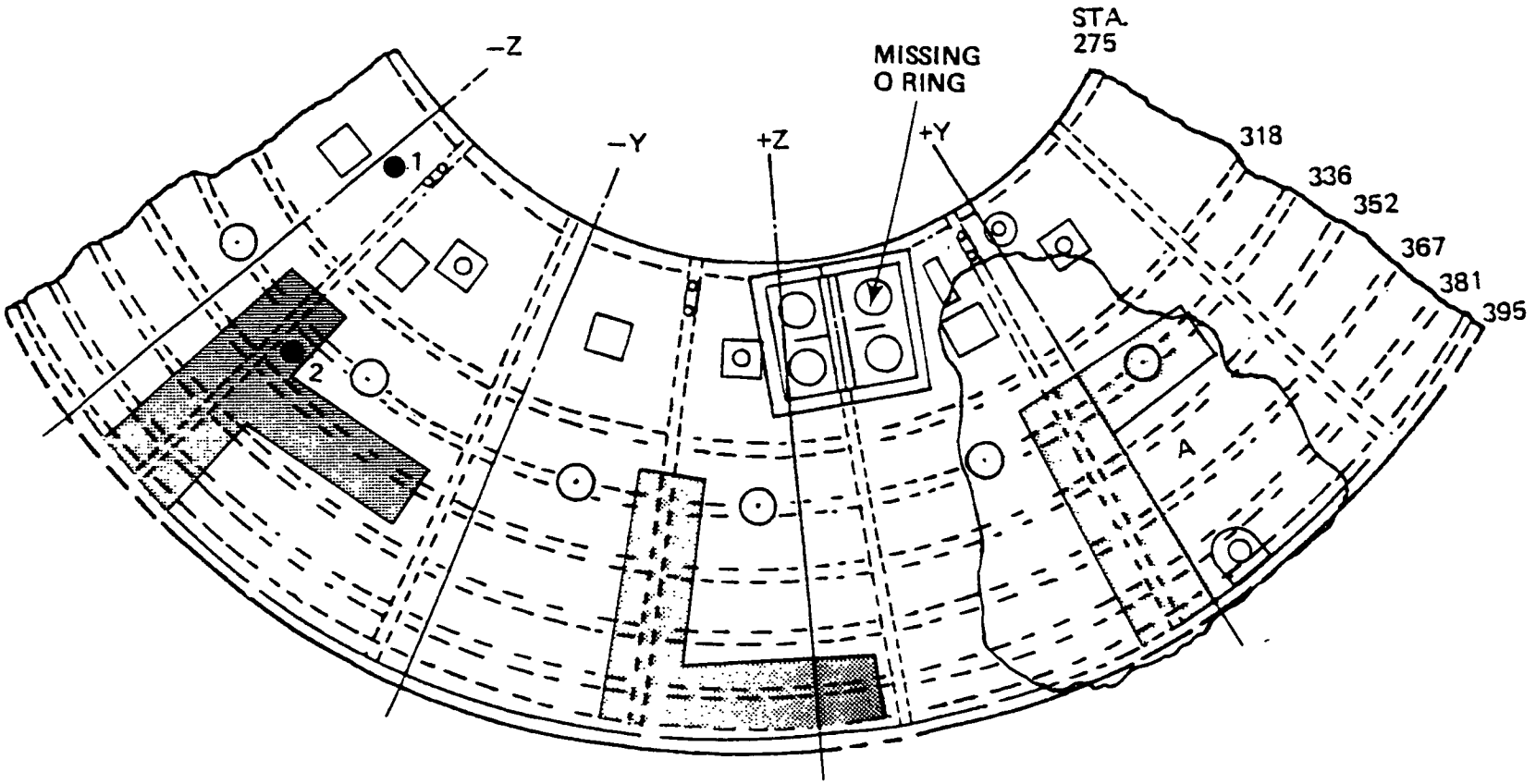
The LH frustum exhibited 1 debond and 1 TPS divot. Severe blistering and peeling of topcoat (considerably more than RH frustum) had occurred and the layer underneath showed evidence of aeroheating or BSM exhaust pattern. The frustum appears to have been topcoated twice. All BSM covers were intact less one missing O-ring.

Two debonds and 9 divots to substrate were visible on the LH FWD Skirt. The Hypalon black visibility stripe had blistered and peeled. The K5NA closeout was cracked around the banjo fitting. Phenolic plates were still attached to the RSS antenna covers, but the J5220 SLA on the forward ramp of the +Z antenna had broken off (7"x6") at water impact. Separation appeared nominal at the forward attach fitting and the sep bolt was present. Some ablator had eroded forward of the access door.

All factory and field joints looked good on the LH SRB. System tunnel covers were in place and K5NA closeouts intact. DFI closeouts along the length of the boosters showed varying degrees of cracks, debonds, or missing pieces (Ref Figures 17 - 23). Stiffener rings, instafoam, and the IEA structure sustained only minor water impact damage. Lower ET/SRB struts had separated normally though one upper strut electrical connector was broken.

All four of the new Aft Skirt debris containers with attaching bolts were intact but the lockwire had melted or broken on post #5 and #6. Lockwire was still present on posts #7 and #8. The #7 plunger was prevented from seating properly by pieces of frangible nut. Twenty percent of fresh green primer on Epon shim #7 and 10% on shim #8 were visible with no sign of heating. Both lost approx 15% of the sidewall material. All BSM's were intact. The aft skirt TPS had more problems than the RH SRB with a total of 7 divots. Fifty percent of the K5NA was missing from the aft skirt-to-case ring bolts. The phenolic ring had eroded and delaminated. The cork closeout above the pin retainer band was missing or loose through 360 degrees and the cause appeared to be entrapped air. The stiffener band closeout near the BSM's exhibited debonds and divots over a 6-foot length. Cork near the BSM's was severely charred. Divots were present or cork missing entirely from the DFI closeouts.

FIGURE 17. LEFT SRB FRUSTUM



MISSING TPS

1) 1" DIA

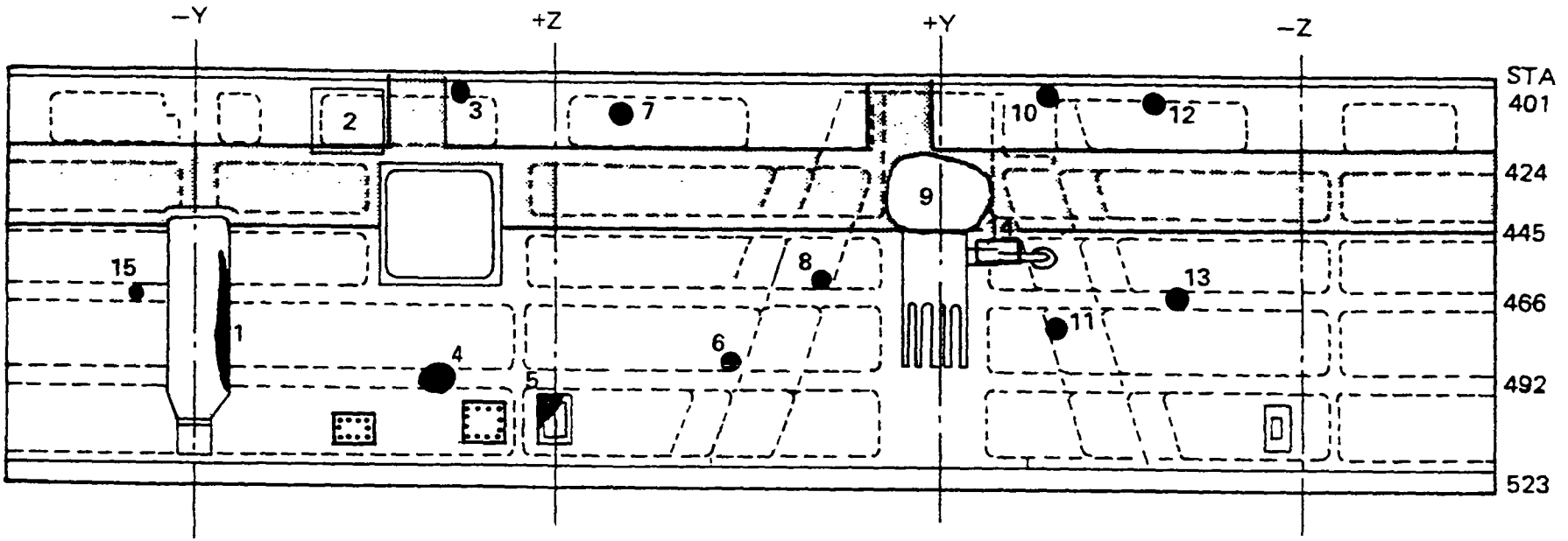
DEBONDS

2) 1" DIA

1. SEVERE BLISTERING OVER ENTIRE SURFACE MOST SEVERE IN AREA A SOME UNDERCOAT IS CHARRED.
2. ALL BSM COVERS INTACT
3. ALL OTHER COVERS & PRESS PORTS INTACT

EGG/V-326E

FIGURE 18. **LEFT SRB FWD SKIRT**



TPS MISSING

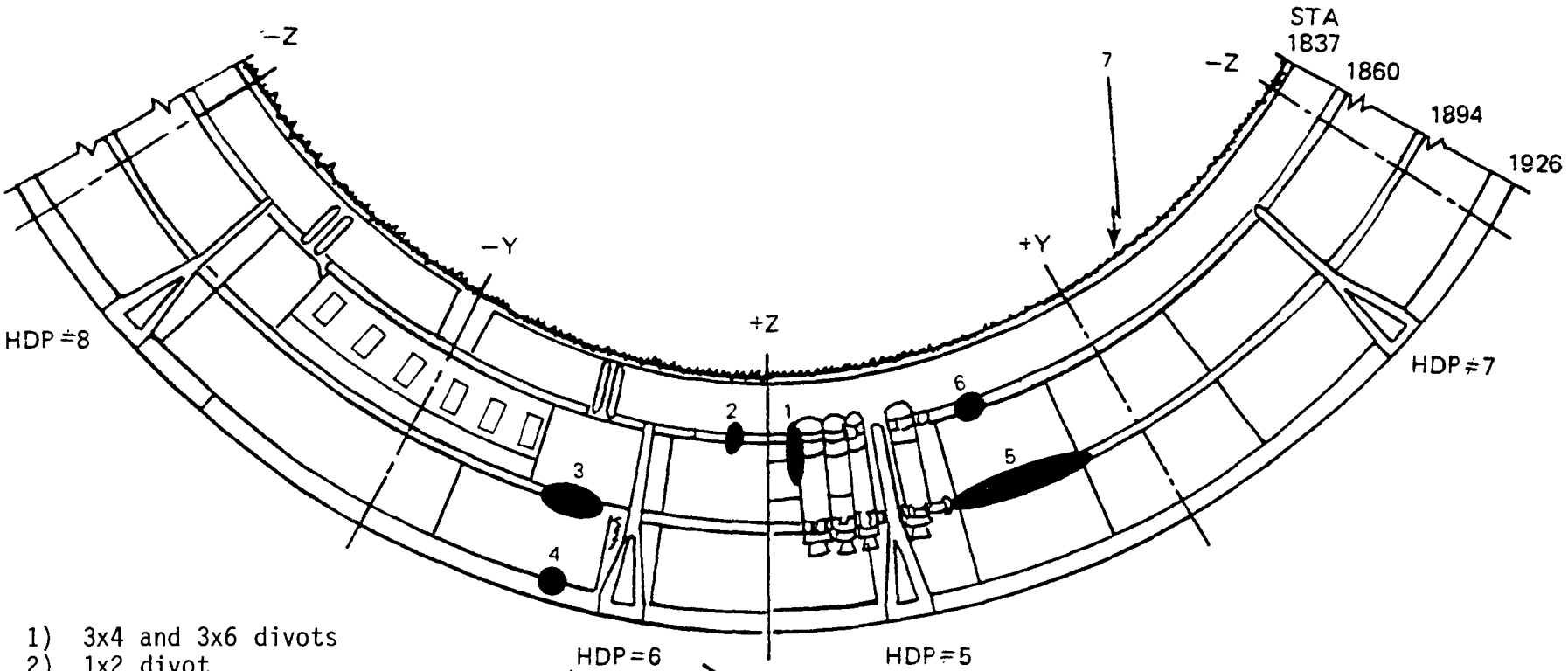
3) 3x2
4) 3x4
5) 7x6 SLA
7) 6x2
8) 4x3
10) 1½x3
11) 3x5
12) 2x6
13) 6x10

DEBONDS

6) 3" DIA
15) 4" Across

1) Topcoat blistered, peeling
2) Hypalon blistered, peeling
9) Hypalon blistered, peeling
14) Hypalon blistered, peeling

FIGURE 19 LEFT SRB AFT SKIRT EXTERIOR TPS



1) 3x4 and 3x6 divots
2) 1x2 divot
3) 1x2 divot, 1x4 divot
4) 3 inch long crack
5) 6 foot section divots and debonds
6) 1½x3 divot
7) DFI closeout divots

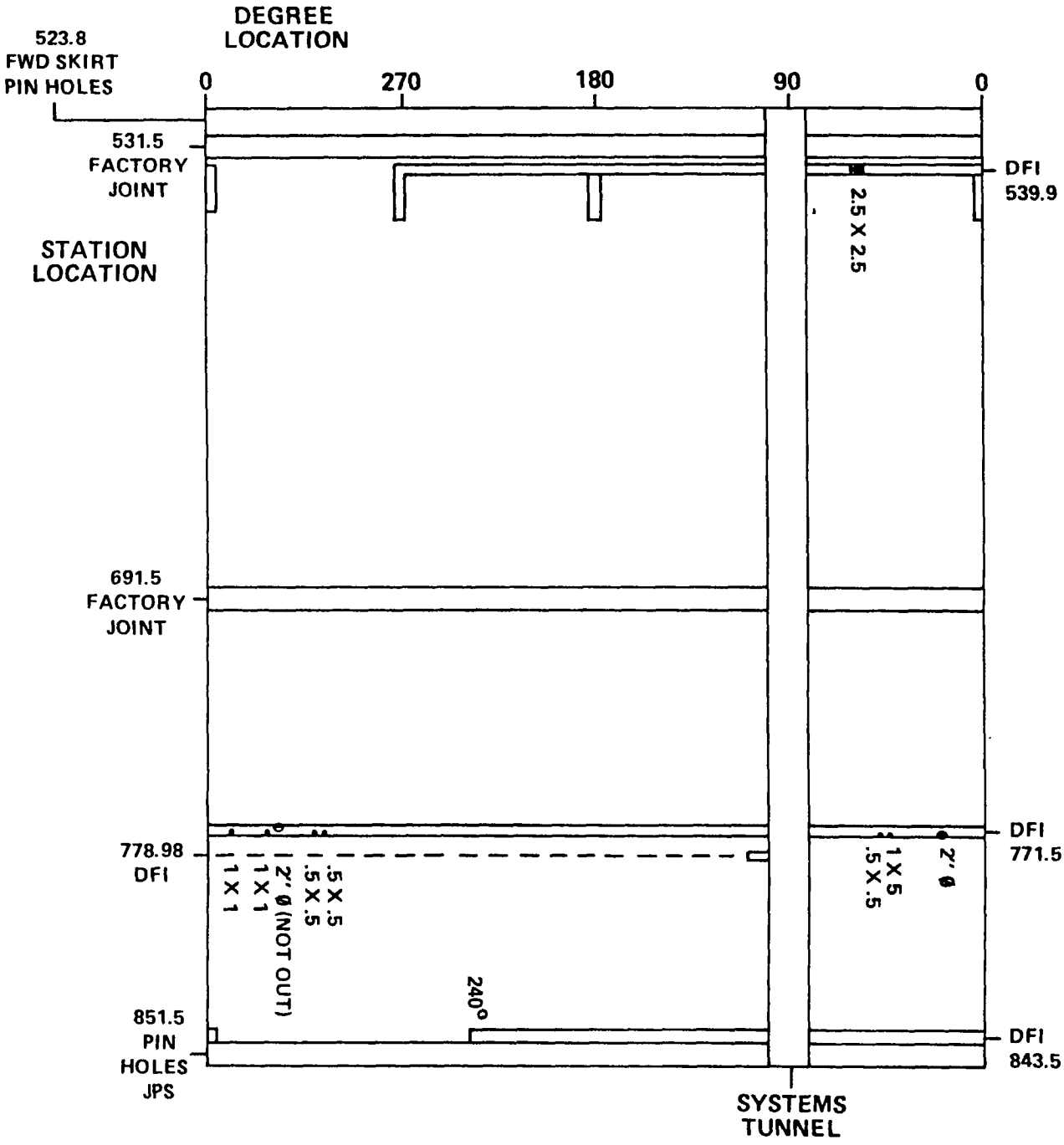


FIGURE 20. **LEFT FORWARD CASE SEGMENT**

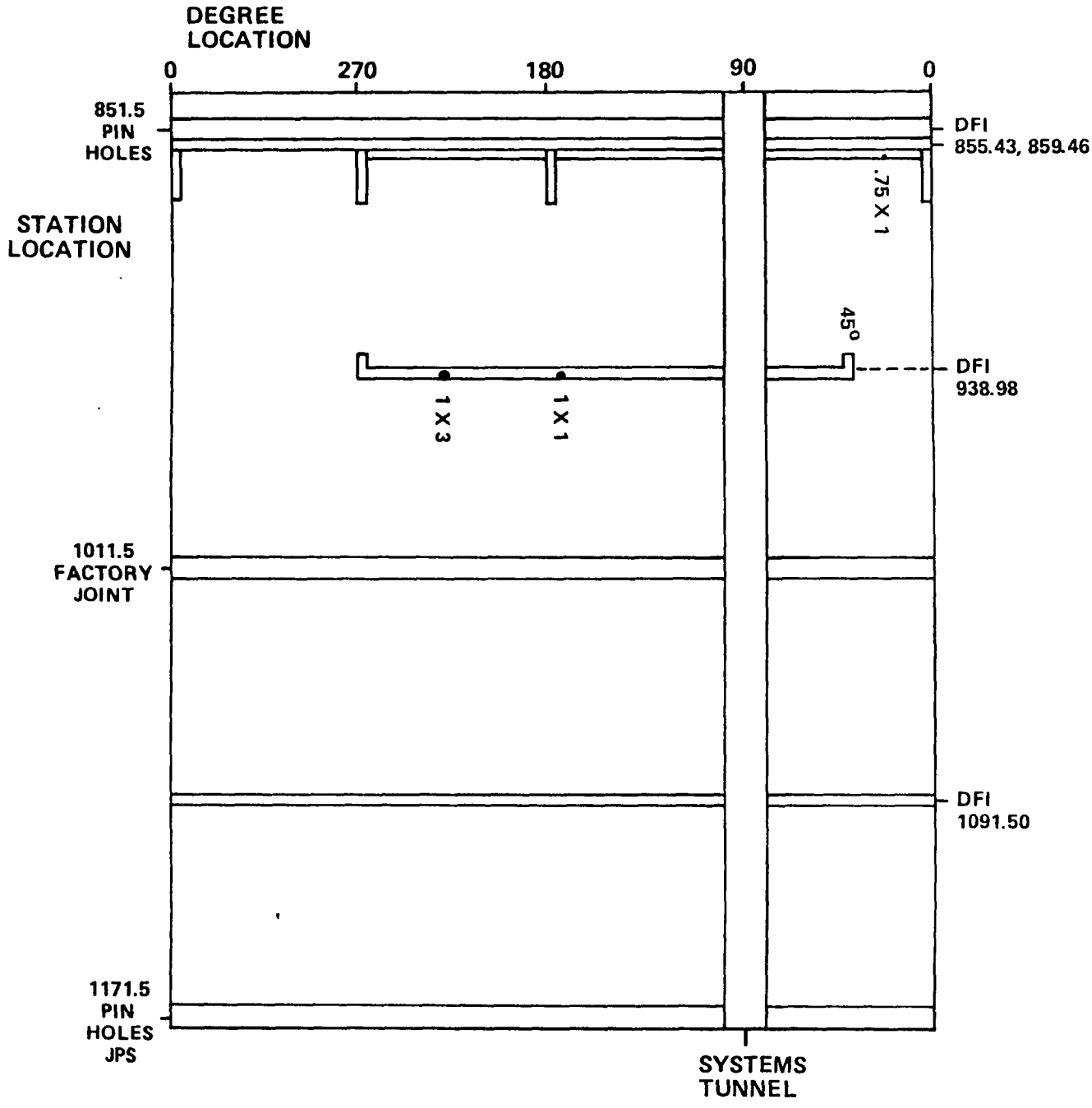


FIGURE 21. **LEFT FORWARD CENTER CASE SEGMENT**

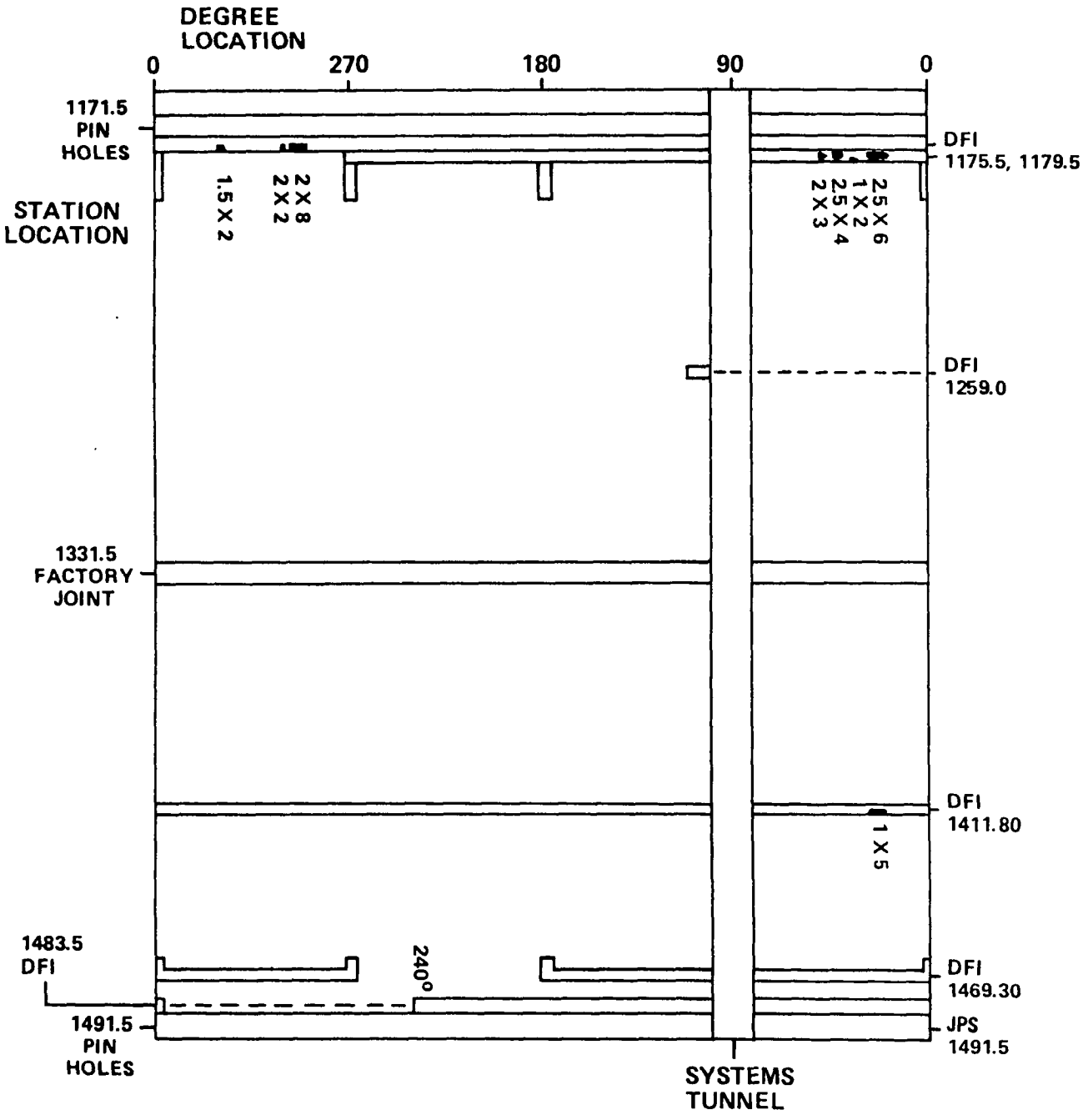


FIGURE 22. **LEFT AFT CENTER CASE SEGMENT**

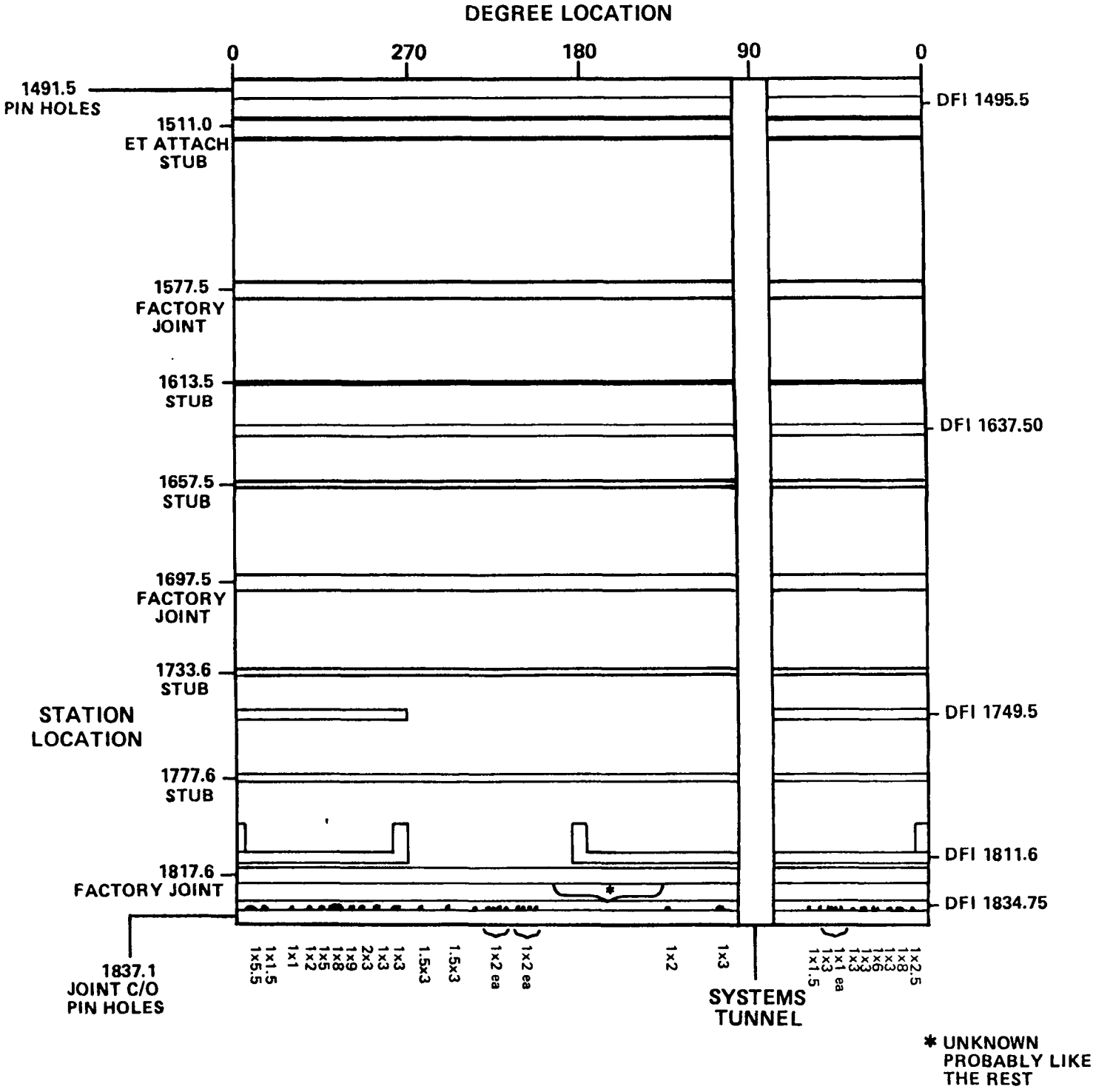


FIGURE 23. **LEFT AFT CASE SEGMENT**

C-3

10.3 RECOVERED SRB DISASSEMBLY FINDINGS

TPS was missing on the frustums (MSA), forward skirts (MSA), and SRM DFI wiring runs (cork). The most significant of these from a debris standpoint was on the right SRB at Station XB-939 190 degrees where a 12 inch strip of DFI cap cork was missing. The substrate showed evidence of poor or no bonding. Corrective action for this condition was taken on the STS-27 SRB's for all locations of debris concern within the area from 0 to 270 degrees.

According to MTI-UTAH installation procedures, each DFI cable run is bordered on the leading and trailing edges by a cork dam. The cork dams, which vary in thickness to 1/2-inch max, are bonded to substrate with EA934 and either vacuum bagged or taped in place during cure. Both bonding surfaces are wetted with adhesive for this installation. The cable run cavity between the dams is then filled with K5NA. A cap cork, which is positioned over the K5NA and spans both cork dams, is wetted with EA934 adhesive and held in place with vinyl tape for cure. Cap cork is usually 1/4-inch thick and varies in width. The cured closeout is then topcoated with Hypalon paint.

The STS-27 SRB's were tap tested and a significant number of voids and debonds were discovered. Debonds that did not extend to the edge of the closeout and not larger than 1.6"x1.6" were vented by drilling 1/8-inch holes. Debonds that did extend to the closeout edge were trimmed to remove the debonded cork and replaced with K5NA.

The blast containers were redesigned for STS-26 providing a debris containment system. Posts 1, 3, 6, and 7 did not close completely, but did contain the frangible nut fragments. Although the plunger in Post 8 was seated, major nut fragments were missing and the plunger assembly could not have functioned properly. The debris containers had been qualified by testing, but a design fix will be required to provide proper function. The attachment to the holddown post may have failed prematurely allowing plunger misalignment during the instant of stroking when the stud drops.

Water impact damage occurred to the right SRB stiffener rings and aft IEA cover. Torn IEA covers, sheared bolts, and stub ring hole damage was found. One end cover of the IEA was torn away and missing. Sea water was found in all field joint protection systems and was caused by leaking vent valves. Cold welding occurred in the field joints and produced scratches on the clevis inner leg when the joints were separated. This condition, varying in severity from no scratches to 99 on one joint, was unique to the first flight and had not been seen on static test motors. The sealing surfaces were not affected and the condition is a refurbishment problem.

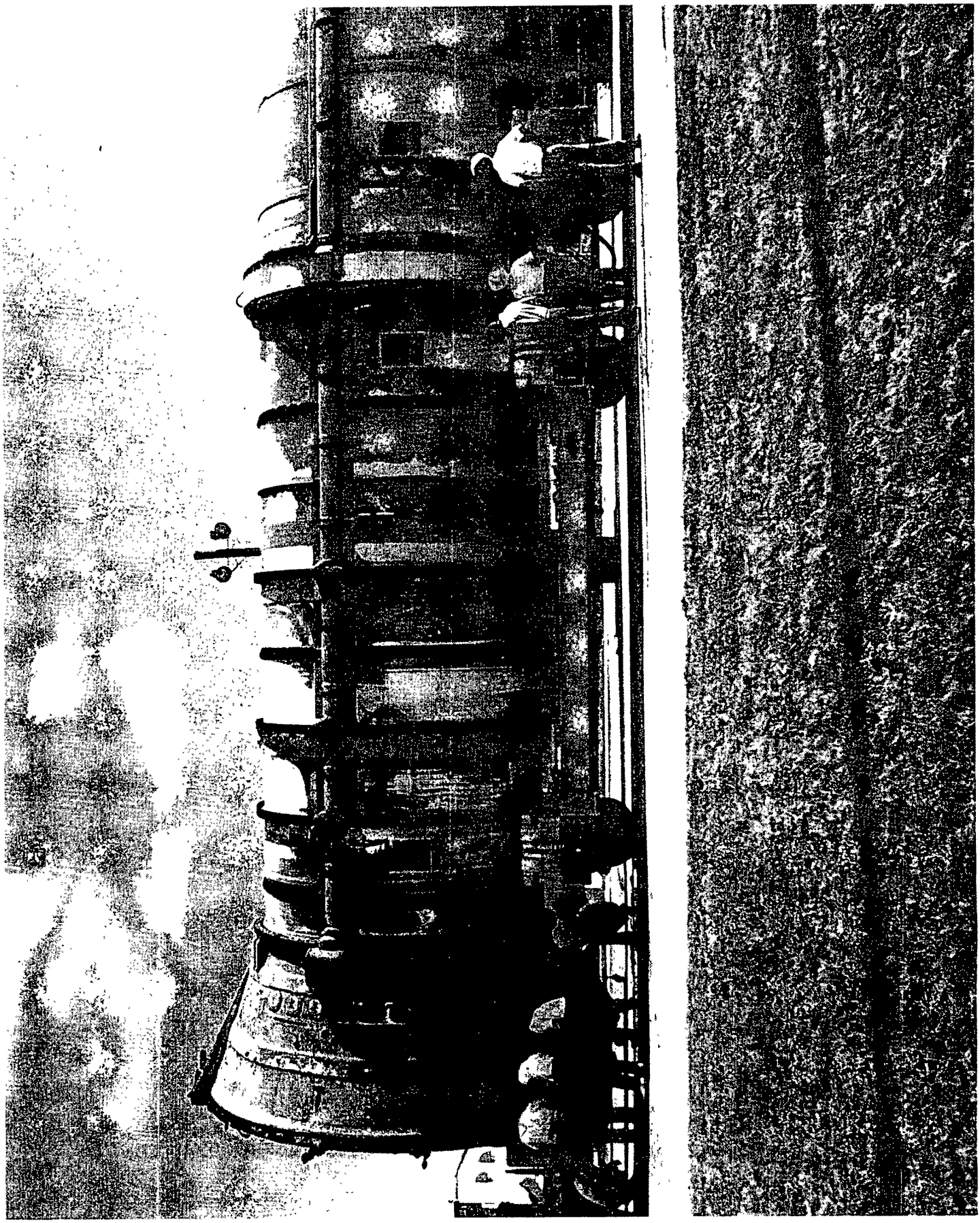
Disassembly of the field joints showed no soot past the tip of the J-joints confirming excellent J-leg performance. All joint O-rings were in excellent condition. Some corrosion was found on the tang exterior circumference at the pin clips (joint shims).

The factory joints showed no water penetration and adequate insulation thickness remained after motor burn.

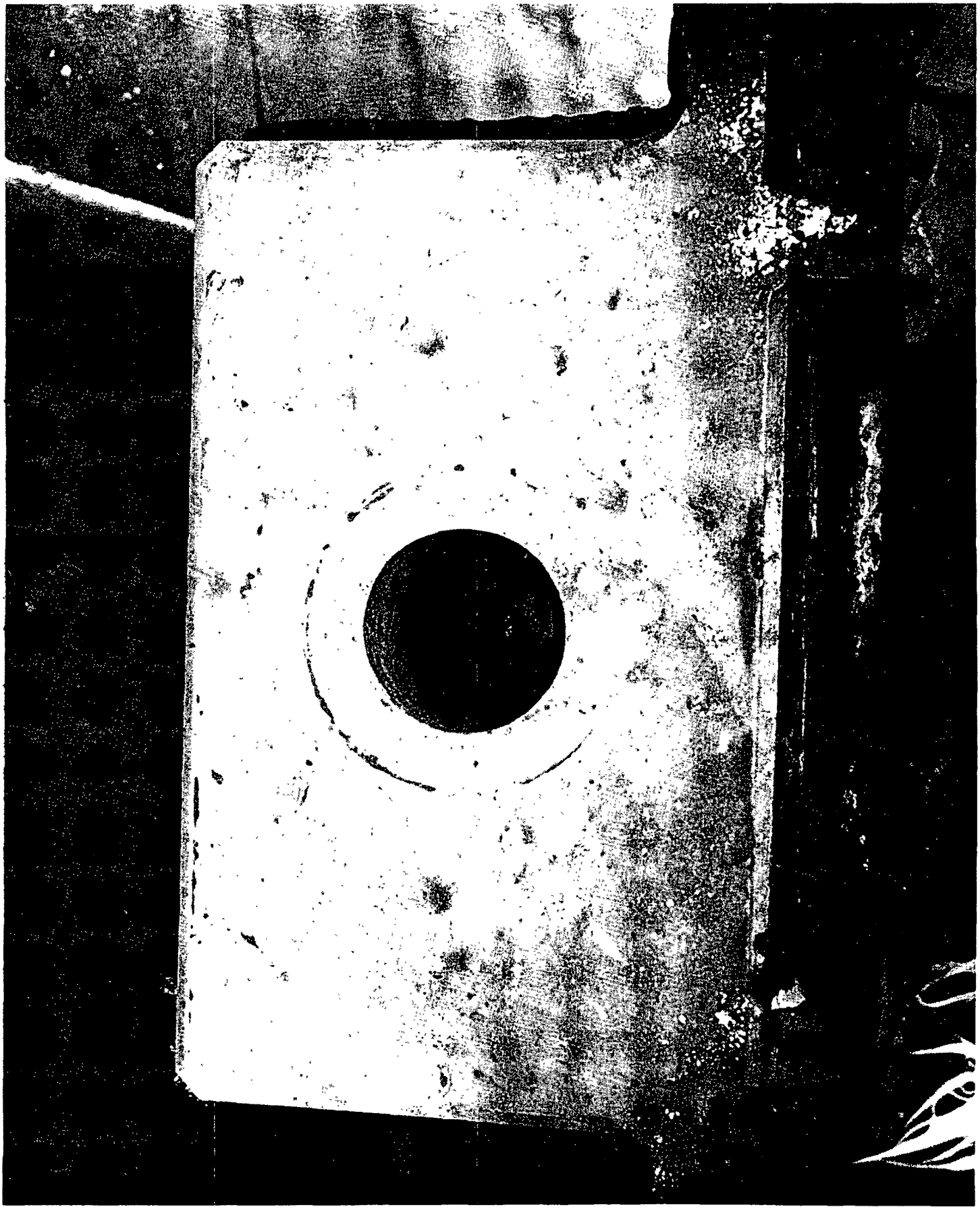
The nozzle joints were in excellent condition with no blowholes in the polysulfide. There was no damage to the seals or pressure blow-by past the wiper seal. The flex boot was in good condition on both nozzles and the nozzle rings were also satisfactory from an erosion standpoint.

Parachute #3 on the RH SRB sustained significant damage to a couple of gores and witness paint evidence showed contact with the bipod strut had occurred.

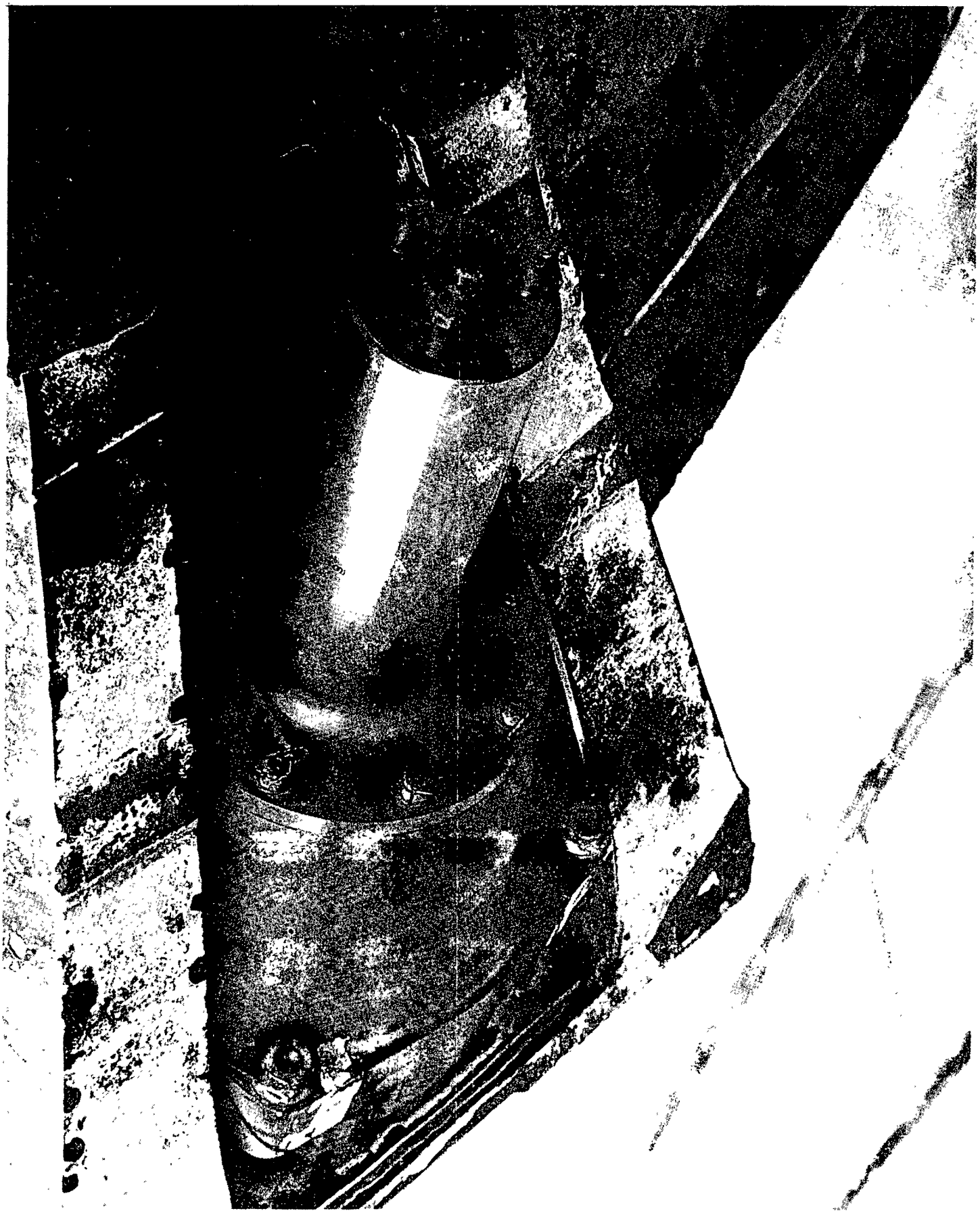
Blowholes were found in the putty on both igniters. This has occurred previously and does not appear preventable. No hot gas paths or seal damage was found.



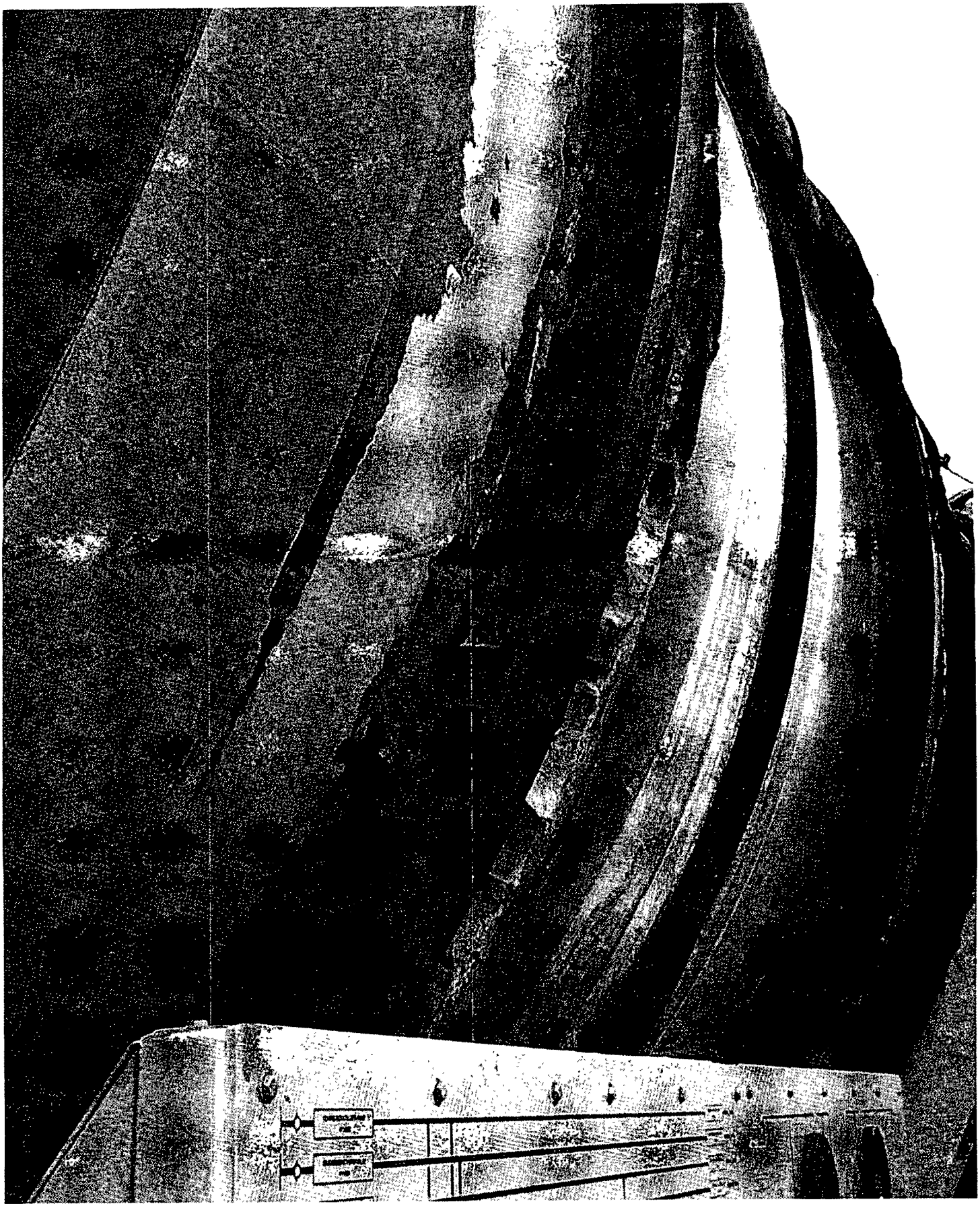
RIGHT SRB AFT BOOSTER AND SKIRT



PLUNGER IN REDESIGNED DEBRIS CONTAINER PLUGS HOLE IN AFT SKIRT FOOT. INSTAFOAM IS CHARRED BY EXHAUST PLUME BACKFLOW

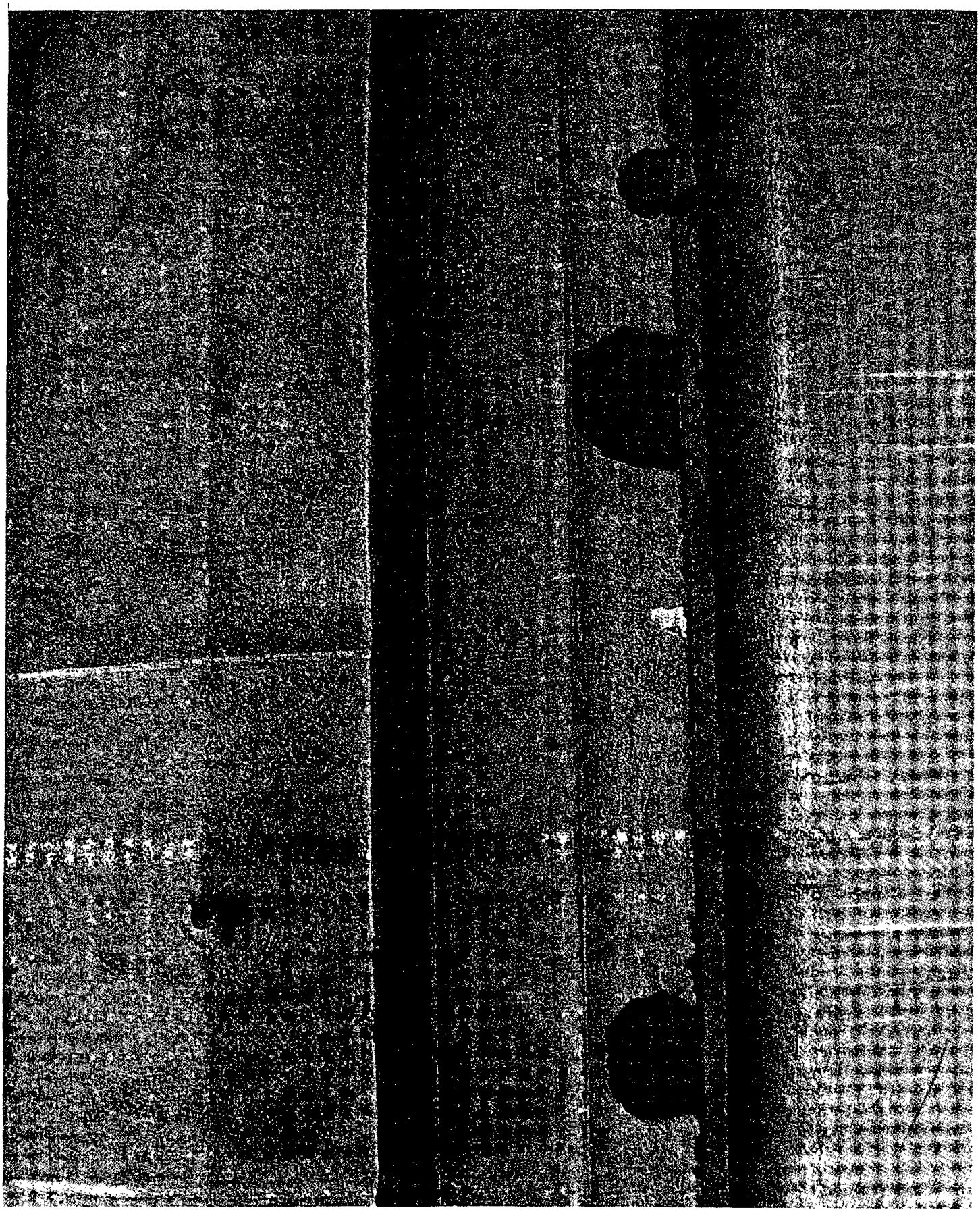


LOCKWIRE HAS MELTED ON REDESIGNED DEBRIS CONTAINER, BUT ALL BOLTS ARE INTACT

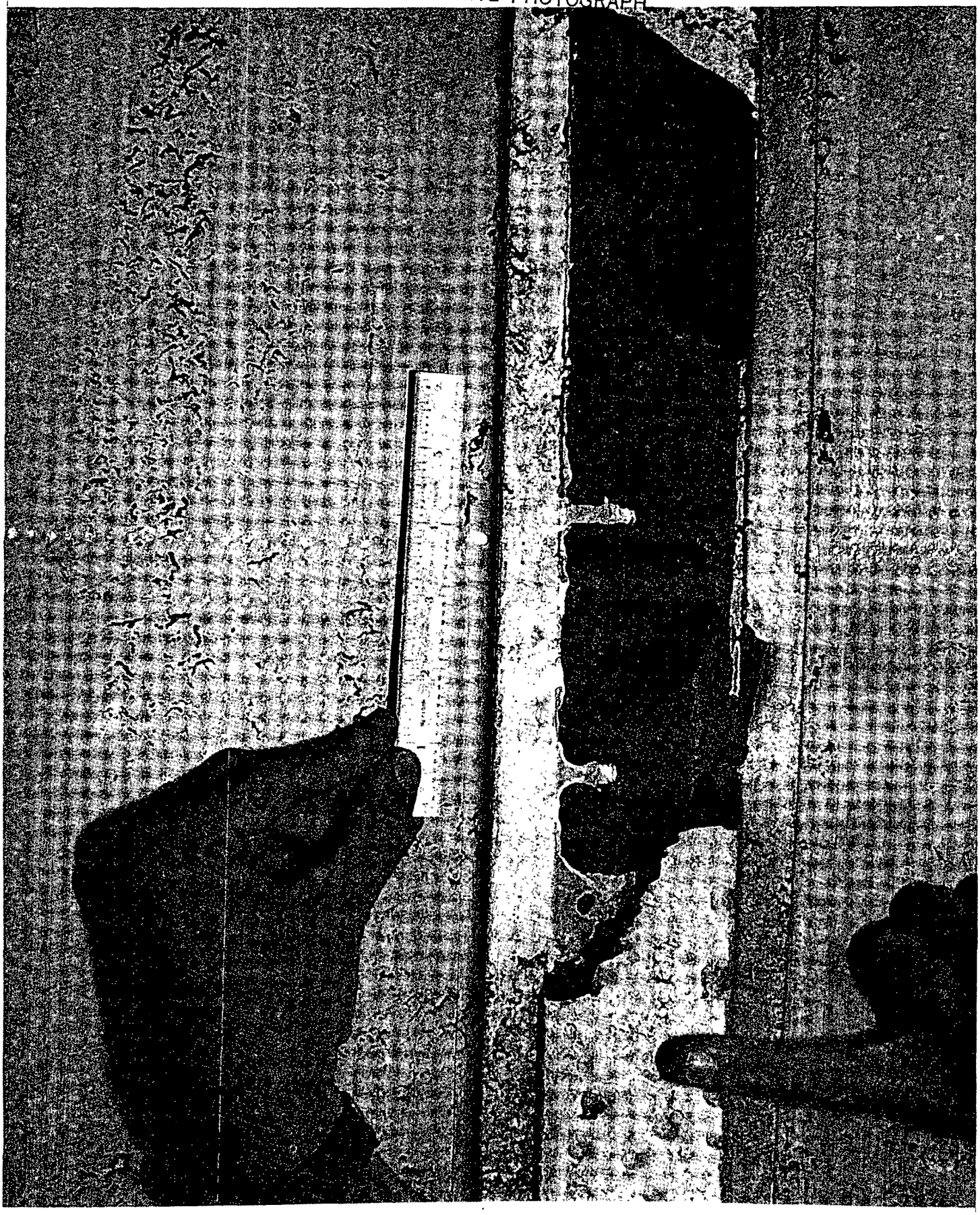


CRACKED STIFFENER RING/MISSING INSTAFOAM DUE TO WATER IMPACT

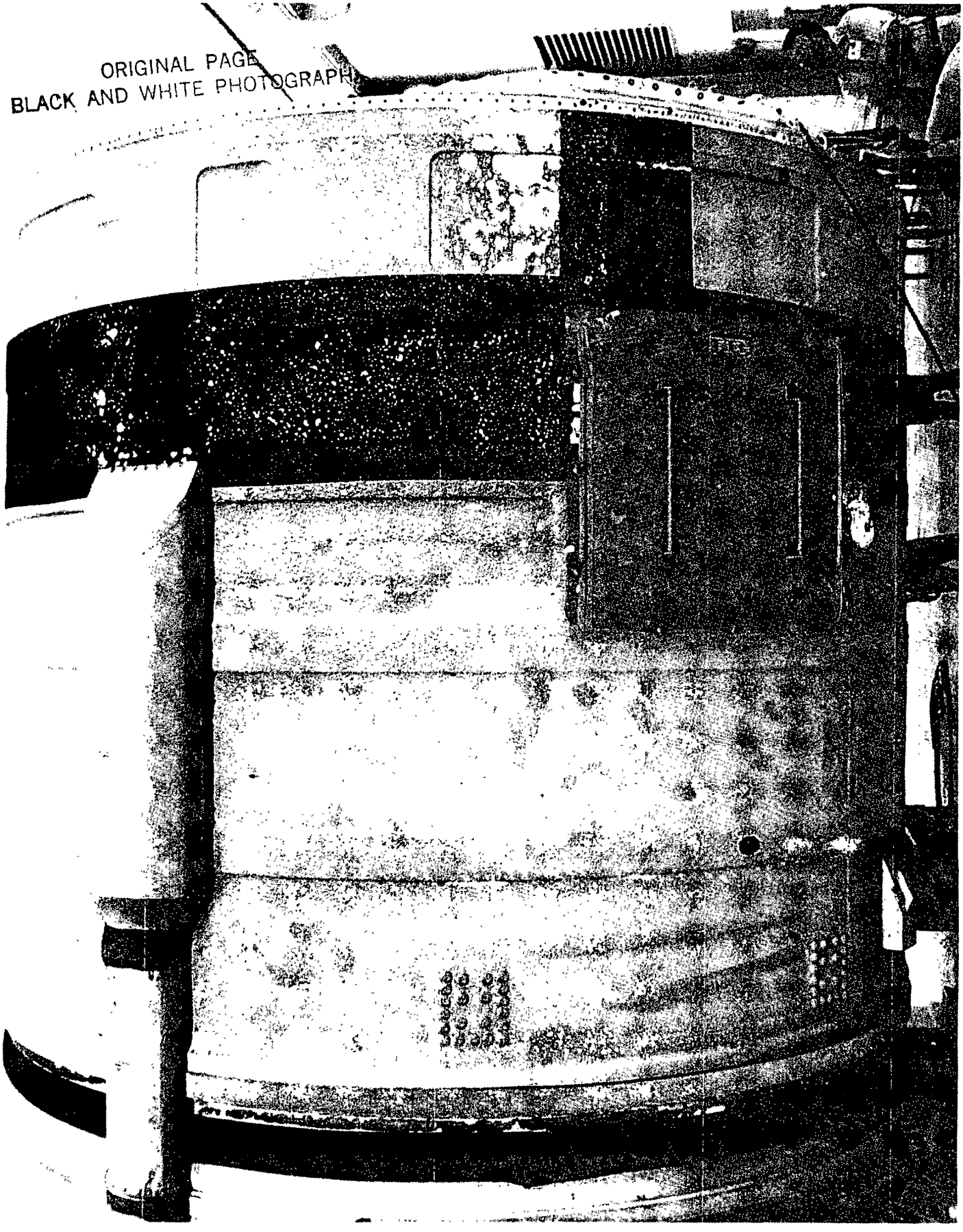
ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



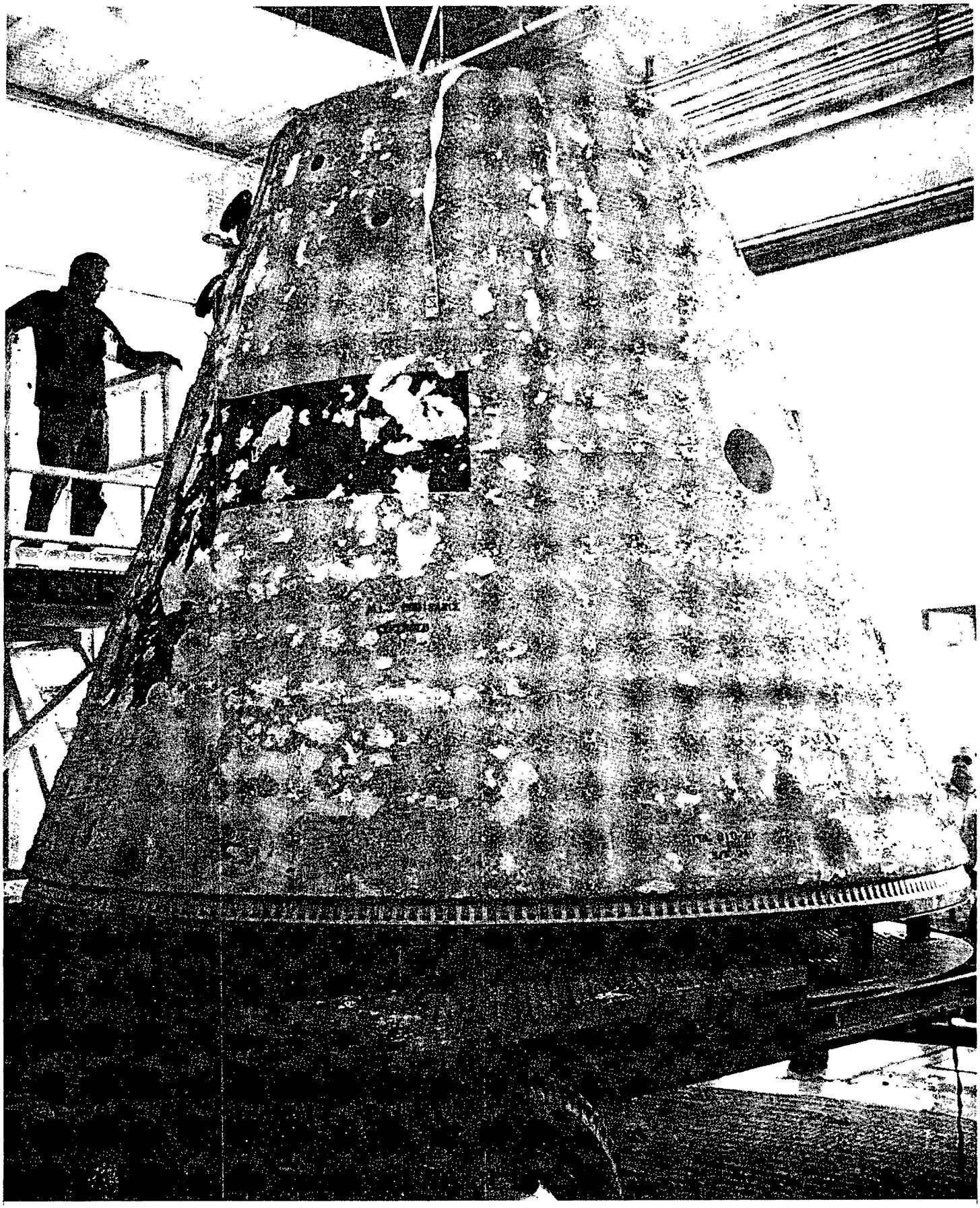
MISSING CORK FROM GIRTH INSTRUMENTATION BAND



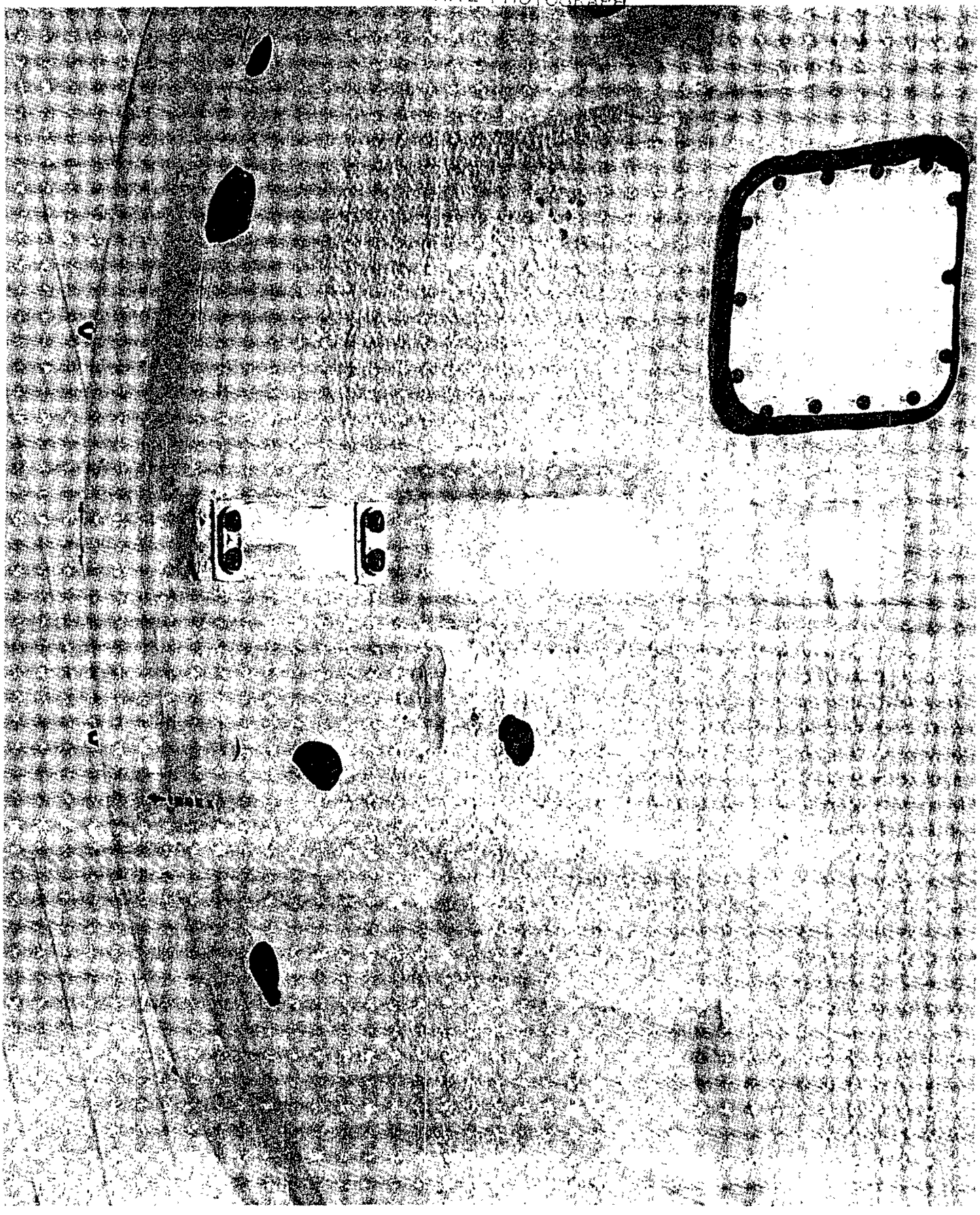
MISSING CORK FROM DFI CLOSEOUT ON RH SRB XB-939, 190 DEGREES.
DEBOND IS EVIDENT BY PAINT DRIPS ON SUBSTRATE



LEFT SRB FORWARD SKIRT EXHIBITS BLISTERING OF HYPALON PAINT



SEVERE TOPCOAT BLISTERING OVER ENTIRE SURFACE OF LH SRB FRUSTUM



MISSING ABLATOR AND DIVOTS FROM RIGHT SRB FRUSTUM

11.0 ORBITER POST LANDING DEBRIS ASSESSMENT

A detailed post landing inspection of OV-103 was conducted October 3-4, 1988 at Dryden (EAFB) on Lakebed Runway 17L and in the Mate/Demate Device (MDD) to identify debris impacts, damage caused, and if possible, debris sources. The Orbiter sustained a total of 411 hits, of which 55 had a major dimension of one inch or greater. By comparison, the debris impacts for STS-32 (61-C) were 193 and 39, respectively (Figure 24). These numbers do not include the numerous small hits typically occurring on the base heat shield and upper body flap (approximately 350 for this flight).

The post landing walkdown of Runway 17L was performed L+1 hour. Three broken pieces of black tile (first was 5-1/2"x4", second was 5"x3", and third was 1-3/4"x1") were found on the runway in the vicinity of main landing gear deployment. All three pieces were triangular in shape and corresponded to two areas of missing tile on the main landing gear doors (forward outboard corner tiles on the right and left hand doors). A 2"x2" landing gear door thermal barrier spacer also lay on the runway in the same general area as the tile pieces. The spacer originated from the nose landing gear door. In general, the runway was in good condition. The Orbiter touched down to the left of the centerline with both main gear contacting the runway simultaneously. During rollout, the right main gear rolled into the centerline tar and remained there until shortly before wheel stop. Orbiter roll distance was recorded as 7451 feet.

The most significant tile damage site was located on the right wing lower surface 6 feet outboard of the main landing gear door hinge line. The damage crater, which spanned six tiles, measured 18"x6"x1-1/2" with the exposed tile material showing indications of heat exposure, i.e. crusty surface, erosion, and melted tile coating (Figure 25). An area aft of this damage site on the elevons showed a high concentration of 116 small hits and approximately 3 damage hits greater than one inch in major dimension. This damage is believed to be a result of secondary impacts of particles from the large forward damage site. Another significant area on the right wing lower surface was located slightly inboard and aft of the right main gear door. The damage consisted of a cluster of 26 hits perpendicular to the tile surface with four hits greater than one inch in major dimension. No streaking consistent with aerodynamic streamlines was apparent. This damage site is believed to originate from a common unidentified source.

The damage pattern on the left wing lower surface was, in general, consistent with previous missions. The large concentration of small damage sites (57 less than 1-inch) is attributed primarily to protruding tile leading edge erosion caused by small debris particles in the boundary layer flow.

The total count of 342 hits for the lower surface, with 47 hits greater than one inch, was considered nominal for the number of damage sites greater than one inch and above nominal for the number of smaller damage sites (which can be attributed as 1) secondary hits from the primary site damage debris and 2) the high concentration of damage to tile leading edges due to erosion by small particles trapped in boundary layer flow. The small hits resulting from secondary debris impacts and the leading edge tile erosion were included in the totals. These types of hits should be given less weight when compared with data from previous flights due to their small size and lack of repeatability.

The body flap received minimal damage with only one hit greater than one inch. The lower elevon surfaces showed no damage. Although there were many hits forward of the main landing gear wells, only 15 had a major dimension greater than one inch.

The upper nose surface exhibited minor damage. Only 5 hits were observed with none larger than one inch. Both forward facing windows #3 and #4 were hazed. Other than two hits on the tiles adjacent to the right hand payload bay door hinges, no damage occurred on the Orbiter sidewalls.

Two AFRSI blankets on the left side of the aft compartment were torn. The first damage area consisted of an 18-inch long vertical tear just above vent door #9 while the second damage site was also a vertical tear 6 inches inches above the first.

Although the OMS pods sustained several debris impacts, damage is considered minimal. Some gap fillers were loose and protruding.

The rudder speed brake had one impact on the trailing edge of each side. No other damage was noted on the vertical stabilizer.

The thermal barriers around all three SSME's were badly frayed in some localized areas. The base heat shield exhibited the usual pattern of tile damage, though the amount of damage appeared somewhat greater than previous flights. One half of a tile was missing from a mounting bracket at the base of the LH OMS pod. (This tile was observed during the film review falling from the heat shield area during SSME ignition).

Debris impact maps are presented in Figures 26 - 29.

The tires, wheels, and brakes were in good condition and were not a debris contributor. No tire damage resulted from loose runway objects - rocks and other metal and wood debris.

The LOX ET/ORB umbilical face sheet was structurally damaged in the area of the disconnect mechanism. A U-shaped piece of metal dropped to the ground when the ET doors were opened. This metal

object originated from the umbilical separation bolts. One 2"x2" piece of tape from the LOX umbilical area was trapped in the umbilical bellows. The 4-inch LH2 recirculation line QD was audibly leaking due to ax piece of black debris jammed in the quick disconnect mechanism. The QD leakage was known, measured, and found within specifications prior to launch. The inner seal on the 17-inch disconnect was partially dislodged, but undamaged.

For the first time, an infrared imaging scanner similar to the KSC Shuttle Thermal Imagers (STI) was used to record the thermal signature of the Orbiter and estimate the kinetic surface temperatures of several areas. Values obtained are shown in Figure 30 along with the approximate times the measurements were taken. All readings were obtained by positioning the imager perpendicular to the surface of interest and averaging the values over a small surface for statistical validity.

FIGURE 24. STS-26R DEBRIS DAMAGE ASSESSMENT SUMMARY

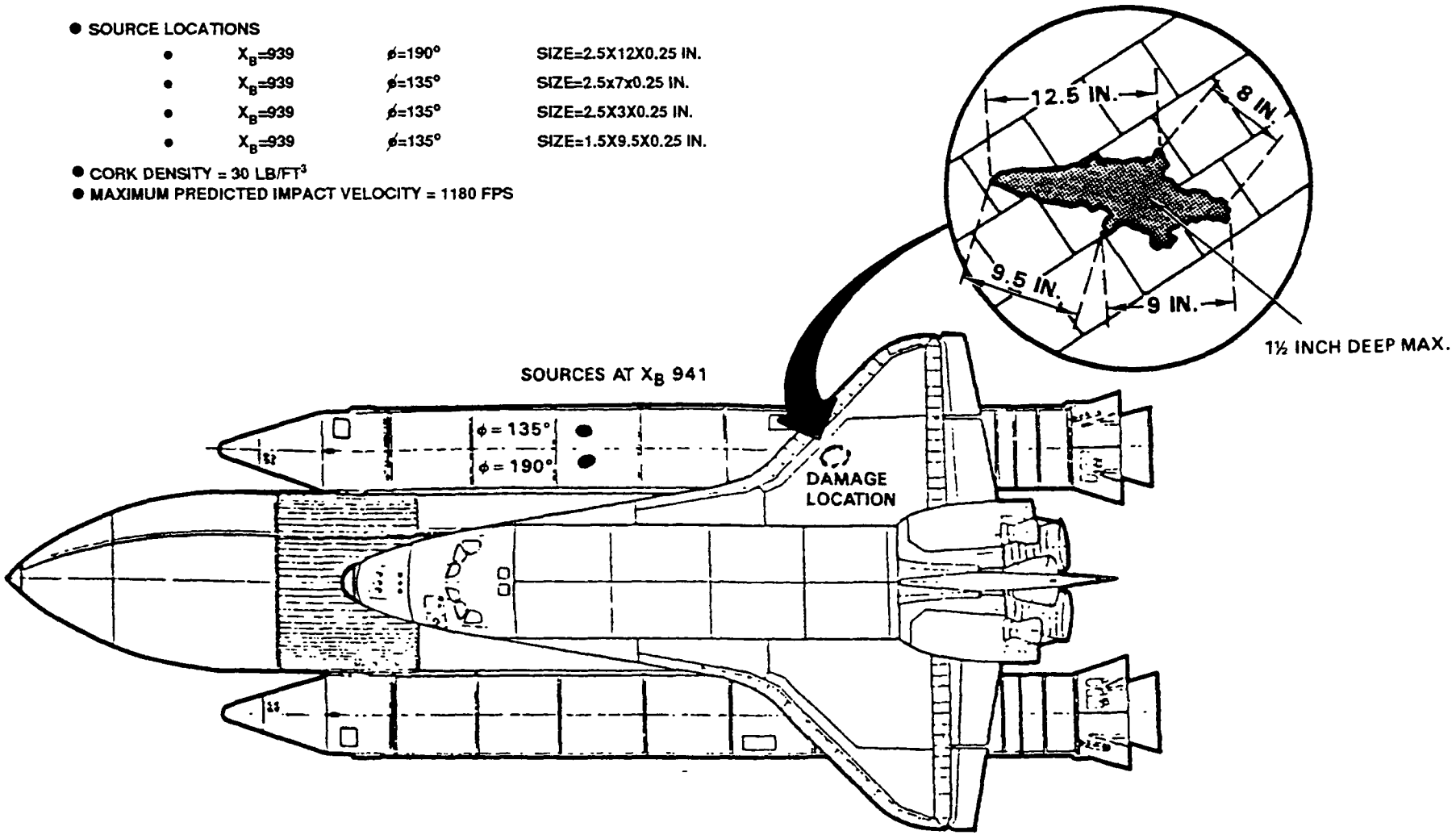
	Hits > or = 1"	Total Hits
Lower Surface	47	342
Upper Surface	0	5
Right Side	0	5
Left Side	0	9
Right OMS Pod	2	23
Left OMS Pod	6	27
TOTALS	55	411

COMPARISON TABLE

STS-6	36	120
STS-7	48	253
STS-8	7	56
STS-9 (41-A)	14	58
STS-11 (41-B)	34	63
STS-13 (41-C)	8	36
STS-14 (41-D)	30	111
STS-17 (41-G)	36	154
STS-19 (51-A)	20	87
STS-20 (51-C)	28	81
STS-23 (51-D)	46	152
STS-24 (51-B)	63	140
STS-25 (51-G)	144	315
STS-26 (51-F)	226	553
STS-27 (51-I)	33	141
STS-28 (51-J)	17	111
STS-30 (61-A)	34	183
STS-31 (61-B)	55	257
STS-32 (61-C)	39	193
STS-26R	55	411

FIGURE 25. STS-26 Right-Hand SRB Cork Insulation Debris Sources

- SOURCE LOCATIONS
  - X_B=939 ϕ=190° SIZE=2.5X12X0.25 IN.
  - X_B=939 ϕ=135° SIZE=2.5x7x0.25 IN.
  - X_B=939 ϕ=135° SIZE=2.5X3X0.25 IN.
  - X_B=939 ϕ=135° SIZE=1.5X9.5X0.25 IN.
- CORK DENSITY = 30 LB/FT^3
- MAXIMUM PREDICTED IMPACT VELOCITY = 1180 FPS



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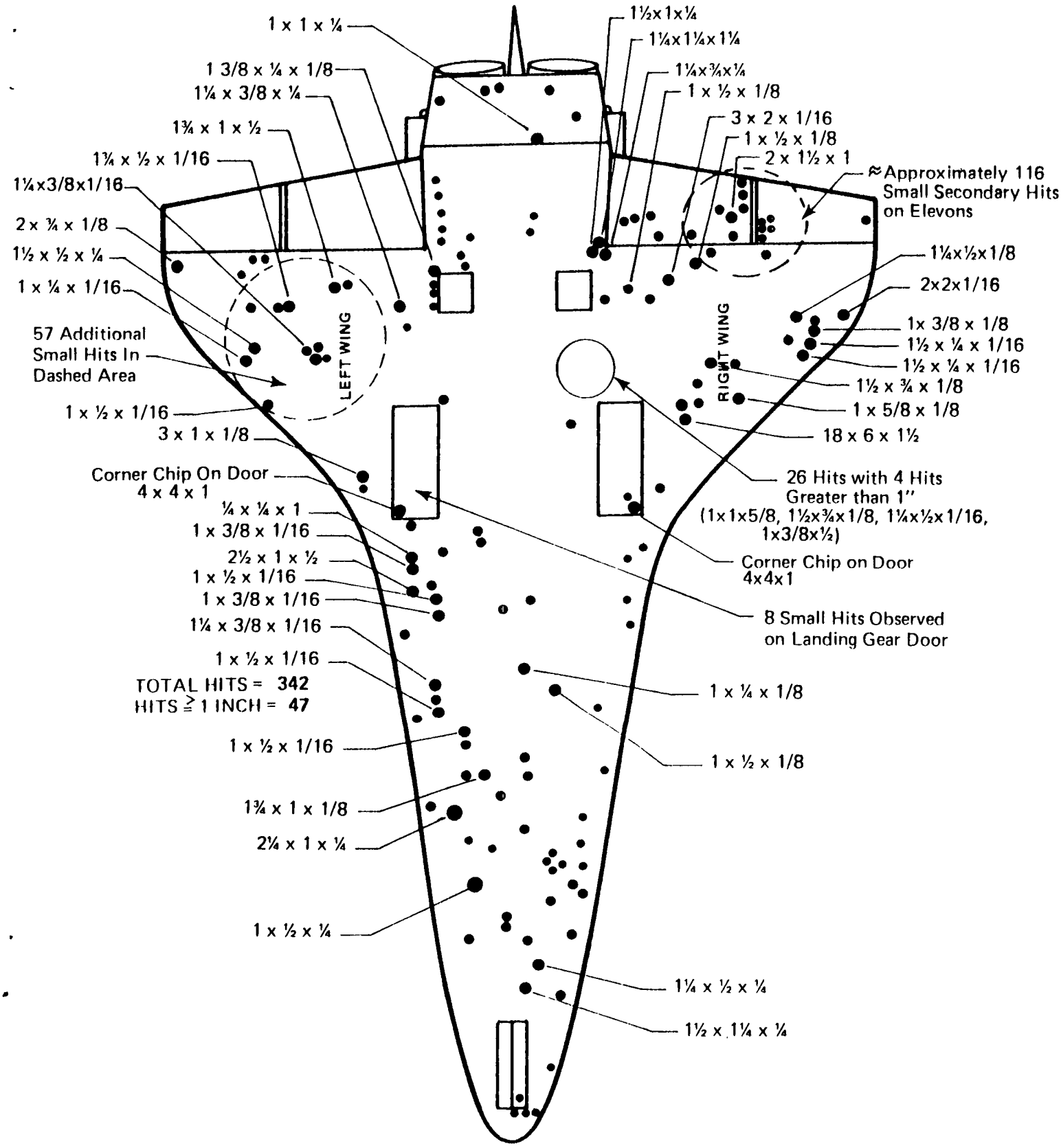
John F. Kennedy Space Center

KSC FORM 4-607 (1/87)

200

FIGURE 26. **DEBRIS DAMAGE LOCATIONS** Lower Surface



EGG/V 0888

FIGURE 27. **DEBRIS DAMAGE LOCATIONS** Right Side

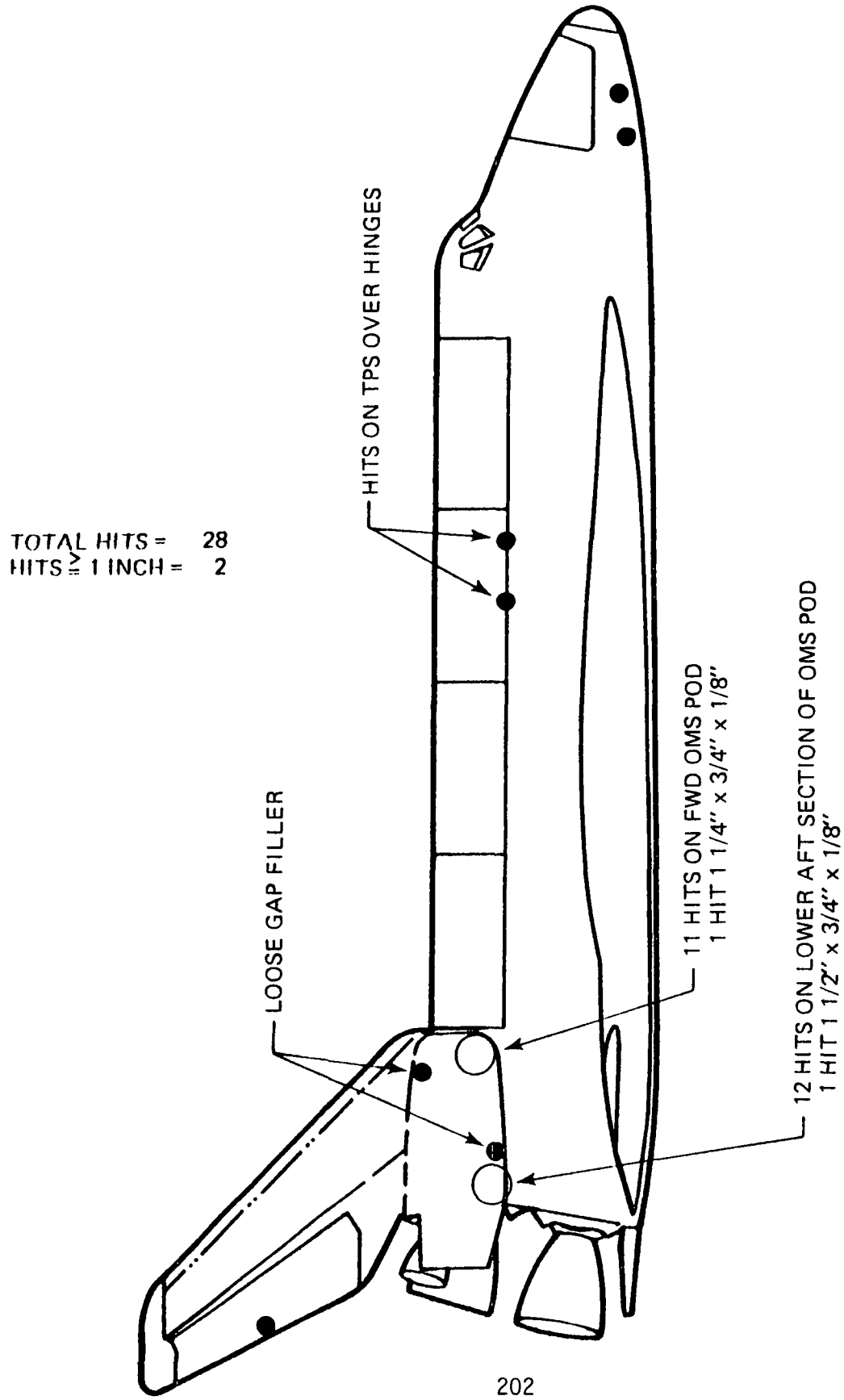


FIGURE 28 **DEBRIS DAMAGE LOCATIONS** Left Side

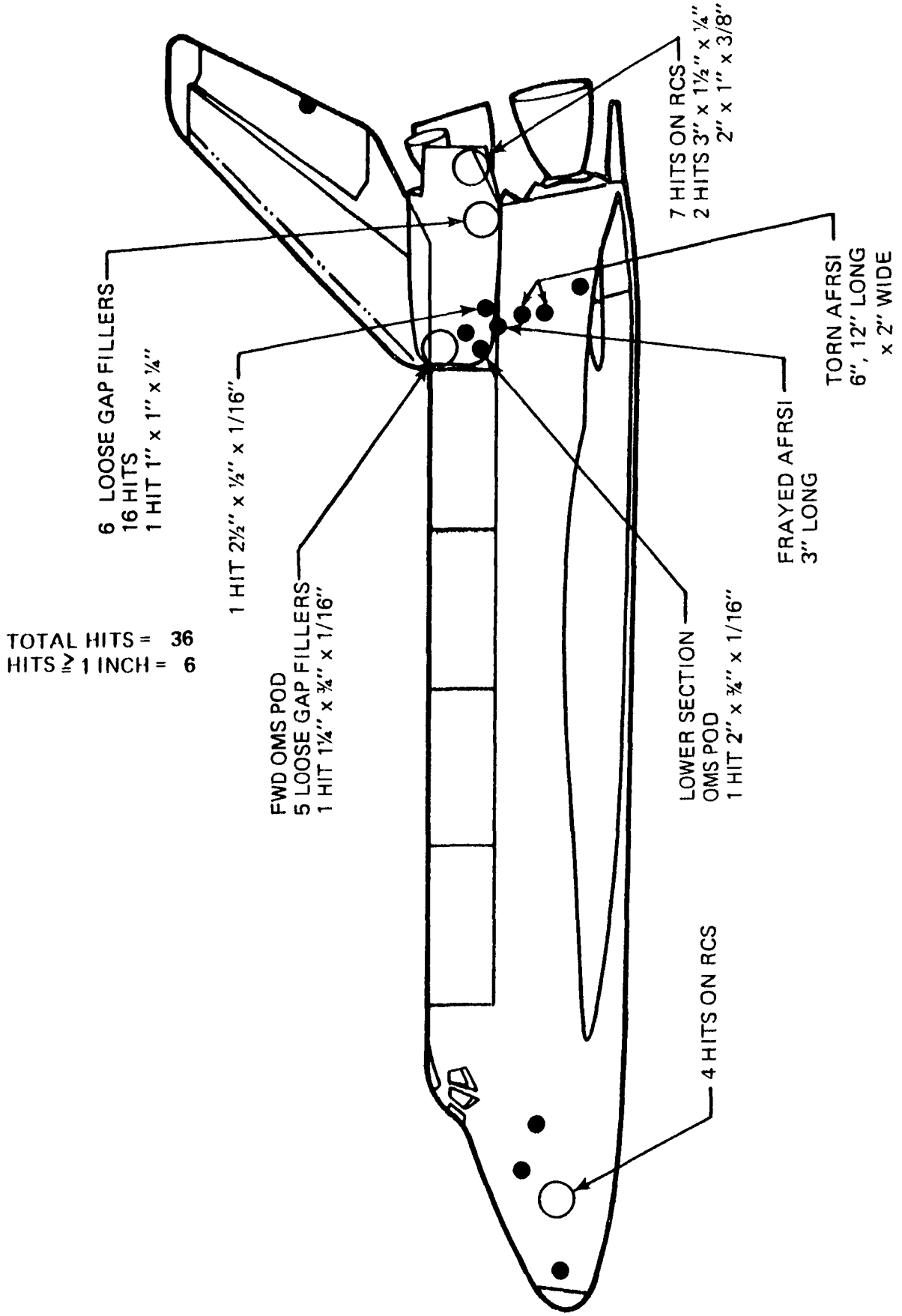
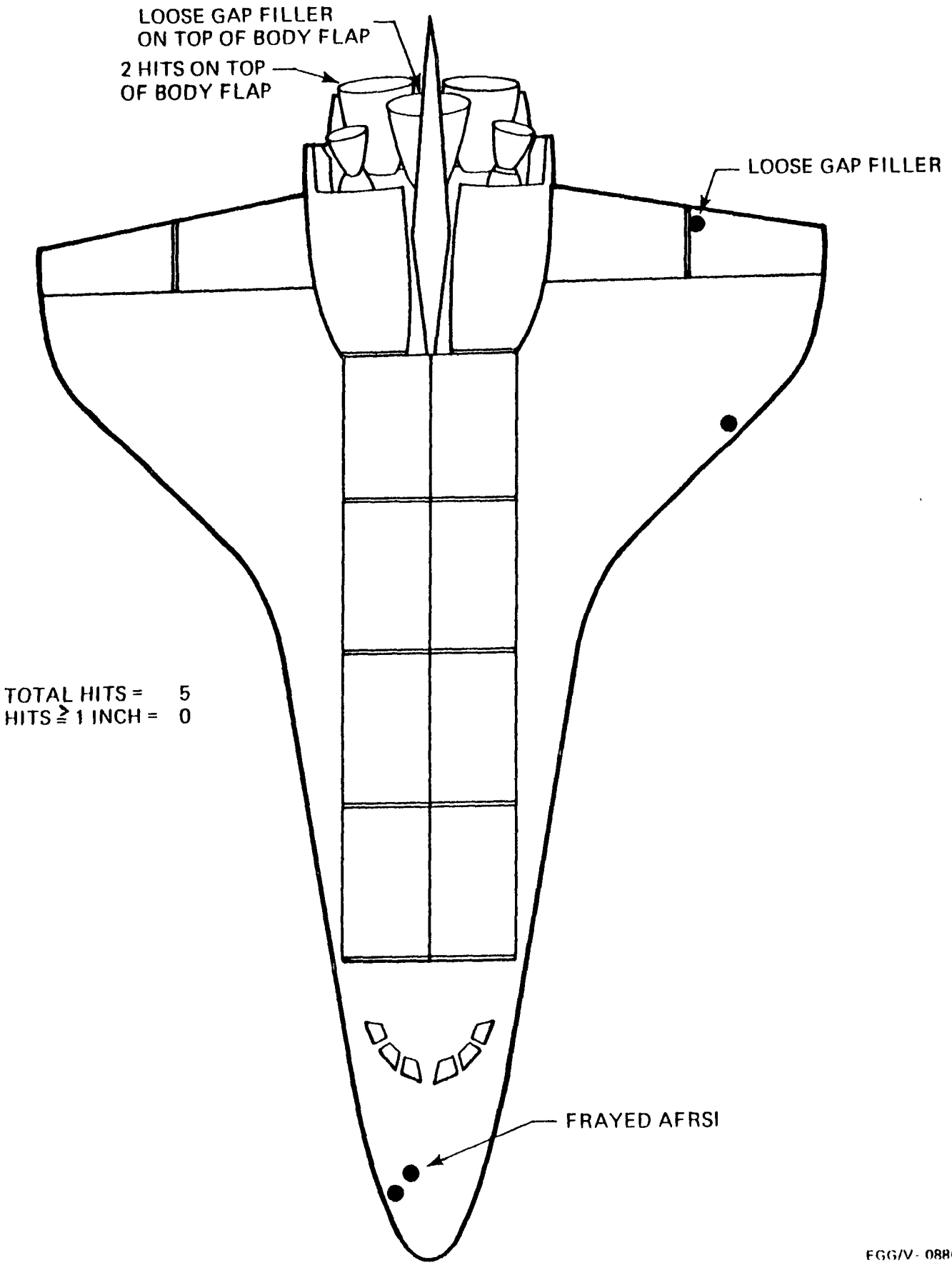


FIGURE 29. **DEBRIS DAMAGE LOCATIONS** Upper Surface



STS-26R

POST-LANDING RCC TEMPERATURE MEASUREMENTS

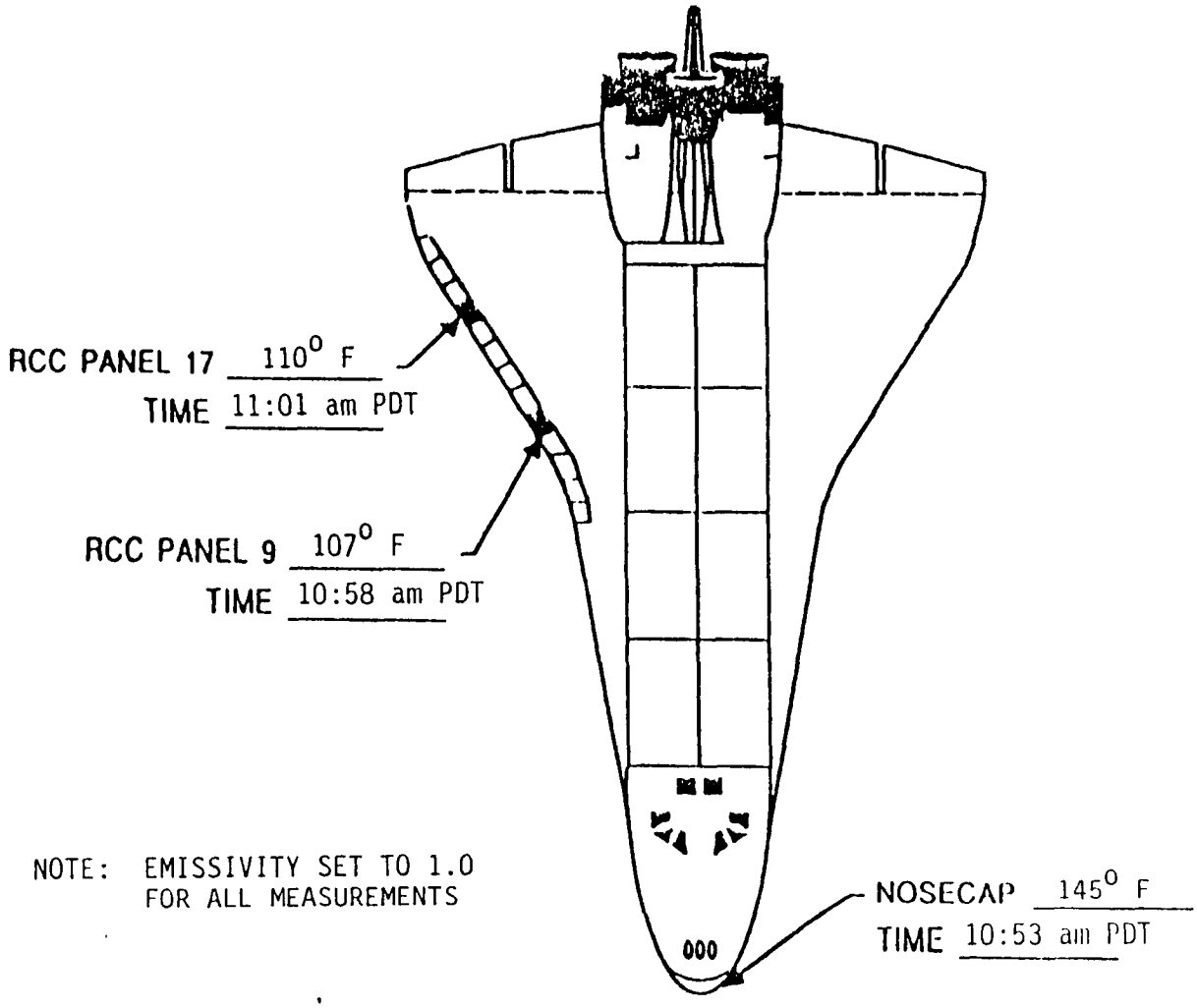
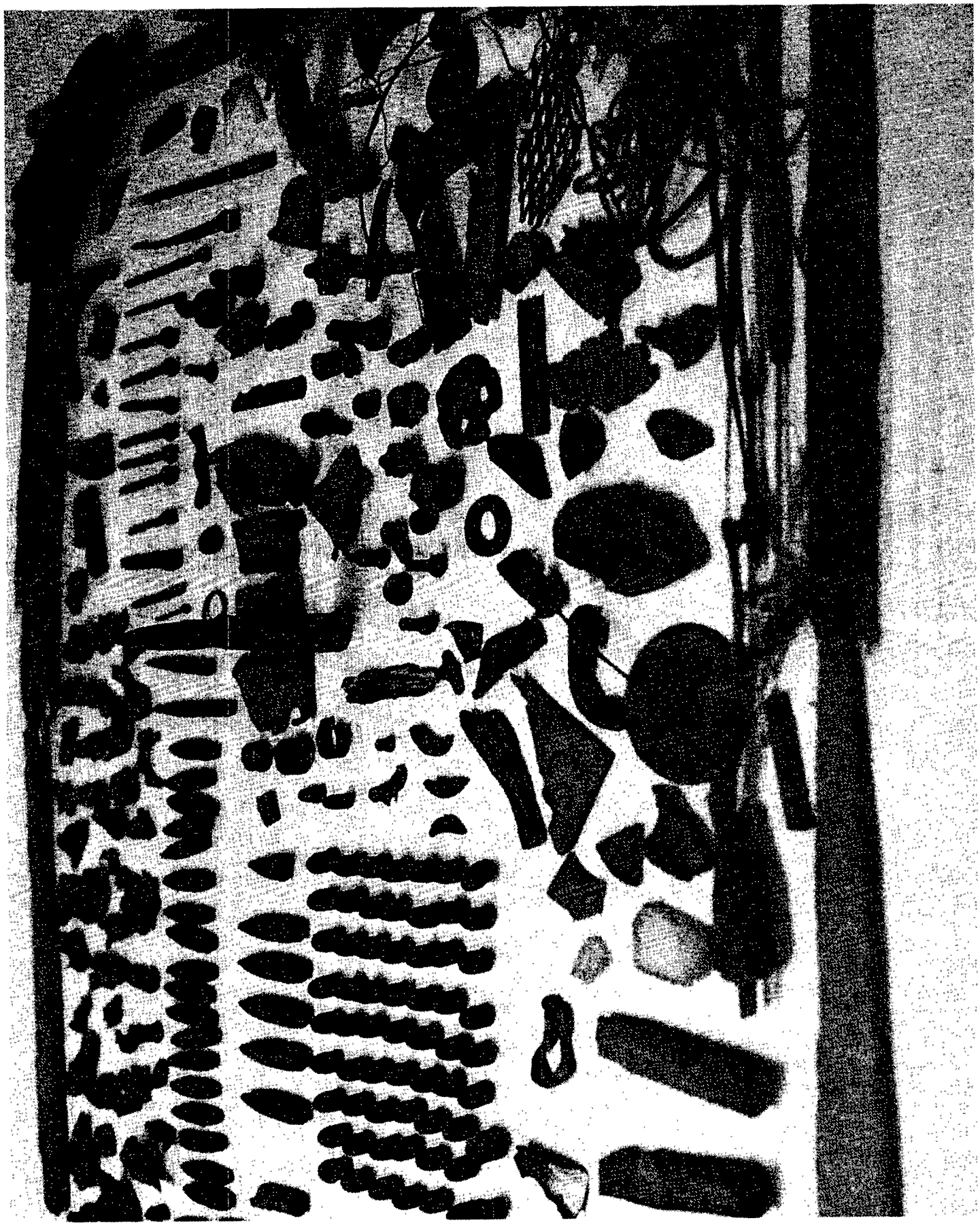
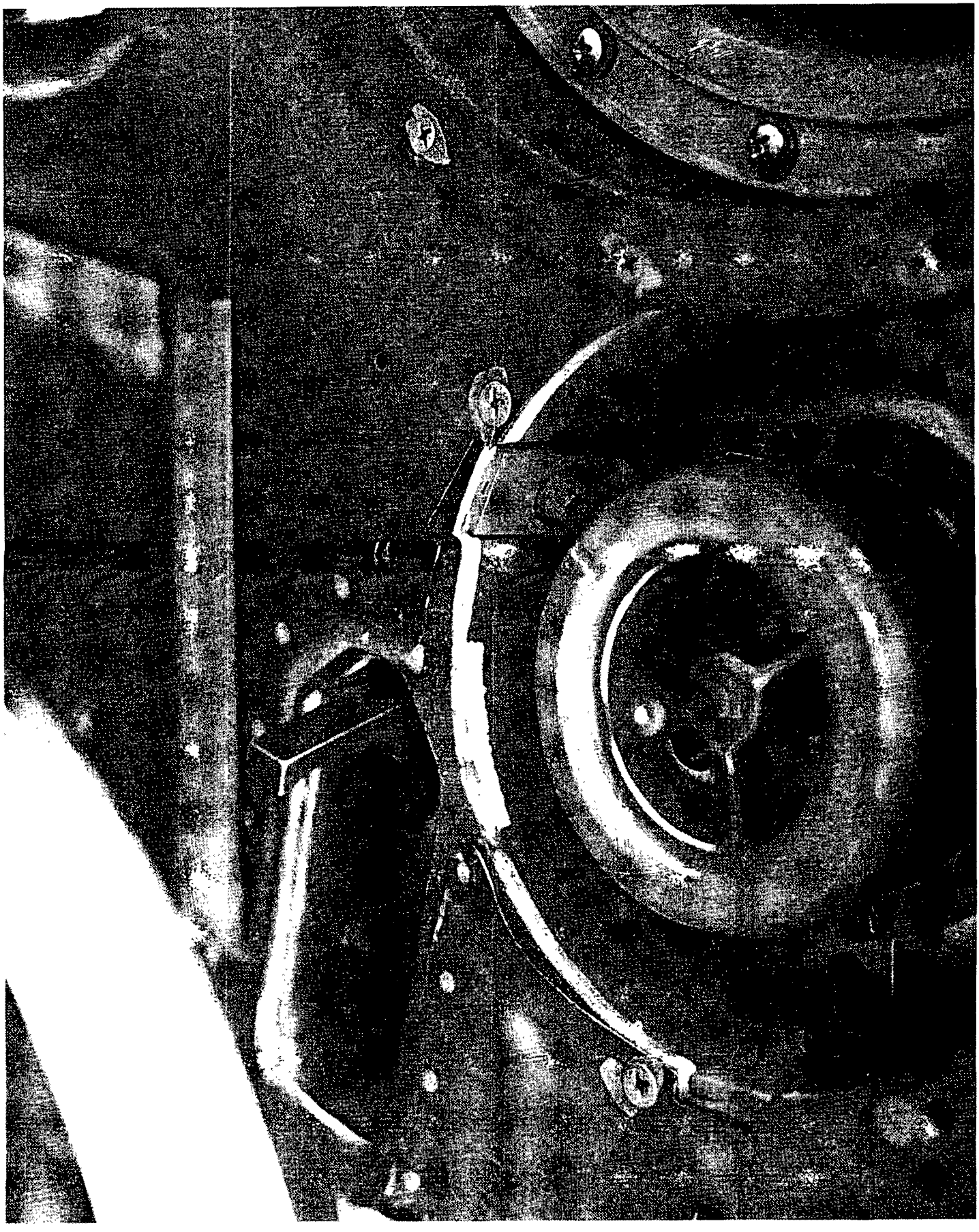


FIGURE 30

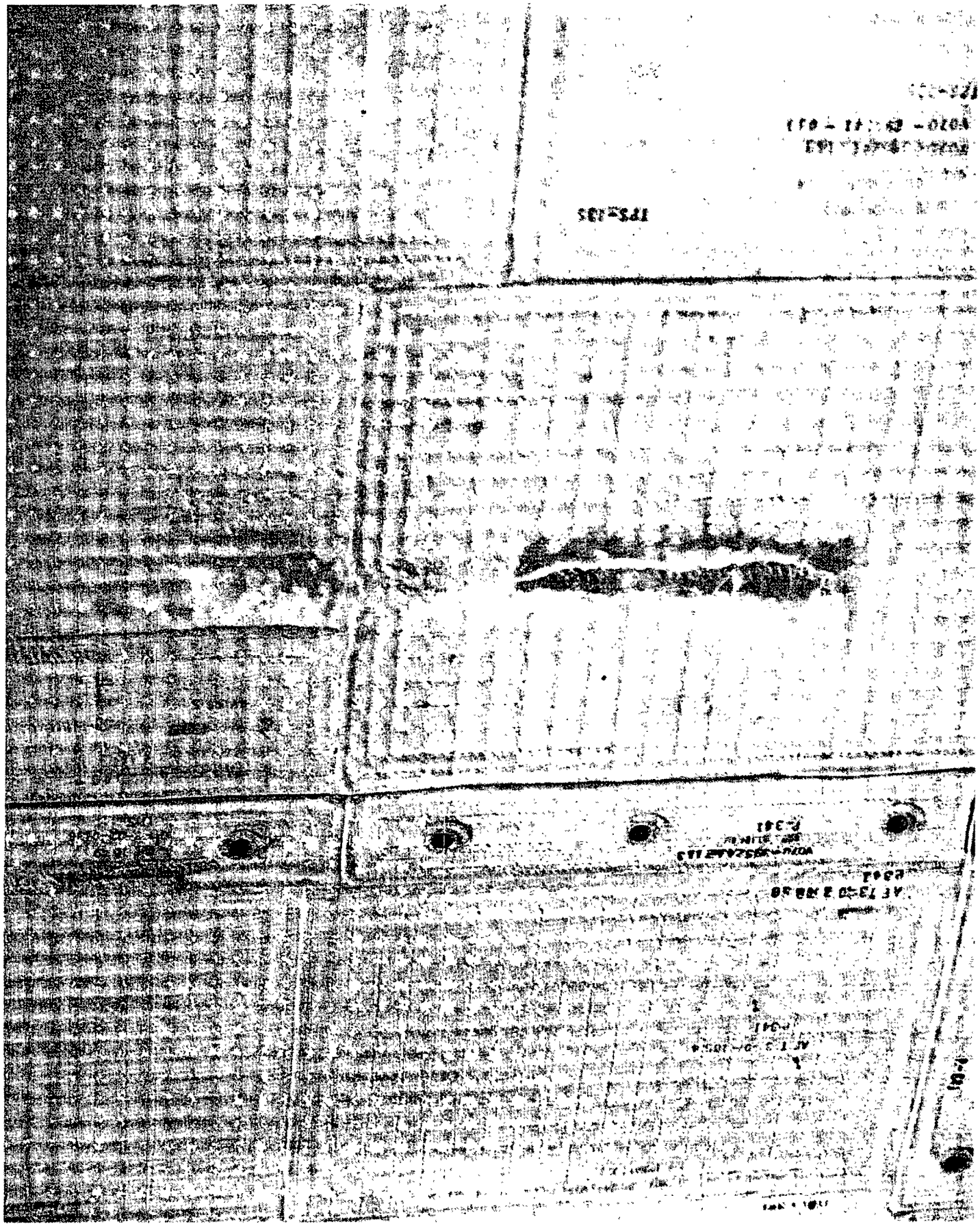


DEBRIS COLLECTED DURING RUNWAY PRE-LANDING INSPECTION

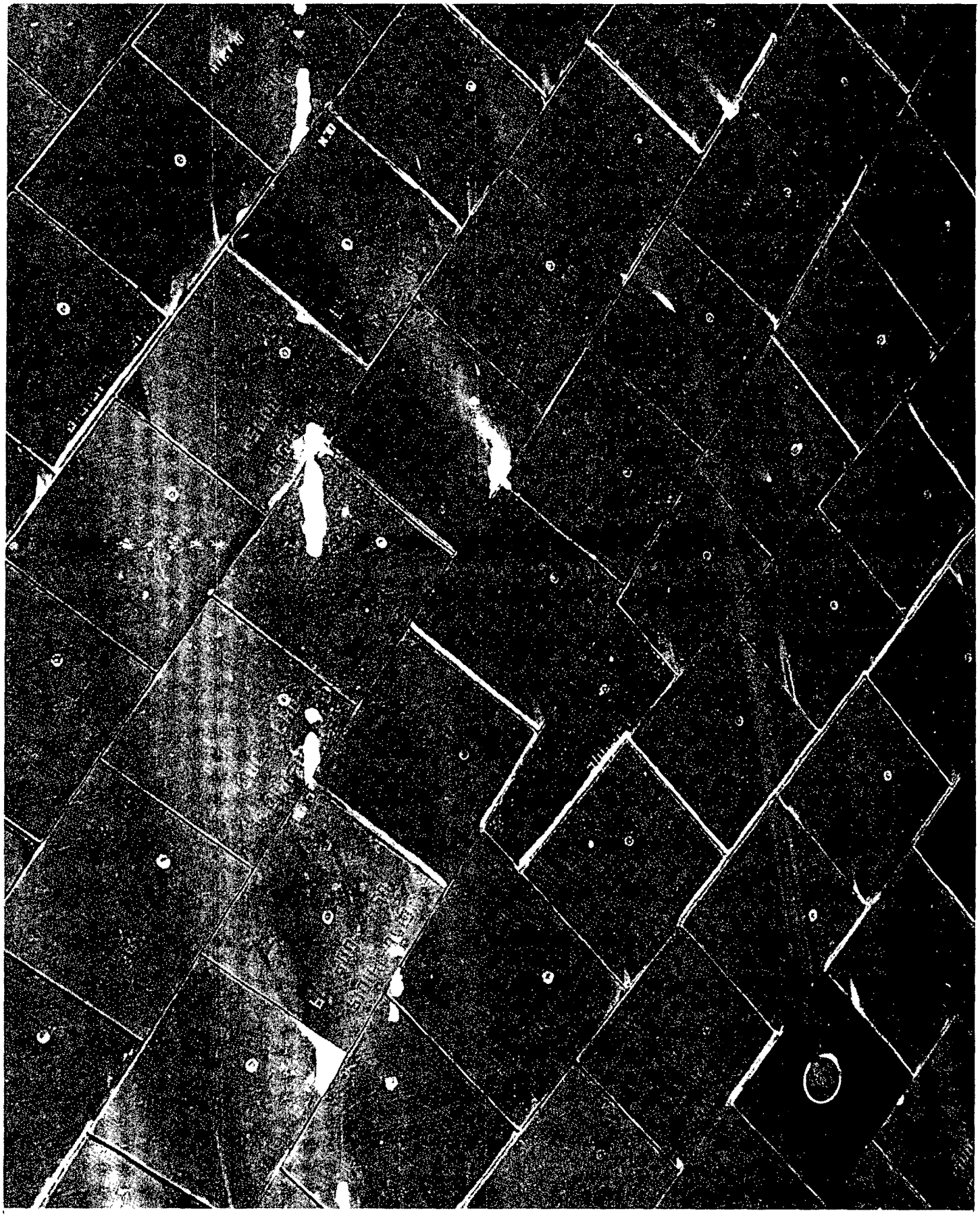
PIECE OF MLG DOOR CORNER TILE RECOVERED NEAR RUNWAY THRESHOLD



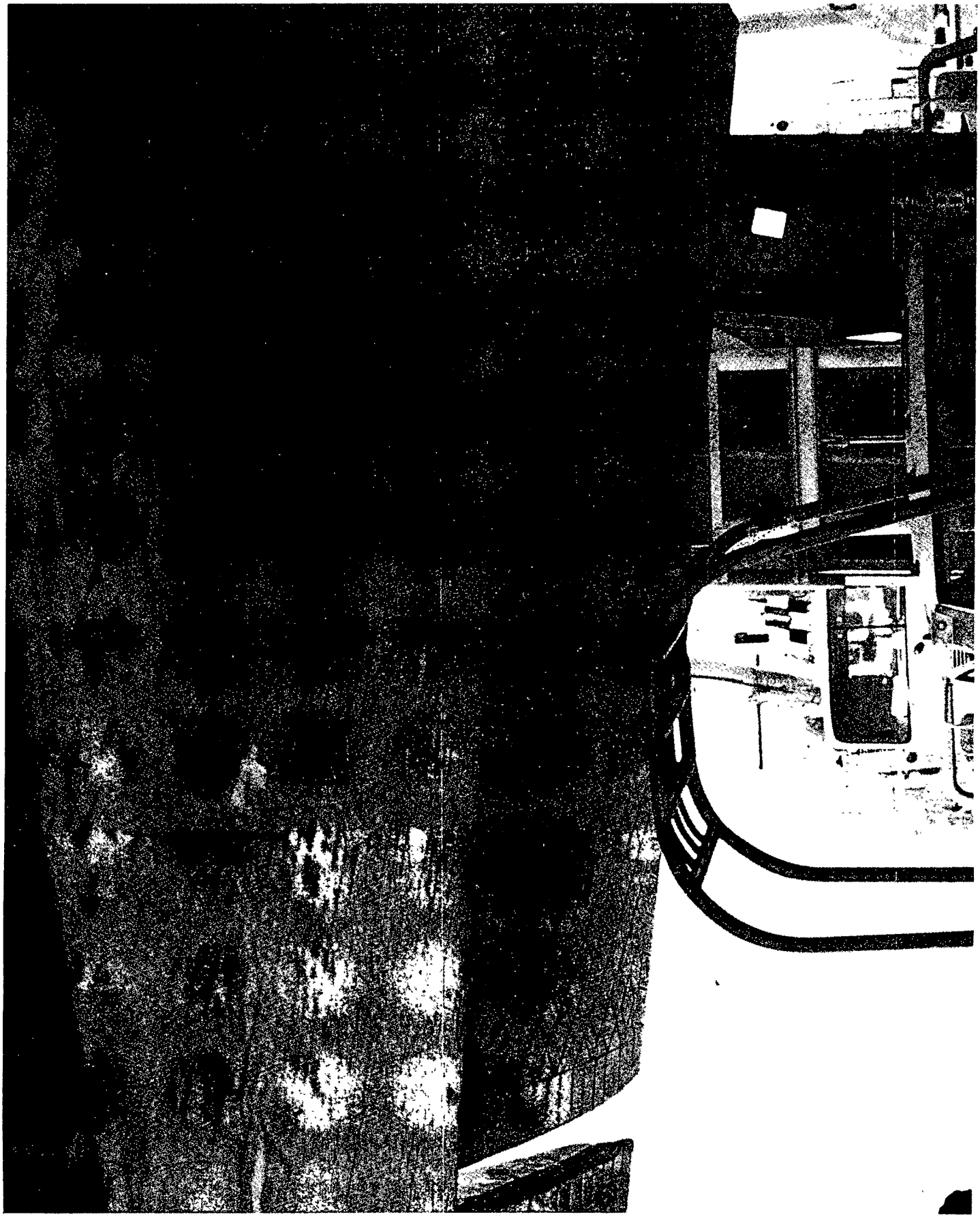
ET/ORB LO2 UMBILICAL FACE SHEET DAMAGE
IN AREA OF DISCONNECT MECHANISM



AFRSI BLANKET DAMAGE NEAR LEFT VENT DOOR #9



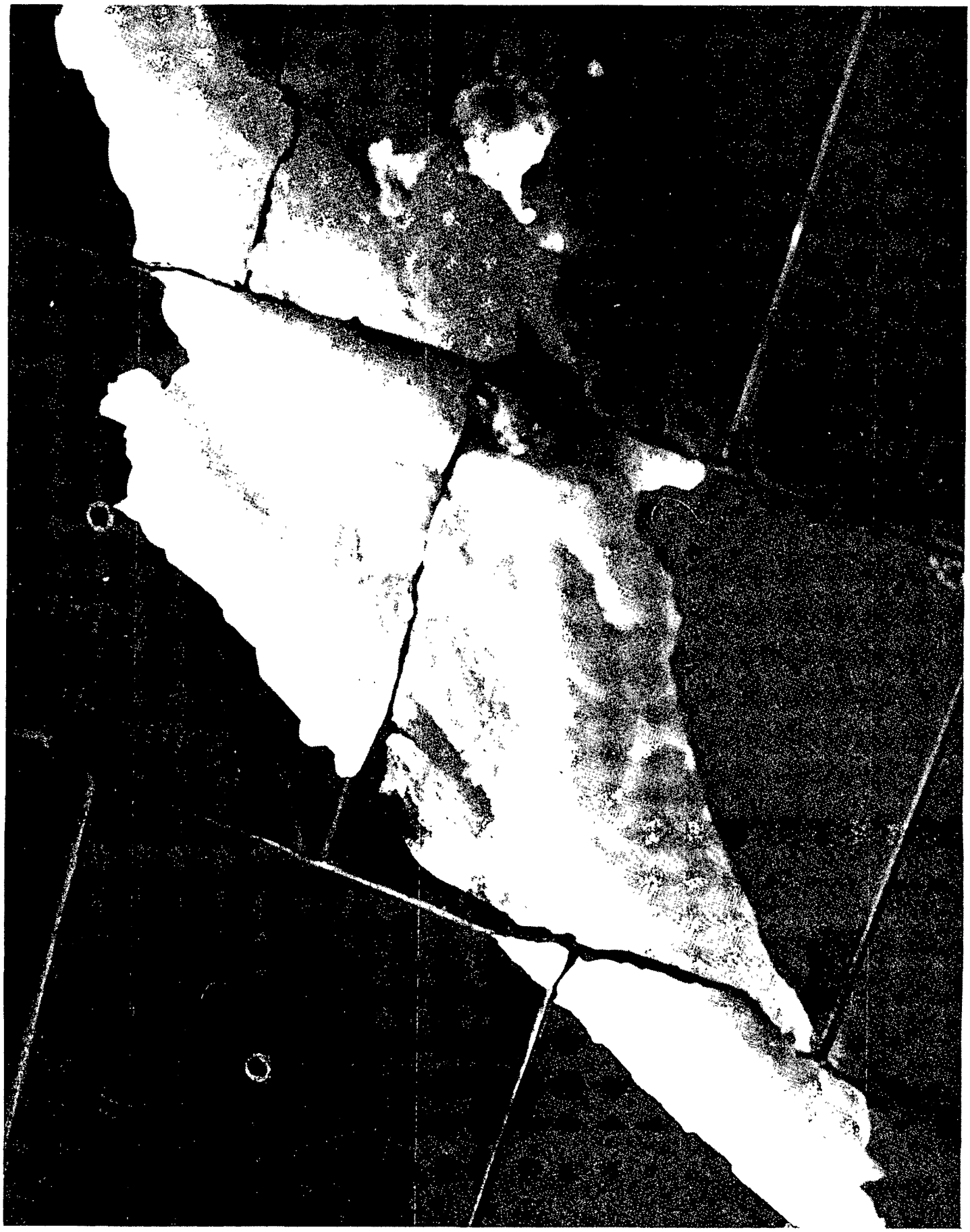
LINEAR STREAK OF TILE DAMAGE ON RIGHT WING LOWER SURFACE



TILE DAMAGE CRATER ON RIGHT WING LOWER SURFACE
CAUSED BY DEBRIS IMPACT DURING ASCENT

SIX TILES ARE DAMAGED BY INITIAL DEBRIS IMPACT

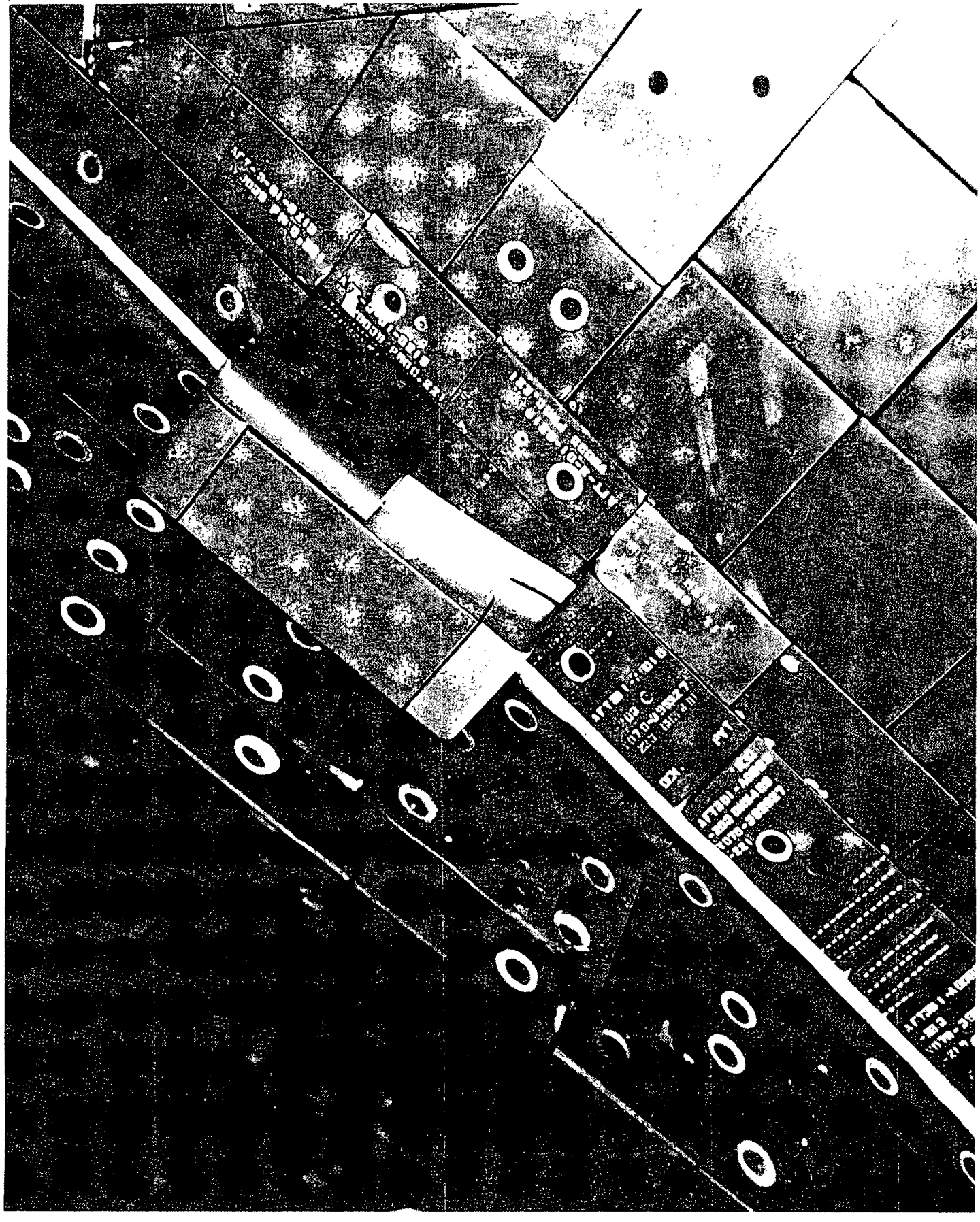
ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



TILE MATERIAL IN DEBRIS IMPACT CRATER
EXHIBIT SIGNS OF RE-ENTRY HEATING

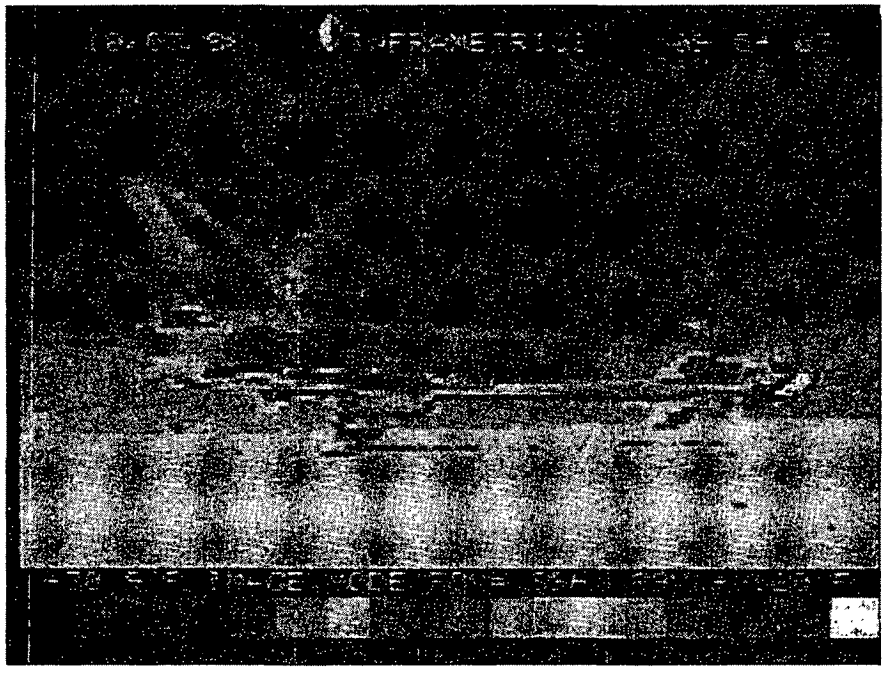
TYPICAL DAMAGE TO TILES ON ORBITER AFT HEAT SHIELD

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



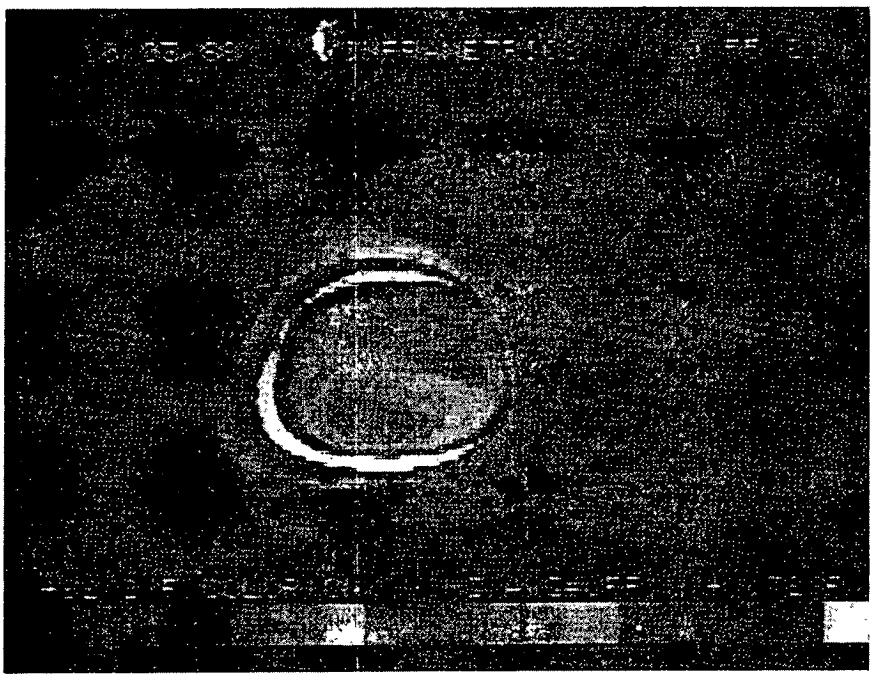
MISSING TILE FRAGMENT FROM LEFT OMS POD MOUNTING BRACKET BROKE LOOSE AT SSME IGNITION

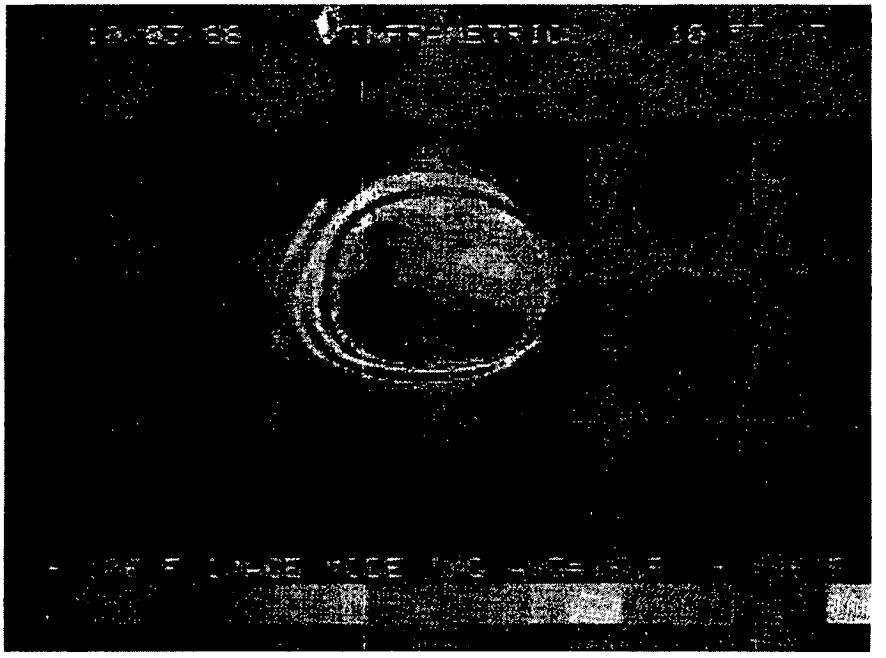
ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH



THERMAL INFRARED SIGNATURE OF ORBITER SHORTLY AFTER WHEEL STOP. APU EXHAUST IS VISIBLE NEAR VERTICAL STABILIZER

ORIGINAL PAGE
BLACK AND WHITE PHOTOGRAPH





THERMAL INFRARED SIGNATURE OF RCC NOSECAP 90 MINUTES AFTER LANDING

MICROCHEMICAL ANALYSIS BRANCH
DM-MSL-1, ROOM 1274, O&C BUILDING
NASA/KSC
October 17, 1988

SUBJECT: Tile Dust from Marked Locations

LABORATORY REQUEST NO: MCB 769-88

1.0 FOREWORD:

1.1 REQUESTER: L.R.Duncil/TV-MSD-11/7-0947

1.2 REQUESTER'S SAMPLE DESCRIPTION:

Tile dust removed from orbiter TPS, OV-103 and the samples were identified as follows:

#1. V070 - 191018-115, MDR

#2. V070 - 394038-130, MID-3-08-1129

#3. V070 - 191008-037

1.3 REQUESTED:

Identify contaminants in the dust.

2.0 CHEMICAL ANALYSIS AND RESULTS:

2.1 Procedures:

The submitted samples were analyzed by means of optical microscopy (OM) and electron microprobe with energy dispersive spectrometry (EDS).

2.2 Results:

2.2.1 The particles were classified into components on the basis of color and texture by OM.

2.2.2 Table I lists estimated amounts of each component by volume percent and elemental analysis by EDS.

Table I

Component ID	Elemental Analysis by EDS* Major	Minor
(1) MDR		
a. White fibrous mtls (90)	Si	
b. Dark glassy mtls (10)	Si	
(2) MID 1129		
a. Dark glassy mtls (95)	Si	
b. White fibrous coatings (5)	Si	
(3) 037		
a. White fibrous mtls (93)	Si	
b. Dark glassy mtls (4)	Si	
c. Red mtls (2)	Fe,Si	Ti,Ca
d. Blue mtls (T)	Si, Ti, Cr	Ca, Al
e. Grey mtls (1)	Si	
f. Black rusty mtls (T)	Si, Fe	

*: O,C,H, and B are not detectable by using this technique

(90): estimated volume percent

3.0 CONCLUSION:

3.1 The particulates were composed of white fibrous materials and dark glassy materials. The particulates from sample #3 contained red materials, blue materials, grey materials and black rust coatings in addition to the components mentioned above.

3.2 The white fibrous materials, dark glassy materials and grey materials appeared to be composed totally of tile materials.

3.3 The red materials in sample #3 appeared to be composed of room temperature vulcanizing (RTV) materials and blue materials were identified to be paint chips.

3.4 The black rusty materials were found on the surface areas of dark glassy materials and appeared to be a rust material.

3.5 No evidence of metallics from all samples was noted.

3.6 The samples were attached with this report.

CHEMIST: H. S. Kim
H. S. Kim

APPROVED: J. V. Jones
J. V. Jones

NASA

Report Documentation Page

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10. Work Unit No.

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13. Type of Report and Period Covered

12. Sponsoring Agency Name and Address

14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

An Ice/Frost/Debris Assessment was conducted for Space Shuttle Mission STS-26R. Debris inspections of the flight elements and launch pad are performed before and after launch. Ice/frost conditions are assessed by use of computer programs, nomographs, and infrared scanner data during cryogenic loading of the vehicle followed by an on-pad visual inspection. High speed photography is viewed after launch to identify ice/debris sources and evaluate potential vehicle damage. This report documents the Ice/Frost/Debris conditions of Mission 26R and their effect on the Space Shuttle Program.

17. Key Words (Suggested by Author(s))	18 Distribution Statement
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