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TECHNICAL PUBLICATION

PHOTOGRAPHIC EVALUATION REPORT
MISSION 4007
23-27 APRIL 1964

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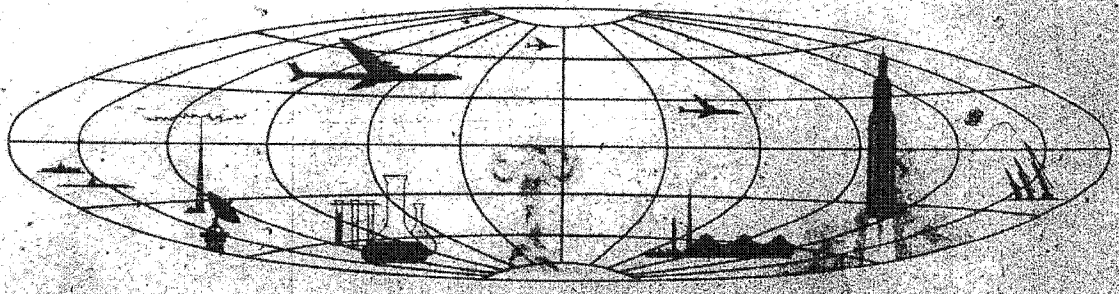

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LIST OF ILLUSTRATIONS

All photographs in this publication have been reproduced from the original negatives.

LIST OF ILLUSTRATIONS (Continued)

SYNOPSIS

The vehicle carrying camera number 1 M-7 was launched into a retrograde orbit on 23 April 1964. The purpose of the mission was to obtain high resolution satellite photographs of preselected targets, and to demonstrate full operational system capability of orbit adjustment, vehicle stabilization, and pointing capabilities. The mission was successful, and the payload capsule was recovered dry during the 65th revolution on 27 April 1964.

The vehicle achieved the planned orbit with a perigee of 83.9 nautical miles (nm), and after 16 revolutions which included 8 operational and 2 experimental photographic passes, the perigee altitude was adjusted to 71.5 nm. At this lower altitude an additional 23 operational and 5 experimental photographic passes were accomplished.

The photography acquired on this mission is some of the best satellite photography to date. Two hundred and fourteen targets were observed and reported in the preliminary intelligence report.

The weather was nominal and clouds covered 18.6% of the mission. The main camera operated satisfactorily throughout the mission. An obstruction in one yaw slit, and extremely overexposed stellar negatives preclude compiling accurate pitch, roll and yaw data; however, the index camera did record some horizons from which pitch and roll error was reduced.

No color film was included on this mission.

GENERAL FLIGHT DATA

Date of launch: 23 April 1964, 1847Z

Orbital Parameters:

	Revolutions 1-16	Revolutions 17-66
Period	88.15 min	88.01 min
Perigee	83.90 nm	71.50 nm
Apogee	210.60 nm	196.00 nm
Eccentricity	0.0177	0.0190
Perigee Latitude	1.50 N	57.37 N
Inclination Angle	103.50°	103.50°

The altitude was readjusted to the original orbital parameters between passes 60 and 63 for re-entry purposes.

PART I. CAMERA OPERATION

1. Main Camera: The main camera functioned properly on this mission. There are continuous minus density lines parallel to the major axis of the negatives which are caused by the accumulation of foreign matter in the aperture slit or imperfections in the manufacturing of the slit. Compression of imagery persists at the beginning and end of each frame, rendering this area unusable for photographic interpretation. Plus and minus density bars appear along the minor axis of the film in some frames (D05, D06, D07, D08, D09, D20, D25 and D39). These transverse bars are more prominent at the beginning of passes but are detected elsewhere (pass D08, frames 05 and 06; pass D09, frame 04; passes D20 and D39, all frames). The periodicity of

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the bars was measured in pass 1Z3. Although the frequency of occurrence is not consistent, they appear to be associated with the looper loading and unloading. These bars do not preclude accurate mensural computations although they do introduce possible error and degrade the photography for photographic interpretation. Some transverse bars may be the result of the film acquiring a warp from sitting in the looper under tension between passes.

The imagery from one of the view slits on the non-timing track edge of the negatives is vignetted, causing the loss of accurate vehicle attitude information. This vignetting was detected prior to launch, but it could not be rectified without a delay which was not considered advisable. Some vehicle attitude information was derived from the index camera when the vehicle roll was such that the image included portions of the horizons.

2. Stellar Camera. Although the stellar camera apparently functioned on this mission, stellar imagery cannot be detected because of extreme overexposure or non-image-forming light entering the lens. Inadequate baffling permitted earth flare to enter the optics in such quantity that proper shutter operation cannot be substantiated. A single frame appears to have received the proper exposure but stellar images cannot be detected in this frame.

3. Index Camera. This was the first mission of this type that successfully recorded imagery with the index camera. The camera functioned properly and the exposure was adequate. One frame (408) was double exposed. The two corners on the take-up side of all frames are slightly vignetted. The imagery on the index negatives can be readily correlated with the main camera imagery. The camera recorded 532 frames before the 100-foot film supply was exhausted in pass D54. The last four frames are damaged. Fifty-six frames of the index camera contain

( ) minus pitch indicates that the vehicle is nose down.
(-) minus roll indicates that the right wing is up.

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from 1.0 to 4.6. The photographs included snow-covered areas, granular areas, and tropical terrain. In general, the exposures to areas of high reflectivity were heavy, and the normal and tropical areas received normal to slightly less than optimum exposure.

2. Processing: Eleven percent of the mission material received primary development, five percent was processed at the intermediate level, and 58 percent received full development. The remaining 26 percent received varying levels of development during the transition between levels. All frames could not be given optimum development because of location. Frames containing imagery of high reflectivity, which normally would receive primary development, were adjacent to frames containing imagery of low reflectivity that required full development. In a Machett [illegible] densitometer and [illegible] 20 attachment and a 0.5 mm aperture using a tungsten light source, base plus fog gross densities of 0.28 were recorded in pass 026. Although this portion of the mission received full processing, these readings are higher than normally expected. The Dmin readings reflect this increase in gross fog density but the Dmax readings do not appear abnormal. Sensitometric control strips indicate that the processing was not the cause of the higher than normal gross fog.

4. Contrast: A qualitative study of the contrast was not undertaken. A subjective analysis of the mission indicates that the contrast is good. Special printing of the frames that received less than optimum exposure or development enhanced the interpretability of the material.

5. Degradations:

a. Main Camera: The original negatives from the main camera of Mission 4007 totalled approximately 2,900 feet. There were no major film degradations. Continuous minus density lines along the longitudinal axis are present throughout the mission. These lines appear as fine scratches. Minus density comets are noted in passes D16, D26, D31, D32, D45, D47, D48, and D58. Emulsion digs are present randomly throughout some passes. These digs project approximately 2.5" into the format from the edge opposite the time track and are most prominent in passes D07, D09, D22, D25, D38, D44, D47, and D54. Passes D56 and D58 contain severe creases. Minor base scratches are noted in the last half of the mission and are most notable in passes D58 and D641. A series of small minus density spots, 3.2" apart and 3.8" from the time track edge are present intermittently. Small pinholes appear randomly throughout the mission.

b. Stellar Camera: The negatives from the stellar camera contain corona and dendritic static in the first two and last twelve frames. The last 2 feet contain severe scratches and abrasions.

c. Index Camera: The negatives from the index camera contain intermittent dendritic static along the edge opposite the camera number. Approximately one-half of the negatives were scratched after processing. The last four frames contain severe scratches and abrasions.

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MAIN CAMERA NEGATIVES

Index	Main Camera	Index	Main Camera
001-013	D01	265-271	D37
014-031	D02	272-285	D38
032-053	D06	286-301	D39
054-058	D07	302-317	D40
059-066	D08	318-326	D41
067-085	D09	327-344	D42
086-103	D10	345-360	D43
104-105	D11	361-375	D44
106-128	D15	376-391	D45
129-153	D16	392-414	D46
154-159	D20	415-427	D47
160-173	D21	428-446	D48
174-193	D22	447-466	D49
194-200	D23	467-481	D47
201-215	D24	482-492	D48
219-242	D25	493-506	D53
243-264	D26	507-532	D54

PART III. IMAGE QUALITY

1. Photographic Interpretation (PI) Suitability: This is an assessment of the information content of photographic reconnaissance material and its interpretability. A number of interrelated factors are involved, such as the quality of the photography, the extent of target coverage, scale, weather limitations, and similar considerations. However, the criteria for assigning a PI suitability rating may be reduced to a) the scope of the photographic coverage and b) the degree to which a photo interpreter may extract useful and reliable information from the material.

PI suitability ratings are categorized as Excellent, Good, Fair, Poor, and Unusable. These ratings refer to the overall interpretive value of the photography obtained from a particular reconnaissance mission. Individual targets may also be assigned PI suitability ratings if that is necessary or desirable. The standards that determine assignment of the various ratings are as follows:

Excellent: The photography is free of degradation by camera malfunctions or processing faults and weather conditions are favorable throughout. The imagery contains sharp, well-defined edges and corners, with no unusual distortions. Contrast is optimal and shadow details, as well as details in the highlight areas, are readily detectable. Observation of small objects and a high order of mensuration are made possible by the consistently good quality of the photography.

Good: The photography is relatively free of degradation or limiting atmospheric conditions. Edges and corners of objects are well-defined. No unusual distortions are present. Detection and accurate mensuration of small objects is feasible, but to a lesser degree than in material rated as "Excellent".

Fair: Degradation is minimal but the acuity of the photography is less than optimum. Edges and corners of objects are not crisply defined and there is loss of detail in shadow and/or highlight areas. Detection and identification of small objects is possible but accuracy of mensuration is reduced by the fall-off in image quality and the less-than-optimum contrast that prevails.

Poor: Camera-induced degradations and/or weather limitations severely reduce the quality of the photography. Definition of edges and corners is not sharp. Only gross terrain features and culture may be detected or identified and distortion of form may exist. Accurate mensuration of even large objects is doubtful.

Unusable: Degradation of the photography completely precludes detection, identification, and mensuration of cultural details.

2. PI Suitability For Mission 4007: The PI suitability of this mission is given a rating of good. This mission produced photography equivalent to or better than any satellite photography received to date. With each successive mission of this type the interpreters are becoming more familiar with the material and are gaining more confidence in the photography. Stereo pairs make up 60 percent of the photography in this mission, and another 30 percent (identified in the Mission Correlation Data as strip photography) contains areas of overlap that can be viewed stereoscopically. The obliquity ranges from true vertical strips (pass D15, frame 02) to 45.38° oblique strips (pass D54, frame 08). No stereoscopic photography was attempted with the vehicle in a vertical attitude. The lowest stereo obliques were acquired while the vehicle was in a 0.71° roll (pass D59, frames 01 and 02). The highest stereo obliques were acquired while the vehicle was in a 44.67° roll

on a domestic pass (pass D47, frames 05 and 07, which are a portion of a stereo triplet).

Operational high stereo obliques were successfully accomplished with a roll angle of 42.54° (pass D27, frames 05 and 06). The photographs taken at oblique angles greater than 35° are more difficult to interpret because of the scale factor and unfamiliar perspective. However, with continued use these difficulties are being overcome. Photographic Interpreters observed and reported on 214 targets in the preliminary target readout. Highlights of this preliminary report include:

(a) Apparent efforts to disguise launch site proved ineffective.

(b) Launch area confirmed.

(c) A newly identified tracking station located.

(d) The first good look at a new electronic facility.

(e) Evidence noted of expansion of facilities at an aircraft assembly plant.

(f) Nuclear weapons storage and assembly site confirmed.

Domestic coverage on this and previous satellite missions has been invaluable to the interpreters. Photographs of domestic installations assist in the identification of facilities associated with similar foreign targets. The scale of the photography in Mission 4007 is the best scale of any satellite photography acquired to date. Information previously unattainable has been derived from 80 to 100 diameter enlargements of some targets.

The solar elevation was near optimum during the acquisition of the majority of the operational photography.

A subjective analysis of the mission material indicates that the main deterrents to the quality of the photography from this mission are the transverse bars and the high oblique photography in excess of 35°. However, neither of these deterrents impair mensuration.

FIGURE 1. STEREO PAIR WITH VEHICLE IN NEAR VERTICAL ATTITUDE.

Snow-Covered Terrain

Although there are no cultural features in the following stereo pair, it is included as an example of stereo when the vehicle is in a near vertical attitude.

Pass 1069
Frame 01
Index [illegible]
Enlargement 20x
Solar Elevation 24.0°
Solar Azimuth 218°
Solar Bearing 34°
Roll Angle 0.71°

FIGURE 7. STEREO PAIR WITH VEHICLE IN NEAR VERTICAL ATTITUDE.

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[illegible]

The following stereo pair is inserted as a comparison of the [illegible] targets imaged near center line in the [illegible] and targets imaged near the margins. The [illegible] strip imaged in pass 1040, frames 13 and 14 [illegible] pass 5 & 6) are approximately [illegible] from the center line. All [illegible] figures show [illegible] stereo pairs taken when the vehicle is in a pure vertical [illegible] to produce near optimum photographs for PI suitability.

Pass: 1040
Frame: 13
Index: 29 69.5-19.1
Enlargement: 20X
Solar Elevation: 62.3
Solar Azimuth: 156
Solar Bearing: 313
Roll Angle: 4.25

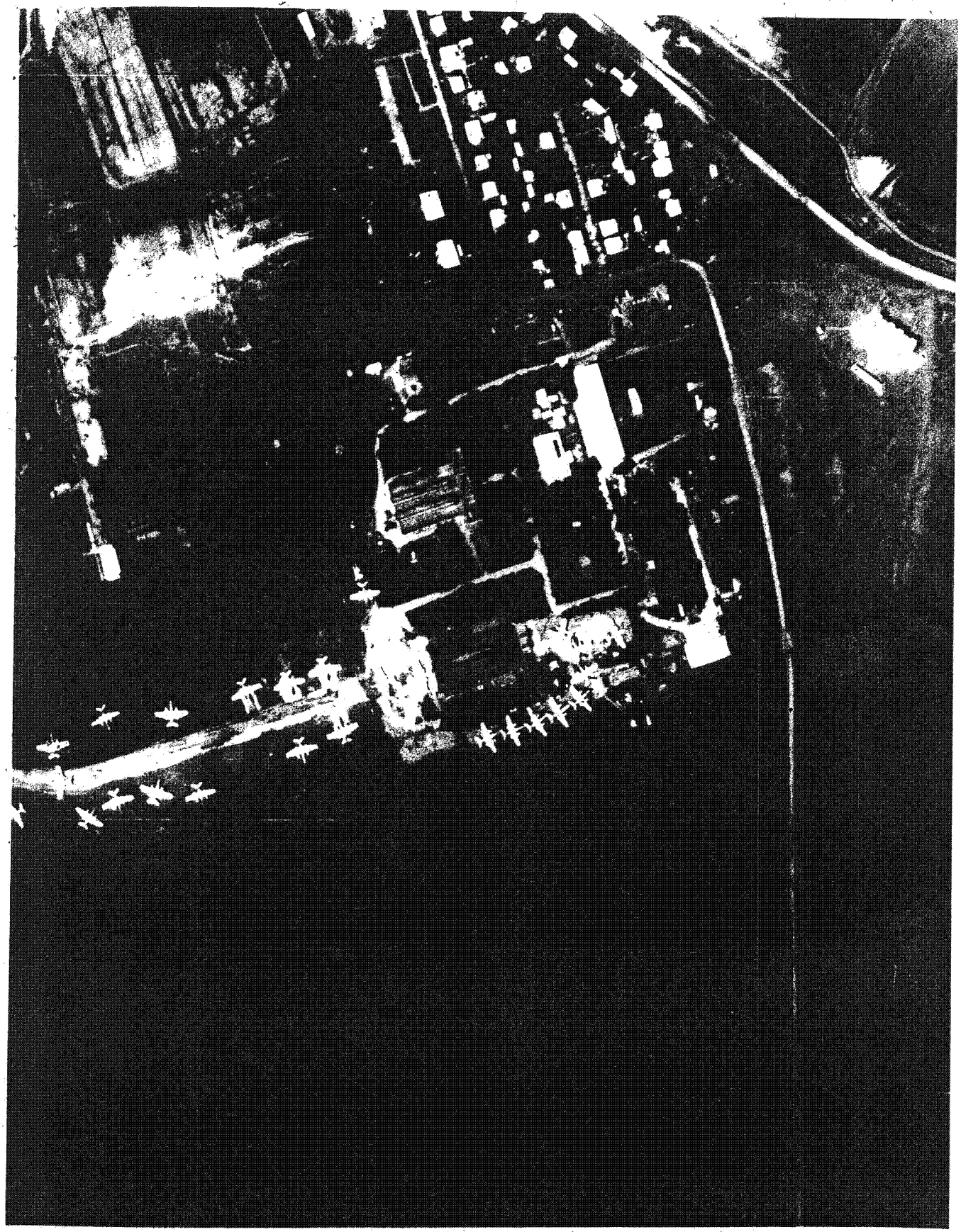

FIGURE 4. STEREO PAIR IMAGED NEAR CENTER LINE OF FORMAT.

ICS-7825/64
NPIC/TP-18/64

Pass: 1040
Frame: 13
Index: 29-76.0-04.5
Enlargement: 20X
Solar Elevation: 62.3
Solar Azimuth: 156
Solar Bearing: 313°
Roll Angle: 4.25°

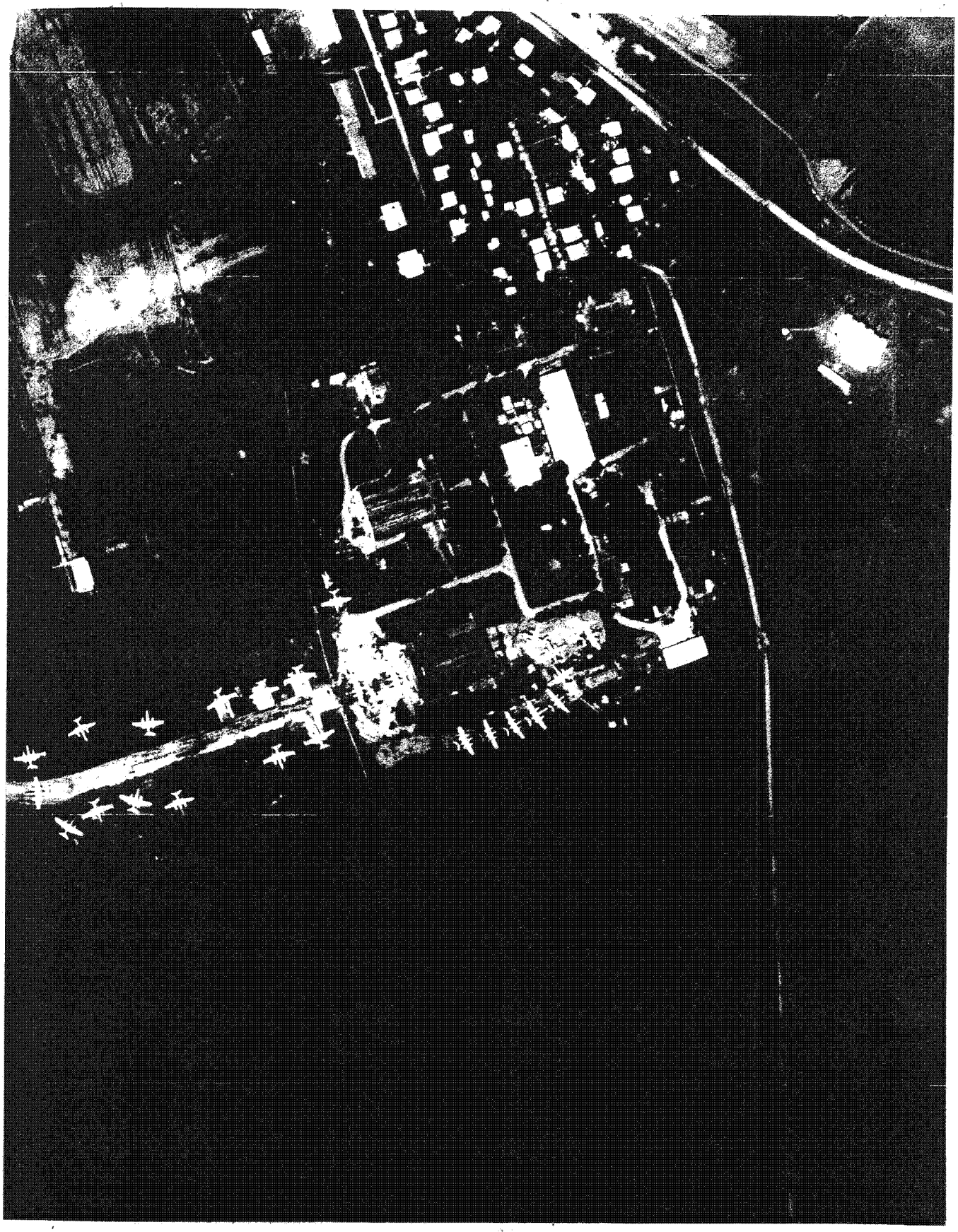

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FIGURE 5. STEREO PAIR IMAGED NEAR EDGE OF FORMAT

Airfield Test Strip Showing Aircraft on Light-tone Background

The following stereo pair shows the nominal quality attained in Mission 1007 when the vehicle was in a near vertical attitude. The acuity of these photographs, which are located 11.5 cm from the center-line of the frame, can be compared with the acuity in the retrofit area photographs. Figures 3 & 4 which are imagery is located closer to the center-line in the same frame.

Pass: 1040
Frame: 044
Index: 30 48.8-15.8
Enlargement: 20X
Solar Elevation: 62.3
Solar Azimuth: 156
Solar Bearing: 145
Roll Angle: 4.25

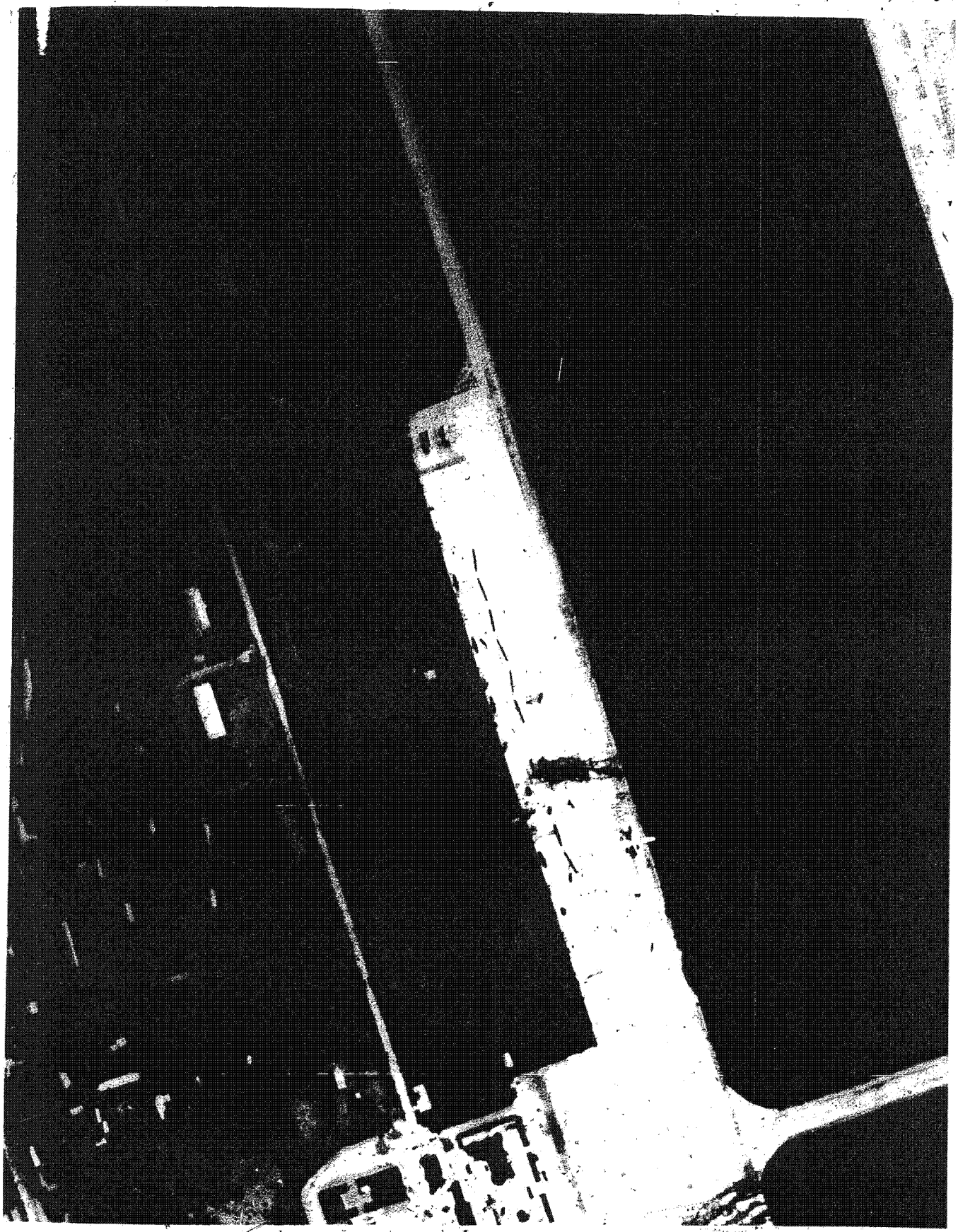

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FIGURE 1. TERRAIN MAP, PERSPECTIVE FORMAT

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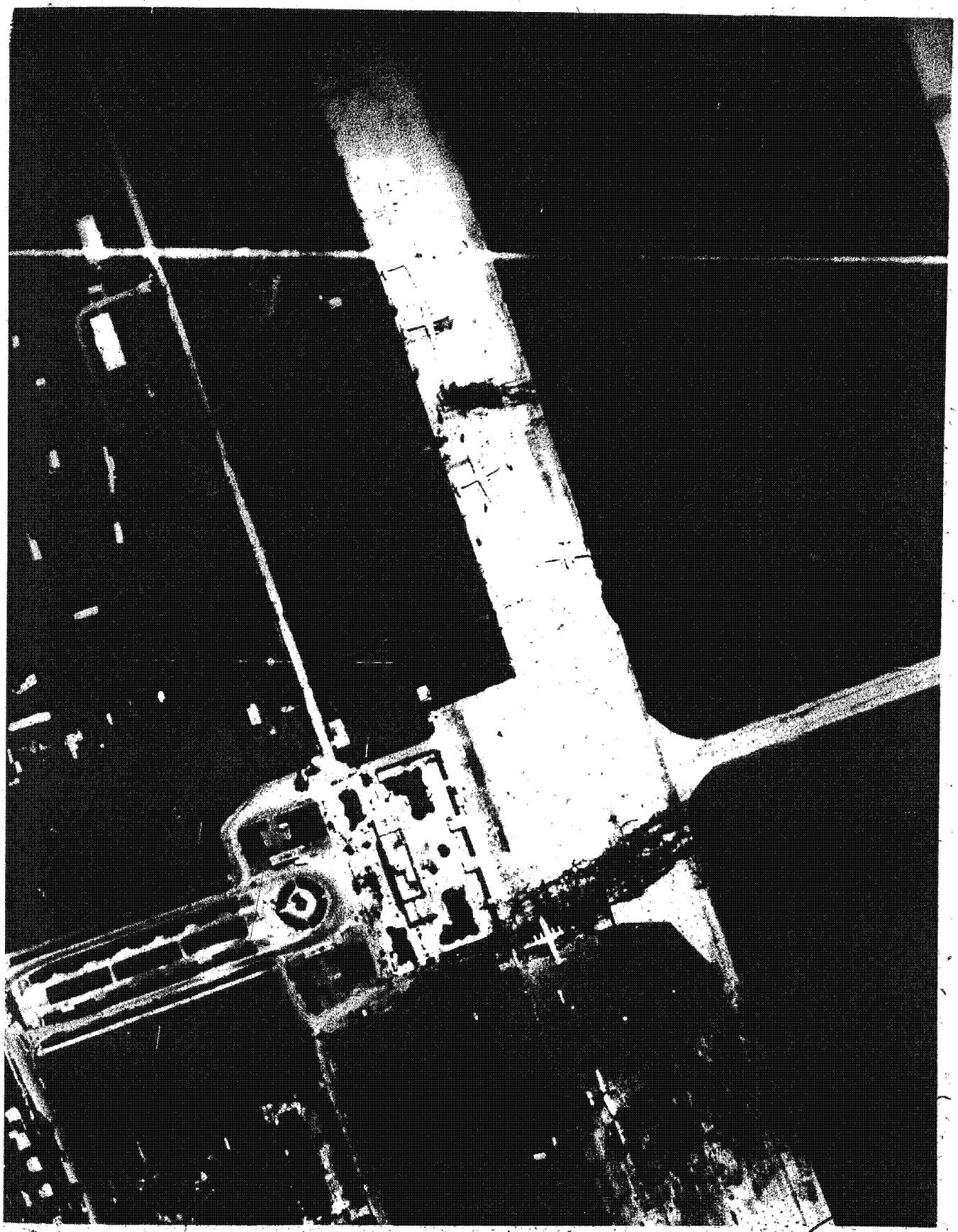

FIGURE 7 STRIP PHOTOGRAPH OF AIRCRAFT ON DARK-TONED BACKGROUND.

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Airfield Taxi Strip Showing Aircraft on a Dark-tone Background

This photograph shows the nominal quality attained in Mission 4007 when the vehicle was in a slight roll. It can be compared with pass 1040, frame 13, (Figure 3) where similar type aircraft can be identified on a light-tone background.

Pass: 1064
Frame: 14
Index: 31 (85.5-13.5)
Enlargement: 40X
Solar Elevation: 68.7°
Solar Azimuth: 147°
Solar Bearing: 93
Roll Angle: 8.5↓

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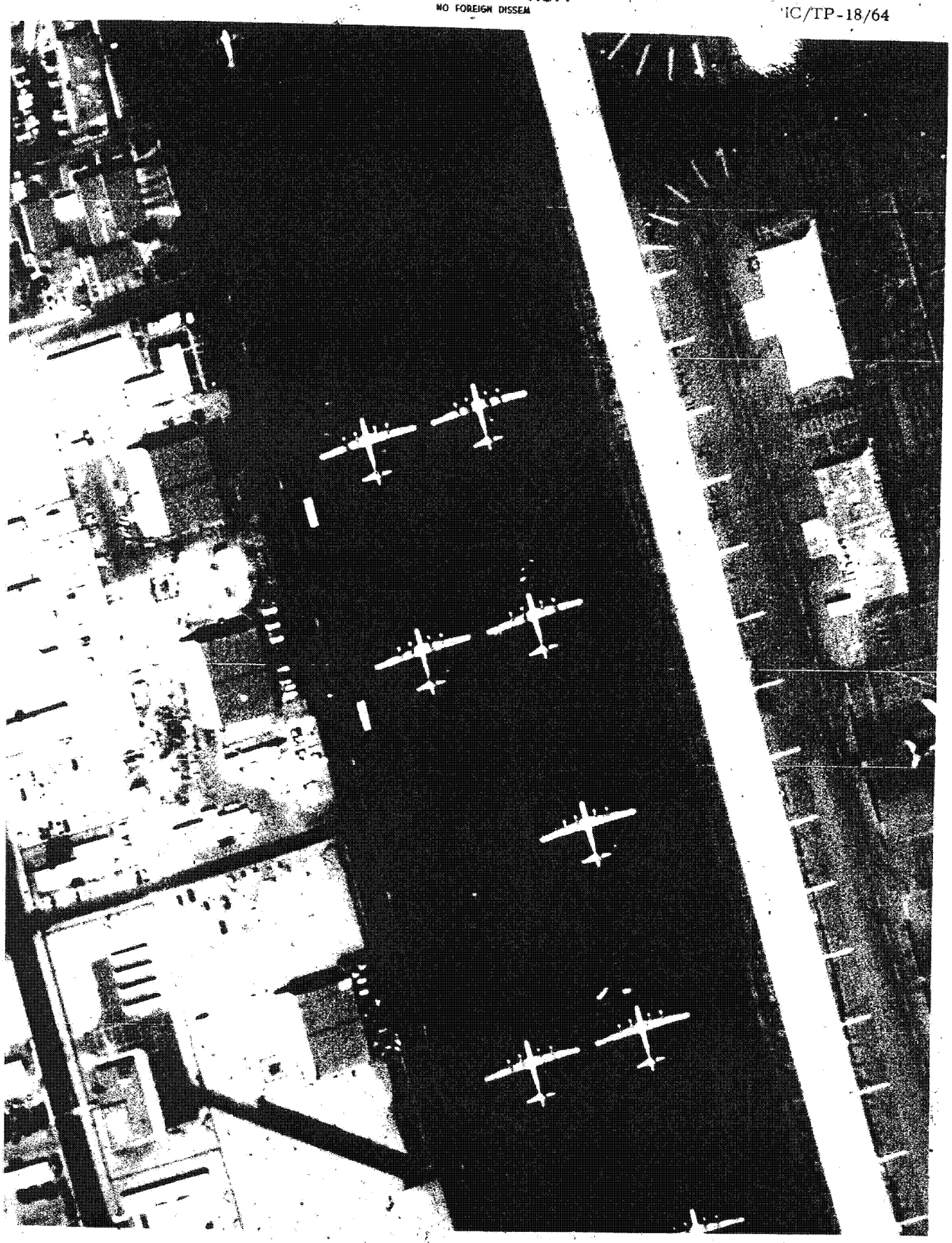
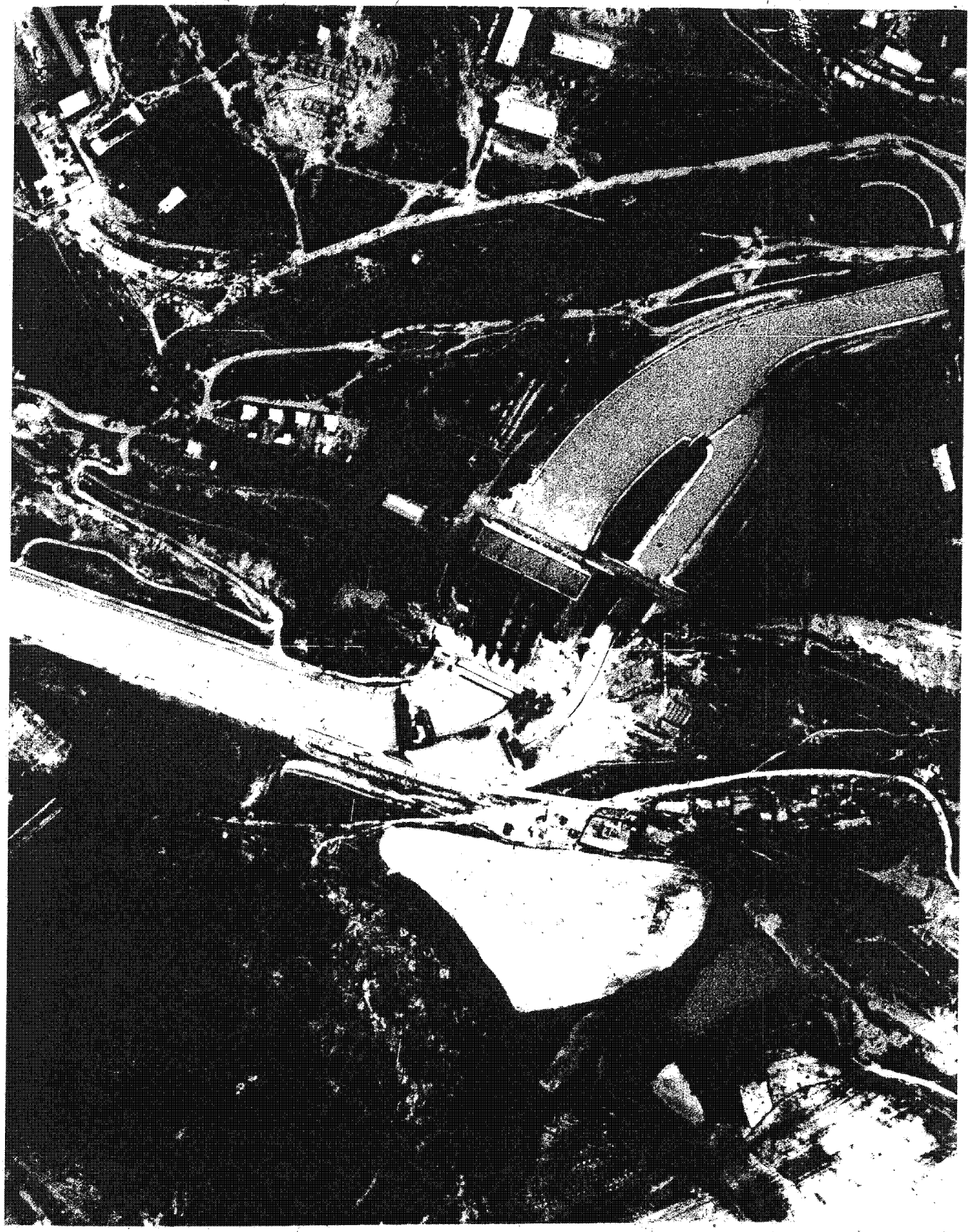


FIGURE 8. STEREO PAIR WITH VEHICLE IN MODERATE ROLL.

Hydroelectric Power Plant Showing Penstocks

The following stereo pair shows the nominal quality attained in Mission 4007 when the vehicle was in a moderate roll. A comparison of the two prints illustrates the effect of solar bearing on PI suitability.

Pass: 1040
Frame: 11
Index: 24-68:14093
Enlargement: 20X
Solar Elevation: 59.8
Solar Azimuth: 159
Solar Bearing: 269
Roll Angle: 22.69



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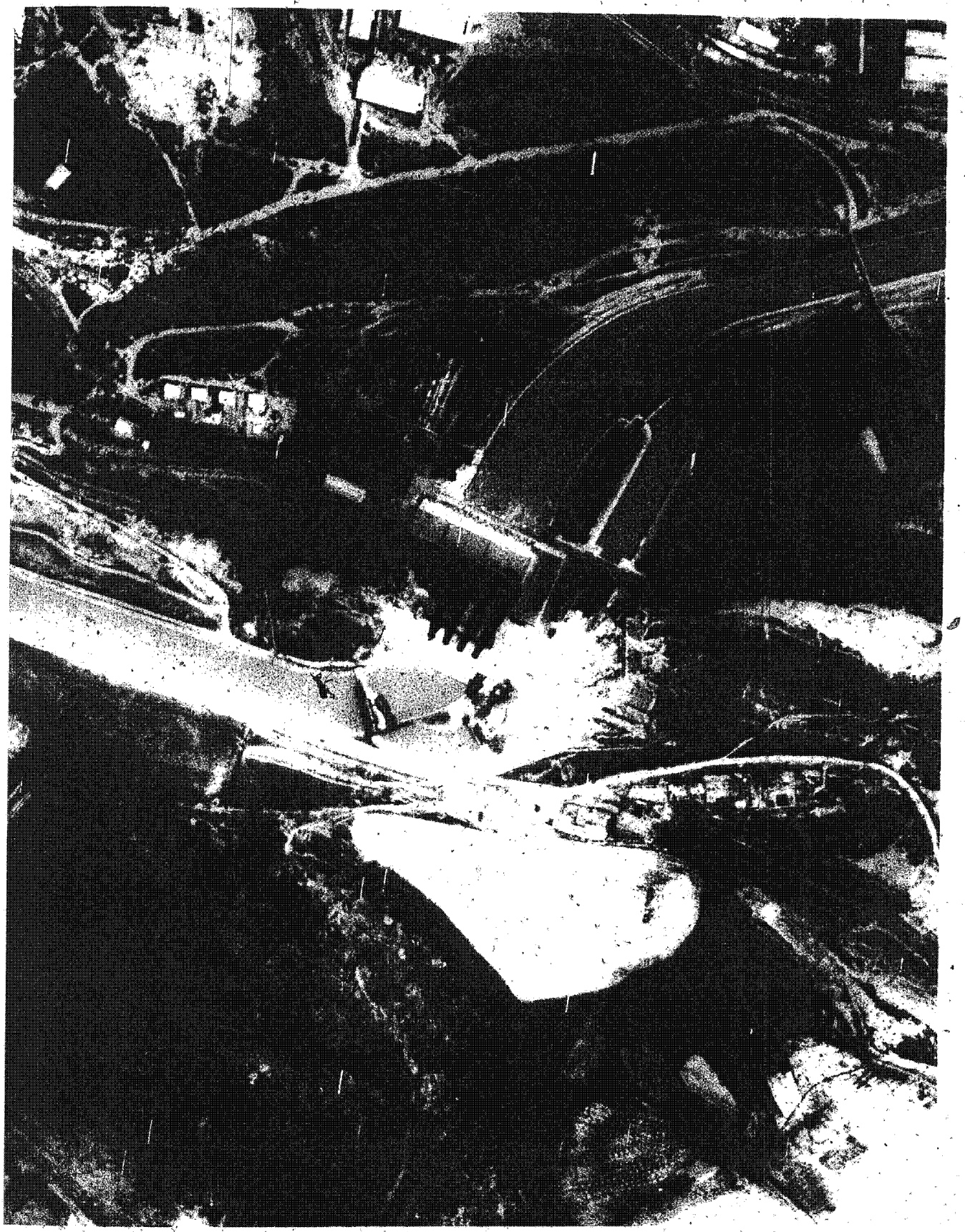

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FIGURE 12. [illegible] ABOVE CENTER LINE OF FORMAT.

aircraft on taxiway

The following photographs show the acuity of imagery when the vehicle is in a moderate roll attitude. In both instances the imagery was recorded slightly above the center line in the format.

Pass: 1048
Frame: 097
Index: 31 60.0-14.0
Enlargement: 20X
Solar Elevation: 67.6
Solar Azimuth: 148
Solar Bearing: 12
Roll Angle: 25.52

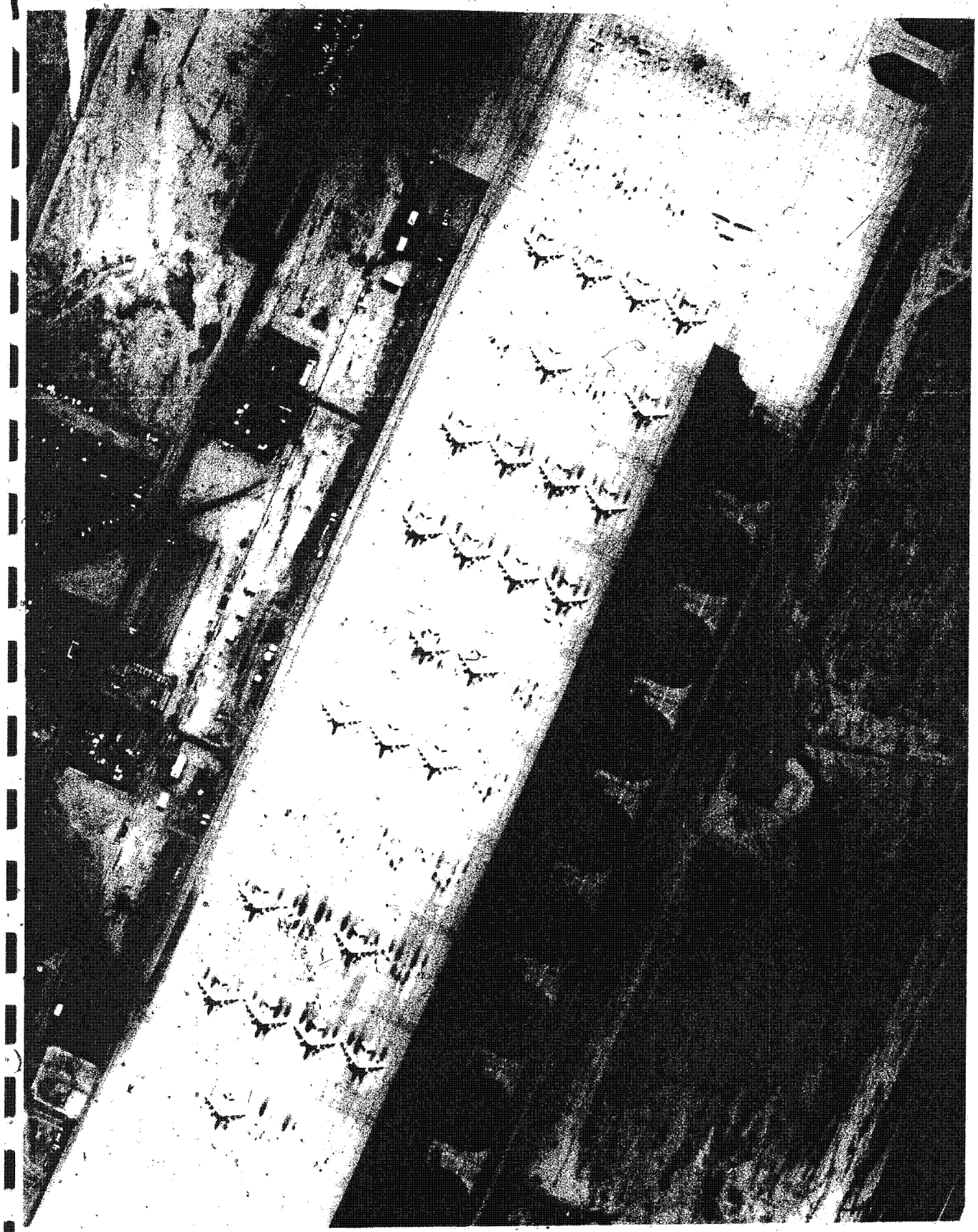

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FIGURE 11. STEREO PAIR IMAGES ABOVE CENTER LINE OF FORMAT

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Pass: DIS
Frame: 19
Index: 38-617-115
Enlargement: 20X
Solar Elevation: 67.8
Solar Azimuth: 11°
Solar Bearing: 69
Roll Angle: 26.23

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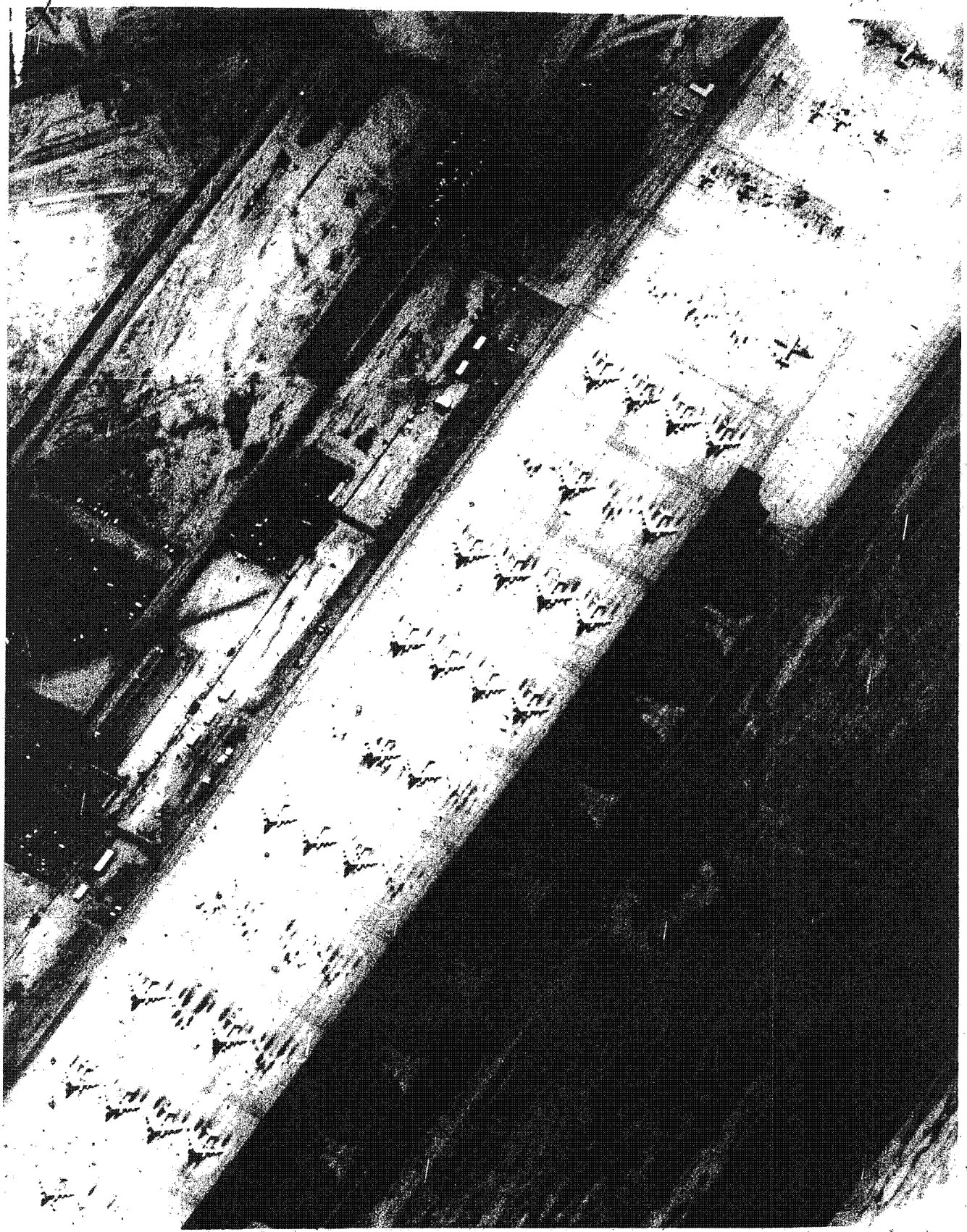

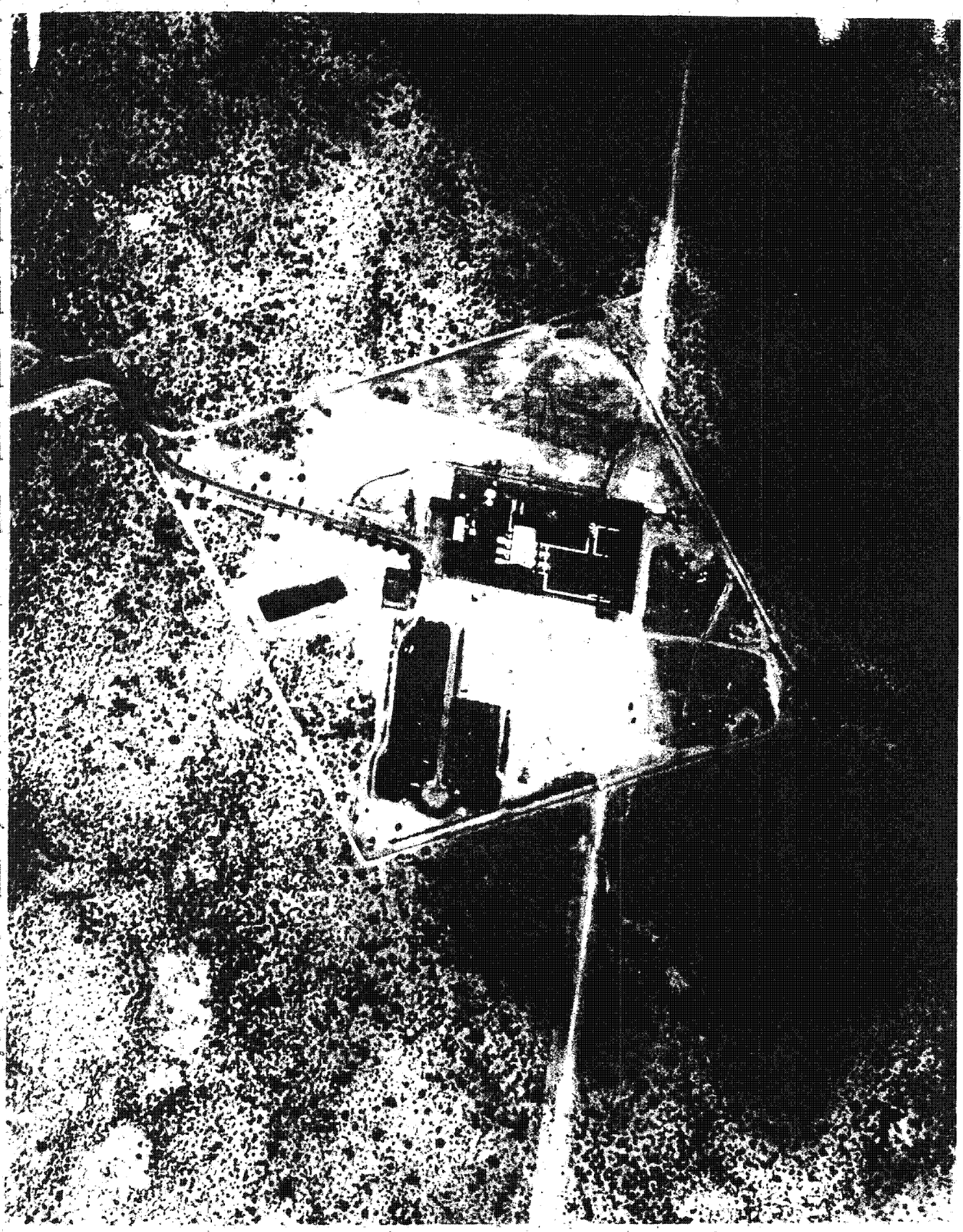

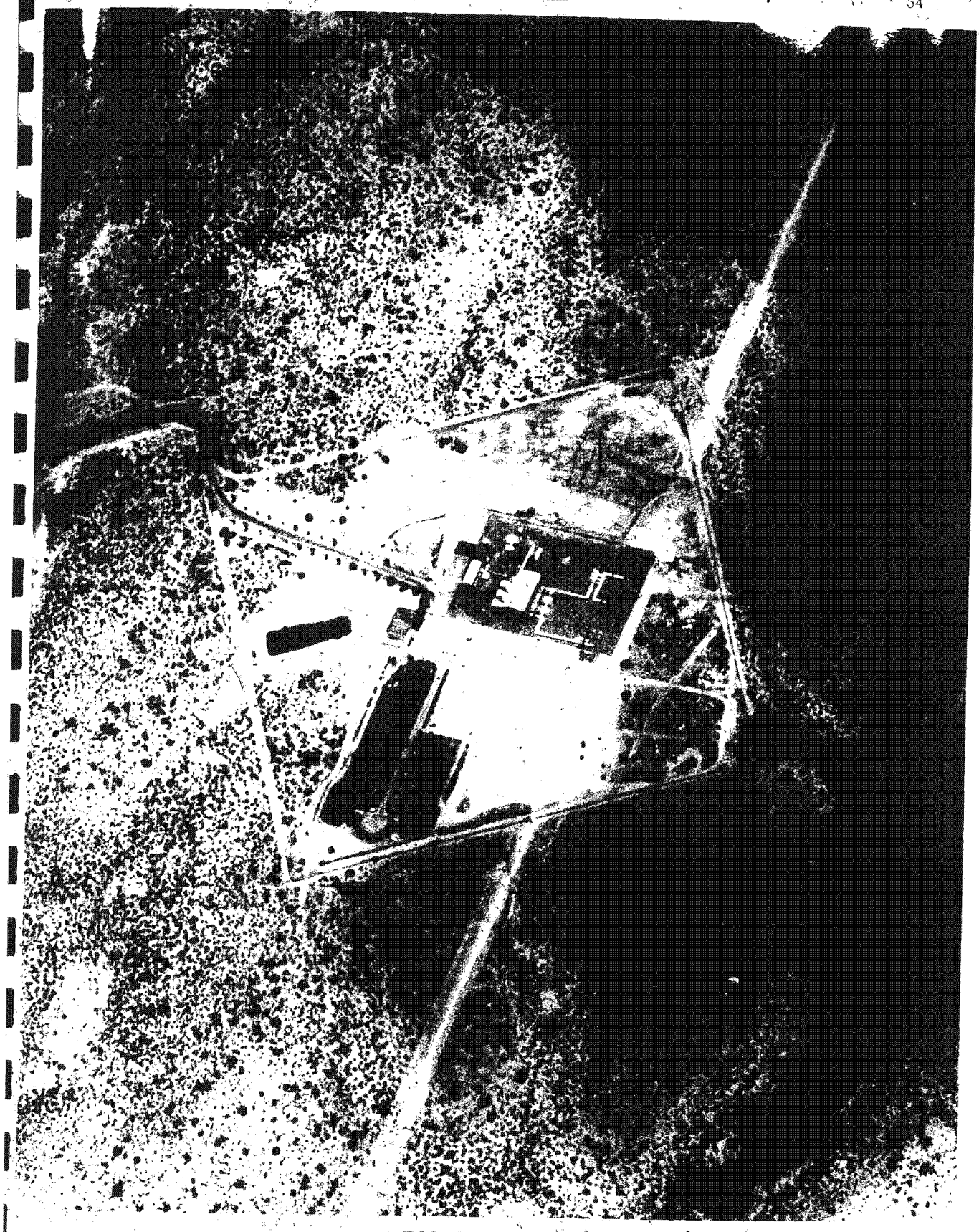

FIGURE 14. STEREO PAIR SHOWING EFFECT OF SOLAR BEARING

Stereo Pair of a Section of a Railroad Yard

The following stereo pair shows the nominal quality attained in Mission 4007 when the vehicle was in a moderately high roll. There is a slight change in the roll angle between photographs. The imagery was recorded approximately 7.0 cm above the center line. The photographs show the effects of solar bearing on PI suitability.

- Pass: 148
- Frame: 09
- Index: 31 (61.7-20.0)
- Enlargement: 40X
- Solar Elevation: 67.6
- Solar Azimuth: 148
- Solar Bearing: 12
- Roll Angle: 25.52

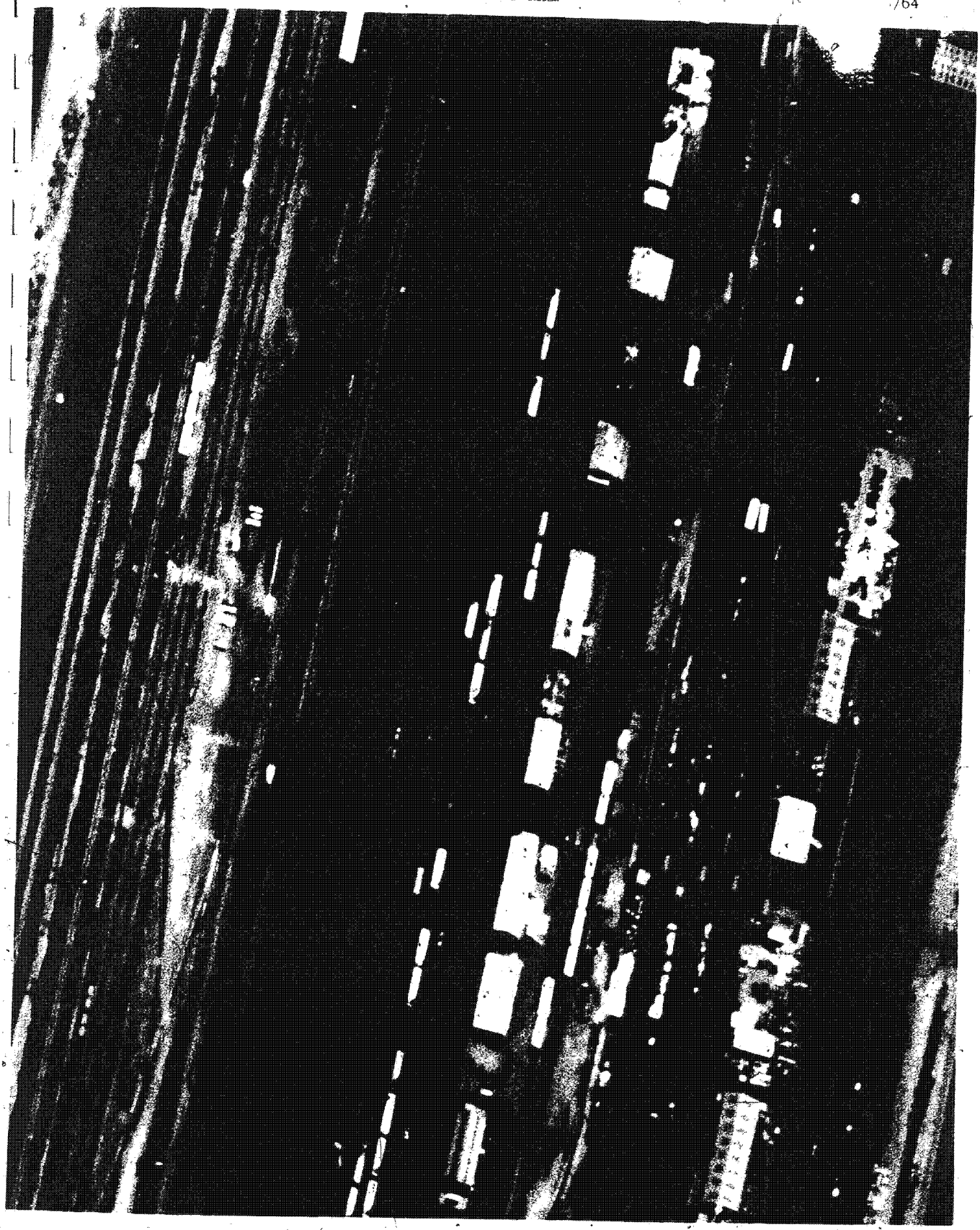

FIGURE 15. STEREO PAIR SHOWING EFFECT OF SOLAR BEARING

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Pass: DAS
Frame: 10
Index: 33 03.9 19 S
Enlargement: 10x
Solar Elevation: 6°S
Solar Azimuth: 41°
Solar Bearing: 60
Roll Angle: 26.23

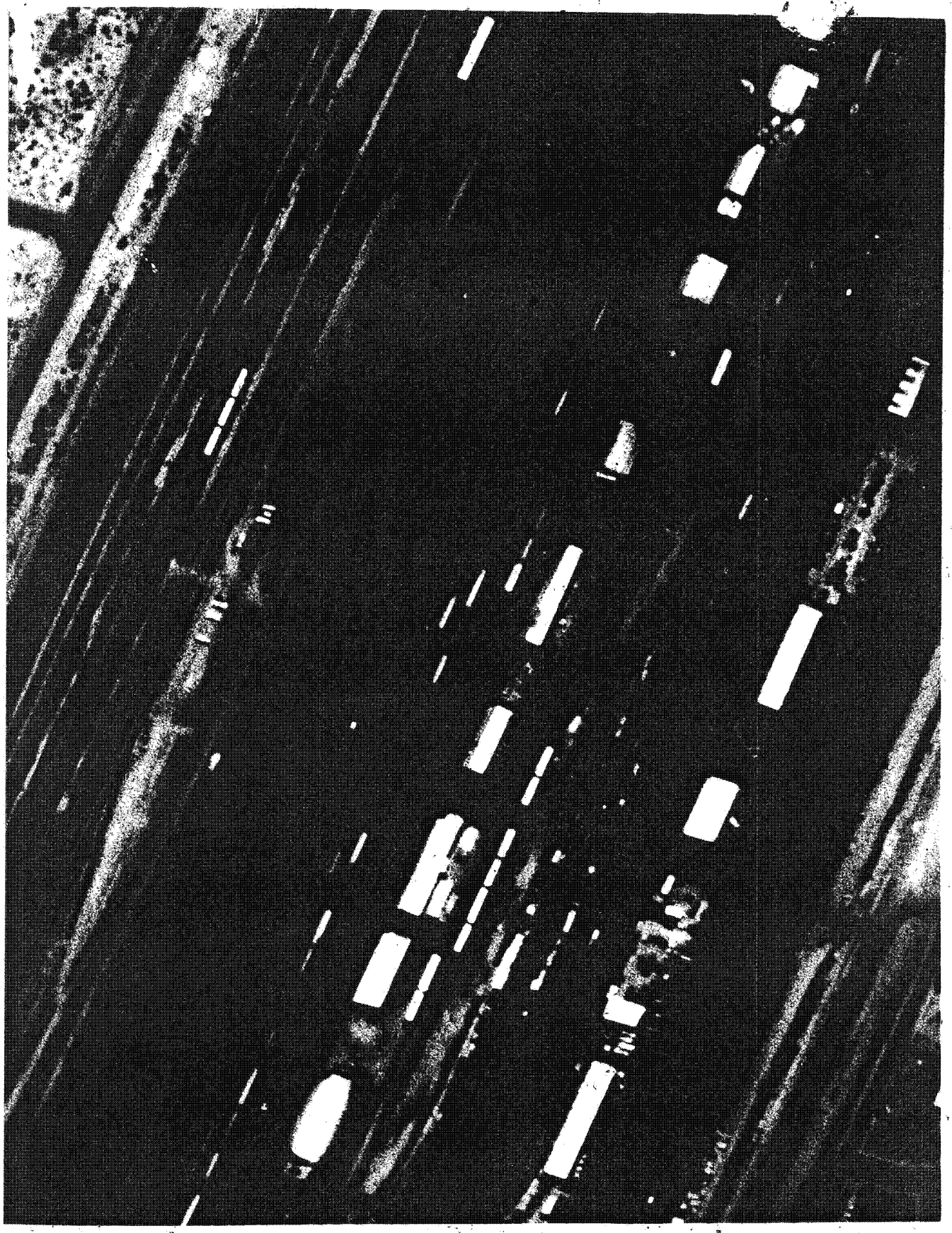

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FIGURE 16. STEREO PAIR WITH VEHICLE IN MODERATELY HIGH ROLL.

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Coast Line

The following photographs show the nominal quality of a stereo pair when the vehicle is in a moderately high roll attitude. They also show the effect of solar bearing on PI suitability.

Pass: 1043
Frame: 10
Index: 26 (69.2-11.8)
Enlargement: 10X
Solar Elevation: 64.3°
Solar Azimuth: 156°
Solar Bearing: 24°
Roll Angle: 34.03°

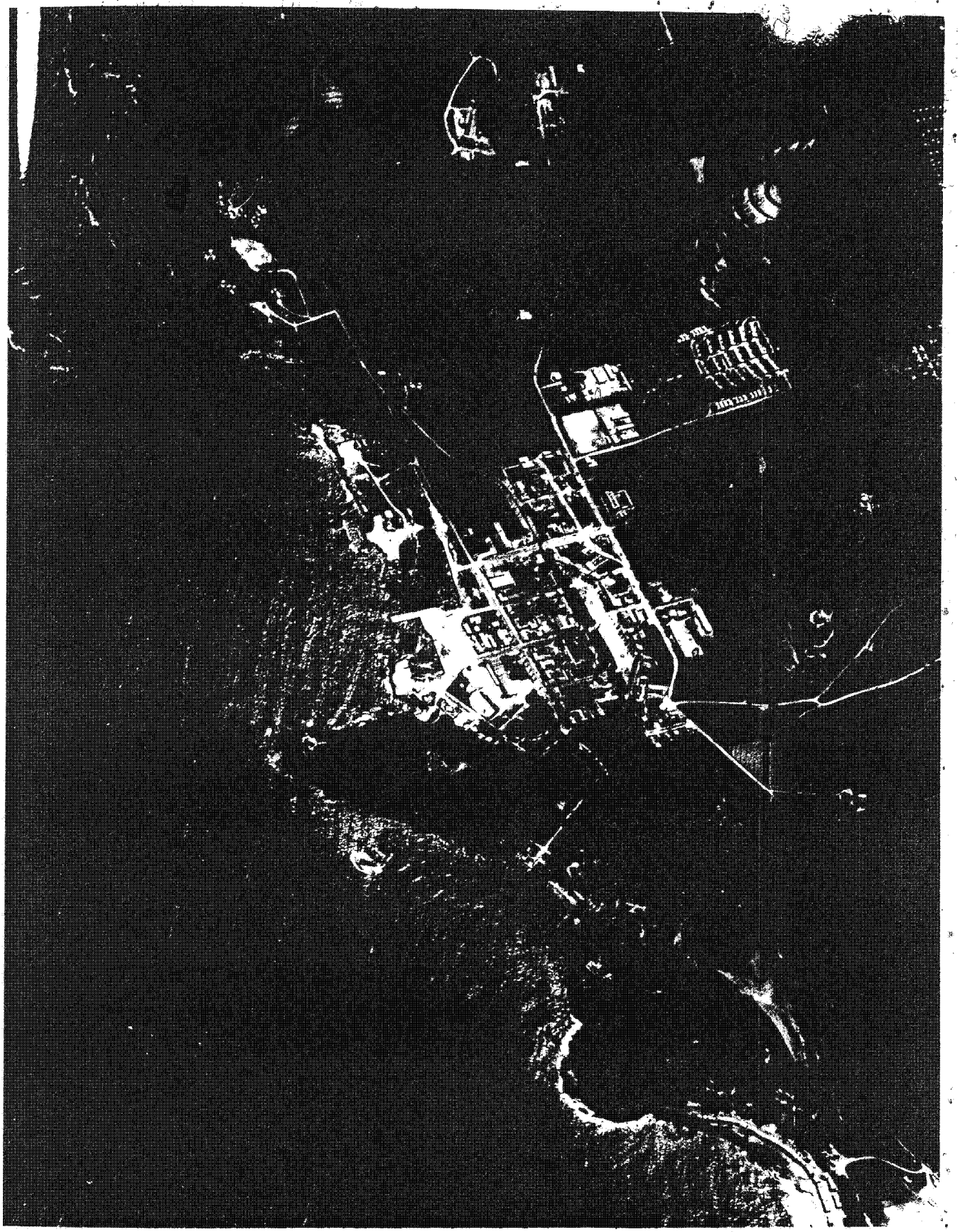

FIGURE 17. STEREO PAIR WITH VEHICLE IN MODERATELY HIGH ROLL.

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Pass: 1043
Frame: 11
Index: 27-37.5-11.5
Enlargement: 10X
Solar Elevation: 64.3
Solar Azimuth: 156
Solar Bearing: 72
Roll Angle: 34.03

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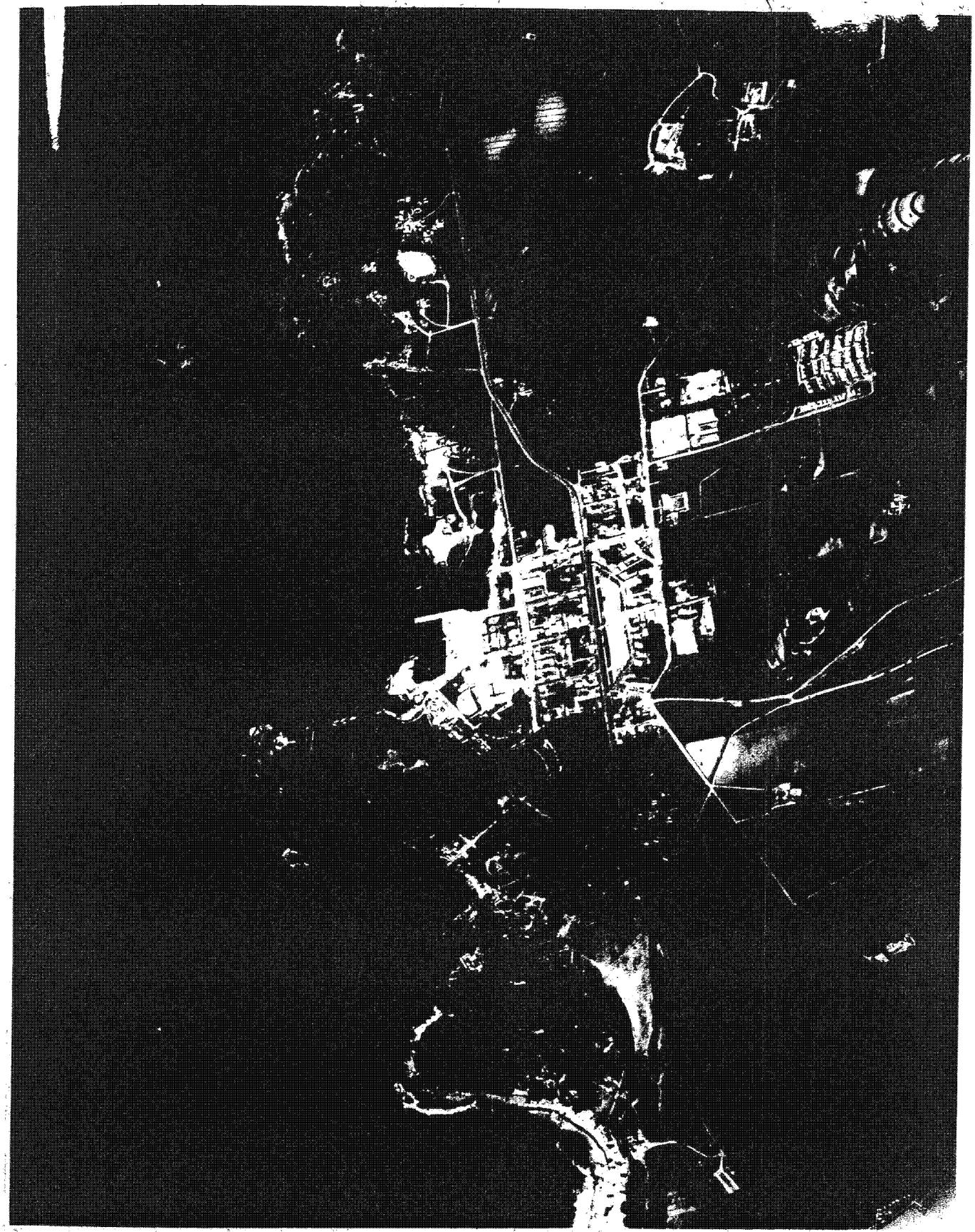

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Aircraft

The following photograph shows the nominal quality attained in Mission 4007 when the vehicle was in a moderately high roll.

Pass: 1064
Frame: 12
Index: 29-64, -69.97
Enlargement: 20X
Solar Elevation: 65.4
Solar Azimuth: 151
Solar Bearing: 106
Roll Angle: 37.58

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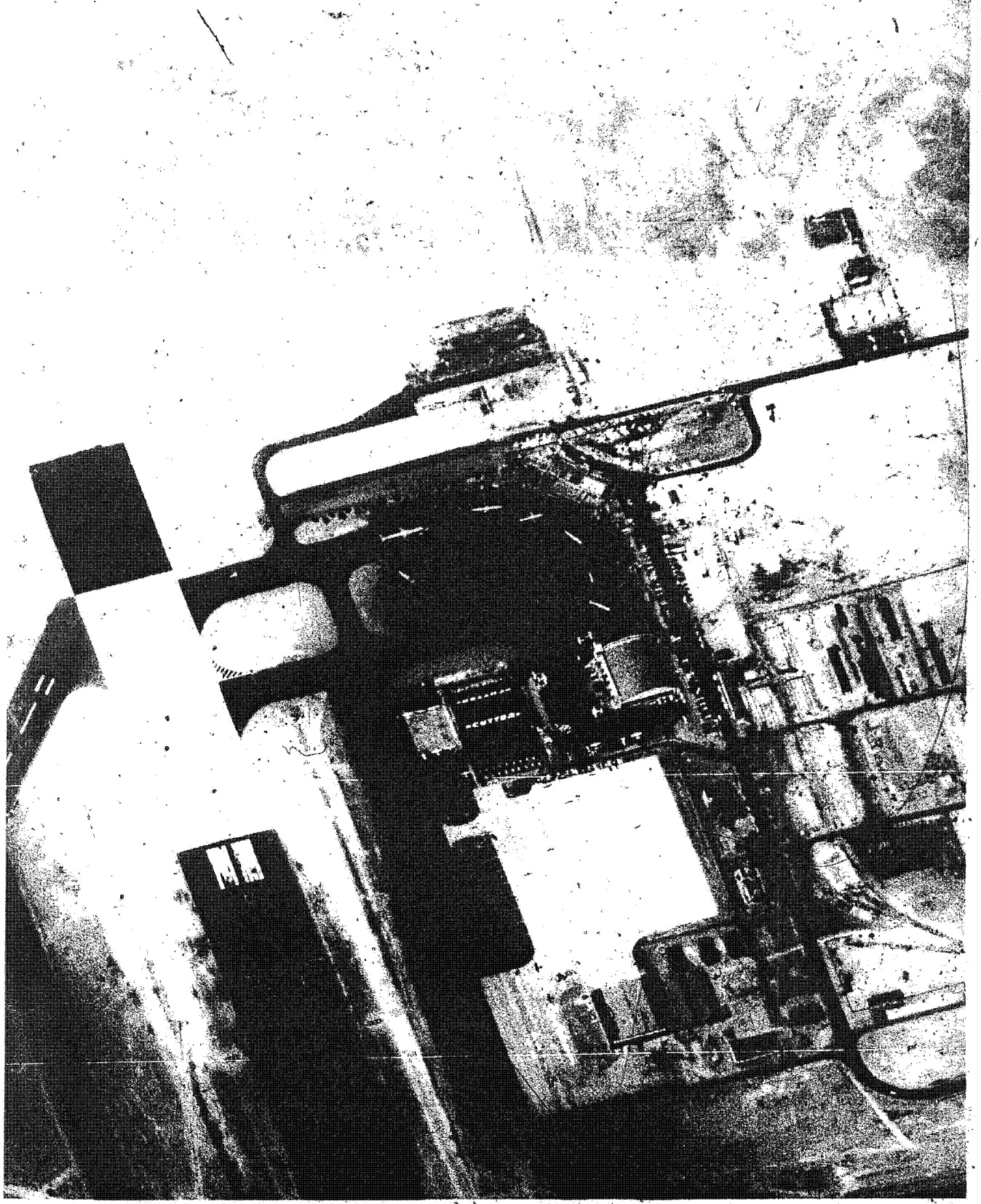

FIGURE 19. STEREO TRIPLET.

Bridge

The following stereo triplet is a portion of the "Line of Sight" experiment that is graphically displayed in the Experimental Operation Section. It shows that targets can be photographed from three different angles and what effect the solar bearing has on PI suitability. These photographs were acquired with the vehicle in the extreme high roll attitude.

Pass: 1047
Frame: 05
Index: 23 (66.1-17.8)
Enlargement: 20X
Solar Elevation: 55.6
Solar Azimuth: 165
Solar Bearing: 258
Roll Angle: 44.67

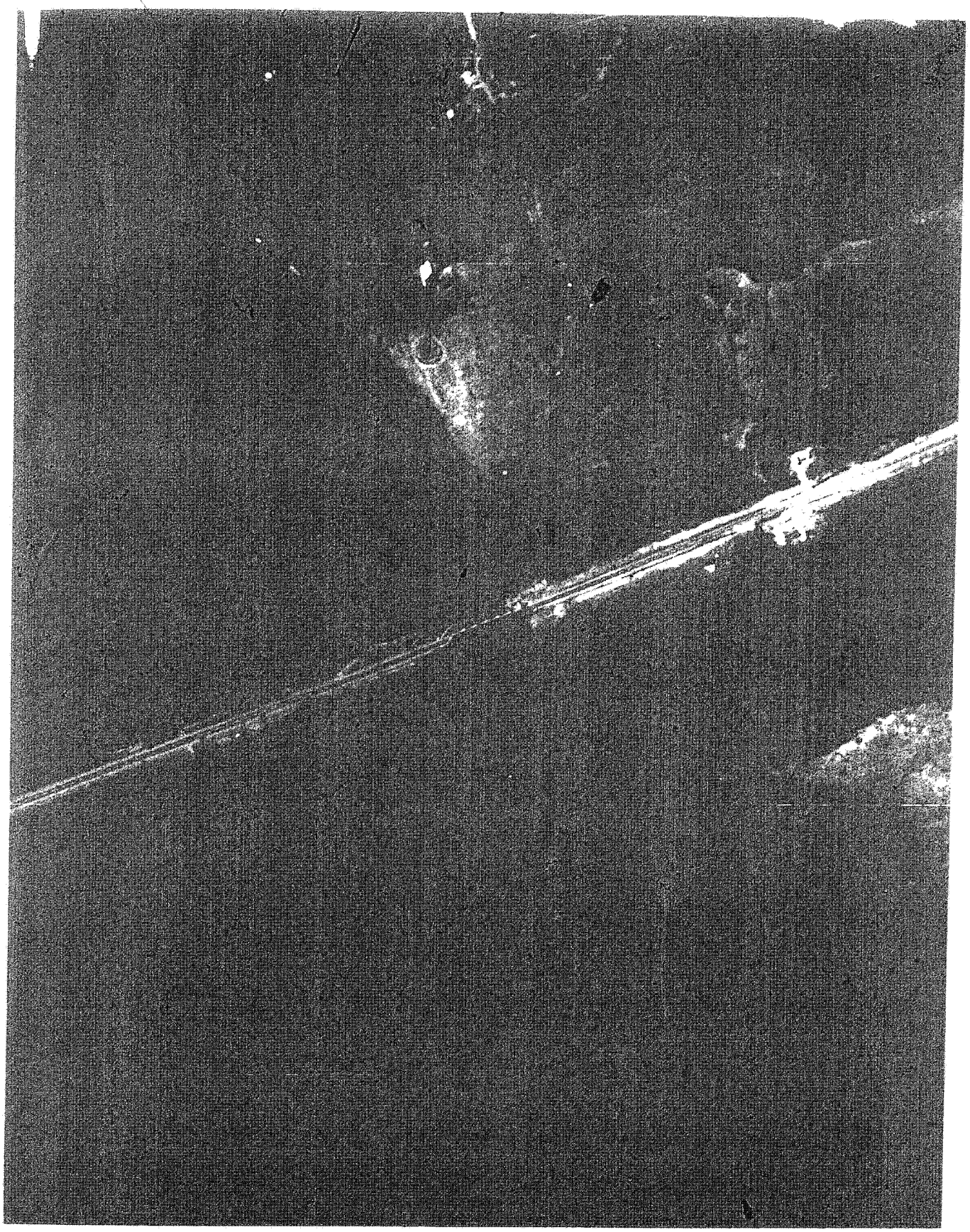

FIGURE 20. STEREO TRIPLET.

- 6mm -

Handle Via
TALENT-KEYHOLE
Control System Only

TCS-7825/64
NPIC/TP-18/64

Pass: 1047
Frame: 06
Index: 24 68.5-15.9
Enlargement: 20X
Solar Elevation: 55.6
Solar Azimuth: 165
Solar Bearing: 236
Roll Angle: 44.67

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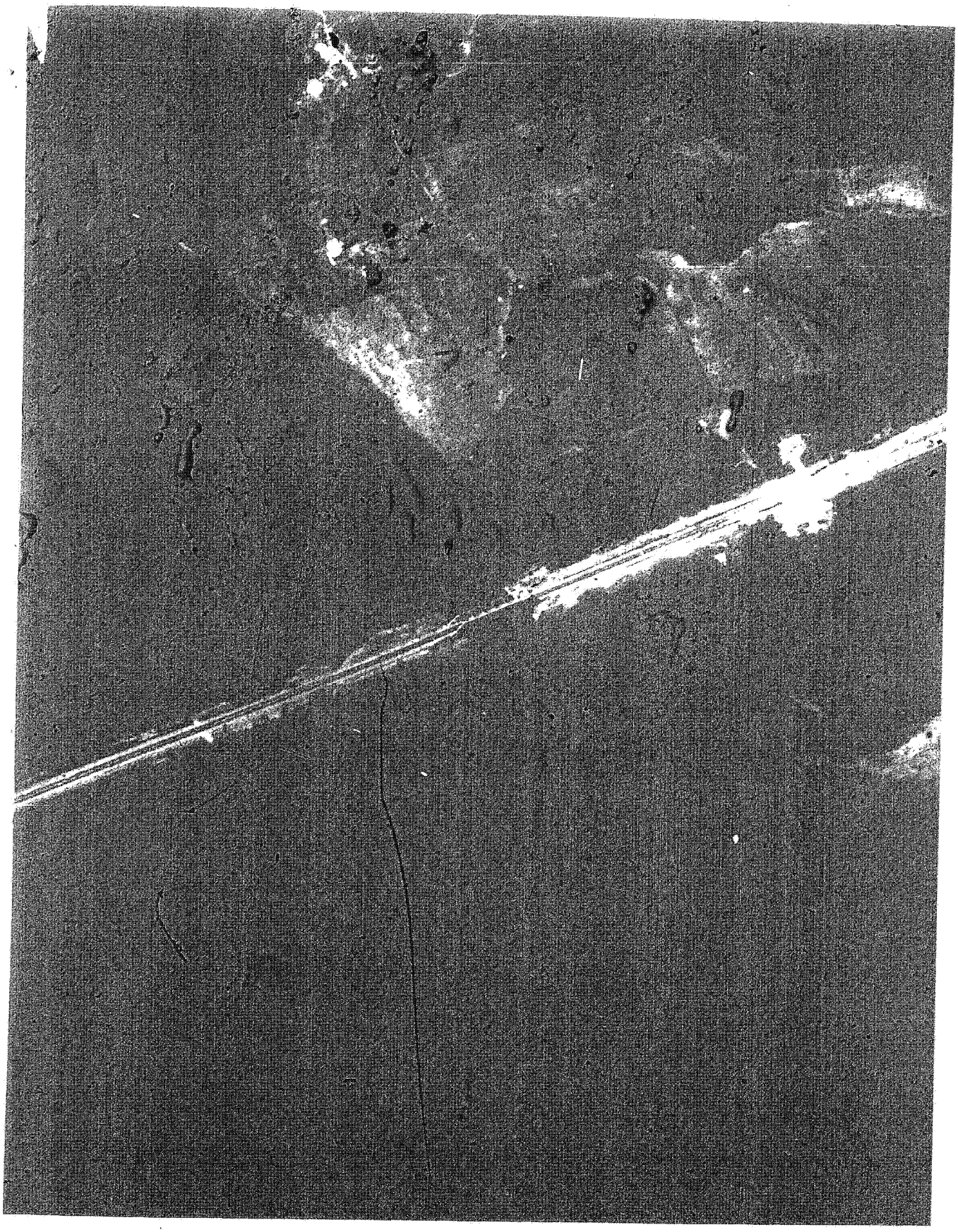
NO FOREIGN DISSEM

Handle Via
TALENT-KEYHOLE
Control System Only

Approved for Release: 2021/04/27 C05133952



~~TOP SECRET~~ RUFF

FIGURE 21. STEREO TRIPLET

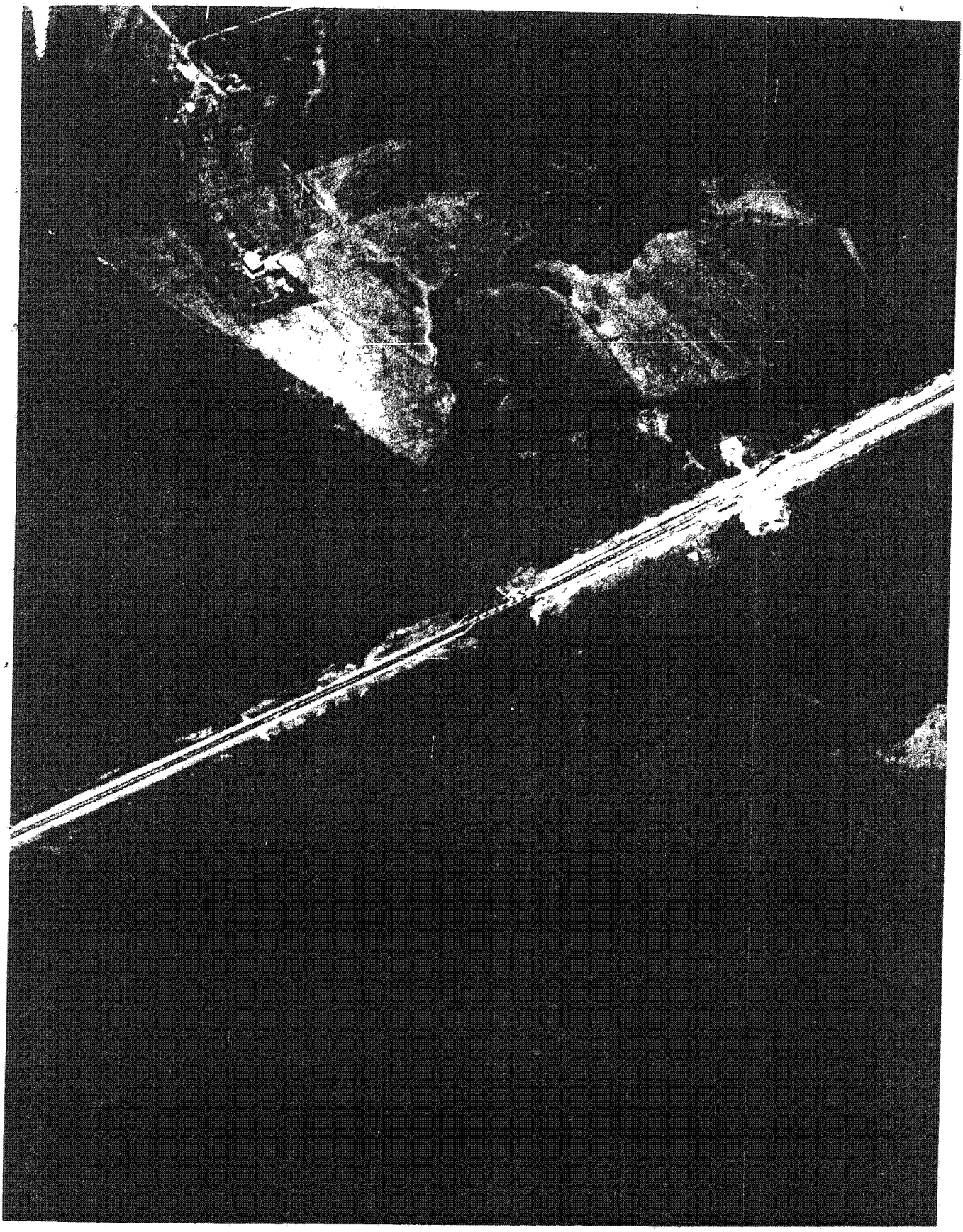


FIGURE 22. STEREO PAIR WITH VEHICLE IN EXTREMELY HIGH ROLL.

NPIC J-2987 8 64

Handle Via
TALENT-KEYHOLE
Control System Only

TCS-7825/64
NPIC/TP-18/64

Protected Harbor

The following stereopair is included to show stereo effect when the vehicle is in the most extreme roll attitude for the acquisition of stereo pairs on this mission.

Pass: 027
Frame: 05
Index: 10 062.8-16.0
Enlargement: 20X
Solar Elevation: 64.9
Solar Azimuth: 152
Solar Bearing: 24
Roll Angle: 42.54

Handle Via
TALENT-KEYHOLE
Control System Only

FIGURE 23. STEREO PAIR WITH VEHICLE IN EXTREMELY HIGH ROLL.

NPIC J 2966 8 64

TCS-7825/64
NPIC/TP-18/64

Pass: 027
Frame: 06
Index: 06 18.6; 10.1
Enlargement: 20X
Solar Elevation: 64.9
Solar Azimuth: 152
Solar Bearing: 65
Roll Angle: 42.54

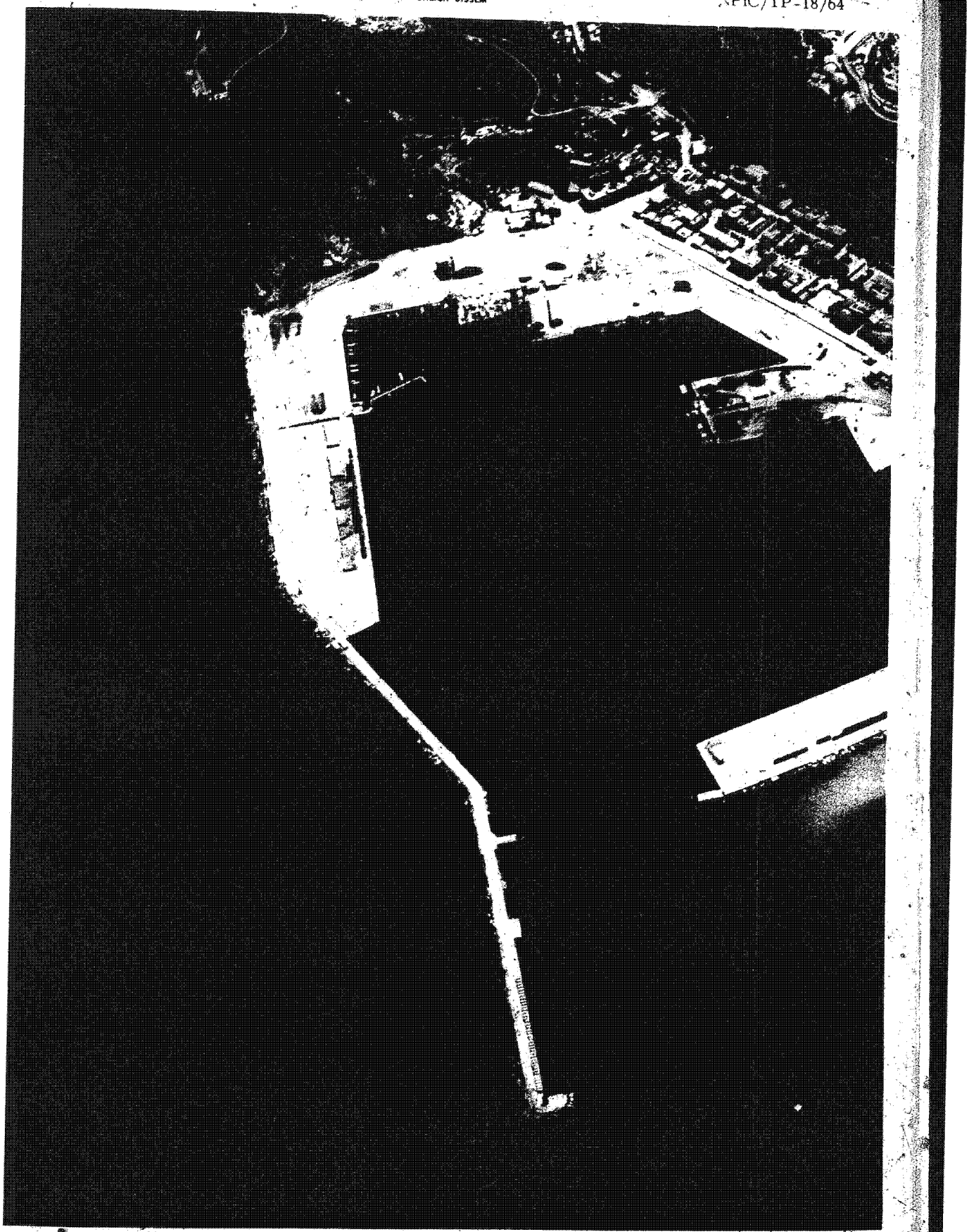


FIGURE 24. STRIP PHOTOGRAPH WITH VEHICLE IN MAXIMUM ROLL AND IMAGERY NEAR EDGE OF FORMAT.

Buildings Under Construction and Buildings Adjacent to Airfield

The following photographs show the nominal quality of strip photography attained in Mission 4007 when the vehicle was in an extremely high roll attitude. The buildings under construction (Figure 24) were imaged near the edge of the frame, and the complex of buildings adjacent to the airfield (Figure 25) were imaged within 1.5 cm of the center line.

Pass: 054
Frame: 08
Index: 30 (73.5-01.0)
Enlargement: 20X
Solar Elevation: 61.7°
Solar Azimuth: 164°
Solar Bearing: 55°
Roll Angle: 45.38°

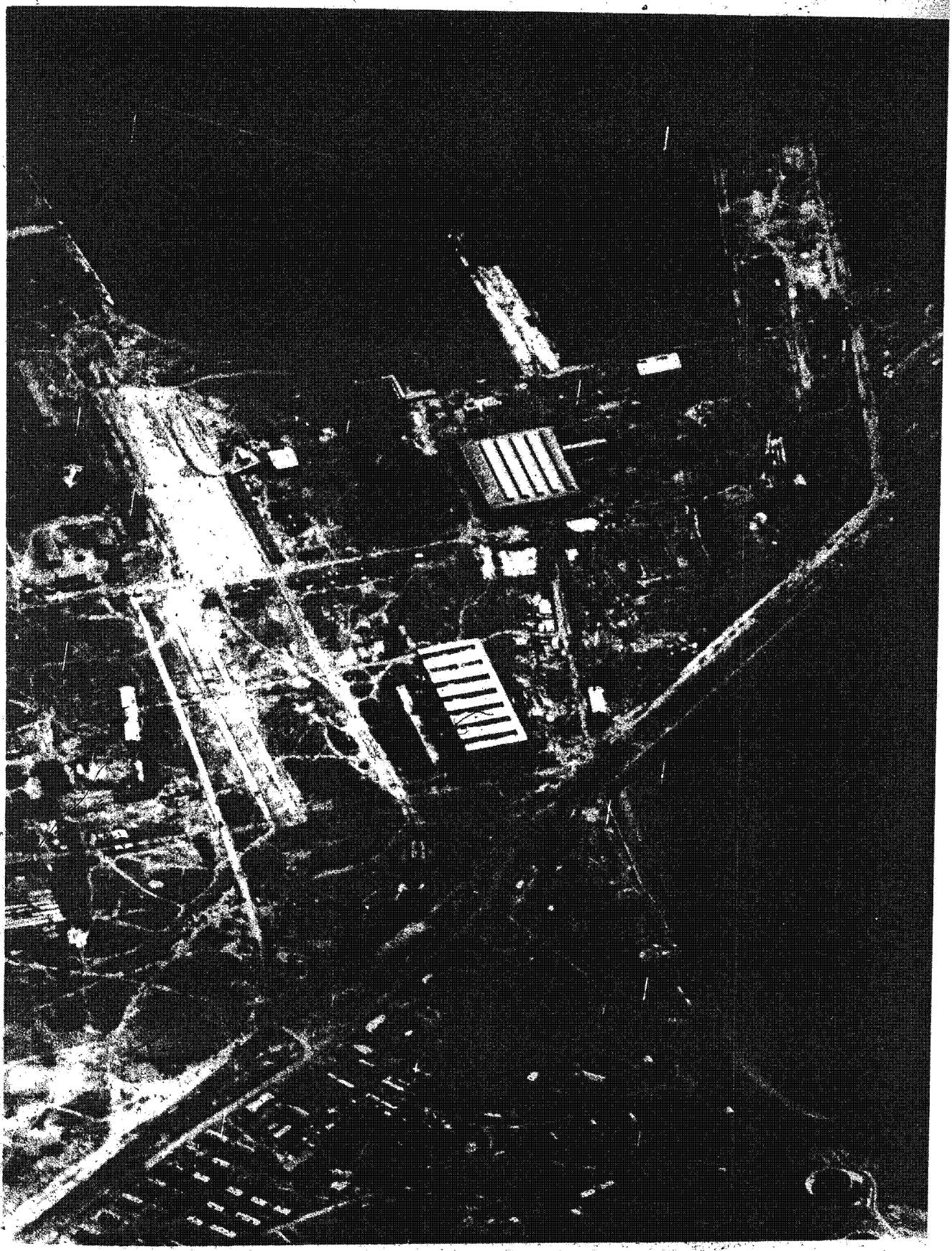


FIGURE 25. STRIP PHOTOGRAPH WITH VEHICLE IN MAXIMUM ROLL AND IMAGERY NEAR CENTER LINE OF FORMAT.

TCS-7825/64
NPIC/TP-18/64

Pass: D54
Frame: 08
Index: 30 (50.5-13.6)
Enlargement: 10X
Solar Elevation: 61.7°
Solar Azimuth: 164°
Solar Bearing: 55°
Roll Angle: 45.38°

- 6xx -

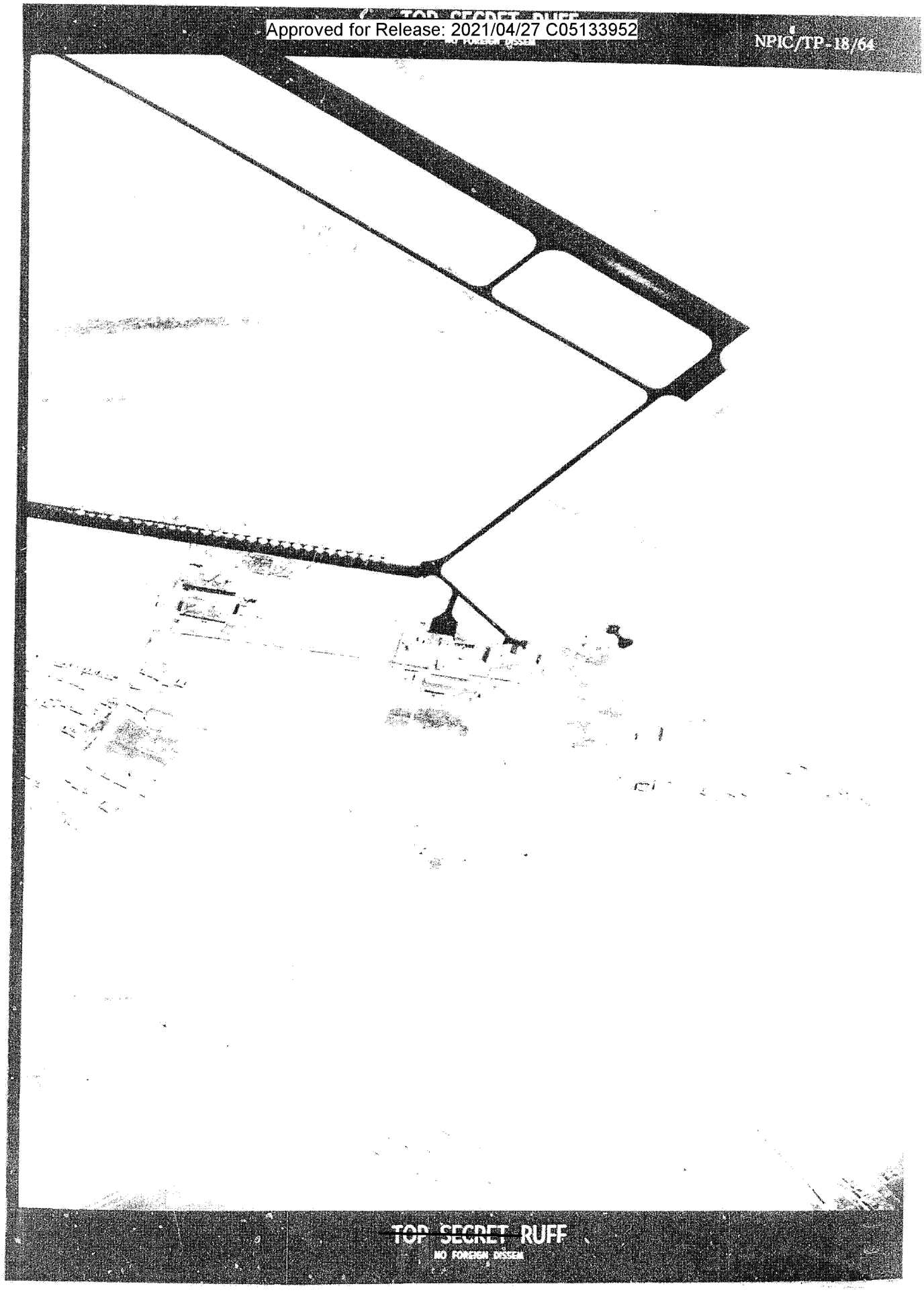


FIGURE 26. STEREO PAIR OF IMAGERY IN OVERLAP AREA OF LATERAL PAIR.

Portion of a Railroad Roundhouse

The following two photographs show stereo quality in the overlap area of a lateral pair. The stereo mirror was in a 15° forward position during the acquisition of frame 13 and in a 15° aft position for frame 14. The film speed was 3.61 inches per second in frame 13 and 3.51 inches per second in frame 14.

Pass: D64
Frame: 13
Index: 30 (66.5-02.7),
Enlargement: 40X
Solar Elevation: 68.6
Solar Azimuth: 147°
Solar Bearing: 329°
Roll Angle: 2.13°

~~TOP SECRET~~ RUFF
NO FOREIGN DISSEM

Handle Via
TALENT-KEYHOLE
Control System Only

Approved for Release: 2021/04/27 C05133952

FIGURE 27. STEREO PAIR OF IMAGERY IN OVERLAP AREA OF LATERAL PAIR

PART IV. EXPERIMENTAL OPERATIONS

1. Cloud Cover. No subjective conclusions can be drawn from the following experiments because of extensive cloud cover in the area.

a. Pass 16. Frames 01-06.

Variations in IMC to determine degradation.

b. Pass 31. Frames 12-14.

Angled, or displaced, triplet.

c. Pass 32. Frames 08-11.

Variations in IMC to determine degradation.

d. Pass 44. Frames 01-13.

Illumination run.

e. Pass 45. Frames 01-13.

Illumination run.

2. Sunline Experiment. Pass 32. Frames 01, 02, 03, and 04.

All four frames were acquired while the vehicle was ascending in northern latitudes.

The photography in frame 01 includes exposures from 67° 22'N to 75° 01'N with the vehicle in a 1.42° (right wing up) roll. The solar elevation was -15° at the start of the frame and -06° at the completion. The principal ray was pointed away from the source of illumination. Tops of clouds are detectible at the higher latitudes although no terrain features are observed.

The photography in frame 02 includes exposures from 74° 26'N to 75° 11'N with the vehicle in a 3.54° (right wing down) roll. The solar elevation was -1.4° at the start of the frame and 0.6° at the completion. The principal ray was pointed toward the source of illumination. There was sufficient illumination for adequate exposure. The nature of the terrain (ice and snow) is conducive to minimal exposure because of its high reflectivity. Photography acquired under these conditions would be acceptable for photographic interpretation.

The photography in frame 03 includes exposures from 75° 50'N to 76° 15'N with the vehicle in a 0.71° near vertical roll. The solar elevation was 3.9° at the beginning of the frame and 4.9° at the completion. The illumination was sufficient for good exposure. No cultured terrain was detected in the area. Photographic acquisitions under these conditions would be acceptable for photographic interpretation.

The photography in frame 04 is completely cloud covered and no subjective analysis can be made.

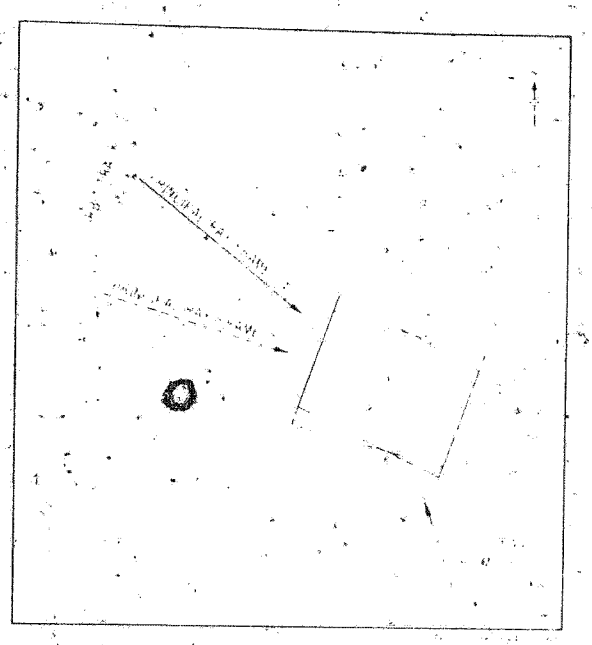
3. Roll Movement Experiment. Pass 47. Frames 02, 03, and 04.

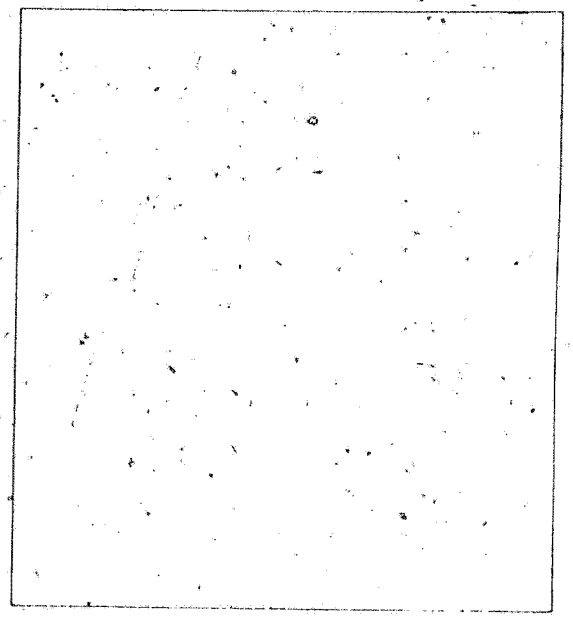
To set up and record high and medium roll movement and settling time on film.

Frame 02 appears normal. There are no streaked areas that indicate roll movement.

The first 19.5 inches of frame 03 contain diagonally streaked imagery and could not be used for photographic interpretation. The remaining 25.0 inches appear normal and are not degraded. Clouds inhibit a more accurate determination of the PI suitability.

The first 0.7 inches of frame 04 contain diagonally streaked imagery and could not be used for photographic interpretation. The remaining 35.5 inches appear normal and are not degraded. Clouds inhibit a more accurate determination of PI suitability.





4. Fifteen Degree Stereo Experiment: Pass 31, frames 04 and 05.

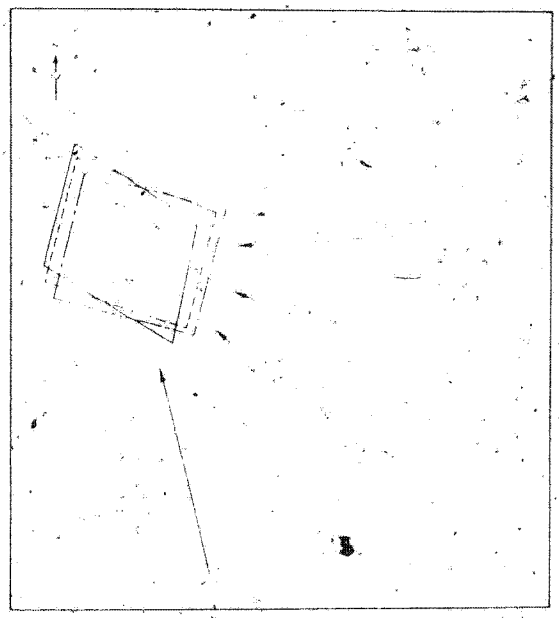
Frame 04 was taken with the mirror in the 15 forward position and the vehicle in a 41.8° roll. Frame 05 was taken with the mirror in the vertical position and the vehicle in a 42.54 roll. The sun was 59.7 above the horizon and at a true azimuth of 163 . The scale of the photography is approximately 1:97,000. The exposure is adequate and the resolution is good.

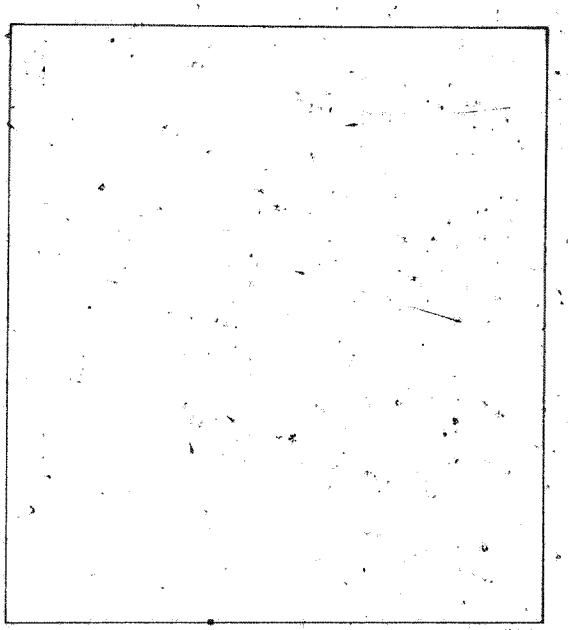
PI Suitability: Although the 15 convergence angle restricts depth perception, the imagery can be viewed stereoscopically. This type of photographic coverage would be acceptable rather than monoscopic coverage but is not recommended to replace normal 30° stereoscopic coverage.

[illegible] Extended Stereo Experiment: Pass 32, frames 18 and 19.

Frame 18 was taken with the mirror in the 15 forward position and frame 19 was taken with the mirror in the 15 aft position. The vehicle was in a 44.6° roll right wing up. The sun was 63.8 above the horizon, frame 18 was clear and the true azimuth of the sun was 148 . The scale of the photography is approximately 1:97,500. The exposure is adequate and the resolution is good.

PI Suitability: There is insufficient overlap for a subjective analysis of the stereo suitability.





6. Stereo Triplet (Line of Sight Experiment): Pass 47, frames 05, 06 and 07.

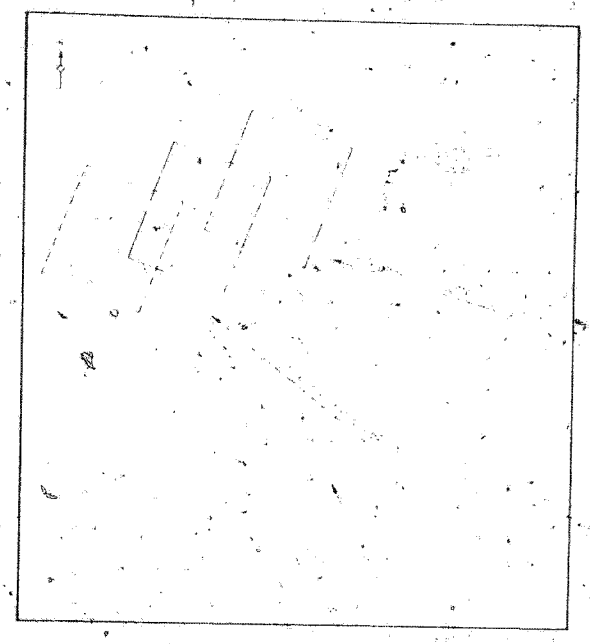
Frame 05 was taken with the mirror in a 15° forward position and the vehicle in a 44.6° roll (right wing up). Frame 06 was taken with the mirror in the vertical position and the vehicle attitude remained unchanged. Frame 07 was taken with the mirror in a 15° aft position and the vehicle in a 43.96° roll. The sun was 55.6° above the horizon and at a true azimuth of 165°. The scale of the photography is approximately 1:95,000 and the area is free of clouds. The exposure is adequate and the resolution is good on all three frames.

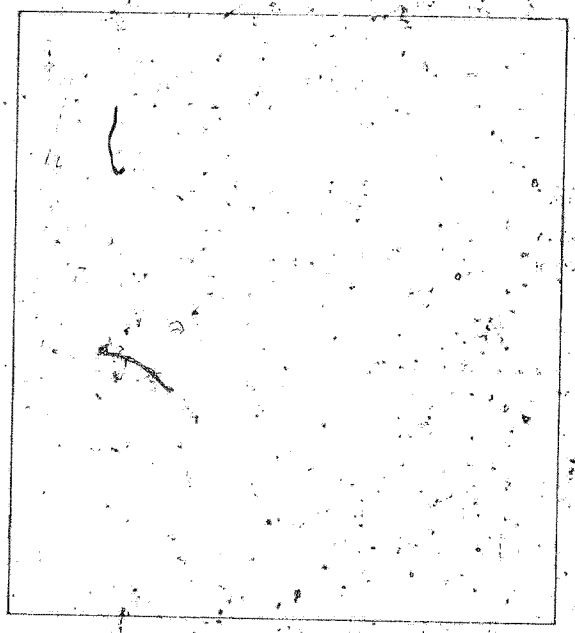
PI Suitability: The area selected for this experiment does not contain cultural features conducive to stereo coverage. Depth perception is readily discernible from any combination of the three frames. This type of coverage would be considered optimun at this roll angle.

7. Extended Stereo (15° aft and 60° vertical strip) Experiment: Pass 48, frames 02, 03 and 04.

Frame 02 was taken with the mirror in a 15° forward position, frame 03 with the mirror in a vertical position, and frame 04 with the mirror in a 15° aft position. The vehicle was in a 42.54° roll (right wing up) during the acquisition of all three frames. The sun was 61.6° above the horizon and at a true solar azimuth of 165°. The scale of the photography is approximately 1:90,000. The terrain is almost completely shrouded in clouds. The exposure is adequate and the resolution of the visible imagery is good.

PI Suitability: Heavy clouds preclude a subjective analysis of the imagery. Enough imagery is detectable to determine that there is stereo coverage between frames 02 and 03; and 03 and 04.





8. Displaced Lateral Triplet Experiment (Pass 48, frames 05, 06 and 07.)

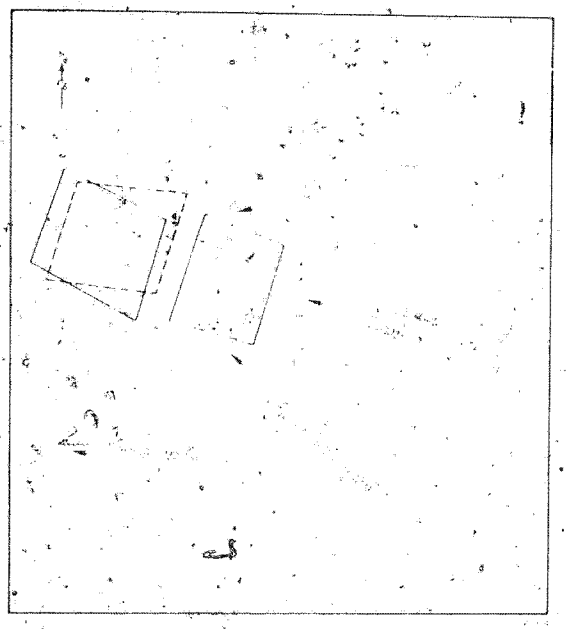
Frame 05 was taken with the mirror in a 15° forward position and the vehicle in a 34.74° roll. Frame 06 was taken with the mirror in the vertical position and the vehicle in a 38.09° roll. Frame 07 was taken with the mirror in a 15° aft position and the vehicle in a 42.54° roll. The sun was 63.4° above the horizon and at a true azimuth of 152°. The area contains scattered clouds. The approximate scale of frame 05 is 1:84,000; frame 06, 1:85,900; and frame 07, 1:93,700. The exposure is adequate and the resolution is good.

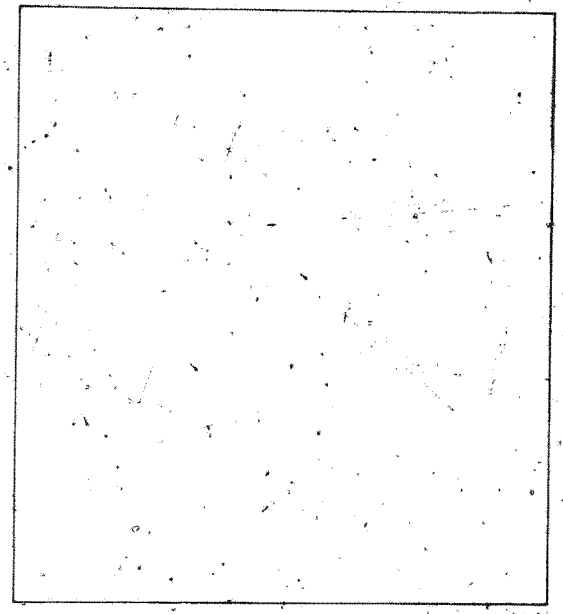
PI Suitability: The 15° convergence angle of the limited overlapped area is not sufficient for a subjective analysis. This type of coverage is not recommended for photographic interpretation unless target cannot be covered by any other means.

9. Double Stereo Experiment (Pass 64, frames 02, 03, 04 and 05.)

Frames 02 and 03 were taken with the mirror in a 15° forward position. The vehicle was in a 41.12° roll during the acquisition of frame 02 and a 38.29° roll during the acquisition of frame 03. The mirror was then moved to a 15° aft position and frames 04 and 05 were acquired while the vehicle was in a 40.41° and 37.58° roll respectively. The sun was 72.3° above the horizon at a true azimuth of 115°, and the area was relatively cloud free. The exposure was adequate and the resolution is marginal. The scale of the photography is approximately 1:109,000.

PI Suitability: Frame 02 contains no terrain imagery. Frame 04 is a mirror image of the target and is severely degraded. Frames 03 and 05 are acceptable images of the target but they are degraded by atmospherics and are severely degraded by image smearing.





10. Lateral Stereo Experiment: Pass 63, frames 06, 07 and 08.

Frame 06 was taken with the mirror in a 15° forward position and the vehicle in a 36.16° roll (right wing up). Frame 07 was taken with the mirror in a vertical position and the vehicle in a 29.07° roll. Frame 08 was taken with the mirror in a 15° aft position and the vehicle in a 34.74° roll. The sun was 73° above the horizon and at a true azimuth of 100°. The scale of the photography in frame 06 and 08 is approximately 1:104,000. The scale in frame 07 is approximately 1:93,000. The area is free of clouds, the exposure is adequate, and the resolution is good.

PI Suitability: Frames 06 and 08 are a normal 30° stereo pair. Depth is readily discernible. Frame 07 is a normal monoscopic strip and although usable for interpretation it is not recommended in place of stereo coverage.

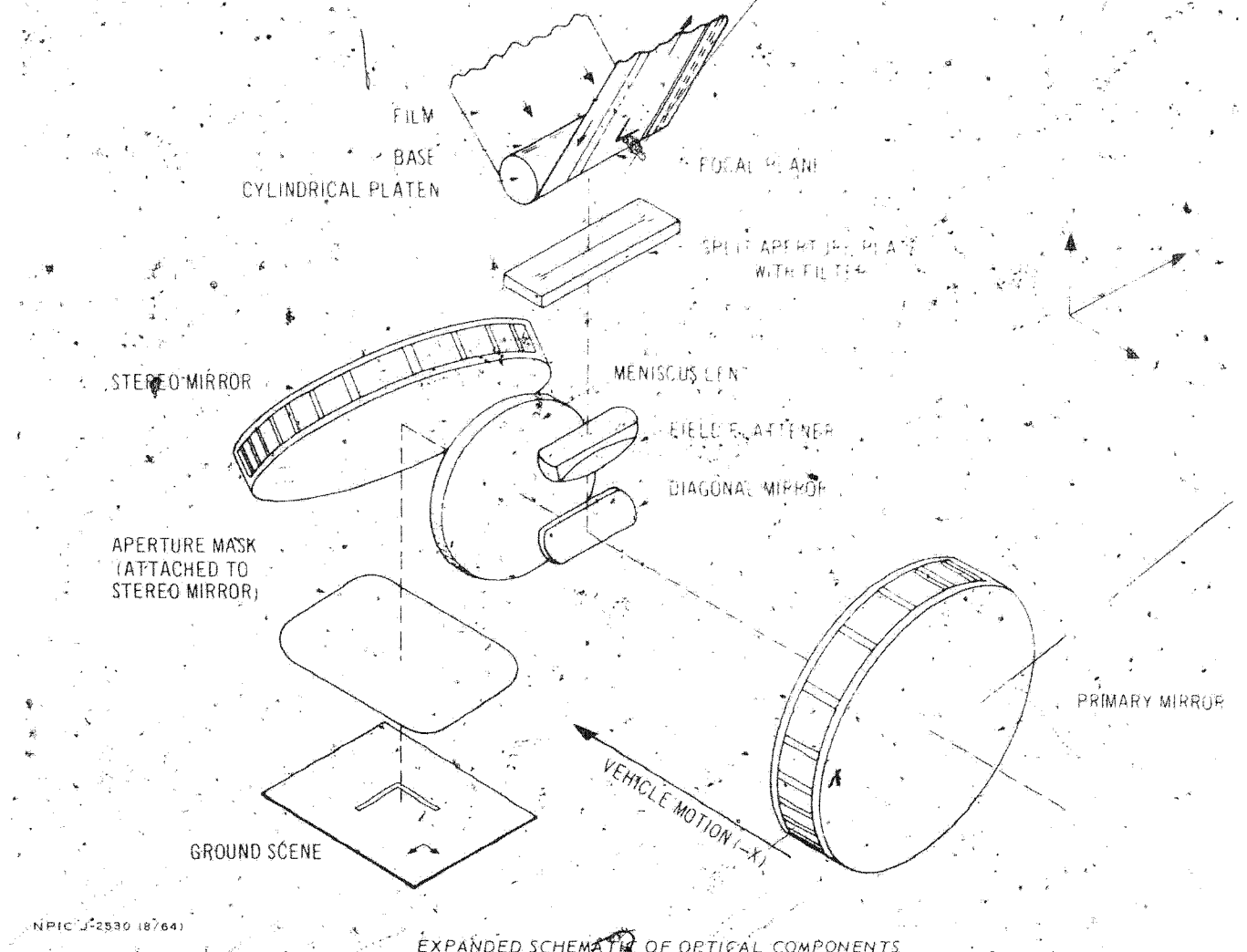
11. Lateral pair strip stereo Combination Experiment: Pass 64, frames 08, 09 and 10.

Frame 08 was taken with the mirror in a 15° forward position and the vehicle in a 41.83° roll (right wing up). Frames 09 and 10 were taken with the mirror in a 15° aft position and the vehicle in a 37.58° and 41.83° roll respectively. The sun was 64° above the horizon and at a true azimuth of 154°. The area was free of clouds and the scale of the photography is approximately 1:105,000. The exposure is adequate and the resolution is good.

PI Suitability: The 30° convergence angle of the overlapped area produces excellent stereo coverage. This type of photography is considered excellent at this roll angle for photographic interpretation.

APPENDIX A ORBITAL DATA AND CAMERA SPECIFICATIONS

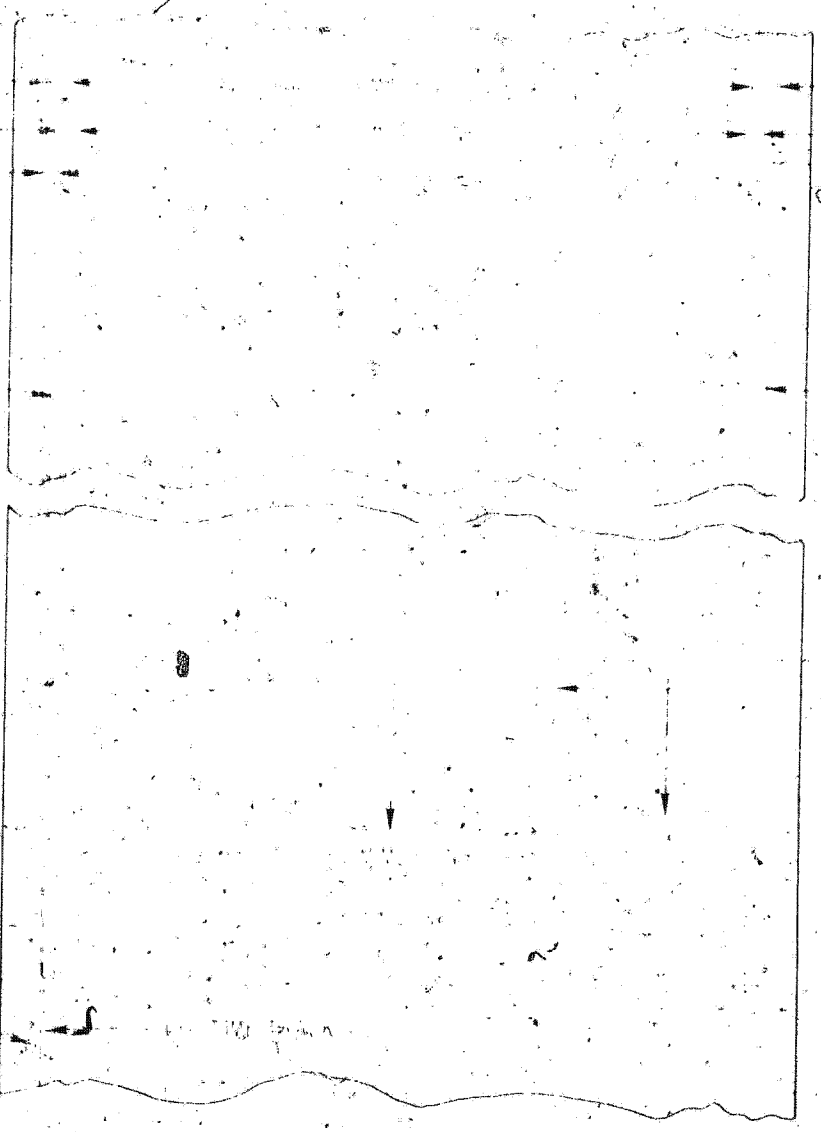
[redacted]



NPIC/J-2530 (8/64)

EXPANDED SCHEMATIC OF OPTICAL COMPONENTS

[redacted]



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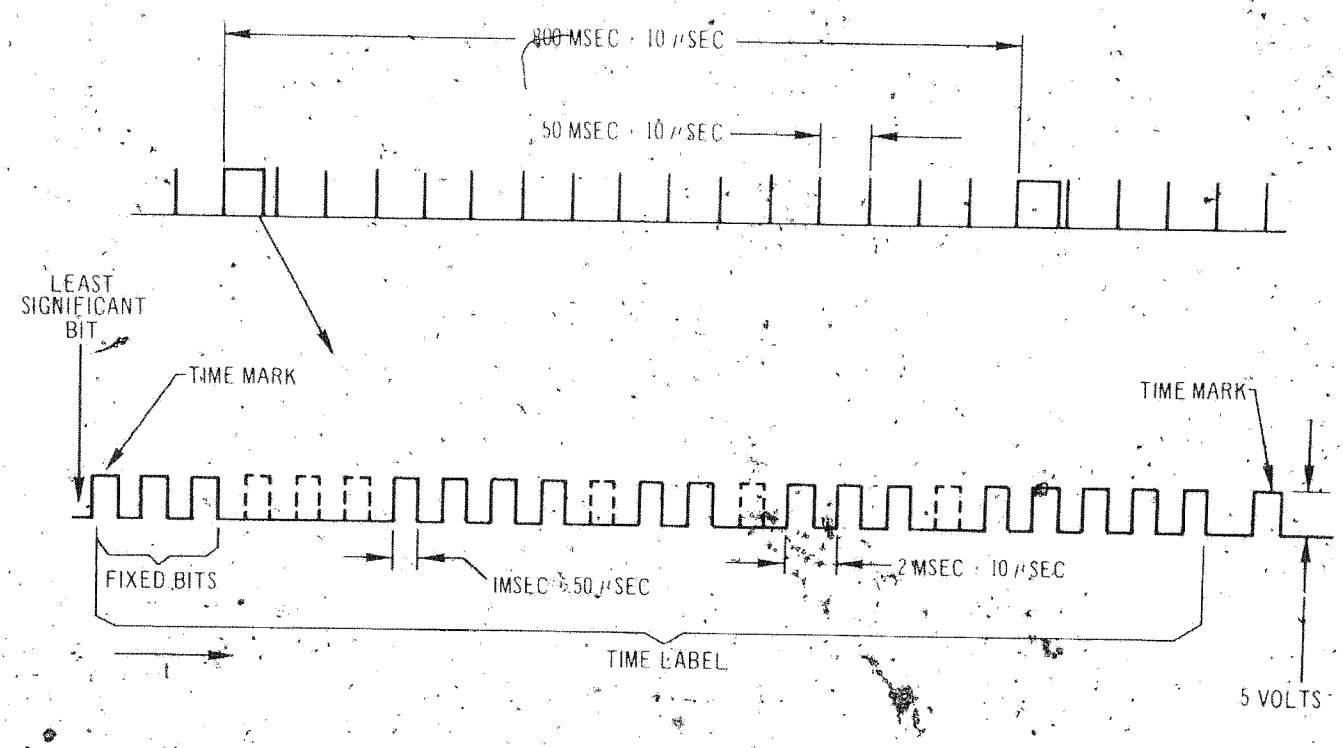


PIC J-2532 (8/64)

TIME-TRACK FORMAT

APPENDIX B. TECHNICAL COMPENDIUM

EXPLANATION OF COLUMN HEADINGS

Pass frame: The pass is the orbital revolution during which the photography was acquired. A prefix "A" indicates that the photography was acquired as the vehicle was orbiting from the south to the north point of tangency. A prefix "D" indicates that the photography was acquired as the vehicle was orbiting from the north to the south point of tangency. A prefix "M" indicates that the photography was acquired as the vehicle went through a point of tangency. A suffix "E" (for engineering) indicates that either no imagery was recorded, or that the photography required special editing and a section has been deleted. The pass number changes as the vehicle crosses the equator from south to north. The frame numbers begin with 01 in each pass and are numbered consecutively for each acquisition throughout the pass.

Height in Nautical Miles: The height of the vehicle above the reference ellipsoid as illustrated in Figure 1. The slant range and scale of photography may be computed from this measurement.

Programed Roll: The planned roll of the vehicle during the acquisition of the photography (Figure 1). Programed roll does not include roll error. A minus roll indicates that the right wing of the vehicle is up.

Mirror Positions: The position of the stereo mirror during the acquisition. There are three mirror positions: 15° forward, vertical, and 15° aft (Figure 2).

Type of Coverage:

Stereo
Strip
Triplet
Stereo Triplet
Lateral Pair
Lateral Triplet
Displaced Lateral Triplet

Solar Elevation: The angular elevation of the sun above a plane tangent to the surface of the earth at the point of intersection of the principal ray. A minus solar elevation indicates that the sun is below the plane.

Solar Azimuth: The angular measurement of the rays of the sun measured from true north clockwise (Figure 3).

Azimuth from the Principal Ray: The angular measurement from true north to the line formed by the intersection of the plane generated by the vehicle at the time of acquisition, its projected ground track position, and the principal ray of the camera and the plane tangent to the earth at the point of intersection of the principal ray. The angle is measured clockwise from true north unless it exceeds 180°. In that case it is given a negative prefix and measured counterclockwise.

Solar Bearing from Principal Ray: The angular distance of the sun azimuth measured clockwise from the principal ray.

Percent of Cloud Cover: An estimate of the area obscured by clouds.

Lateral Overlap: Area of duplicate coverage parallel to the line of flight.

Line of Flight Overlap: Area of duplicate coverage along the line of flight.

Area Overlap: The product of the lateral and line of flight overlap.

Limiting D-max: The most dense area within the format that can be detected with an aperture of 0.5 mm in a Macbeth QuantaLog Densitometer. (Usually tops of clouds or glare from highly reflective surfaces.)

Limiting D-min: The least dense area within the format that can be detected with an aperture of 0.5 mm in a Macbeth QuantaLog Densito-

meter. (Usually surfaces of low reflectivity in cloud shadows.)

Limiting Delta: The arithmetical difference between the most dense and least dense area in the format.

Terrain D-max: The most dense area of a topographical feature (discounting glare from water surfaces) that can be detected in the format--usually beaches, roof tops, fields of crops, etc.

Terrain D-min: The least dense area of a topographical feature (discounting cloud shadows) that can be detected in the format--usually forest areas, black-top roads, shadows of buildings, etc.

Terrain Delta: The arithmetical difference between the most dense and least dense topographical feature of the frame.

Gross Fog: The base plus fog density read outside the format along the timing track edge. Usually indicative of the level of processing.

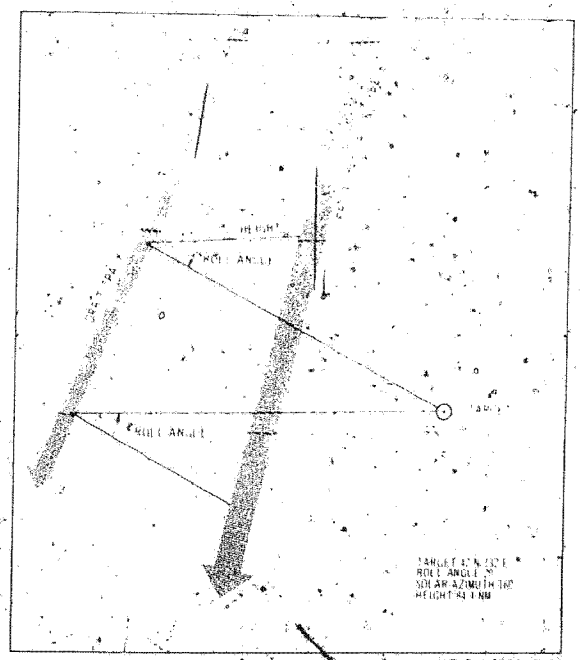


Figure 1. Orbital track and the projected ground track at a 20° right wing down-roll, and the convergence angle for stereographic coverage of a target.

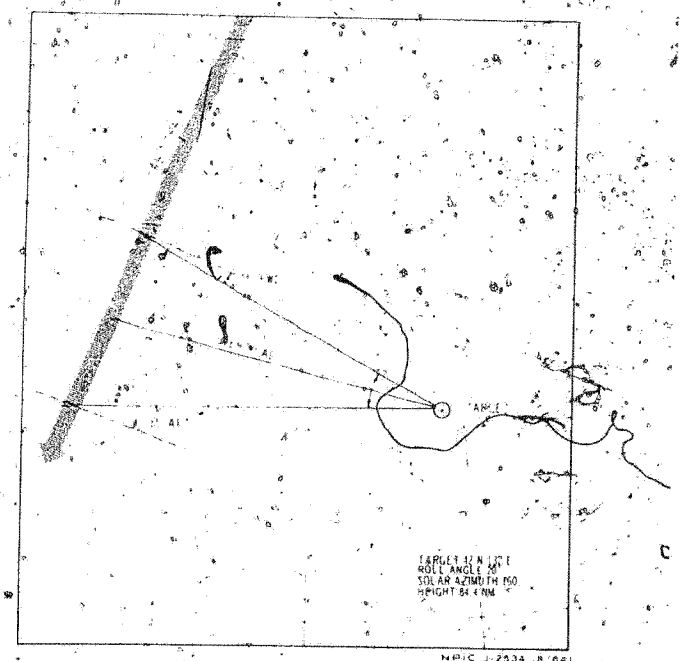


Figure 2. Mirror positions of the stereo mirror relative to the vehicle and the target.

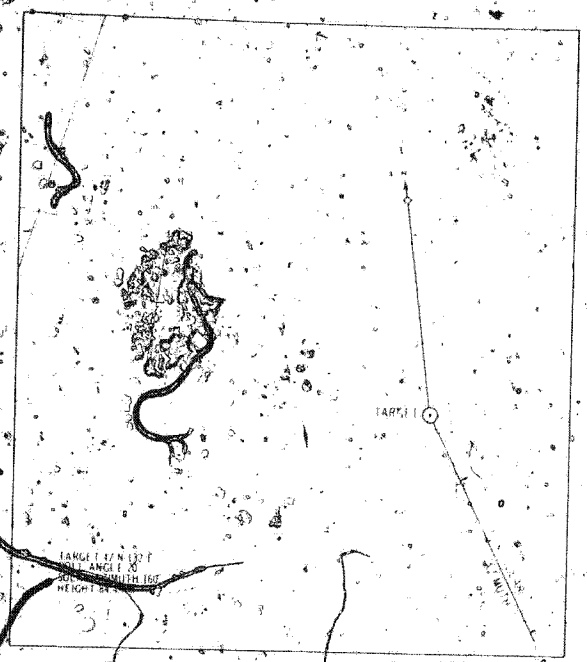


Figure 3. Relative positions of the solar azimuth, true north, and the target.

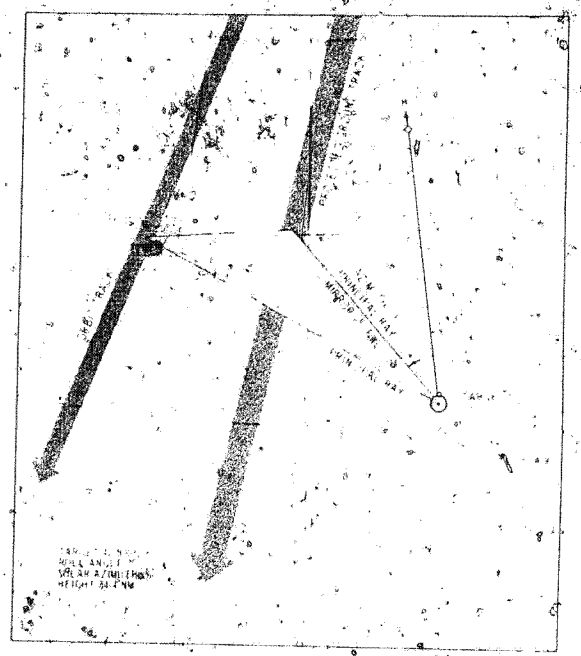


Figure 4. Relative location of the principal ray and the azimuth of the principal ray with the mirror in the 15° FWL position.

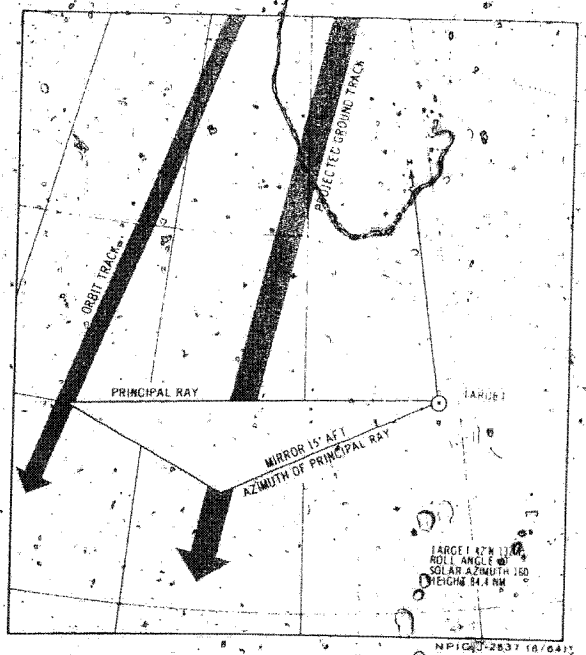


Figure 5. Relative location of the principal ray and the azimuth of the principal ray with the stereo mirror in the 15° AFT position.

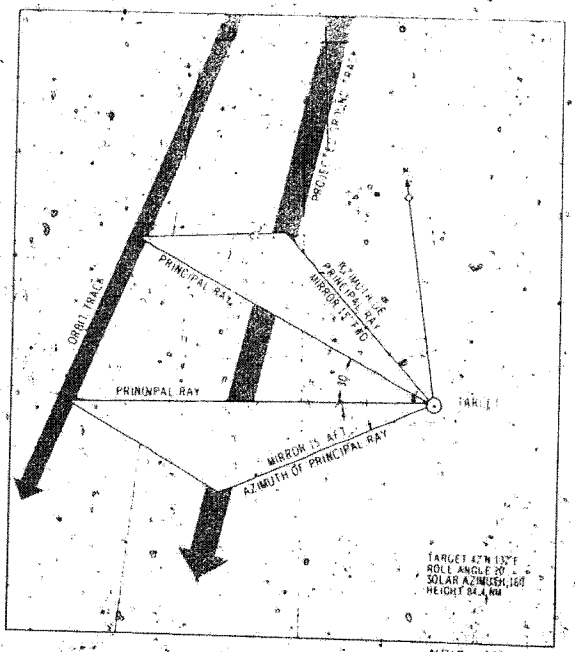


Figure 6. Although the convergence of the two principal rays always forms a 30° angle, the convergence of the azimuths of these principal rays forms an angle that is a factor of the vehicle attitude and altitude.

Pass	Frame	Height (Nautical Miles)	[illegible]	Camera Position	Type of Coverage	[illegible]	[illegible]	[illegible]	Azimuth of Principal Ray (°)	Solar Bearing from Principal Ray (°)	[illegible] Cloud Cover (%)	Lateral Overlap (%)	Line of Flight Overlap (%)	Area Overlap (%)	[illegible] D-Max	[illegible] D-Min	[illegible] Delta	Terrain D-Max	Terrain D-Min	Terrain Delta	Gross Fog
D57	11	71.8	21.81	15 A	Stereo	61.3	162	301	84	0	98	95	93	1.66	0.60	1.06	1.66	0.60	1.06	0.21
D57	12	70.6	41.12	0 A	Strip	71.0	96	75	151	[illegible]	0	0	0	2.02	0.58	1.64	1.87	0.58	1.43	0.20
D58	1	79.8	[illegible]	15 F	Stereo	[illegible]	[illegible]	2	44	100	NM	NM	NM	1.62	1.47	0.15	NR	NR	NR	0.14
D58	2	79.[illegible]	[illegible]	15 A	Stereo	[illegible]	[illegible]	46	58	100	NM	NM	NM	[illegible]	1.49	0.12	NR	NR	NR	0.13
D58	3	77.1	[illegible]	15 F	Stereo	[illegible]	[illegible]	18	0	20	90	98	88	1.66	0.29	1.37	1.64	0.29	1.35	0.13
D58	4	76.8	[illegible]	15 A	Stereo	31.2	[illegible]	110	176	20	90	98	80	1.76	0.28	1.48	[illegible]	0.28	1.37	0.13
D58	5	[illegible]	[illegible]	15 F	Stereo	[illegible]	204	100	271	90	[illegible]	[illegible]	60	1.82	[illegible]	0.70	1.74	1.11	0.63	0.13
D58	6	[illegible]	[illegible]	15 A	Stereo	31.5	104	[illegible]	[illegible]	[illegible]	[illegible]	80	[illegible]	1.84	[illegible]	0.74	1.74	1.10	0.64	0.12
D58	7	[illegible]	[illegible]	15 F	Stereo	[illegible]	[illegible]	60	102	90	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.97	0.12
D58	8	[illegible]	[illegible]	15 A	Stereo	[illegible]	[illegible]	170	[illegible]	90	75	[illegible]	[illegible]	[illegible]	[illegible]	1.74	[illegible]	0.22	0.69	0.12
D58	9	[illegible]	[illegible]	0 A	Strip	[illegible]	[illegible]	[illegible]	218	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.64	0.13
D58	10	72.4	26.23	15 F	Strip	[illegible]	[illegible]	80	277	70	70	9[illegible]	60	[illegible]	[illegible]	1.90	[illegible]	0.25	0.56	0.14
D58	11	[illegible]	26.23	15 A	Strip	18.1	177	[illegible]	[illegible]	[illegible]	70	9[illegible]	60	2.09	[illegible]	[illegible]	1.18	0.38	0.80	0.16
D58	12	[illegible]	26.[illegible]	15 A	Strip	19.0	176	[illegible]	[illegible]	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.76	[illegible]	0.40	0.91	0.19
D58	13	[illegible]	28.29	0 A	Strip	[illegible]	171	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.06	0.34	1.72	1.29	[illegible]	[illegible]	0.19
D58	14	71.0	14.89	15 A	Strip	[illegible]	171	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.24	0.91	[illegible]	0.24	0.91	0.19
D58	15	[illegible]	[illegible]	15 F	Stereo	[illegible]	[illegible]	[illegible]	[illegible]	100	[illegible]	90	[illegible]	[illegible]	[illegible]	1.14	NR	NR	NR	0.20
D58	16	71.6	20.9[illegible]	15 A	Stereo	[illegible]	[illegible]	120	[illegible]	97	9	90	[illegible]	[illegible]	[illegible]	[illegible]	NR	NR	NR	0.20
D58	17	[illegible]	[illegible]	15 A	Strip	[illegible]	171	121	[illegible]	100	[illegible]	[illegible]	[illegible]	1.98	[illegible]	[illegible]	NR	NR	NR	0.20
D58	18	71.6	[illegible]	0 A	Strip	[illegible]	[illegible]	70	[illegible]	100	[illegible]	[illegible]	[illegible]	2.04	1.04	1.00	NR	NR	NR	0.20
D58	19	[illegible]	[illegible]	15 F	Stereo	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	98	96	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.80	0.20
D58	20	71.6	11.71	15 A	Stereo	[illegible]	[illegible]	91	[illegible]	[illegible]	98	98	96	1.99	[illegible]	1.48	1.60	[illegible]	1.09	0.20
D58	21	[illegible]	11.8[illegible]	0 A	Strip	[illegible]	[illegible]	[illegible]	[illegible]	100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	NR	NR	NR	0.20
D58	22	92.6	21.27	15 F	Stereo	[illegible]	[illegible]	11	[illegible]	96	80	80	61	2.06	[illegible]	1.48	[illegible]	[illegible]	1.14	0.20
D58	23	92.3	21.27	15 A	Stereo	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	61	[illegible]	[illegible]	[illegible]	[illegible]	0.59	0.93	0.20
D59	1	79.2	0.71	15 F	Stereo	24.0	[illegible]	[illegible]	[illegible]	[illegible]	9[illegible]	98	9[illegible]	1.91	0.28	1.63	1.91	0.28	1.63	0.12
D59	2	79.0	0.72	15 A	Stereo	26.9	[illegible]	[illegible]	[illegible]	[illegible]	9[illegible]	98	9[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.64	0.12
D59	3	76.4	10.41	15 F	Stereo	[illegible]	207	100	271	80	[illegible]	90	76	1.89	[illegible]	1.61	1.89	0.62	1.27	0.12
D59	4	76.0	40.1[illegible]	15 A	Stereo	[illegible]	207	[illegible]	[illegible]	80	[illegible]	90	76	[illegible]	[illegible]	1.70	2.02	0.91	1.11	0.13
D59	5	[illegible]	[illegible]	15 A	Strip	51.3	196	[illegible]	171	0	0	[illegible]	[illegible]	1.70	0.57	[illegible]	1.70	0.66	1.04	0.19
D59	6	75.0	20.56	15 F	Stereo	77.2	201	39	33	40	[illegible]	[illegible]	90	2.31	[illegible]	[illegible]	[illegible]	0.32	0.99	0.20
D59	7	71.9	20.56	15 A	Stereo	77.2	[illegible]	90	[illegible]	50	[illegible]	[illegible]	90	1.88	0.48	1.40	1.82	0.48	1.40	0.22
D59	8	73.0	14.96	0 A	Strip	14.8	186	62	68	100	30	[illegible]	[illegible]	2.21	NR	NR	NR	NR	NR	0.22
D59	9	72.2	13.[illegible]	15 F	Strip	10.7	184	17	47	100	80	85	68	2.09	0.89	1.20	NR	NR	NR	0.22
D59	10	72.6	14.96	15 A	Strip	10.7	184	84	88	100	80	85	68	2.10	0.89	1.21	NR	NR	NR	0.22
D59	11	72.2	21.98	15 F	Stereo	19.3	176	75	281	2	75	98	73	1.05	0.35	0.70	1.05	0.37	0.68	0.22
D59	12	72.1	21.98	15 A	Stereo	19.0	176	249	297	2	[illegible]	98	73	1.14	0.36	0.78	1.14	0.39	0.75	0.22
D59	13	72.0	28.36	0 A	Strip	50.3	175	112	[illegible]	[illegible]	0	0	0	1.07	0.32	0.75	1.07	0.32	0.75	0.22
D59	14	74.9	26.23	15 A	Strip	50.6	174	144	210	0	0	0	0	1.28	0.35	0.93	1.28	0.38	0.90	0.22
D59	15	71.8	21.98	0 A	Strip	51.6	174	111	243	0	0	0	0	1.11	0.32	0.79	1.11	0.32	0.79	0.22
D59	16	71.7	2.84	15 A	Strip	62.8	173	167	154	0	0	0	0	1.14	0.34	0.80	1.14	0.34	0.80	0.22
D59	17	71.6	1.12	15 A	Strip	[illegible]	173	145	158	0	0	0	0	1.42	0.32	1.10	1.42	0.32	1.10	0.22
D63	1	86.1	12.76	0 A	Strip	71.0	115	104	211	2	0	0	0	2.07	0.42	1.65	NR	NR	NR	0.21
D63	2	86.7	11.12	15 F	Strip	72.2	116	84	[illegible]	0	0	0	0	0.92	0.59	0.33	NR	NR	NR	0.22
D63	3	87.0	38.29	15 F	Strip	72.5	111	72	215	0	80	90	72	1.82	0.81	1.01	1.82	0.81	1.01	0.22
D63	4	87.1	10.41	15 A	Strip	72.5	110	127	169	0	0	0	0	1.98	0.60	1.38	1.98	0.90	1.08	0.22
D63	5	87.3	37.58	15 A	Strip	72.5	111	128	166	0	80	90	72	1.80	0.73	1.07	1.80	0.73	1.07	0.22
D63	6	88.6	36.16	15 F	Strip	72.8	100	78	202	0	80	95	76	1.37	0.82	0.55	1.37	0.82	0.55	0.22
D63	7	88.8	29.07	0 A	Strip	73.1	100	105	177	0	0	0	0	1.24	0.71	0.53	1.24	0.71	0.53	0.22
D63	8	89.0	34.71	15 A	Strip	72.0	100	130	150	0	80	95	76	1.36	0.79	0.57	1.36	0.79	0.57	0.22
D64	1	82.8	-27.65	0 A	Strip	54.2	171	110	244	95	0	0	0	2.14	0.77	1.37	1.35	0.77	0.58	0.21
D64	2	82.7	-39.70	15 F	Strip	54.8	168	86	262	100	0	0	0	2.23	2.20	0.03	NR	NR	NR	0.21
D64	3	82.6	-39.70	15 A	Strip	55.0	168	132	216	100	0	0	0	2.21	2.15	0.06	NR	NR	NR	0.21
D64	4	82.6	38.99	15 F	Stereo	57.6	165	84	261	100	NM	NM	NM	2.23	2.16	0.07	NR	NR	NR	0.21
D64	5	82.6	-38.99	15 A	Stereo	57.6	165	131	214	100	NM	NM	NM	2.26	2.08	0.18	NR	NR	NR	0.21
D64	6	82.8	-41.12	15 F	Stereo	62.6	156	84	252	0	60	95	57	2.26	0.32	1.94	2.26	0.32	1.94	0.21
D64	7	82.9	-41.12	15 A	Stereo	62.6	156	129	207	0	60	95	57	2.02	0.39	1.63	2.02	0.39	1.63	0.21
D64	8	83.0	-41.83	15 F	Strip	63.8	154	84	250	0	*	60	30	2.08	0.68	1.40	2.08	0.68	1.40	0.21
D64	9	83.1	-37.58	15 A	Strip	63.9	154	130	204	0	60	100	60	2.00	0.76	1.24	1.76	0.76	1.00	0.21
D64	10	83.1	-41.83	15 A	Strip	64.1	153	128	205	0	80	100	80	2.04	0.51	1.53	2.04	0.51	1.53	0.21
D64	11	83.2	40.41	0 A	Strip	64.8	152	106	226	0	0	0	0	2.19	0.50	1.69	2.19	0.50	1.69	0.21
D64	12	83.3	-37.58	0 A	Strip	65.4	151	106	225	0	0	0	0	2.12	0.65	1.47	2.02	0.65	1.37	0.21
D64	13	83.8	2.13	15 F	Lat Pr	68.6	147	2	329	0	0	0	0	1.75	0.51	1.24	1.75	0.51	1.24	0.21
D64	14	84.0	8.51	15 A	Lat Pr	68.7	147	126	93	0	0	0	0	1.85	0.41	1.44	1.85	0.41	1.44	0.24
D64	15	85.0	-43.96	15 F	Strip	70.3	132	82	230	100	0	0	0	2.10	1.99	0.11	NR	NR	NR	0.21
D64	16	85.2	-40.41	0 A	Strip	70.5	132	104	208	100	0	0	0	2.05	2.00	0.05	NR	NR	NR	0.21
D64	17	85.3	-36.16	15 A	Strip	70.7	132	130	182	100	0	0	0	2.07	1.96	0.11	NR	NR	NR	0.21
D64	18	85.8	-28.36	15 F	Strip	72.0	125	72	233	100	0	0	0	1.98	1.78	0.20	NR	NR	NR	0.21
D64	19	86.0	-31.90	15 A	Strip	71.9	125	104	204	100	0	0	0	2.04	1.72	0.32	NR	NR	NR	0.21
D64	20	86.1	-34.74	15 A	Strip	71.8	125	130	175	100	0	0	0	1.95	1.81	0.14	NR	NR	NR	0.21

*Not Applicable NR No Reading Made NM Not Measured

APPENDIX C

MICRODENSITOMETER EDGE TRACE DATA

In an attempt to establish an objective measurement of image quality in photography, the technique of obtaining the spread function from microdensitometric edge traces is being investigated. The spread function curve represents the whole photographic system, and is a summation of the separate elements: lens, film, and uncompensated image motion due to vibration, velocity, roll, pitch, yaw, and aerial turbulence.

To assign a single number to the spread function, the width is measured at 50% amplitude. This number, usually expressed in microns, may be converted by use of the scale factors to ground distance in feet.

Edges meeting the criteria described below have been found on domestic passes of missions in the same frame as resolution targets and have been scanned. The ground distance in feet, thus determined, has been close to that determined from the resolution target. Although the techniques used are not refined and are considered to be still in the development stage, the potential of this type of objective analysis should be realized. The example of an edge scan and its respective spread functions is included as a preview of this type quality analysis.

Any optical image can be thought of as being composed of an infinite number of image points (or lines) of light, each being conjugate with points (or lines) in the object. While the object points can be infinitesimal light sources, the image points are always mounds or distributions of light having finite size. This blurring of light points in a photographic system comes from diffraction and aberration in the lens, light spreading and diffusion in the emulsion, and image motion caused by camera movement and atmospheric shimmering. The fundamental building block of the image then is the distribution of light in any of the image points. This distribution is called the spread function of the photographic system.

Lamberts and others have explained the mathematical and experimental correspondence of a sharp edge and its spread function. An analogy exists in the techniques of studying electrical system response. The analysis requires that the source or object fulfill the conditions of a unit step function, i.e. exist for an appreciable time or distance at a fixed signal level and instantaneously or abruptly change to a new level which is maintained for an appreciable time or distance. The spread function is obtained by differentiating the signal output curve point by point; i.e. measuring the rate of change of signal with time or distance, and plotting signal amplitude versus time or distance.

As a starting point the mission is examined to locate examples of best photography with edges long enough and straight enough for use in the microdensitometer, and having uniform density on each side of the edge to fulfill the conditions of a unit step function. This requirement is usually achieved by rooftops of buildings in large-scale photography, and only aircraft runways or taxiways in small-scale photographs.

The microdensitometer used is a Joyce-Lobel Double Beam Model IIIC. It is used with an effective slit of 1 micron by 125 microns. The recording table and sample table are directly linked with a ratio arm of 1000:1. The speed of the scan is variable and is determined by the amount of pen deflection (as the pen is deflected the speed decreases giving the pen time to reach its maximum response). The chart thus produced represents a plot of chart displacement versus distance. This plot is manually smoothed by the analyst and is a judgment of what the edge would be if grain and other anomalies were absent.

The data reduction is done manually at present, but the feasibility of using the UNIVAC 490 computer is being investigated. The linear slope of the calibrated step wedge in the microdensitometer is used to determine the densities at measured distance increments along the trace. The curve for the material showing density versus log exposure (D log E) is used to determine the Log E. The anti-log is obtained to yield the exposure (E) required to produce the determined densities. The difference between adjacent values of E is divided by the corresponding difference of the measured distance increments to produce the slope values (dE/dX) of the original scene reflectance distribution. Finally, 50 percent of the maximum slope is computed, and the distance between the 50 percent slope values is determined by interpolation. The value thus obtained represents the 50 percent amplitude width of the Line Spread Function of the original edge. The actual Line Spread Function Curve may also be plotted and the 50 percent amplitude width measured for verification of the computed value.

The 50 percent amplitude width value is shown on the enclosed original trace in terms of microns on the negative.

MICRODENSITOMETER DERIVED IMAGE QUALITY DATA COLLECTED AND COMPILED BY CONTRACTORS

Microdensitometer tracing of scene edges has been used as an objective technique for evaluating photographic systems. In this report the evaluation data are presented as spread function width in microns and resolving power in lines per millimeter (mm). A statistical summary of all of these type missions traced to date is presented giving the number of edges traced, the arithmetic mean, standard deviation, and coefficient of dispersion in both spread function width and resolution. Frequency plots of the spread function and resolving power data are presented to show the distribution of the values.

The image quality data were obtained from sharp scene edges in the original negative by scanning with a Kodak Model 5 microdensitometer using a 1 by 320 micron slit. The data reduction consisted of the following steps:

(a) hand smoothing of the microdensitometer strip chart recording

(b) key punching of chart (density) values at sample distance increments of 0.35 microns

(c) computer (IBM 1620) conversion of chart values to relative exposure values

(d) computer conversion of exposure data to line spread function and modulation transfer function by numerical methods.

The edge resolving power was predicted graphically as the intersection of the Modulation Transfer Function and the Aerial Image Modulation curve for 4404 type film at a test object contrast of 2:1. The spread function width was calculated from the first differences of relative exposure as the width at which the gradient became 50 percent of the maximum gradient.

Analysis of Image Quality Evaluation of Photographic System Performance

Mission Number	Number of Edges	Spread Function Width at 50 Amplitude in Microns, Computer Calculations			Resolution in lines/mm from A.I.M. 1404 Curve, Computer Calculations		
		Arithmetic Mean	Standard Deviation	Coefficient of Dispersion	Arithmetic Mean	Standard Deviation	Coefficient of Dispersion
4001	15	16.5	5.1	31	73.5	27.4	37
4002	30	14.2	5.7	40	74.7	26.4	35
4003	32	12.3	2.9	24	84.8	18.1	21
4005	16	64.4	32.7	51	19.3	8.5	44
4006	106	13.6	6.1	45	80.1	28.8	36
4007	106	14.4	4.7	33	70.5	21.0	30

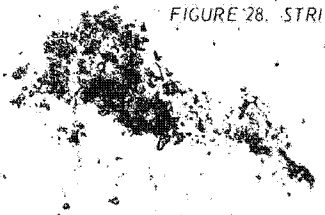
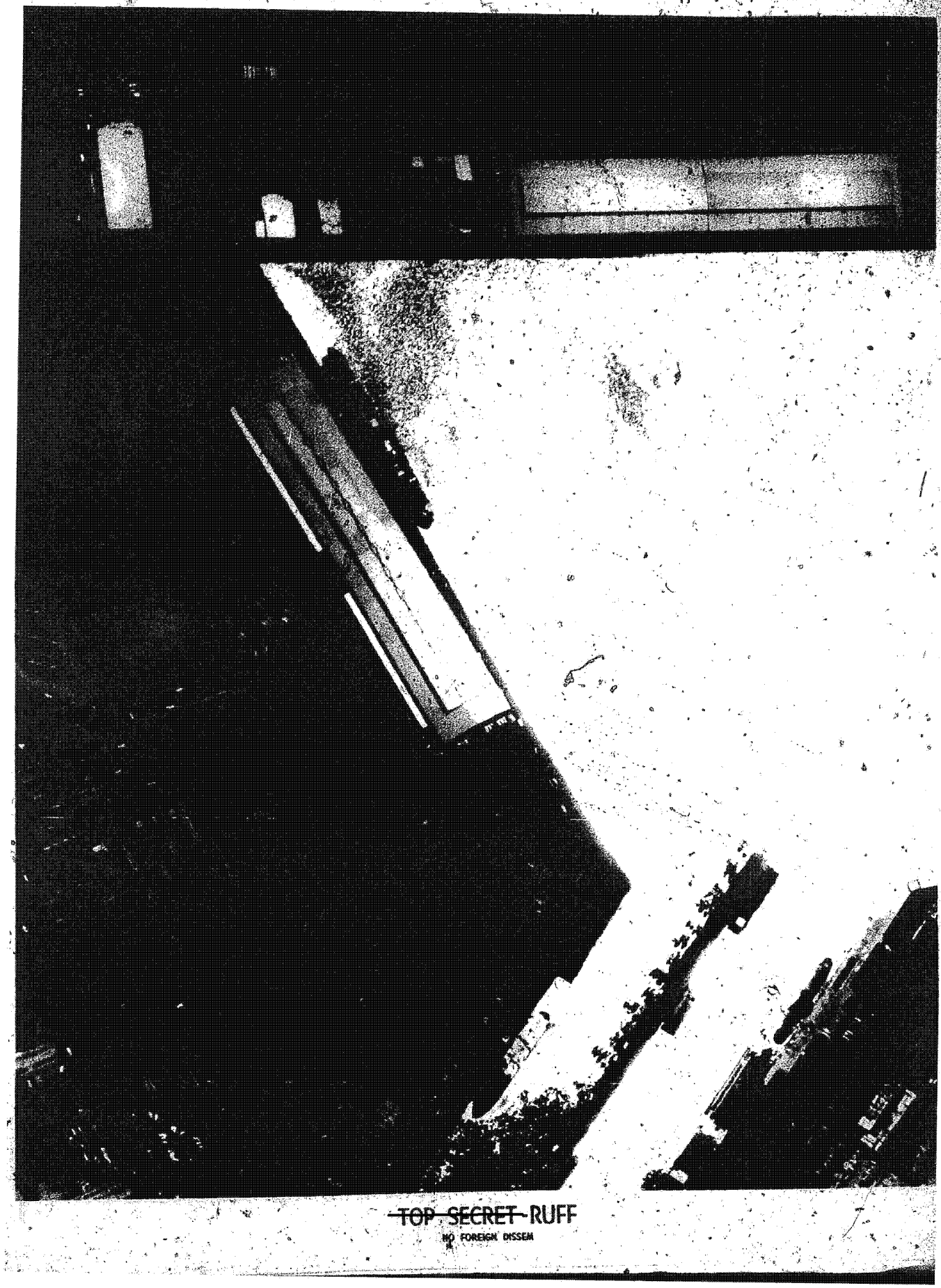


FIGURE 28. STRIP PHOTOGRAPH OF BUILDING FROM WHICH EDGE TRACE WAS REPRODUCED.

Building from which edge trace was made.

Pass: 1016
Frame: 11
Index: 20 47.9-09.2
Enlargement: 20X
Solar Elevation: 64.9
Solar Azimuth: 146
Solar Bearing: 81
Roll Angle: 13.47



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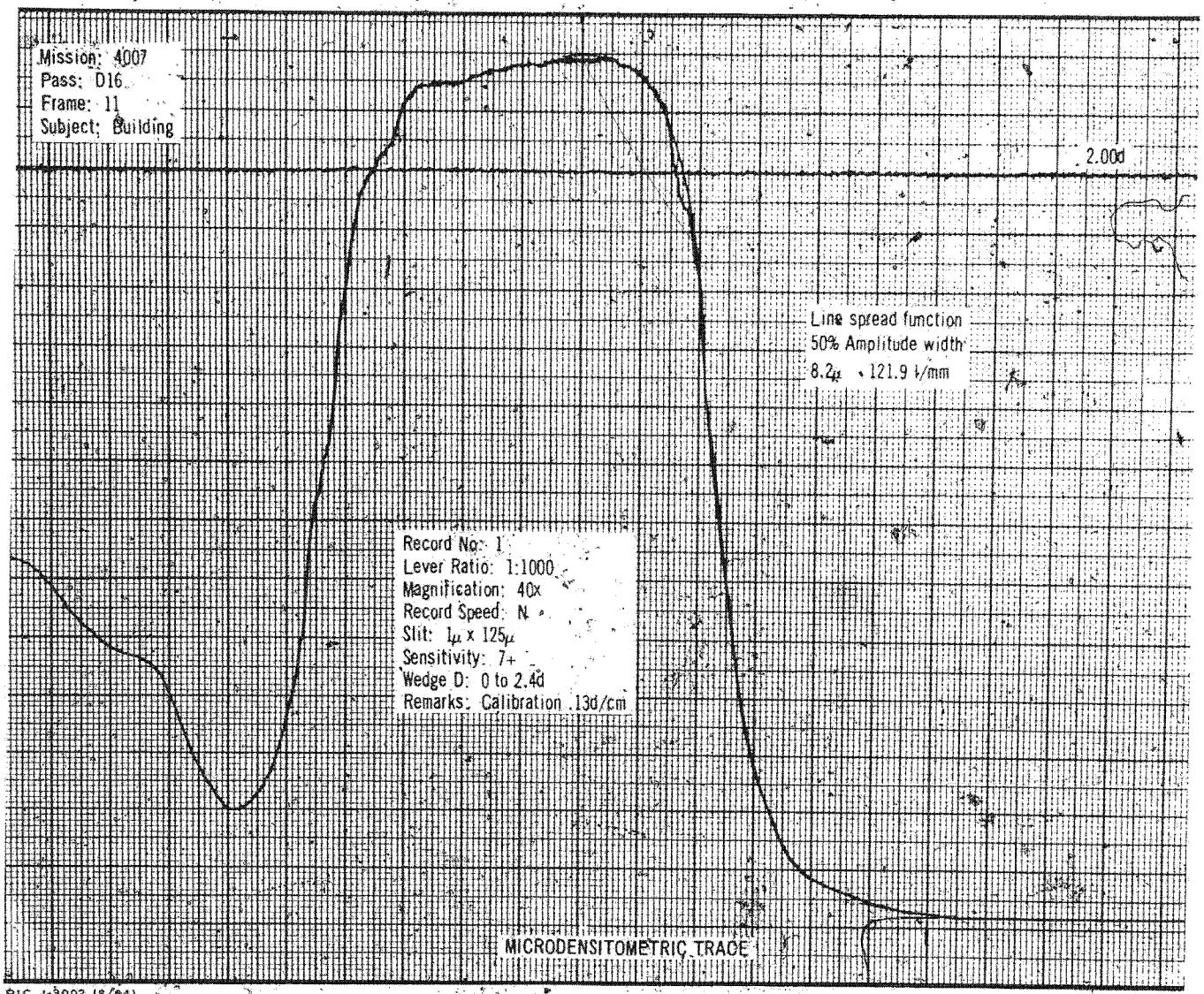

PIC J-3002 (8/64)

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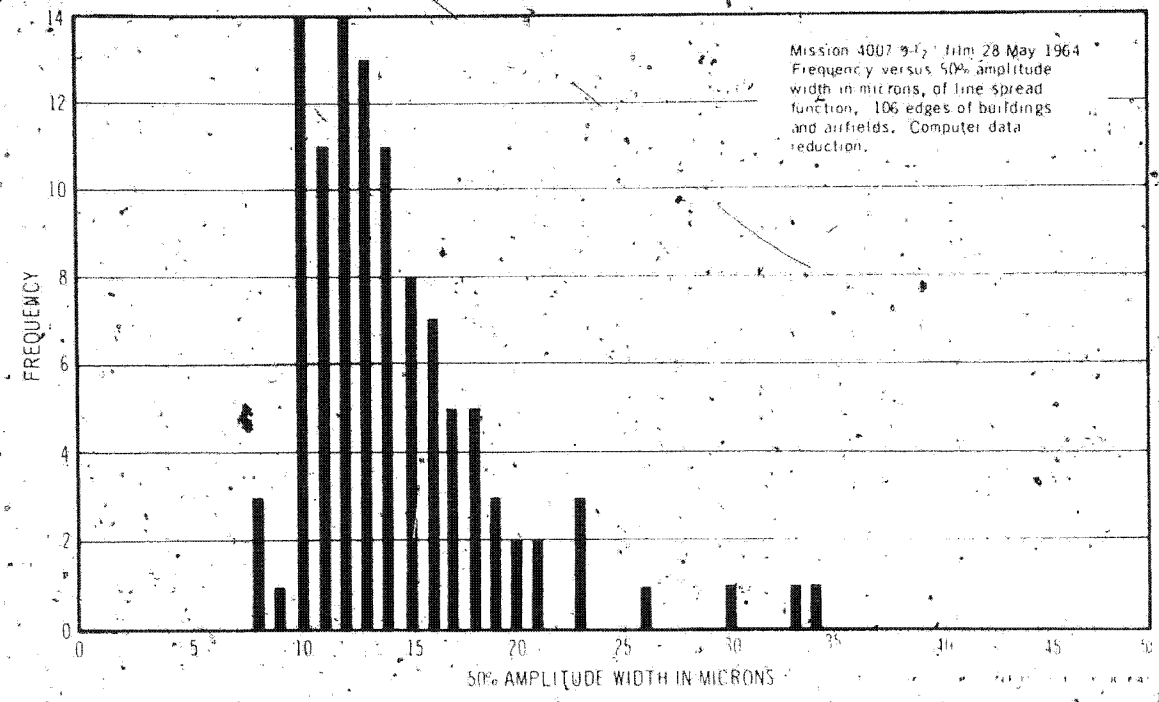

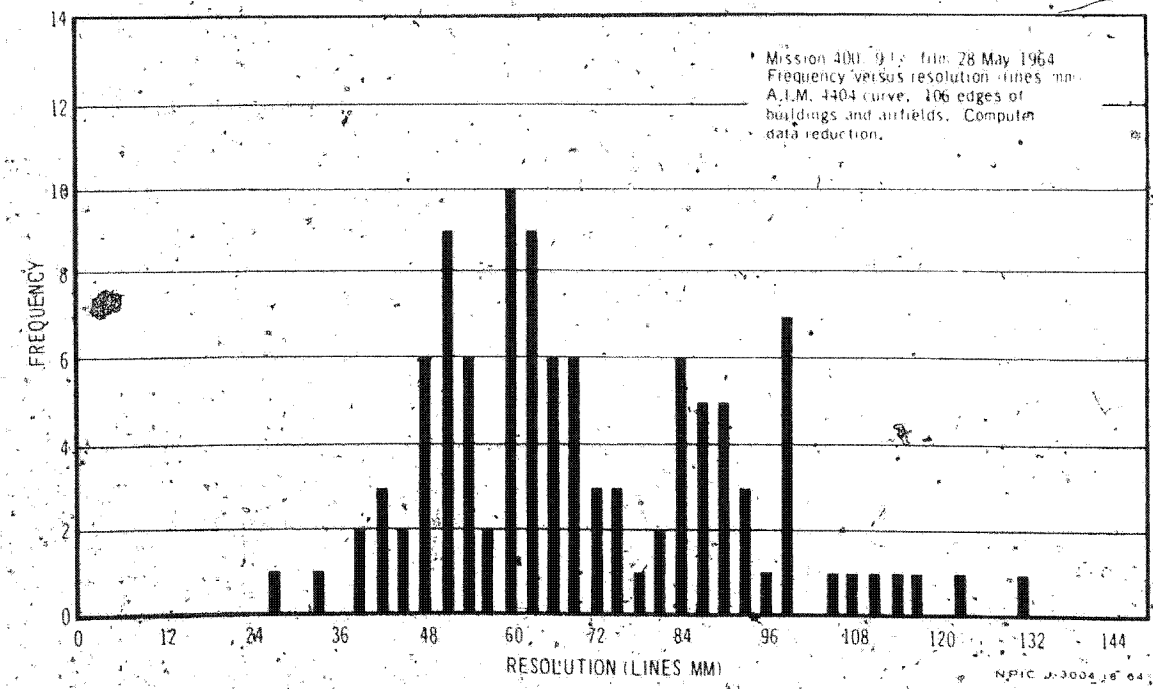

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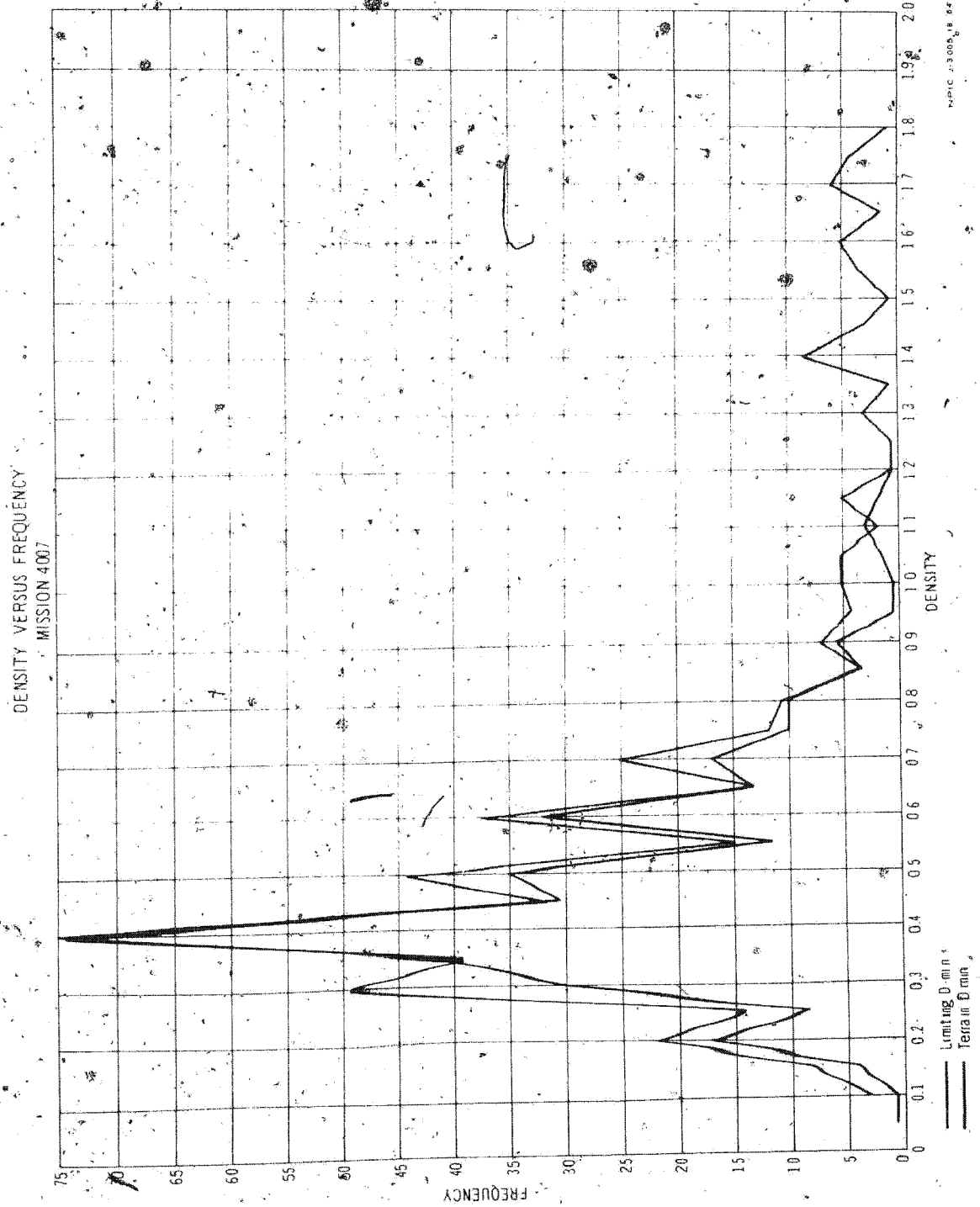
APPENDIX D. DENSITY VERSUS FREQUENCY GRAPHS



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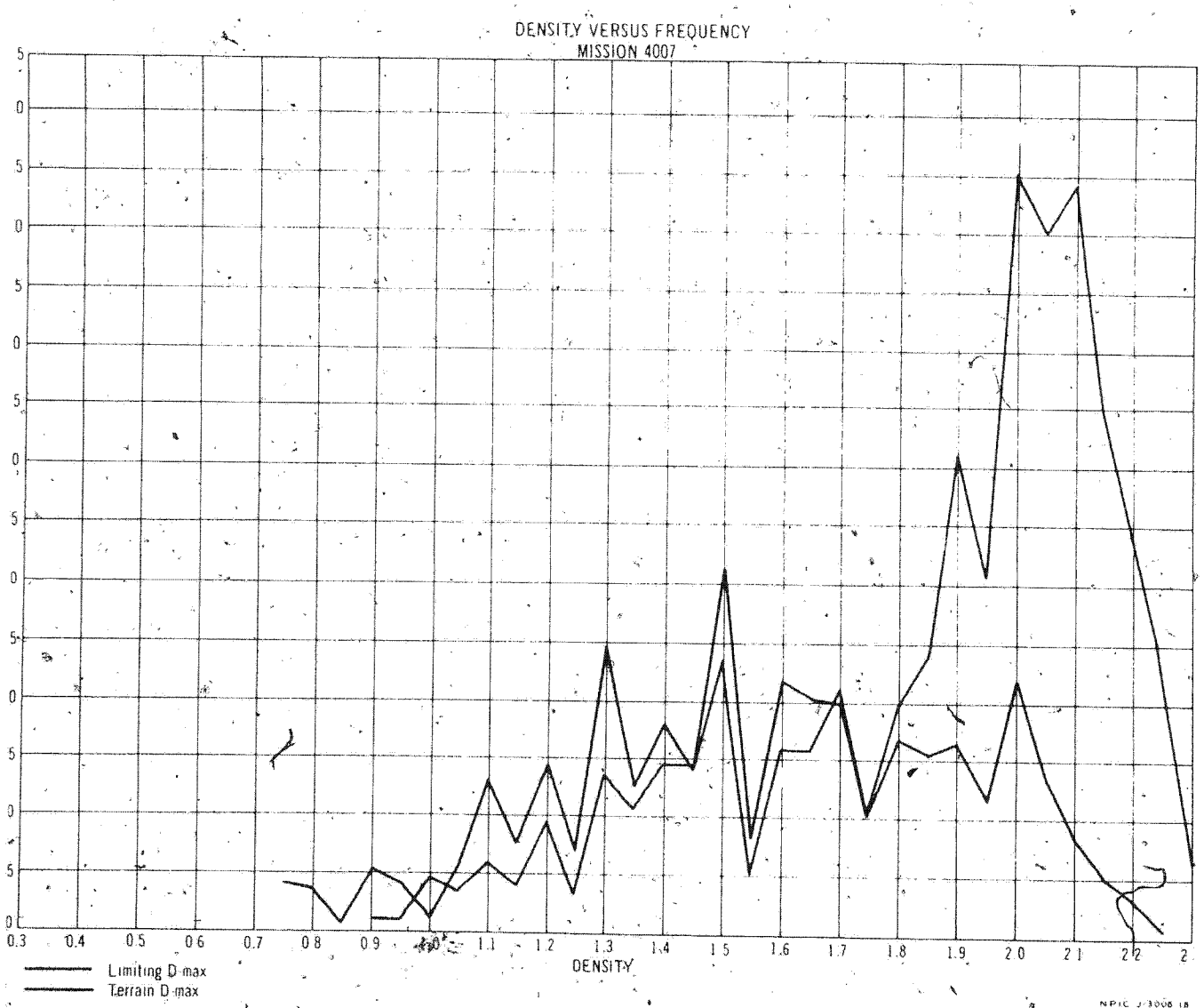

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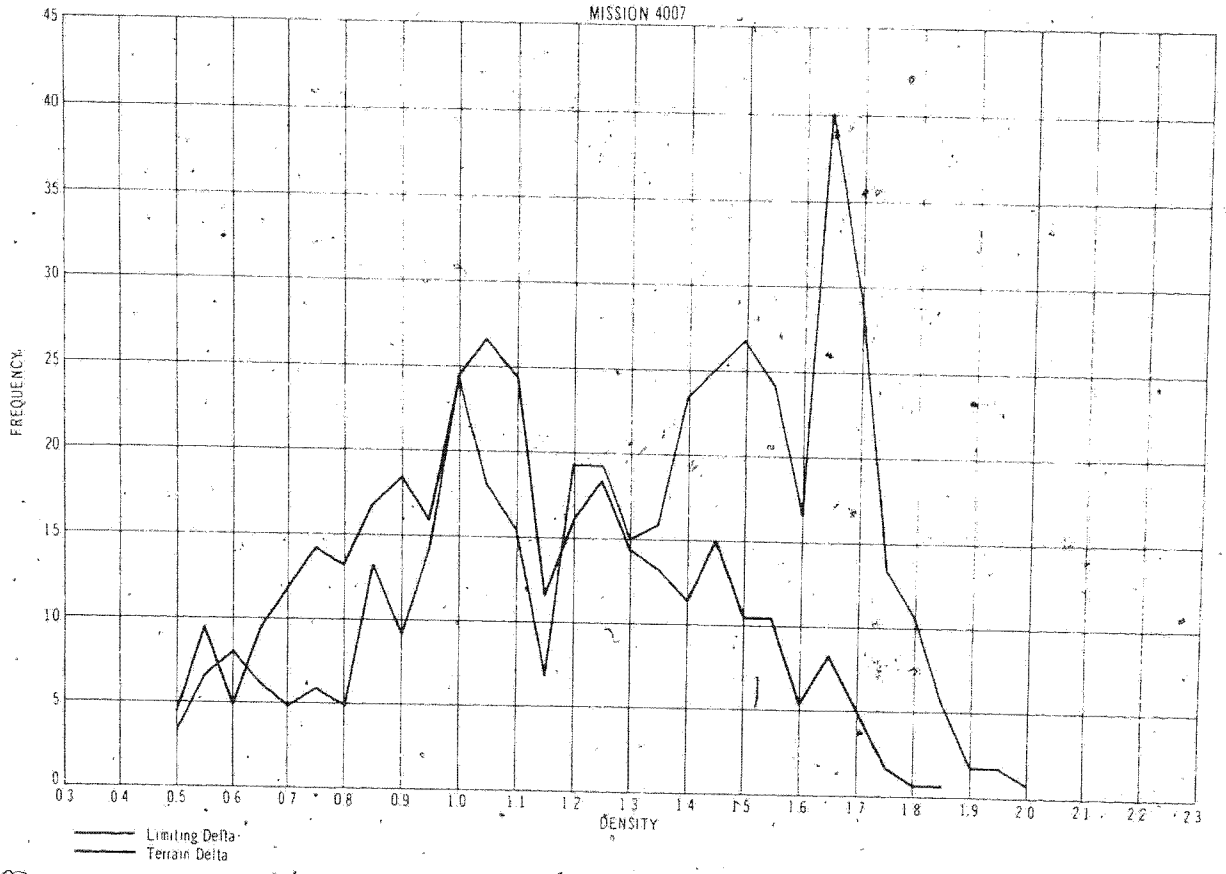
DENSITY VERSUS FREQUENCY
MISSION 4007



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NO FOREIGN DISSEM

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DENSITY READINGS OF INDEX NEGATIVES MISSION 4007

Density readings were taken on each pass, using a Macbeth Quantal Log Densitometer, Model EP 1000, with an ET 20 attachment and a 0.5 mm aperture. The values are correlated below:

DENSITY READINGS INDEX NEGATIVES
MISSION 4007

Pass	Frame	Terrain		Limiting		Gross Fog
		D-min	D-max	D-min	D-max	
D04	01	1.46	2.31	1.46	2.31	0.07
D04	05	1.80	2.32	1.80	2.32	0.07
D04	06	1.79	2.33	0.68	2.33	0.07
D04	09	1.25	2.35	0.78	2.35	0.06
D04	10	1.65	2.35	0.60	2.35	0.07
D04	13	2.00	2.42	0.10	2.42	0.06
D05	14	1.68	2.24	1.68	2.24	0.06
D05	15	1.66	2.24	1.68	2.24	0.06
D05	18	1.64	2.22	1.64	2.22	0.06
D05	19	1.54	2.27	1.13	2.27	0.07
D05	20	1.64	2.32	1.24	2.32	0.07
D05	21	0.63	2.78	0.63	2.78	0.07
D05	26	1.00	1.68	1.00	2.28	0.07
D05	27	0.76	1.84	0.75	2.44	0.07
D05	31	0.92	1.41	0.82	2.62	0.07
D06	32	NR	NR	1.70	2.27	0.07
D06	53	0.70	1.70	0.70	2.54	0.07
D07	54	1.15	2.04	1.15	2.04	0.07
D07	58	0.87	2.10	0.87	2.15	0.07
D08	59	1.26	2.44	1.26	2.44	0.06
D08	66	1.38	2.38	1.03	2.38	0.06
D09	67	1.62	2.10	1.62	2.10	0.06
D09	85	1.32	1.88	1.32	2.44	0.06
D10	86	1.21	2.03	1.21	2.03	0.06
D10	103	1.08	2.50	0.68	2.50	0.06
D11	104	1.43	2.14	0.14	2.28	0.06
D11	105	1.22	2.16	0.13	2.35	0.06
D15	106	1.44	2.14	1.44	2.14	0.06
D15	128	0.88	2.32	0.72	2.32	0.06
D16	129	1.14	1.94	1.14	2.08	0.06
D16	153	1.04	1.78	0.44	2.39	0.06
D20	154	1.62	2.16	1.62	2.16	0.06
D20	159	1.49	2.20	1.49	2.32	0.06
D21	160	1.32	2.26	1.32	2.26	0.06
D21	173	NR	NR	1.28	2.24	0.06
D22	174	1.57	2.06	1.57	2.06	0.07
D22	193	NR	NR	0.96	2.45	0.06
D23	194	0.96	2.03	0.96	2.03	0.06
D23	200	1.08	2.19	1.08	2.28	0.06
D24	201	1.50	2.24	1.34	2.36	0.06
D24	218	0.90	2.01	0.90	2.33	0.06
D25	219	0.97	1.88	0.97	1.88	0.06
D25	242	0.62	1.48	0.62	2.26	0.06
D26	243	NR	NR	1.46	2.12	0.06
D26	264	1.29	1.78	0.11	2.44	0.06
D27	265	NR	NR	1.08	2.04	0.06
D27	271	0.87	1.72	0.10	2.12	0.07
D31	272	NR	NR	1.51	2.45	0.06
D31	285	1.18	1.58	1.18	2.46	0.07
D32	286	0.08	0.50	0.08	0.71	0.06
D32	311	NR	NR	0.55	2.50	0.06
D36	312	1.88	2.28	1.88	2.28	0.06
D36	317	1.72	2.15	1.72	2.26	0.06
D37	318	1.47	2.02	1.47	2.02	0.06
D37	326	NR	NR	1.80	2.35	0.06
D38	327	1.82	2.23	1.82	2.23	0.06
D38	344	0.82	1.72	0.82	2.50	0.06
D39	345	1.28	1.84	1.28	1.84	0.06
D39	360	NR	NR	1.35	2.34	0.06
D40	361	1.04	1.92	1.04	2.02	0.06
D40	375	0.64	2.34	0.64	2.34	0.06
D41	376	1.26	2.28	1.26	2.28	0.06
D41	391	0.98	2.38	0.10	2.38	0.06
D42	392	1.55	2.03	1.35	2.11	0.06
D42	414	1.05	1.45	0.88	2.42	0.05
D43	415	0.93	1.91	0.93	1.94	0.06
D43	427	1.05	1.98	0.44	1.98	0.06
D44	428	0.07	0.28	0.07	0.28	0.06
D44	446	NR	NR	0.63	2.40	0.06
D45	447	0.08	0.30	0.06	0.30	0.06
D45	466	NR	NR	0.52	2.24	0.06
D47	467	NR	NR	1.72	2.35	0.06
D47	481	NR	NR	1.28	2.37	0.06
D48	482	0.83	1.82	0.83	2.02	0.06
D48	492	0.93	1.91	0.93	1.91	0.06
D53	493	1.38	1.98	1.38	1.98	0.06
D53	506	0.82	1.42	0.82	2.44	0.06
D54	507	1.19	2.04	1.19	2.04	0.06
D54	519	0.86	1.72	0.06	2.10	0.06

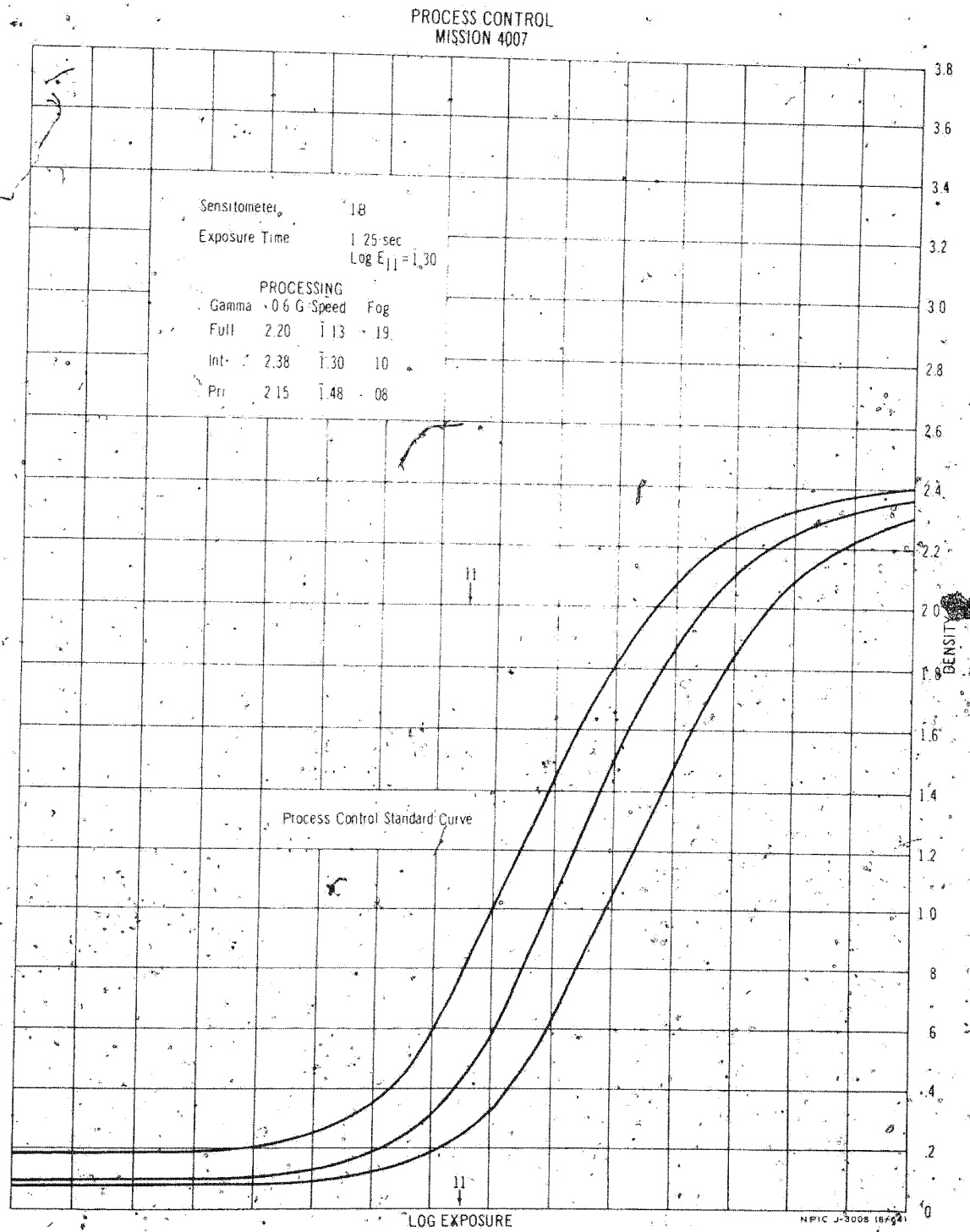
NR denotes no reading made

	Averages:		Ranges:		Gross Fog
	Limiting	Terrain	Limiting	Terrain	
D-max	2.19	1.99	2.78	2.78	0.07
D-min	1.02	1.18	0.06	0.06	0.06
Gross Fog		0.06			

Handle Via
TALENT-KEYHOLE
Control System Only

TCS-7825/64
NPIC/TP-18/64

APPENDIX E. PROCESSING GRAPHS



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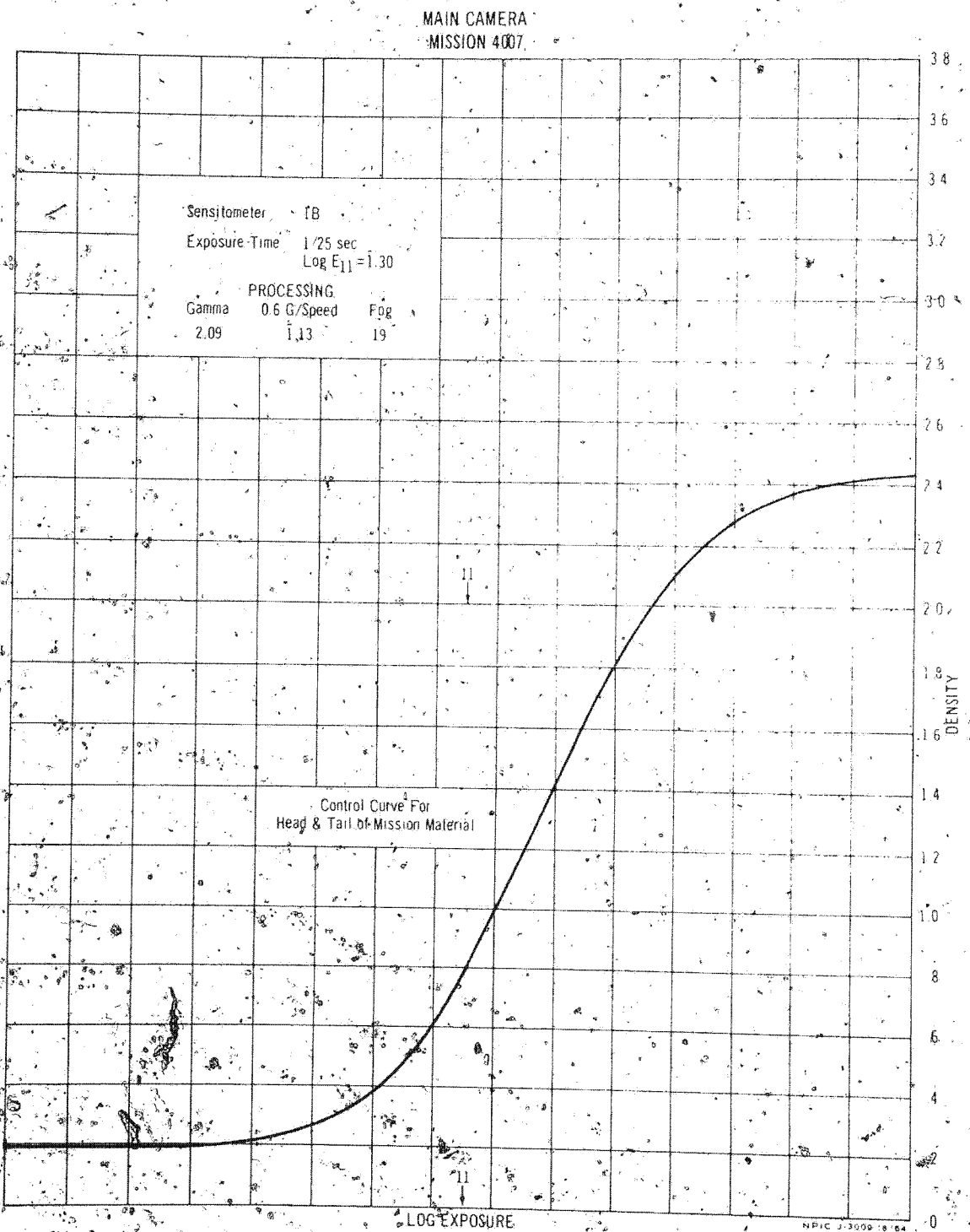

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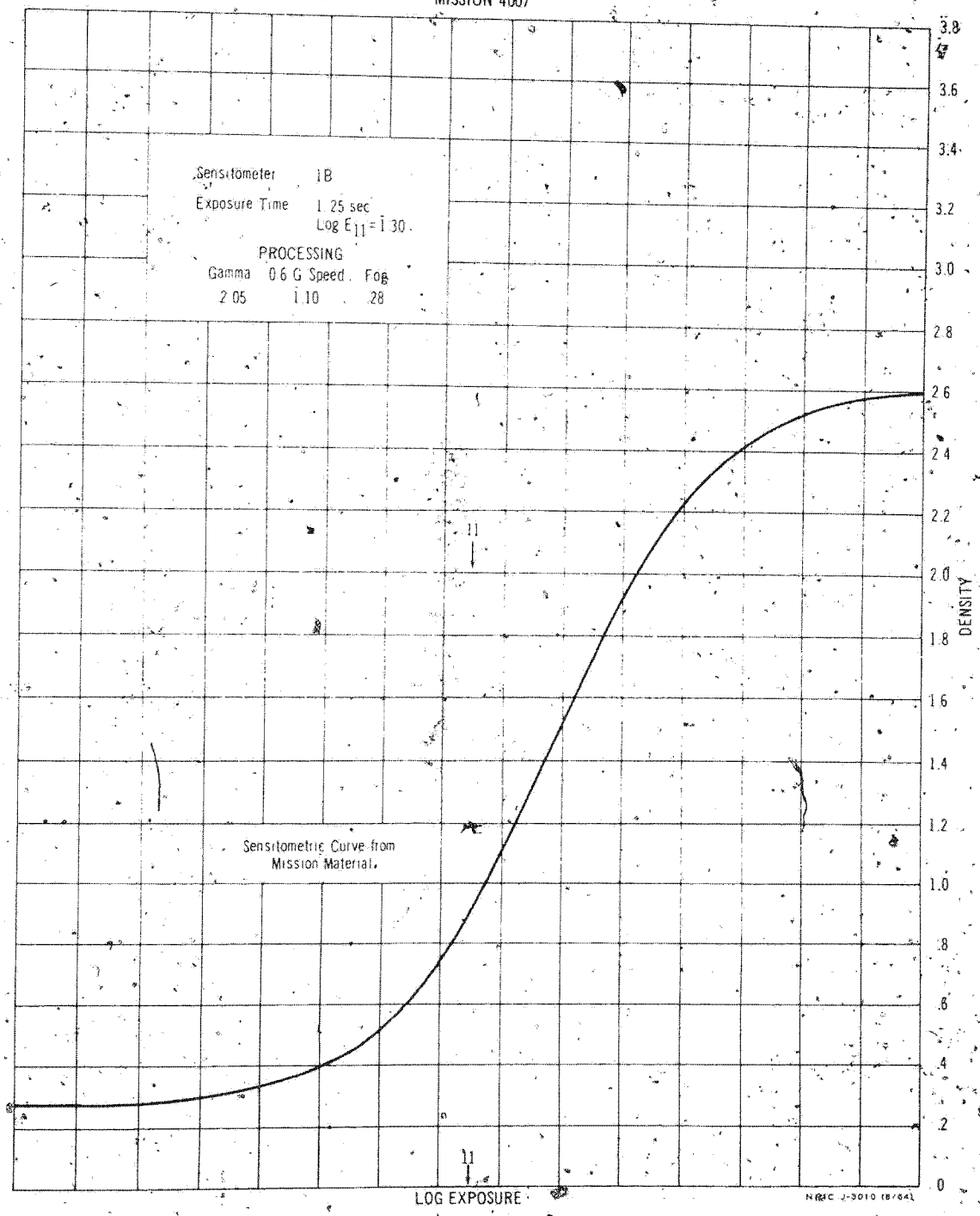
Control System Only

MAIN CAMERA
MISSION 4007



Handle Via
TALENT-KEYHOLE
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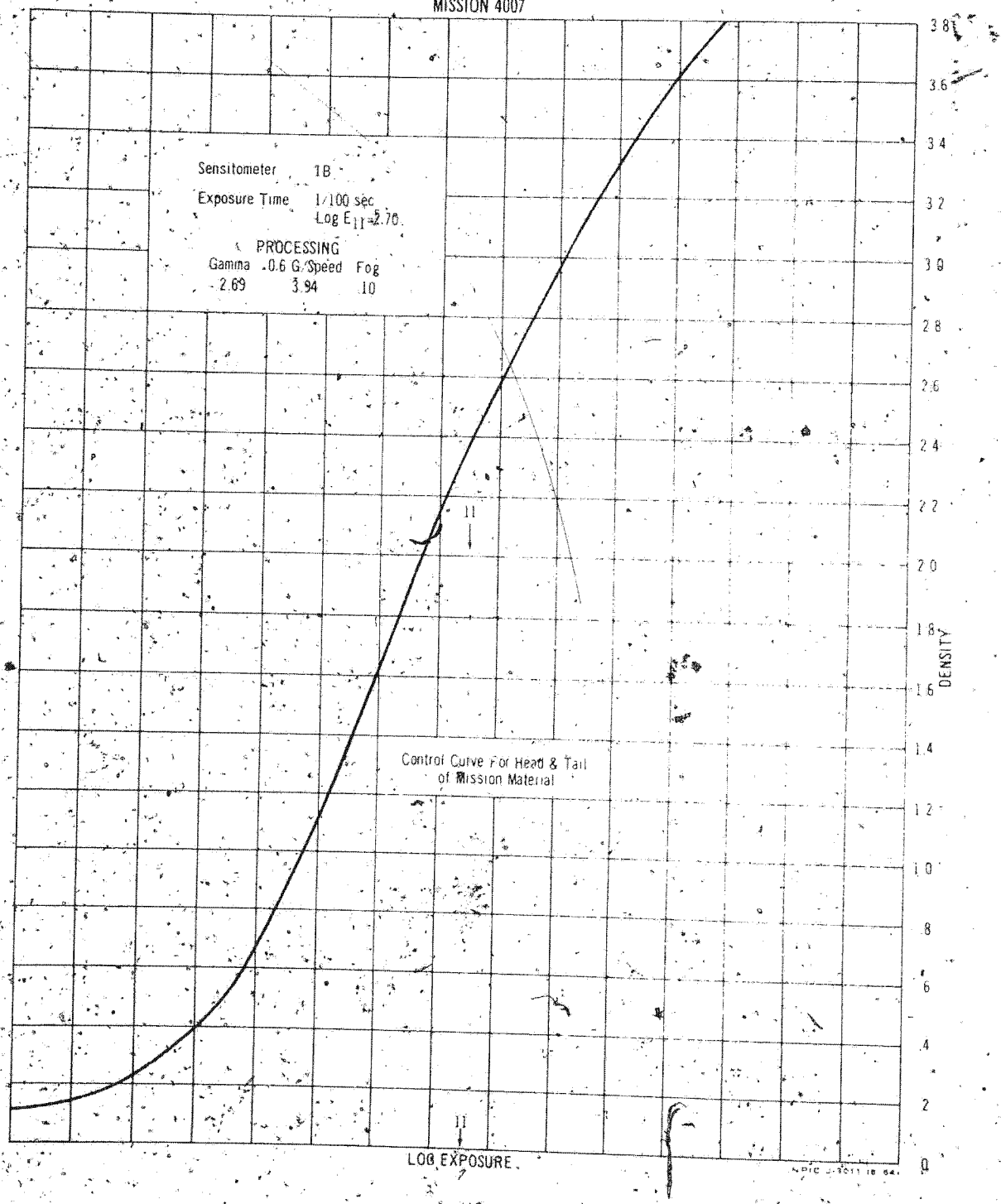
TCS-7825/64
NPIC/TP-18/64

STELLAR CAMERA
MISSION 4007



Handle Via
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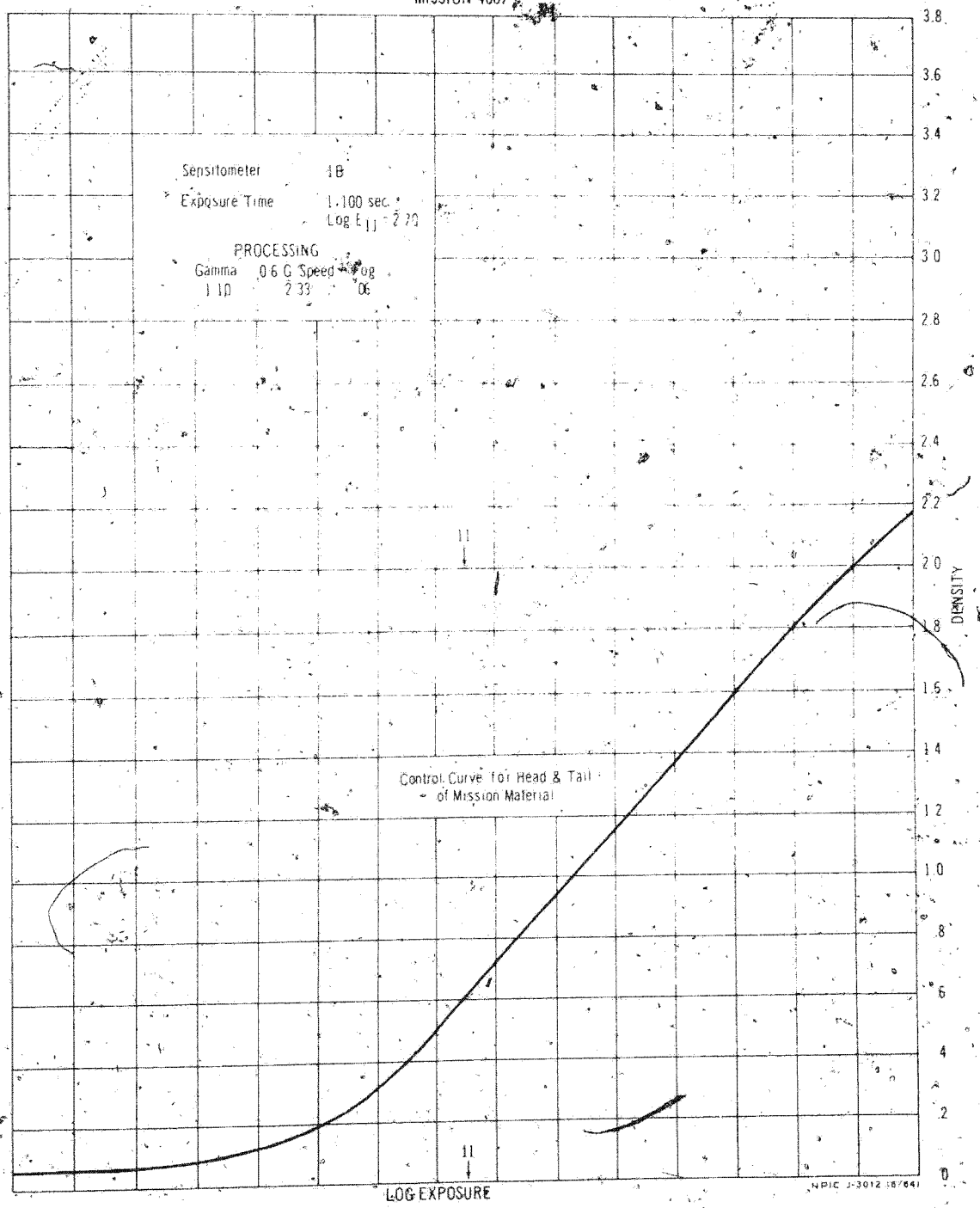
Handle Via
TALENT-KEYHOLE
Control System Only

TCS-7825/64
NPIC/TP-18/64

INDEX CAMERA
MISSION 4007



Handle Via
TALENT-KEYHOLE
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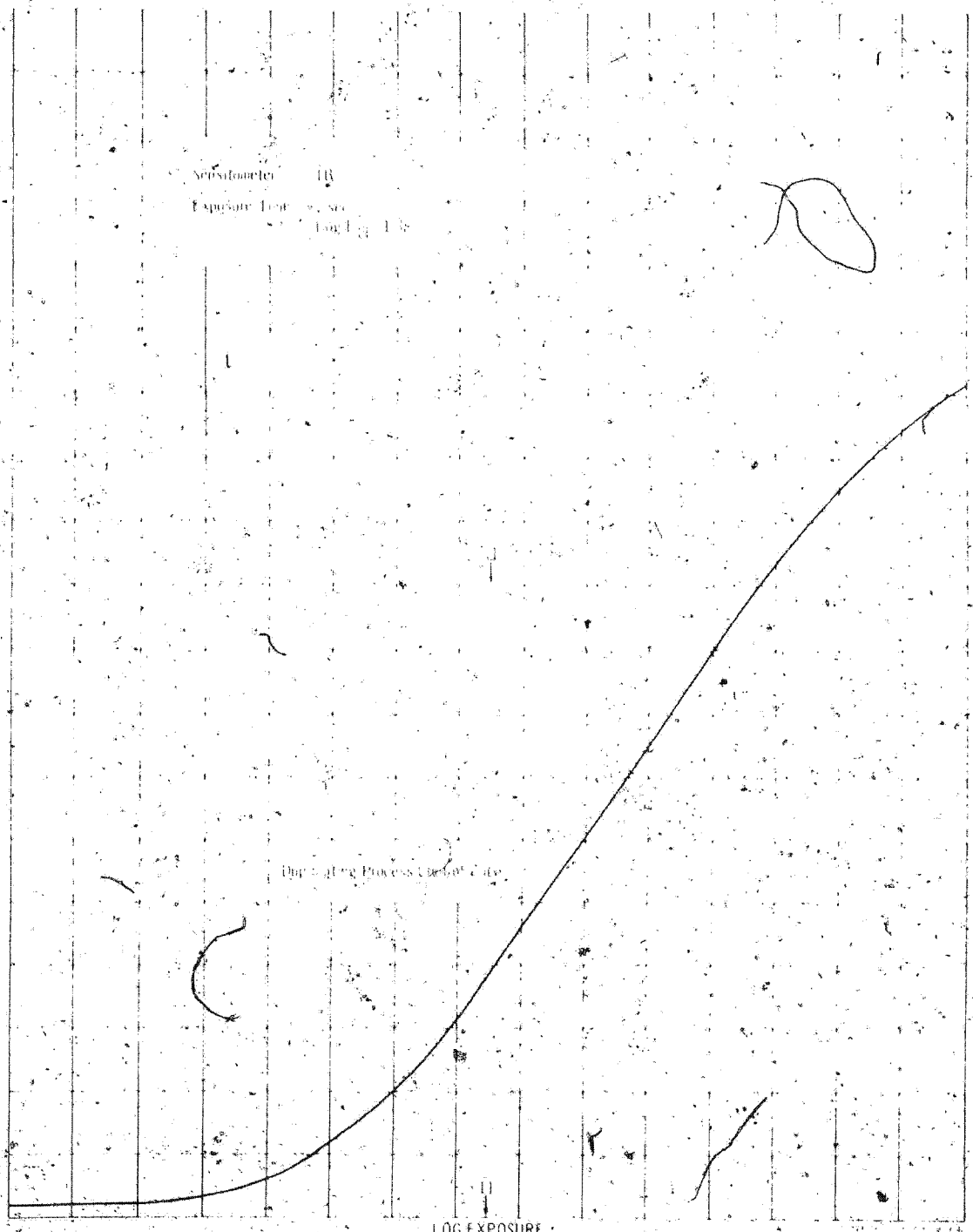
USSC/825/64
NPIC/TP 18/64

DUPLICATING PROCESS
MISSION 4007



APPENDIX F. CLOUD COVER STATISTICS

This study represents a statistical analysis of the cloud cover on the photography of Mission 4009. The basis for the statistical analysis of cloud coverage, produced by a strip camera, is the correlation of the length of camera operation in seconds to the estimated cloud category on the resultant photography. For stereoscopic photography, only the forward-looking frame is employed in the statistical analysis because the aft-looking frame is exposed to cover the same area. The data are obtained by analysts specifically trained in estimating cloud cover by designated categories.

Five cloud categories have been formulated for use in this type photography (Table 1). These categories allow for the wide latitude of cloud cover conditions commonly found on a photographic pass. Note in Table 1 that a mean cloud percentage value has been calculated for each category for use in determining a combined cloud cover percentage for all operational passes of the mission.

The occurrence of each cloud category within an operational pass is expressed as a percentage and appears in Table 2. The analyst delineates the cloud categories by segments of film and observes the time recorded on the frame margin required for the camera to expose each film segment. A proportion is established between camera operation time for a given cloud category and the total camera operating time during the photographic pass. For example: if the camera operation time for category 1 photography is 20 seconds in a given pass, and the total camera time for that pass is 100 seconds, then 20 percent of the pass would be classed as category 1.

Also, a cloud cover percentage for each pass is included in the last column of Table 2 under "cloud cover percentage per pass." This value is determined by the summation of the products of category percentage in each pass and the mean cloud percentage for that category as established in Table 1. For example: if it is determined that the following percentages exist in a given pass:

20 percent	Category 1
15 percent	Category 2
50 percent	Category 3
5 percent	Category 4
10 percent	Category 5

Then, by using the mean cloud percentage established in Table 1 the following computations are made:

0.20 x 5.0	1.00 percent
0.15 x 17.5	2.63 percent
0.50 x 35.0	17.50 percent
0.05 x 75.0	3.75 percent
0.10 x 100.0	10.00 percent
Total	43.75 percent

Hence, 43.8 percent of this pass is cloud covered.

The last horizontal line of percentages in Table 2 gives the mission averages (weighted) for each cloud category and the over-all mission cloud cover percentage.

Table 1. Cloud Cover Categories

Category Number	Percent of Cloud Cover	Description	Mean Clouds Percentage
1	Less than 10	Clear	5
2	10 - 25	Small scattered Clouds	17.5
3	26 - 50	Large scattered Clouds	35
4	51 - 99	Broken or Connected Clouds	75
5	100	Complete overcast	100

APPENDIX G. PLOTTABLE PHOTOGRAPHIG COVERAGE

MISSION 4007

Country	Linear nm	Square nm
USSR	7,862	84,147
China	2,357	27,648
Canada	854	8,840
Congo	307	2,855
Yemen	244	3,740
East Germany	209	2,536
Mexico	143	1,224
Saudi Arabia	124	2,074
Poland	98	1,178
Algeria	74	410
Afghanistan	59	944
Albania	50	600
Israel	50	900
Indonesia	50	540
Mongolia	50	500
Pakistan	50	450
West Germany	49	637
Rumania	46	460
Japan	46	414
Czechoslovakia	44	396
French Somaliland	41	272
Norway	25	80
Turkey	22	220
Hungary	22	220
Guatemala	21	294
Iran	5	90
TOTALS	13,340	141,668
Continental United States	1,294	15,951
GRAND TOTALS	14,634	157,619

APPENDIX H. MISSION COVERAGE TRACK

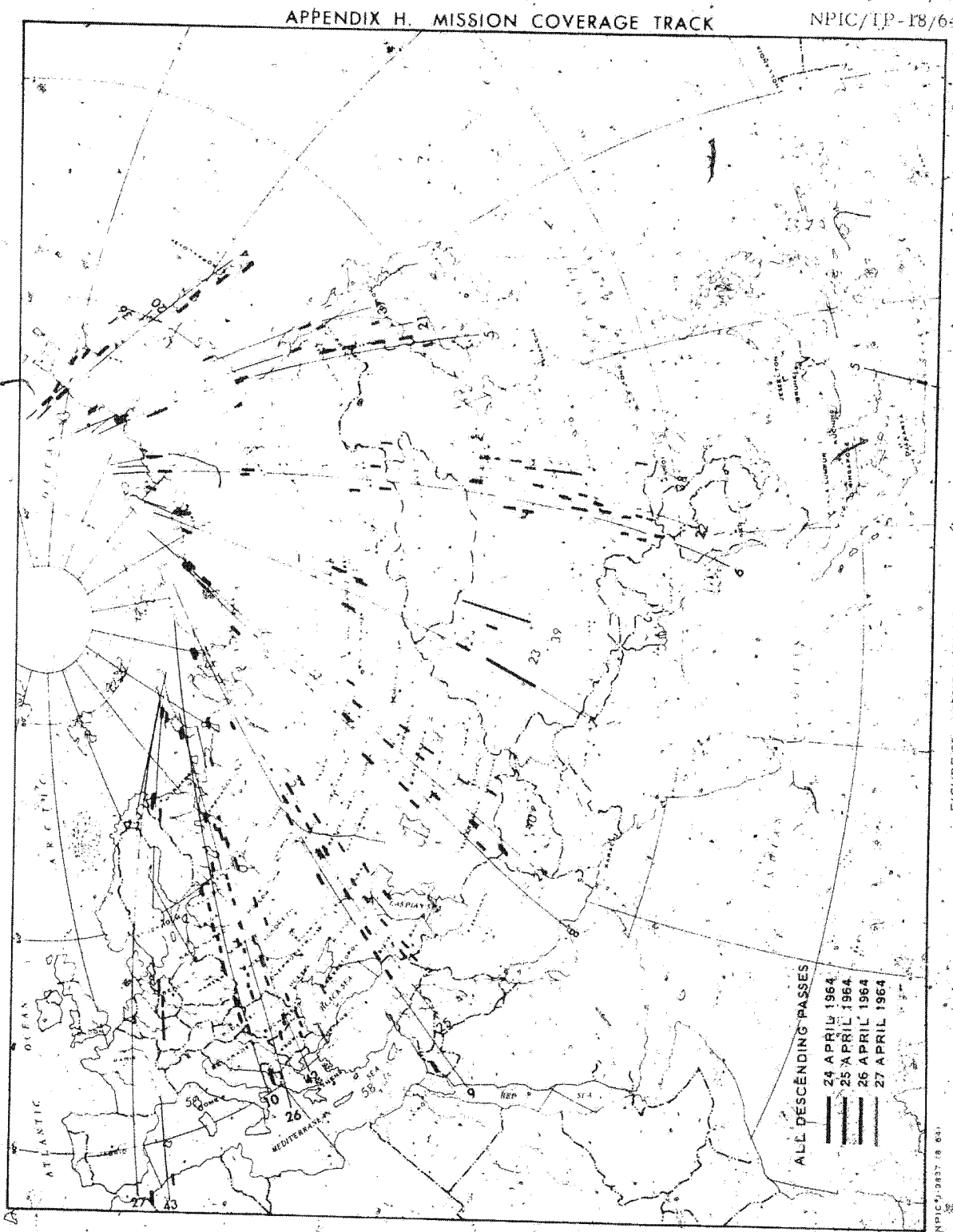


FIGURE 29. MISSION COVERAGE TRACK, ASIA.

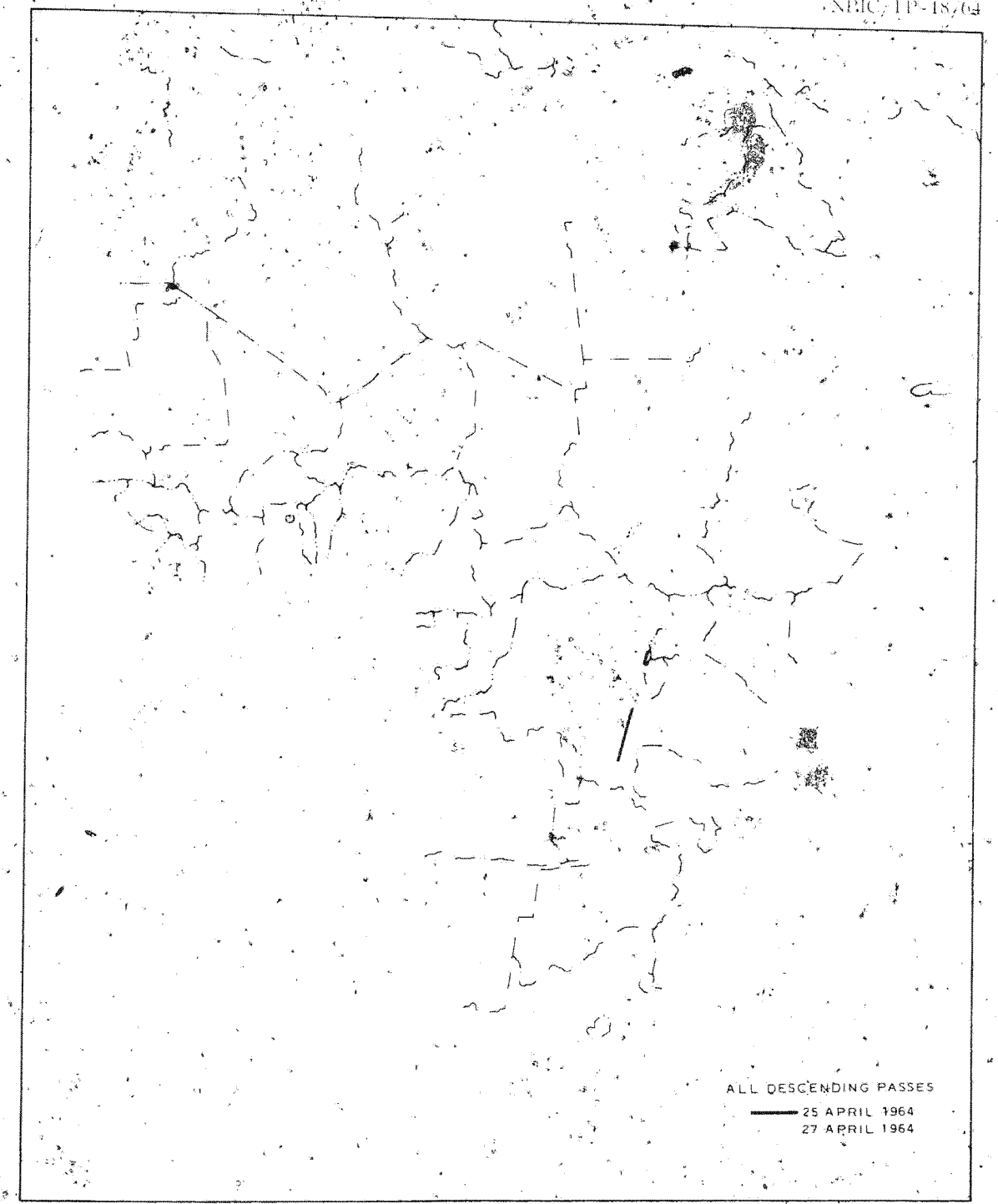


FIGURE 30. MISSION COVERAGE TRACK AFRICA.

END

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