Report No. FAA-CT-81-40

LEVEL II

(12)

A COMPENDIUM OF AIRCRAFT COCKPIT VISION SURVEYS 1950 THROUGH 1980 – VOLUME I

Anthony J. Barile

FINAL REPORT

MAY 1981

Prepared for

U. S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
TECHNICAL CENTER
Atlantic City Airport, N.J. 08405

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
(14) FAA-CT-81-40-VOL-1	AD-A202 473	

4. Title and Subtitle	5. Report Date
(6) A COMPENDIUM OF AIRCRAFT COCKPIT VISION SURVEYS, 1950 THROUGH 1980. VOLUME 1.	(11) May 1981
	6. Performing Organization Code

7. Author(s)	8. Performing Organization Report No.
(10) A. J. Barile (Anthony)	ACT-340

9. Performing Organization Name and Address	10. Work Unit No. (TRAIS)
Federal Aviation Administration Technical Center Atlantic City Airport, New Jersey 08405	11. Contract or Grant No. 184-340-400

12. Sponsoring Agency Name and Address	13. Type of Report and Period Covered
U.S. Department of Transportation Federal Aviation Administration Technical Center Atlantic City Airport, New Jersey 08405 (12) 149	(9) Final Rept. 1950 - 1980
	14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This publication contains a history of cockpit visibility surveys which were conducted to measure and record aircraft (General Aviation, Transport, Helicopter, Military) cockpit visibility. Many of the aircraft were involved in midair collisions, accident investigations, research and development, and the design up through production implementation. The Federal Aviation Administration (FAA) Binocular Camera is a standard means to accurately measure cockpit visibility, which in the certification process for civil aircraft is an invaluable tool for industry and the FAA. Therefore, the information contained in this document is intended to contribute to aviation safety.

17. Key Words	18. Distribution Statement
Cockpit Visibility Midair Collisions Accident Investigations Research and Development Certification Process Binocular Camera Aviation Safety Surveys	Document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified		

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

LIST OF ILLUSTRATIONS (Continued)

INTRODUCTION

Information contained in this publication is intended for those interested in promoting aviation safety; particularly, the prevention of midair collision. Many of the aircraft surveyed in this volume were involved in midair collisions. In some instances, the "other" aircraft was within the field of view afforded by the windshield design. Why those collisions were not avoided is a moot point. The concern here is that, in some of the collisions, one or both aircraft were obscured from each other by design limitations of their windshield such that, even if the crews were looking, they could not see each other (references 1 and 2).

Surveys were conducted to measure and record cockpit visibility. The standard means to accurately accomplish this task and allow for each interpretation of the effect of structural or equipment impairment to the field of vision is available and is known as the Federal Aviation Administration (FAA) Technical Center's Binocular Camera (figure 1).

DISCUSSION

Problems related to cockpit visibility received much attention in 1948 when two aircraft collided over New York City. About that time, the Civil Aeronautics Administration (CAA), predecessor of the Federal Aviation Administration (FAA), promulgated criteria prescribing the minimum field of vision acceptable for transport aircraft cockpit design. Inadequate means to measure and record cockpit visibility hampered implementation of this criteria, and therefore lead to the development of an instrument designed especially for this purpose. A standard means to accurately accomplish the task and allow each interpretation of structural or equipment impairment to the field of vision as seen by both eyes of a pilot was sought. Consequently, such an instrument was developed and is known as the FAA Technical Center's Binocular Camera.

The vision criteria, still in use today after 30 years of aircraft evolution, are to be found in the Civil Aeronautics Manual 4B (CAM 4b) (reference 3). A comparison of standards (reference 4) contained in CAM 4b with those more recently established by the Society of Automotive Engineers (SAE) (reference 5), and the United States (U.S.) Military (reference 6), reveal that differences are generally insignificant. The FAA currently is seeking to adopt new criteria based on more recent studies (reference 7).

Over the years, because there has been considerable effort devoted to understanding the human capacity to "see," the related parameters that determine or affect human sight are very well documented. Blake and Fox (reference 8), in particular, reviewed the major experiments conducted and published in English during this century. They concentrated on the ability of the human visual system to unify two separate monocular fields of vision into a binocular cyclopian view that betrays little trace of its monocular origins. Clearly, the review found that binocular performance is far superior to monocular. For these reasons, and many others, the FAA Technical Center has decided to upgrade and enhance its capabilities of measuring cockpit visibility by designing and developing a new binocular camera. The new binocular camera will provide low-cost availability and facilitate deployment in the field.

Various manufacturers and FAA Regional Offices will be able to make more frequent use of the device during the development and final certification of the windshield system, accident investigation, and other applications such as research and development. Manufacturers expend large sums of money in the design

and development of their transparency systems. Problems become evident when an assessment of cockpit vision is held off until flight testing has begun or by reliance solely on engineering drawings or other graphic representation. All too often, the transparency systems are not in compliance with the standards of CAM 4b or even in agreement with the aircraft drawings. Why not verify and assess the design for visibility compliance during the development phase? This should include tests of a fullscale mockup as well as the finished aircraft. One or more design deficiencies have all too often resulted in considerable additional cost for redesign and requalification of the transparency system.

Officials are reticent to certificate cockpit visibility, for instance, based on just a seat-of-the-pants evaluation. They are now more inclined to be more receptive when adequate documentation is presented validating the manufacturer's product design. In this regard, the binocular camera leaves little or no room for subjective opinion.

Bearing in mind that CAM 4b merely recommends, as a minimum criteria, what cockpit visibility should be, underscores all the more reason why any compromise in visibility can be serious. For example, Captain F. H. Hawkins, who has for many years specialized in cockpit design and human factors, reported on the significance of pilots not properly making use of the visibility afforded them by the cockpit designer, and for which certification was based (reference 9). Aircraft cockpit design is based on anthropometric dimensions, particularly that point in space called the eye space or design eye reference point (DERP). Unfortunately, even in well designed aircraft, visibility problems are induced when optimum available visibility is abrogated by the pilot's failure to position his eye at this DERP.

McDonnell-Douglas, in an operational support bulletin (reference 10), has advised pilots that, for sitting below the DERP, each centimeter results in a 1.4° loss in downward vision over the nose. This loss of downward vision affects how much, if any, of the runway would be visible and becomes very important during a low-visibility approach. In addition, an illusion may be created whereby a pilot seated below the DERP may misjudge his height at landing, and sometimes land short or too hard.

The FAA Technical Center's Binocular Camera was instrumental in determining contributing factors in a midair collision over San Diego which occurred on September 25, 1978, between a Boeing 727 and Cessna 172. Binocular photographs were taken from both aircraft cockpits. Additional information regarding position, orientation, time, altitude, airspeed, etc., was utilized to calculate the perspective vision angles and range between both aircraft using a computer. The resulting calculations were plotted onto the binocular photographs of the field of vision of the respective aircraft. Each photograph consequently contained the track or position of the target aircraft with respect to the particular field of vision available just seconds prior to impact. Through this process, the binocular photographs allow investigators to better comprehend the visibility each pilot had.

EQUIPMENT DESCRIPTION.

Assembled on its tripod, the binocular camera weighs 46 pounds and has overall dimensions of 15 inches in width, 15 1/2 inches in depth, and 35 3/4 inches in height. Tripod legs are used for initial leveling and adapting the camera to various cockpit floor configurations; final leveling is accomplished by use of leveling screws. In operation, a

self-contained battery pack drives the camera in a clockwise rotation while film moves at a precise speed past a vertical slot used for an aperture. The film speed, aperture width, and rotation speed are critically dependent upon each other to produce satisfactory results. Figure 2 is a schematic showing the optical system arrangement. The camera uses two 65 millimeter wide-angle F6.8 lenses, and covers an 88 1/2° field of vision. Matched lenses of identical focal length were selected and mounted on a flat surface so that their optical axes are parallel. The distance between the axes is 2.5 inches, representing the average human interocular spacing.

SURVEY PROCEDURE.

In order to accomplish a cockpit vision survey using the binocular camera, an aircraft is parked with an unobstructed view of the horizon (figure 3). Using manufacturer drawings of the cockpit geometry, a DERP is determined, and the camera is positioned at this location. A 1-inch round marker is applied to the windshield at a point that lies along an extension of a line-of-sight drawn from the DERP. This marker can later be identified on photographs, and is the "zero reference" point from which measurements are taken (figure 4).

Once set up, the camera (figure 5) can produce a photographic record of the field of vision of a pilot as he turns his head from extreme left to extreme right. Superimposed on the photograph is a grid of horizontal and vertical lines in 5-degree increments. This grid with the "zero reference" mark allows angular measurements to be made. The images produced are representative of what the human eyes see before the brain integrates them into one. Thus, the effect of obstructions to vision may be analyzed. The camera rotates about a vertical axis that is normally located 3.3 inches aft from the lenses. In this "normal" position, the dimension corresponds to the mean distance between the front of the human eyes and the odontoid process; i.e., the pivot about which the skull rotates in the vertebral column (figure 6). By moving the camera to a position as shown in figure 7, the lenses now rotate about an 8.3-inch radius, and is called the "alert" position, which represents the generally accepted additional 5 inches that a pilot leans forward from the "normal" while in a search for other traffic.

BINOCULAR VISION.

Binocular vision is the ability to see "around" vertical obstructions under certain conditions. The width of the obstruction or target, the relative positions of the observer, and the obstruction or target determine whether or not a target is visible. Figure 8 illustrates the twin lenses (eyes) of the binocular camera as it sees a target at infinity around a vertical obstruction of 2.5 inches or less in width. In this example, the target is visible, in part, to both eyes. If the target were to advance into the opaque zone, it would be obstructed from view. If the target were then to bank left or right into the gray zone, the target would become visible to one eye only.

Over the years that the binocular camera has been in existence, many cockpit vision surveys were completed for certification, accident investigation, and research and development studies. In all, the key factor was and is visibility. Regardless of aircraft or equipment in use, or how capable the pilot may be, safety of flight depends on his ability to receive visual cues and information from an internal display or externally through the windshield system.

Since a great percentage of accidents are crew related, one area of improvement in the overall complexity of a modern transport that should take place is in the flight deck, the nerve center

for the management of these flight systems, many of which depend on the pilot's ability to receive visual information.

AUTHORS COMMENT.

No claim of librarianship is made. The style of listing is intended to facilitate publication and to provide maximum utility with some consistency. Annotations are descriptive rather than evaluative. Journalistic comment occurs where it may provide background information on, or identify associated reference documents of, public record. Figures 9 through 131 are the results of the binocular cockpit vision surveys.

REFERENCES

1. Aircraft Pilot Warning Instrument (APWI), a study by W. Graham, Report Number FAA-RD-75-59, I, March 1975.

2. Parker L. C., General Aviation Air Traffic Pattern Safety Analysis, Report Number NASA TM-X-6955, July 1973.

3. Civil Aeronautics Manual (CAM) 4b, pages 351-353, 1952.

4. Goldin R. W., Cockpit Vision Requirements Review, for the Air Safety Foundation, Aircraft Owners and Pilots Association, April 1, 1971.

5. Society of Automotive Engineers (SAE), Aeronautical Specification 580B.SAE Aerospace Recommended Practice 268E.

6. Aircraft Station Vision Requirements for Military Aircraft, Military Standard 850B,November 3, 1970.

7. Draft Advisory Circular 25.773-8, April 24, 1980.

8. The Psychophysical Inquiry into Binocular Simulation, Perception and Psychophysics, Volume 14, Number 1, Pages 161-185, 1973.

9. Hawkins, F. H., Captain, The Pilot's Cockpit Visibility, for Shell Aviation News, Volume 440, 1977.

10. Know Your DC-10, by McDonnell-Douglas, letter Number 56, February 20, 1975.

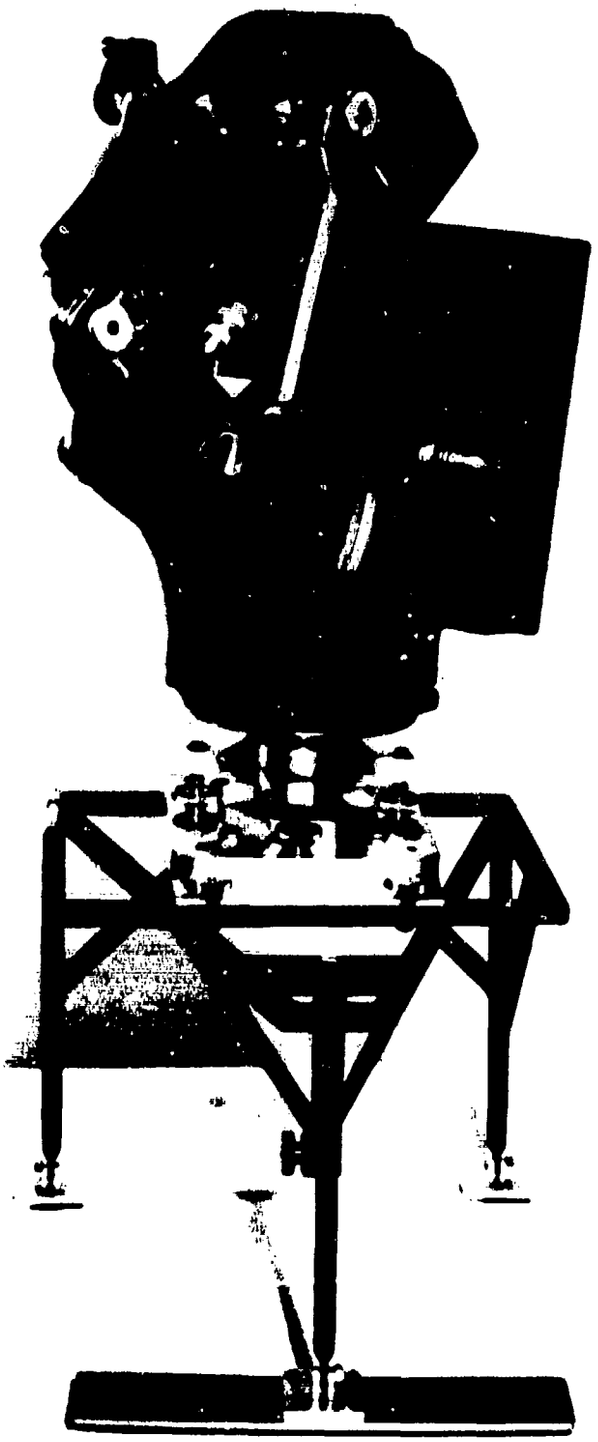


FIGURE 1. FAA TECHNICAL CENTER BINOCULAR CAMERA

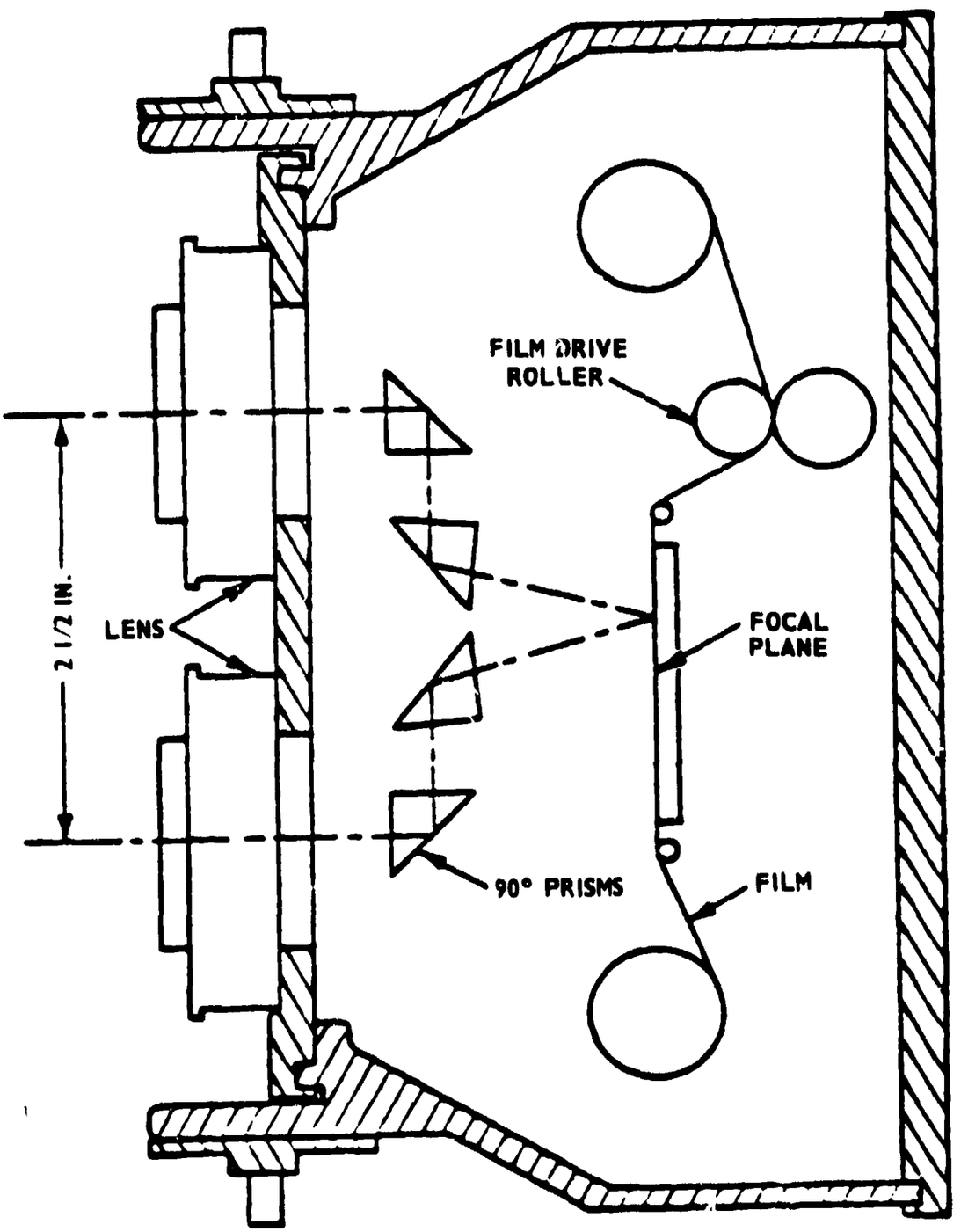


FIGURE 2. SECTION THROUGH CAMERA SHOWING OPTICAL ARRANGEMENT

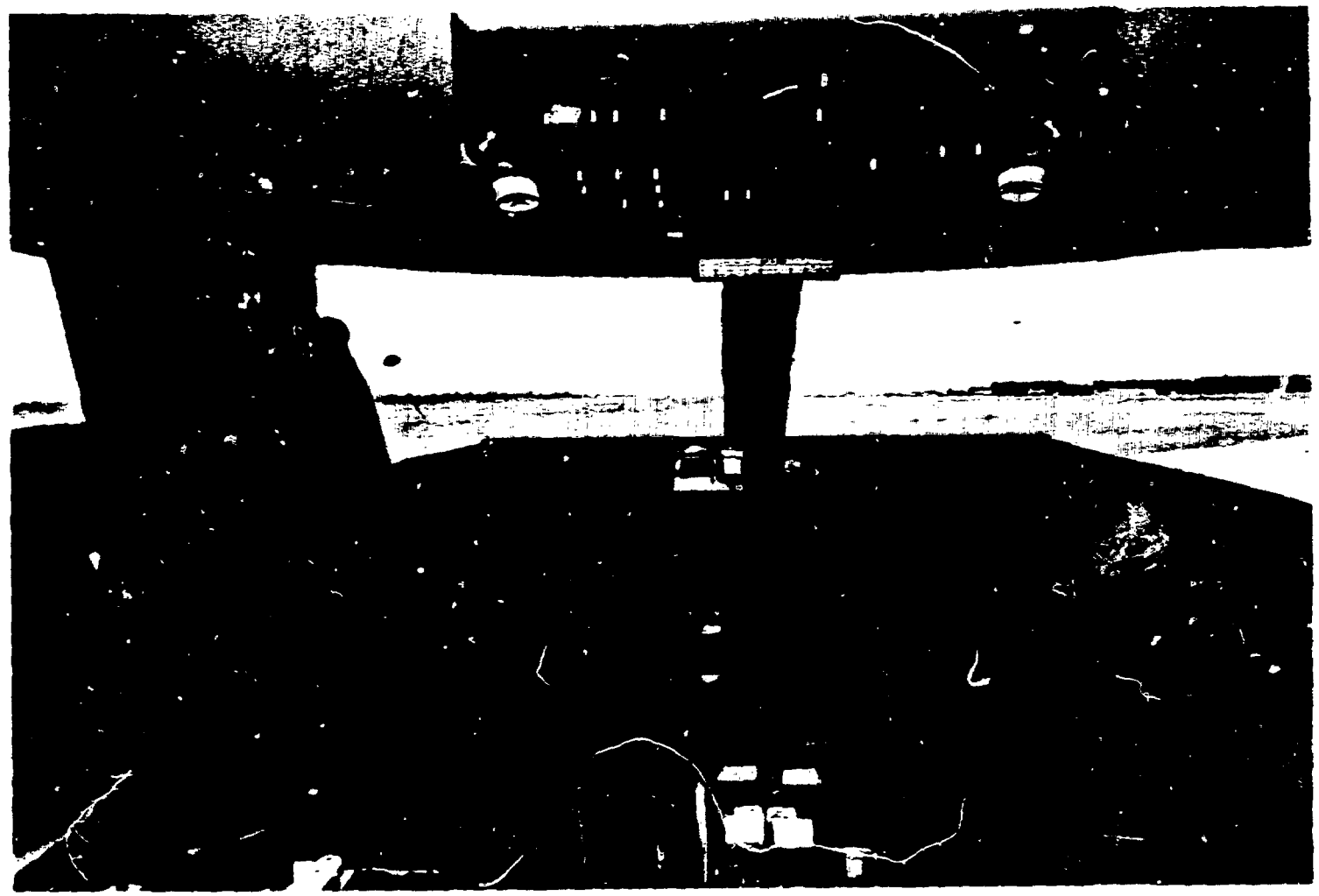


FIGURE 3. CL-600 COCKPIT WITH BINOCULAR CAMERA

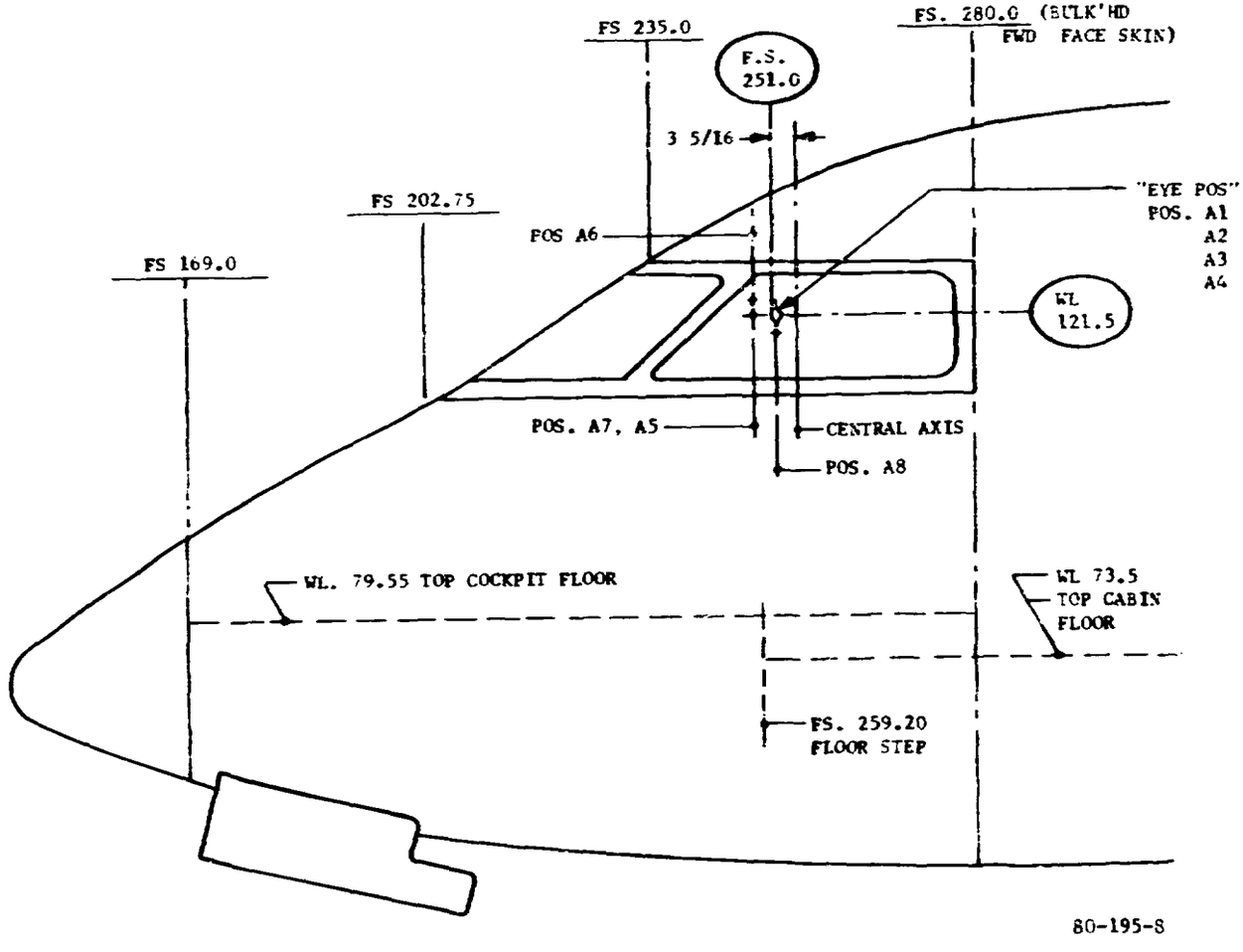


FIGURE 4. CL-600 LEFT SIDE VIEW

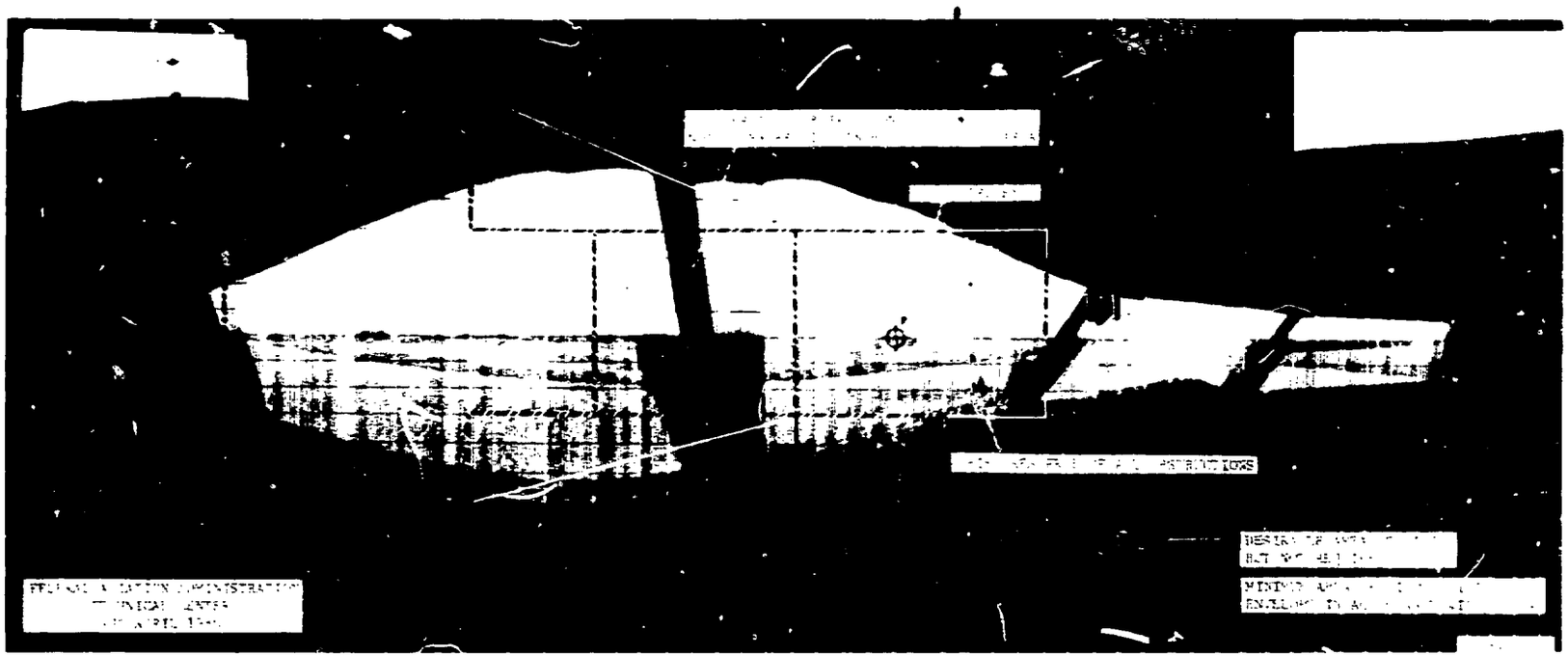


FiGURE 5. PILOTS EYE POSITION

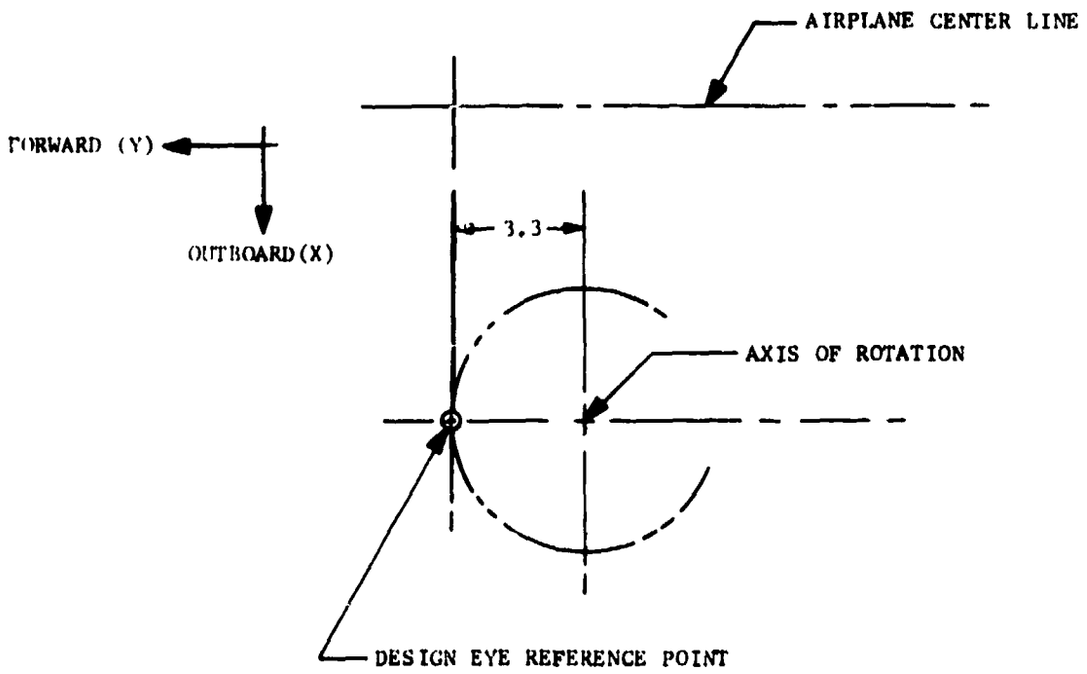


FIGURE 6. NORMAL DESIGN EYE REFERENCE POINT

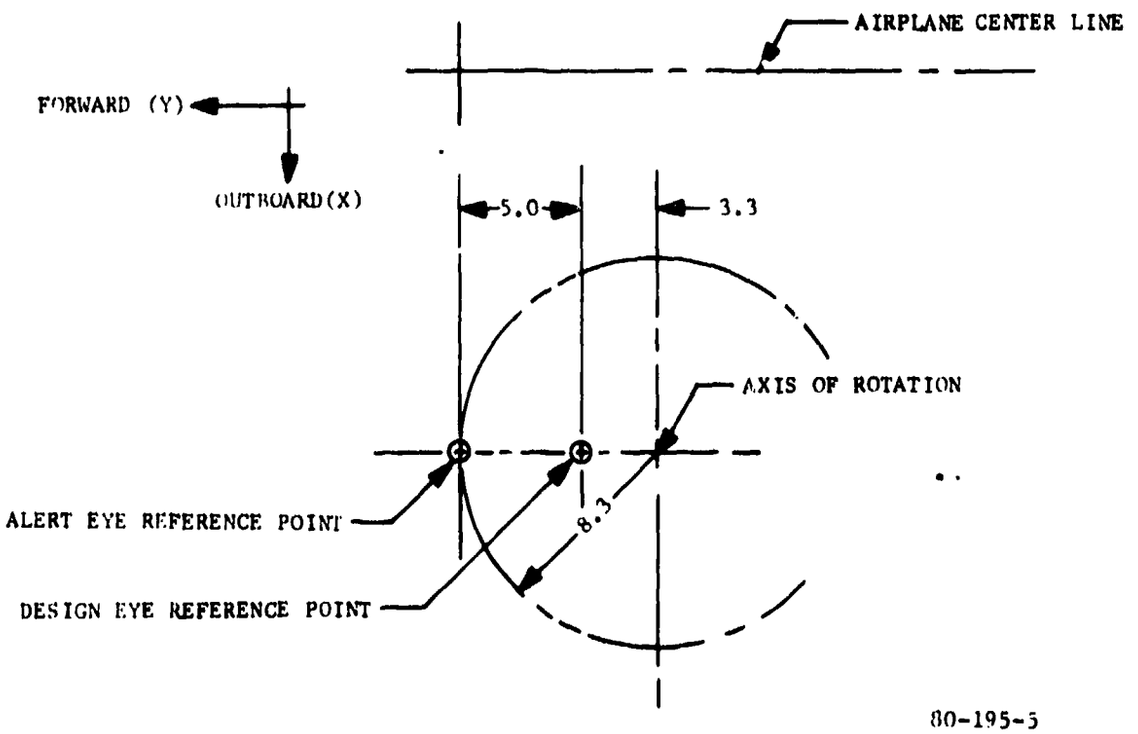


FIGURE 7. ALERT DESIGN EYE REFERENCE POINT

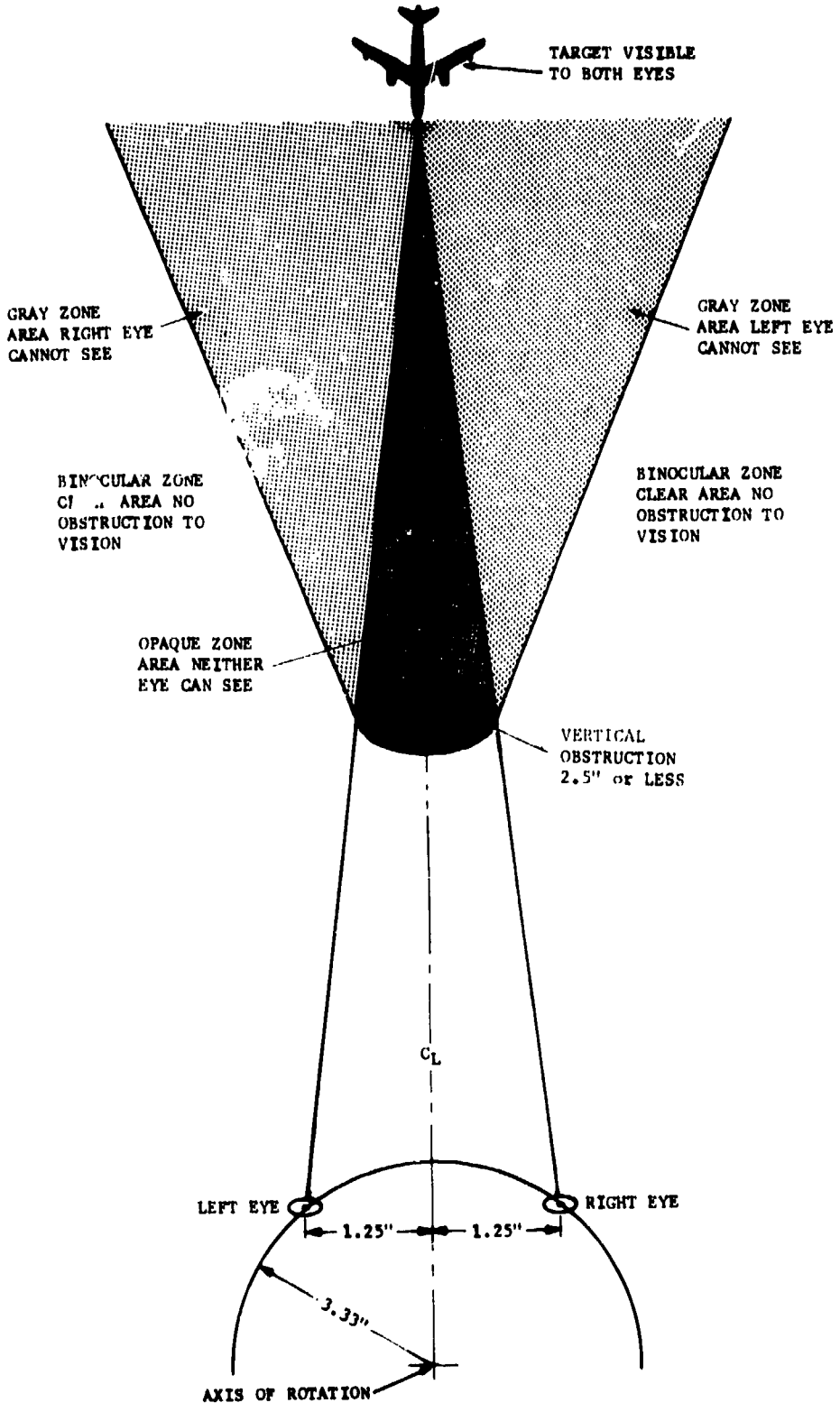


FIGURE 8. BINOCULAR VISION

CIVILIAN AIRCRAFT
Above 12,500 pounds

The aircraft in the following listing are depicted in figures 9 through 48.

Aero 1121

Boeing 707
Boeing 727
Boeing 727-200
Boeing 747

Canadair CL-44
Canadair Challenger CL-600

Cessna 620
Cessna Citation III

Convair 240
Convair 340
Convair 580
Convair 880

Curtiss Model 200

Douglas DC-3
Douglas DC-4
Douglas DC-6
Douglas DC-7
Douglas DC-8
Douglas DC-9
Douglas DC-9-50
Douglas DC-9-80

Fairchild F-27
Fairchild FH-227
Falcon Fan Jet 20

Gates Lear Jet Model 24
Gates Lear Jet Mockup 35/36
Gates Lear Jet 55

Grummal Gulfstream

Howard Model 500

Lockheed Electra
Lockheed Jetstar
Lockheed L-1049A
Lockheed Model 300

Martin 404

Mitsubishi 300

NASA/Boeing-737

Sunrise S-1600

Super G. Constelation

Vickers Viscount

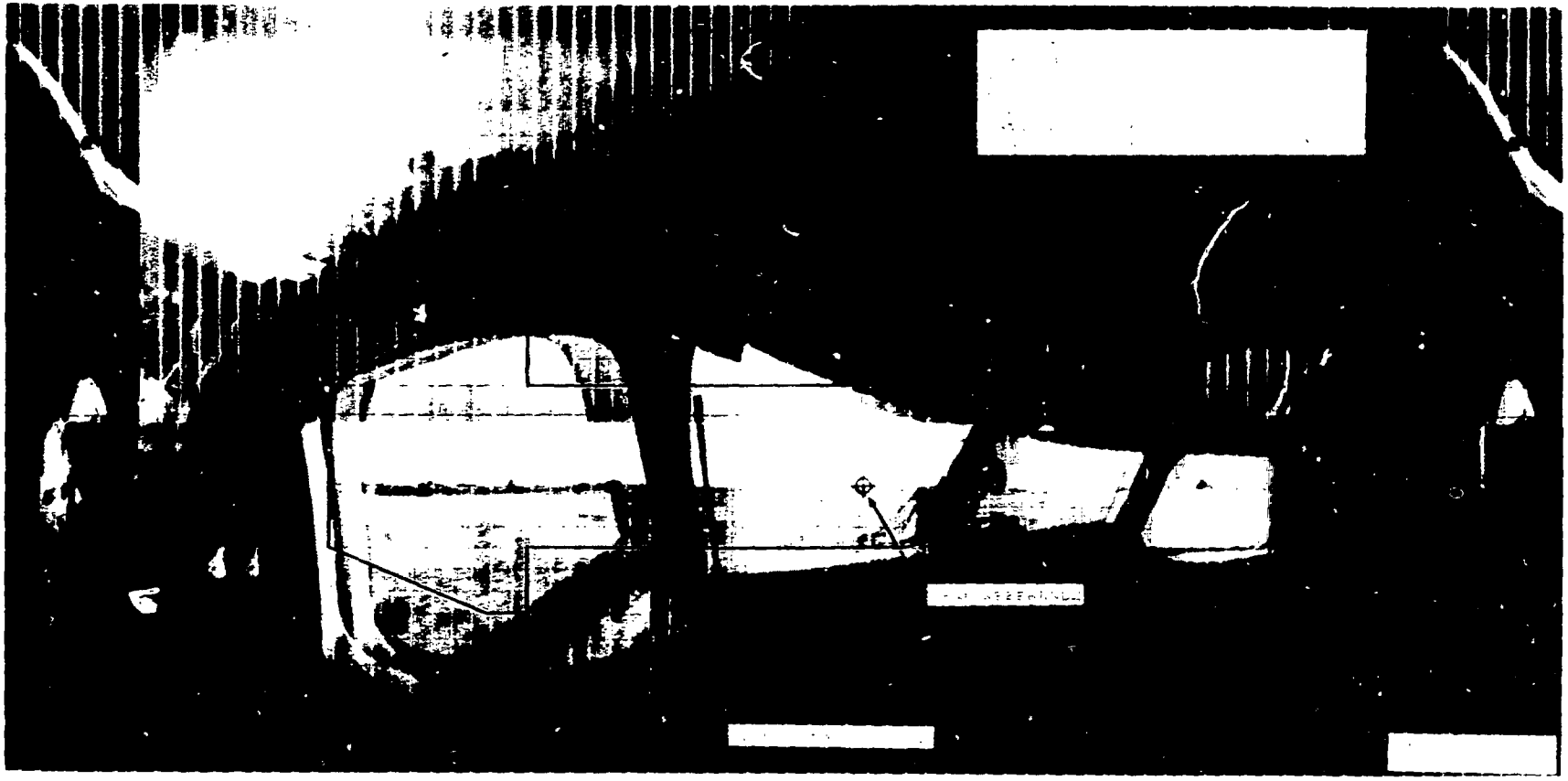


FIGURE 9. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AERO COMMANDER 1121

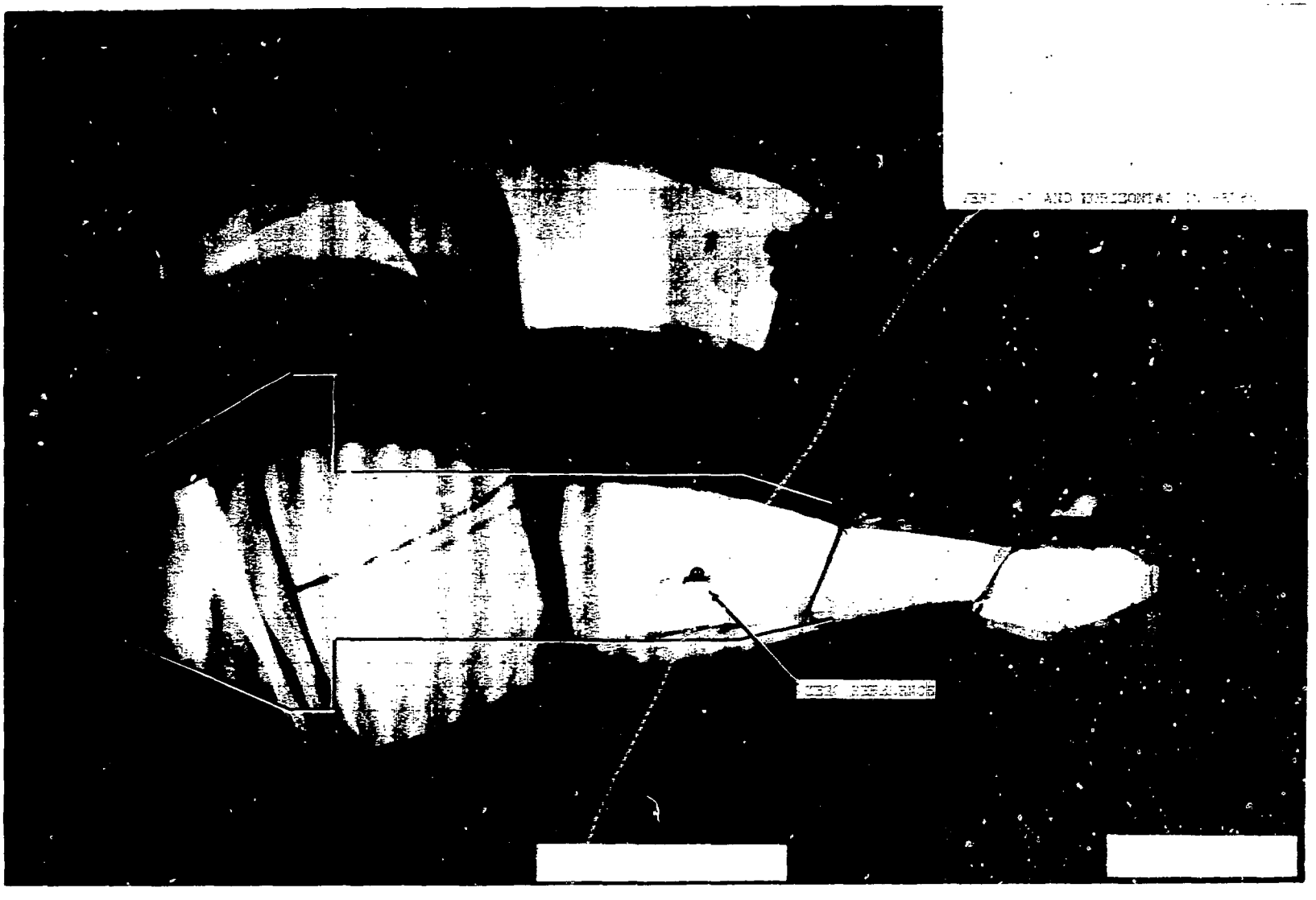


FIGURE 10. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT BOEING 707

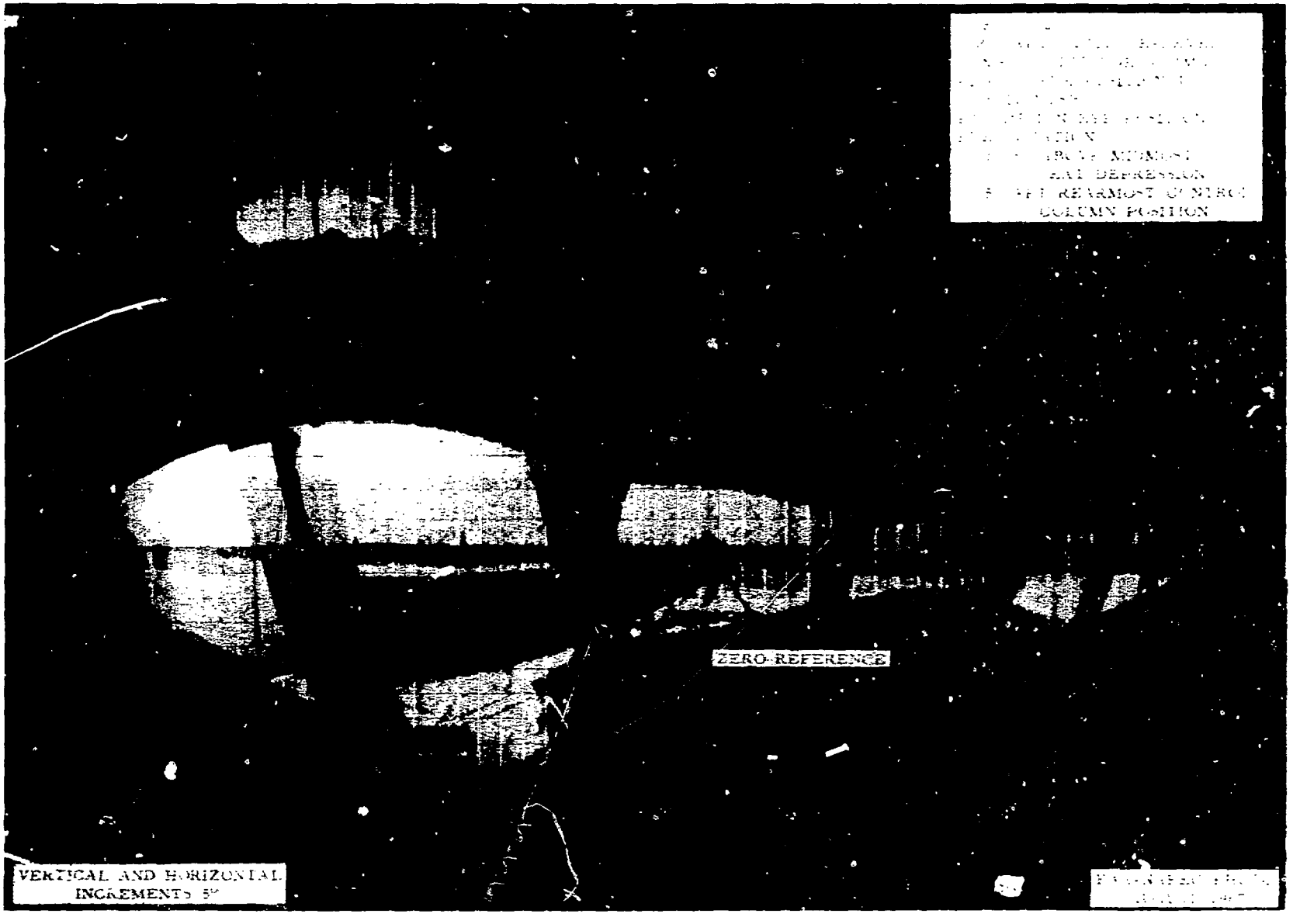


FIGURE 11. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT BOEING 727

FIGURE 12. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT BOEING 727-200

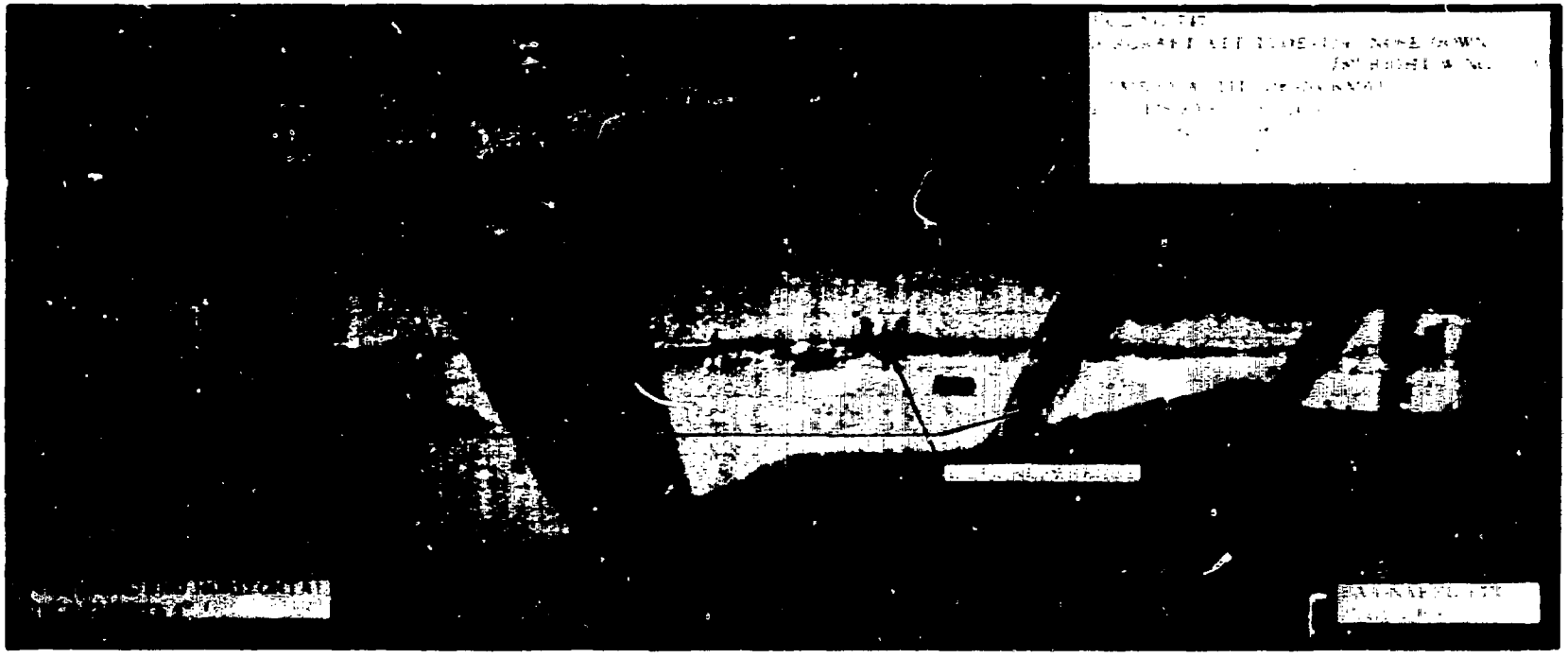


FIGURE 13. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT BOEING 747

FIGURE 14. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CANADAIR, LTD., CL-44

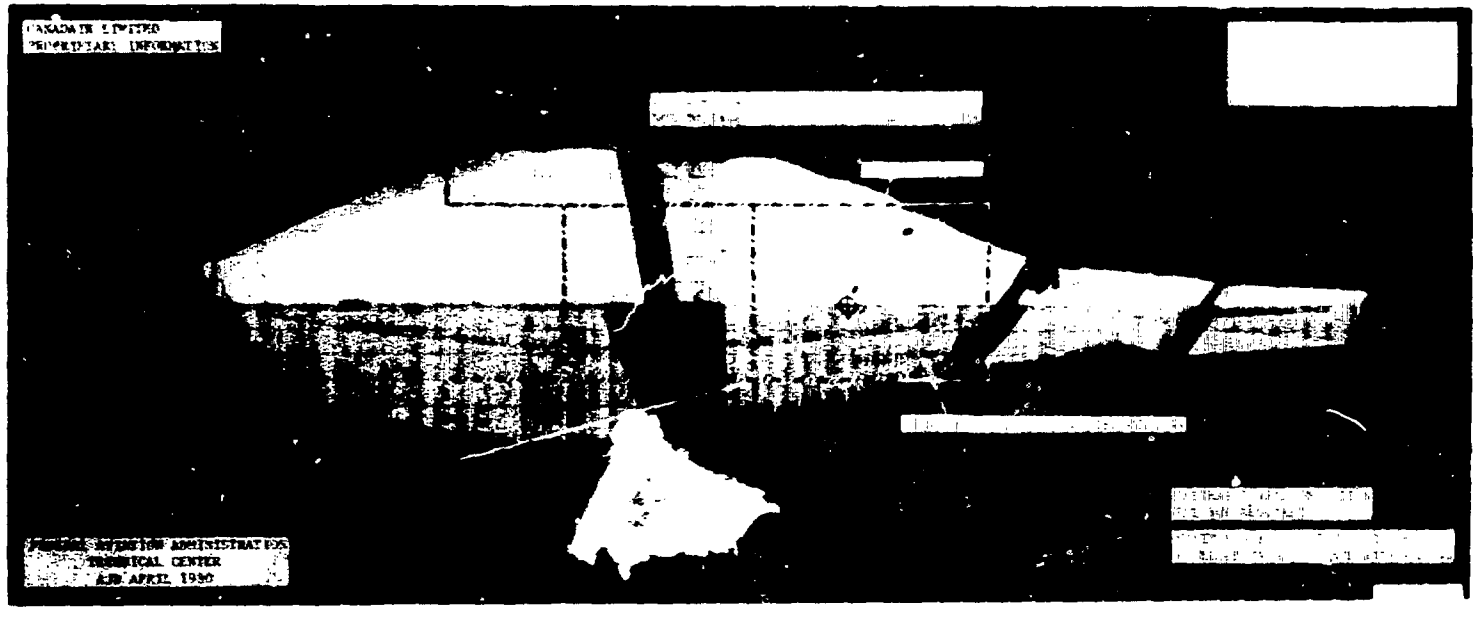


FIGURE 15. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CANADAIR CHALLENGER CL-600

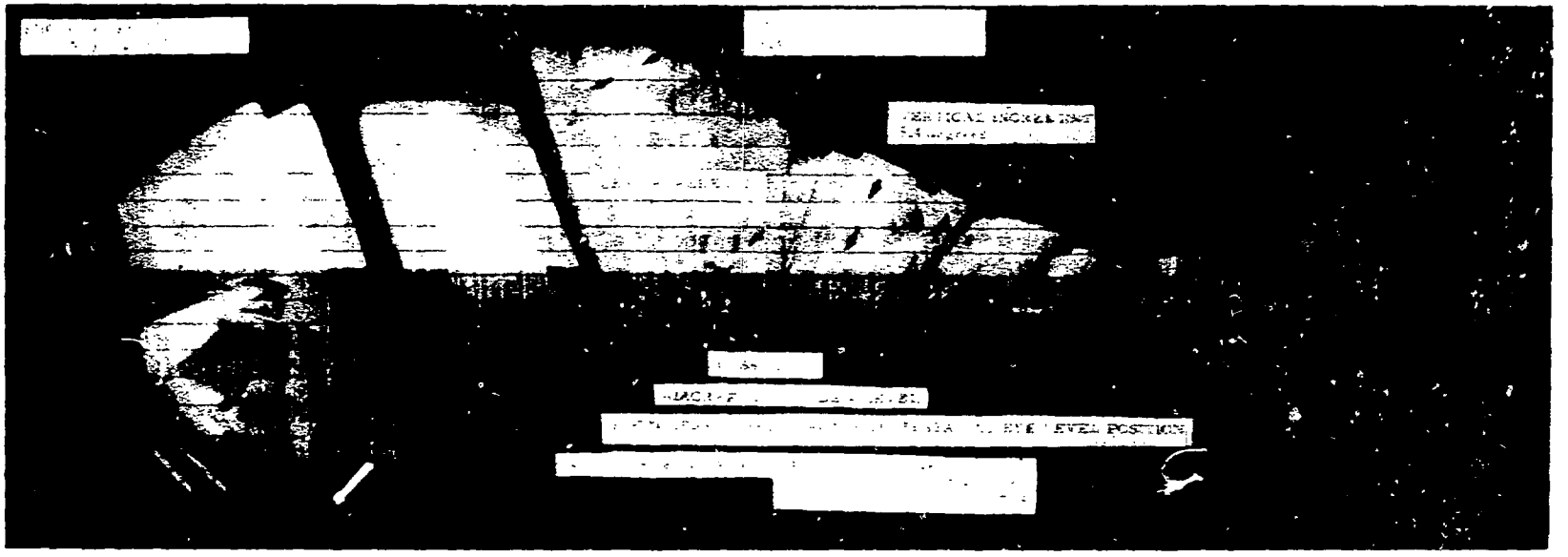


FIGURE 16. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CESSNA 620

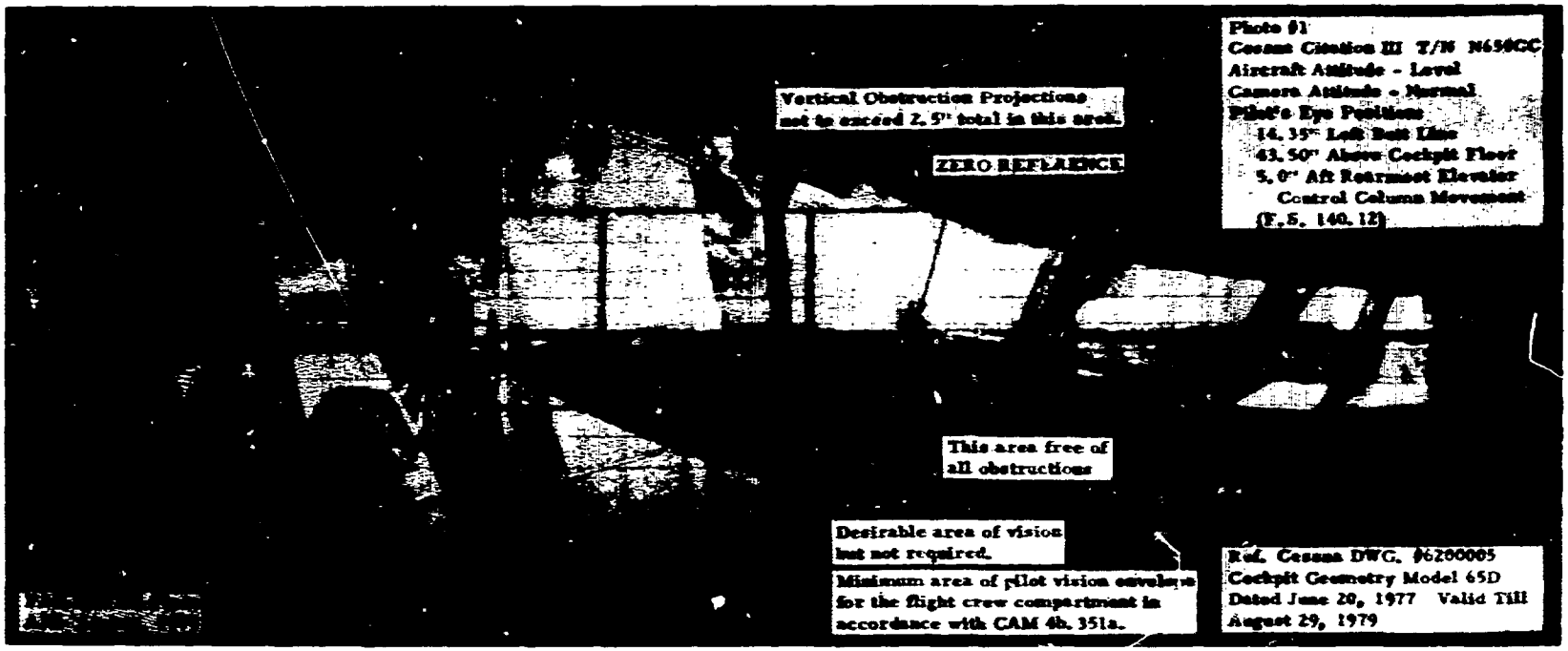


FIGURE 17. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CESSNA CITATION III

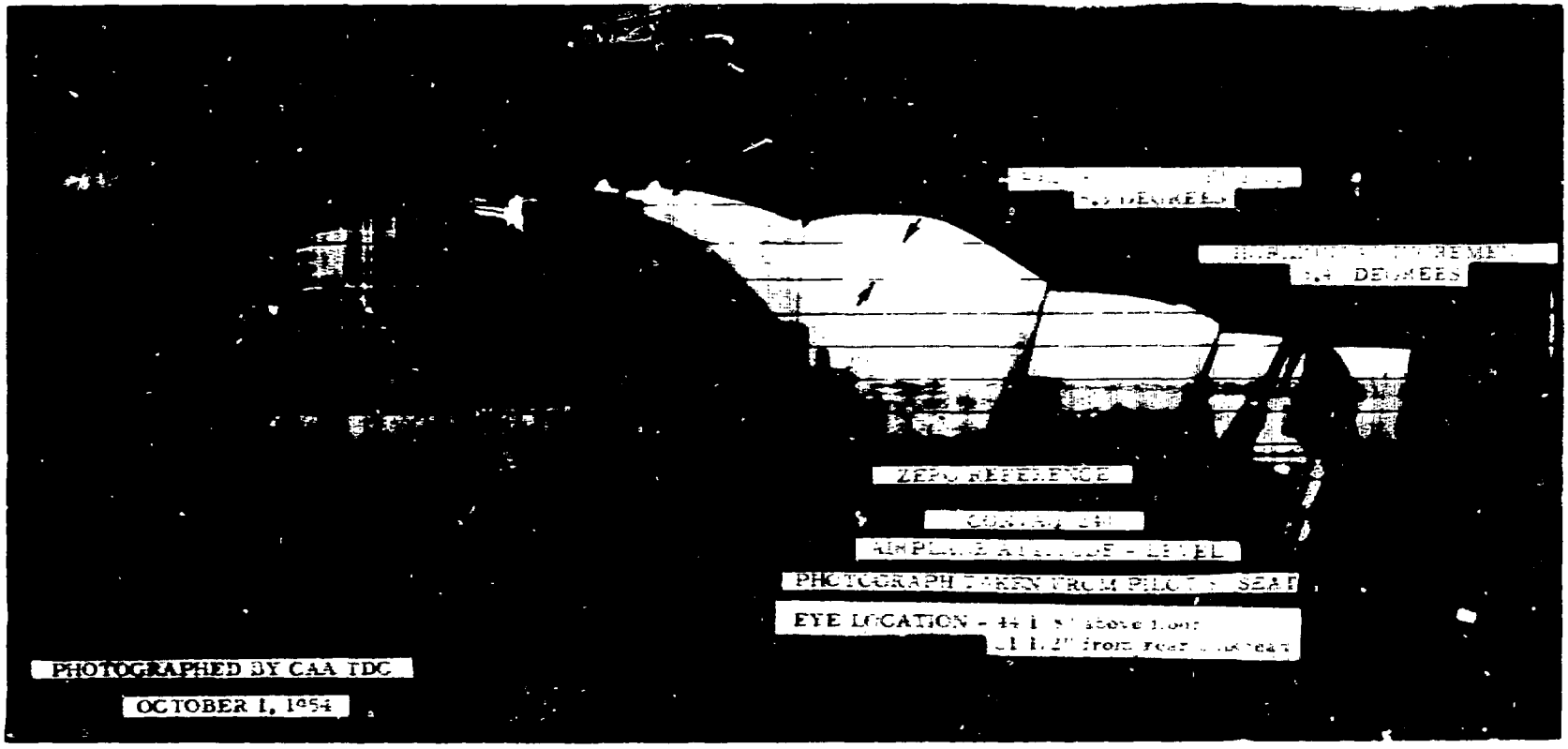


FIGURE 18. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CONVAIR 240

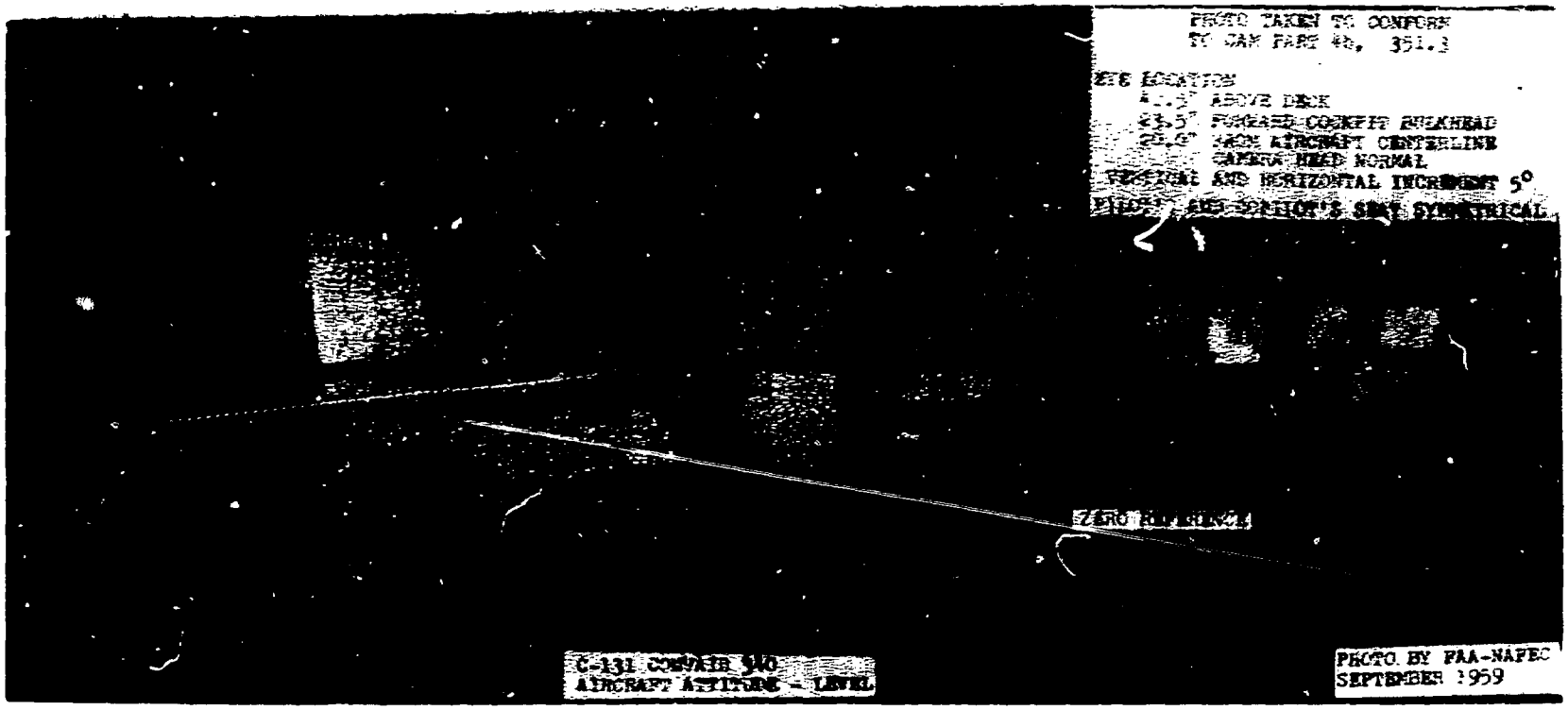


FIGURE 19. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CONVAIR 340

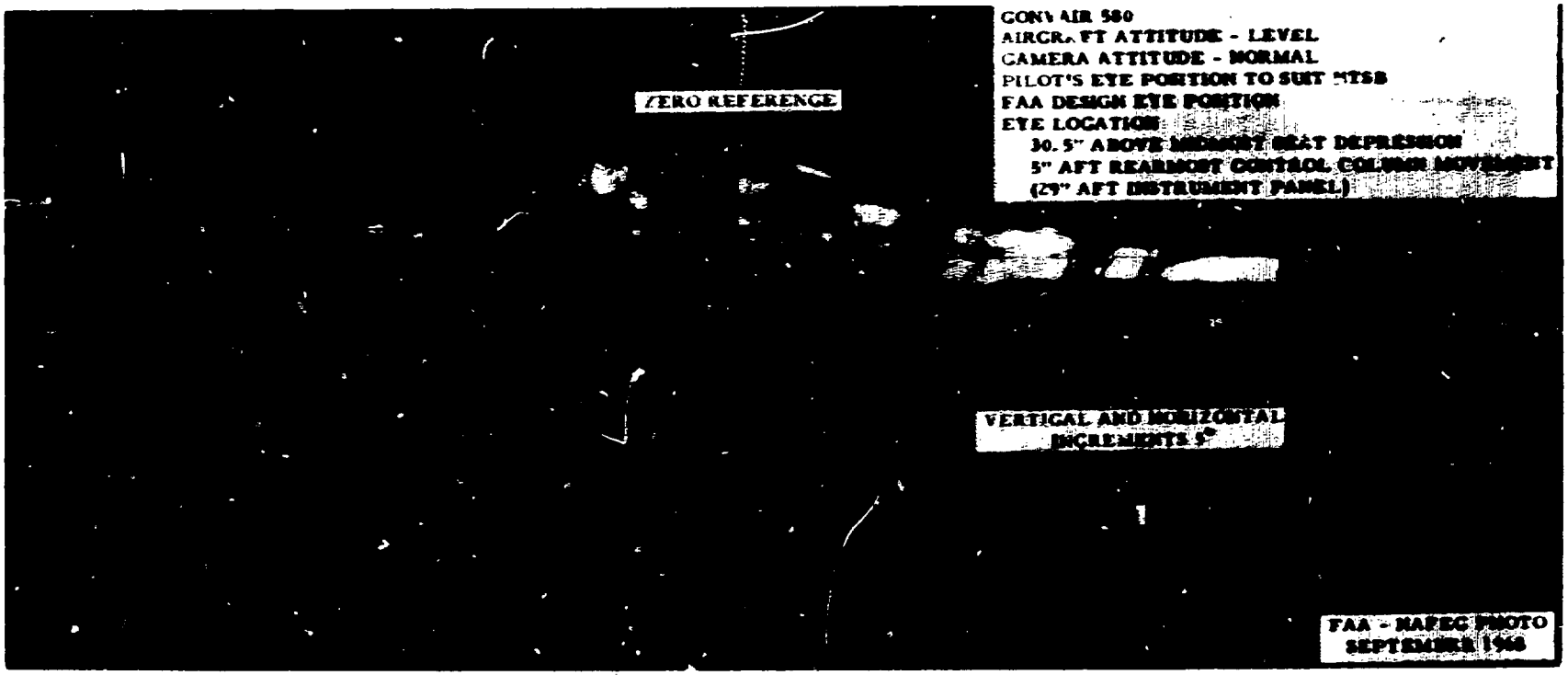


FIGURE 20. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CONVAIR 580

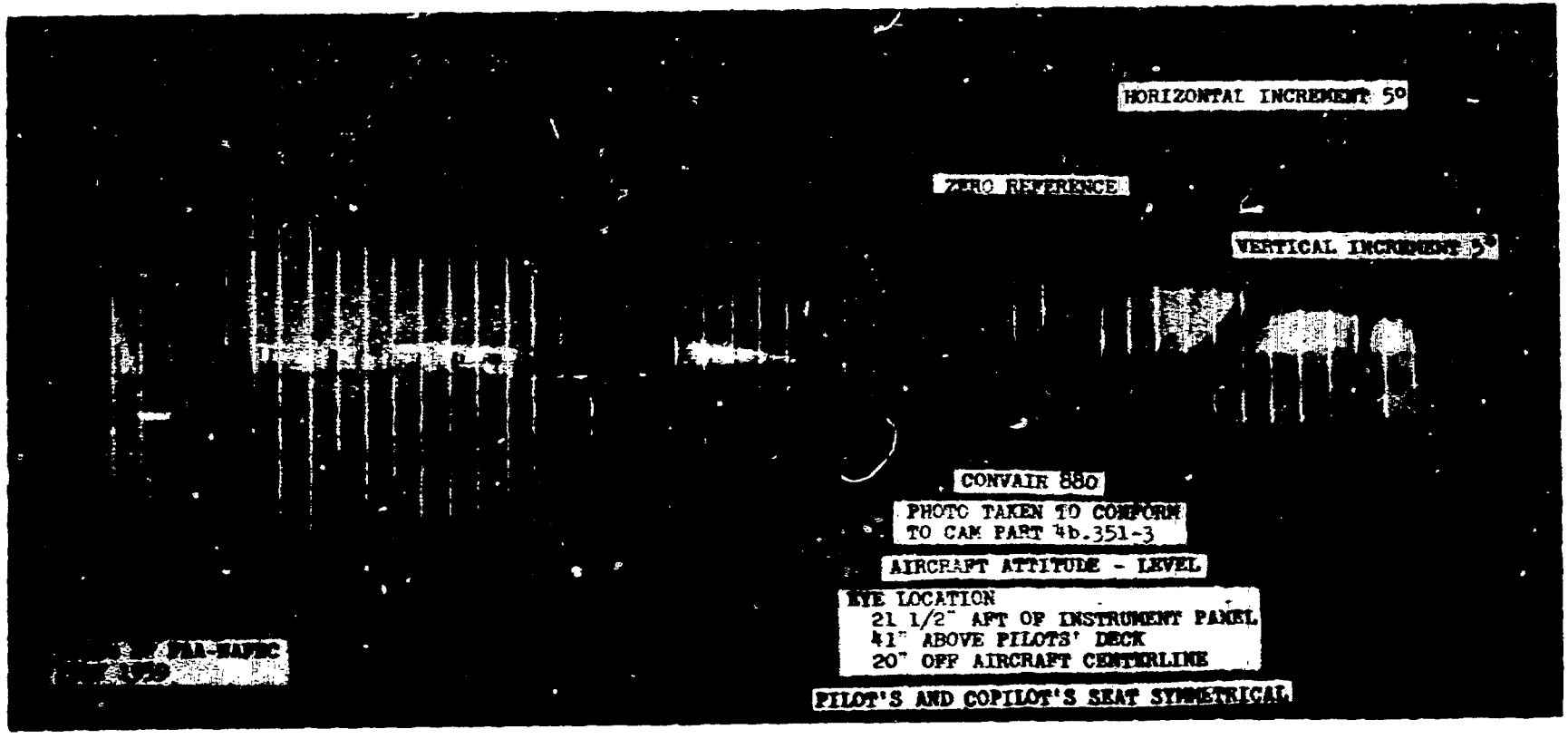


FIGURE 21. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CONVAIR 880

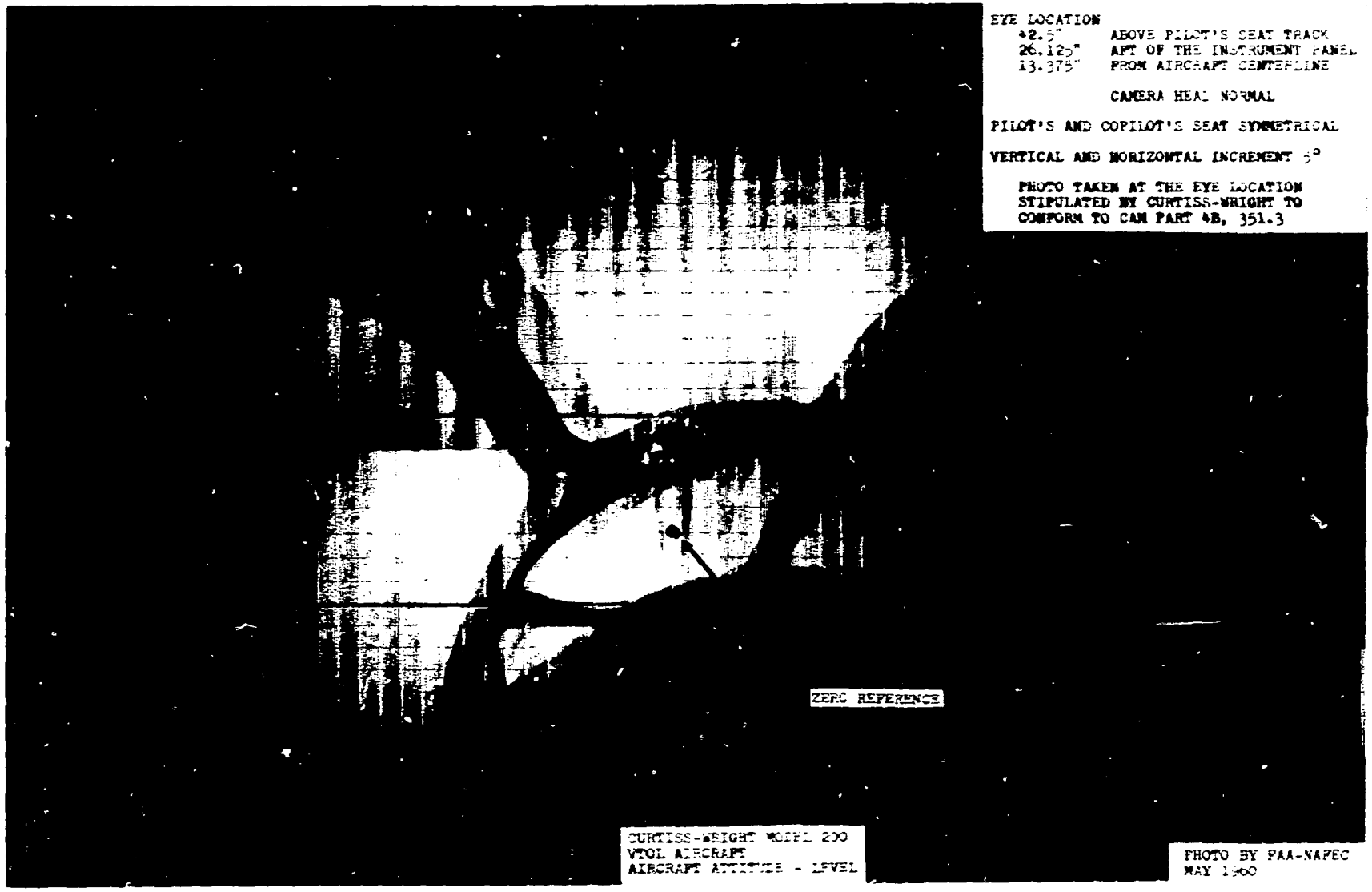


FIGURE 22. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CURTISS-WRIGHT 200

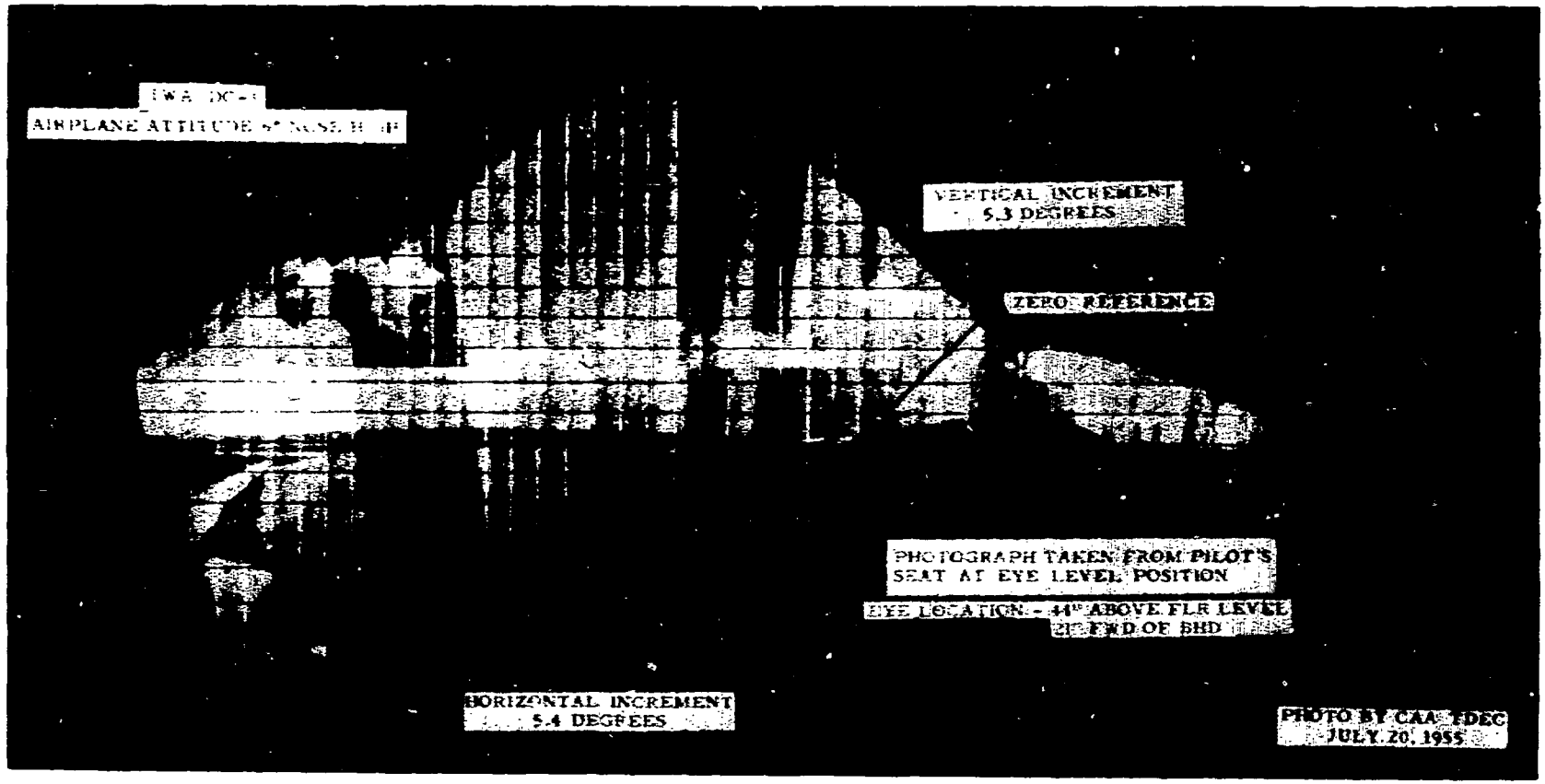


FIGURE 23. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT DOUGLAS DC-3

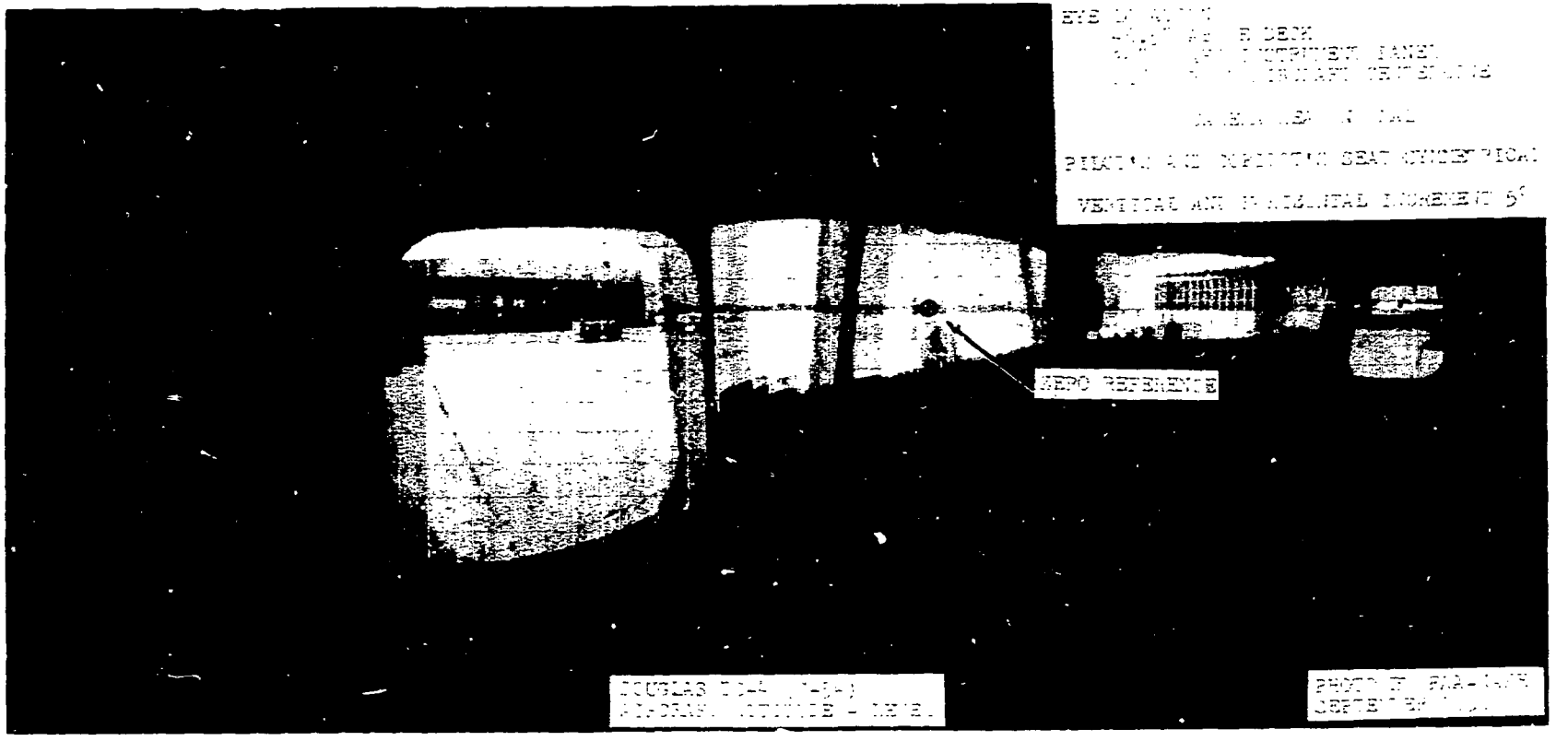


FIGURE 24. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT DOUGLAS DC-4

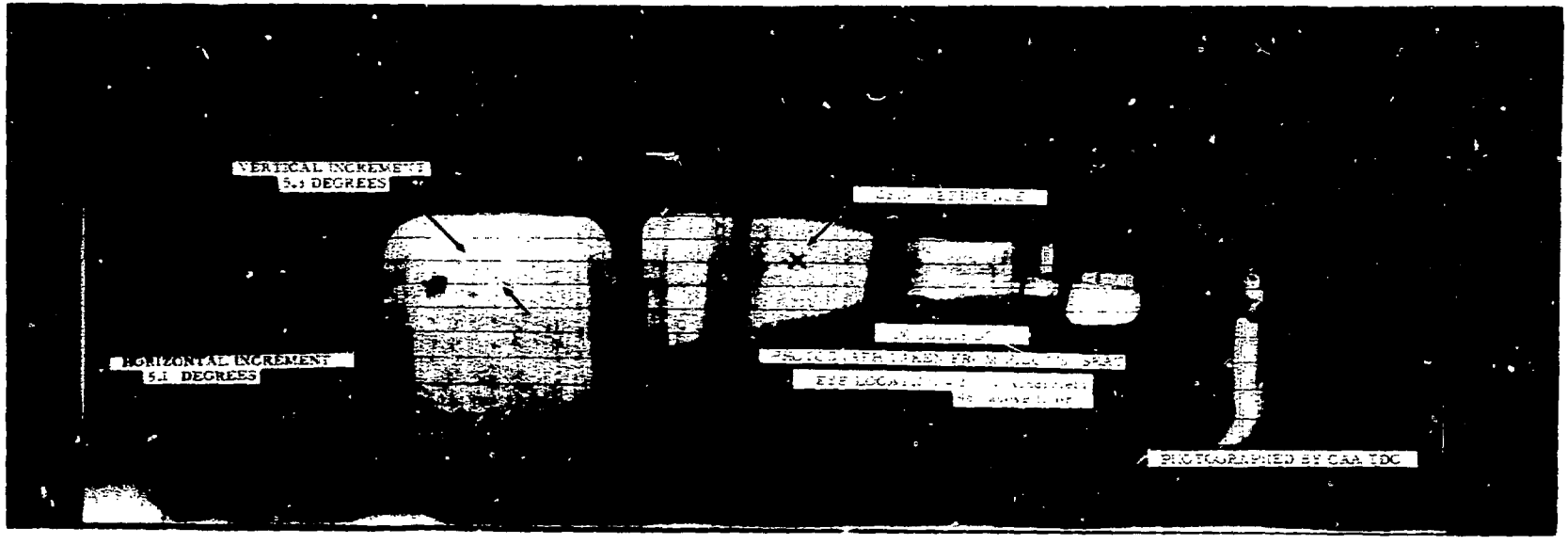


FIGURE 25. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT DOUGLAS DC-6

FIGURE 26. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT DOUGLAS DC-7

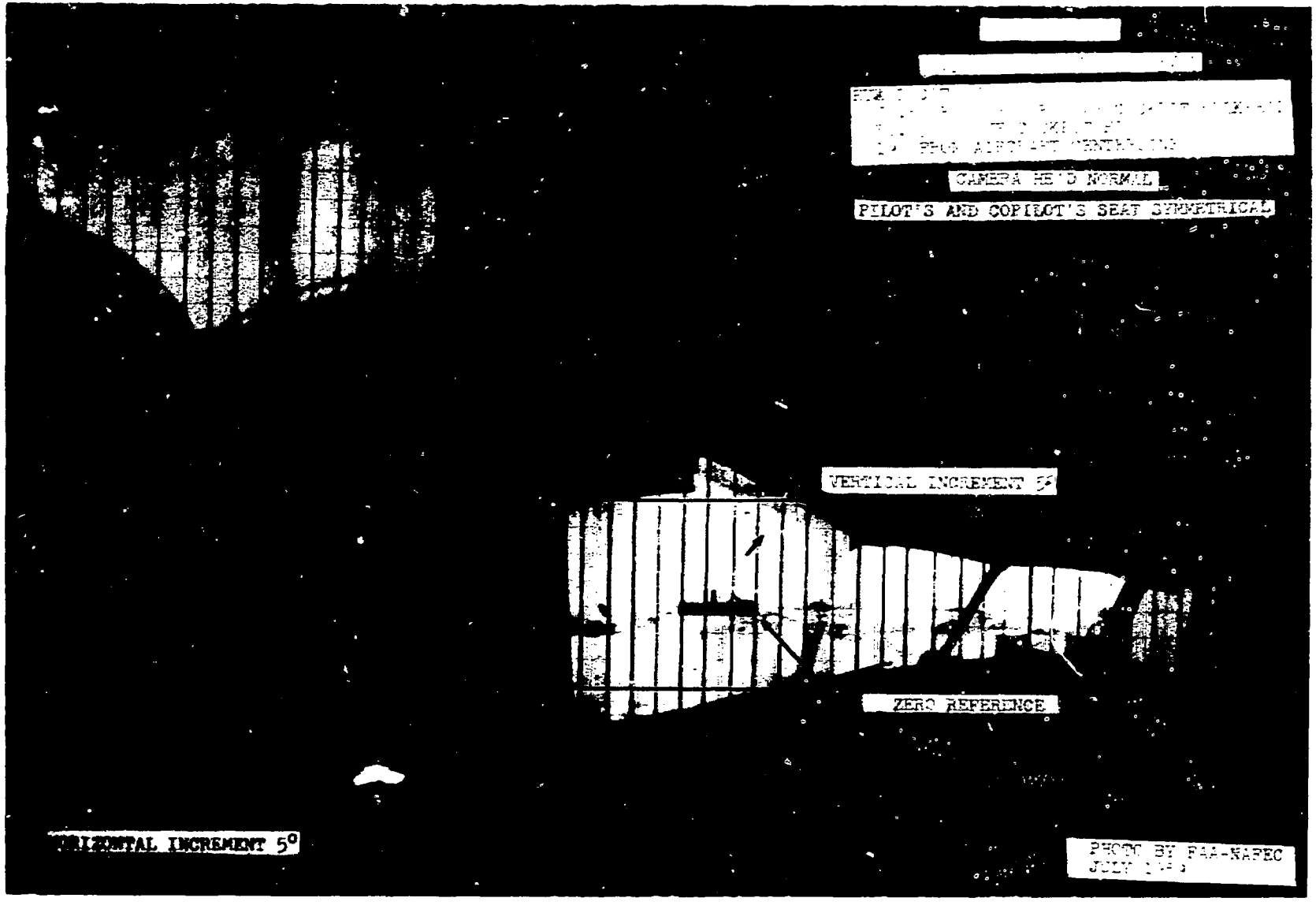


FIGURE 27. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT DOUGLAS DC-8

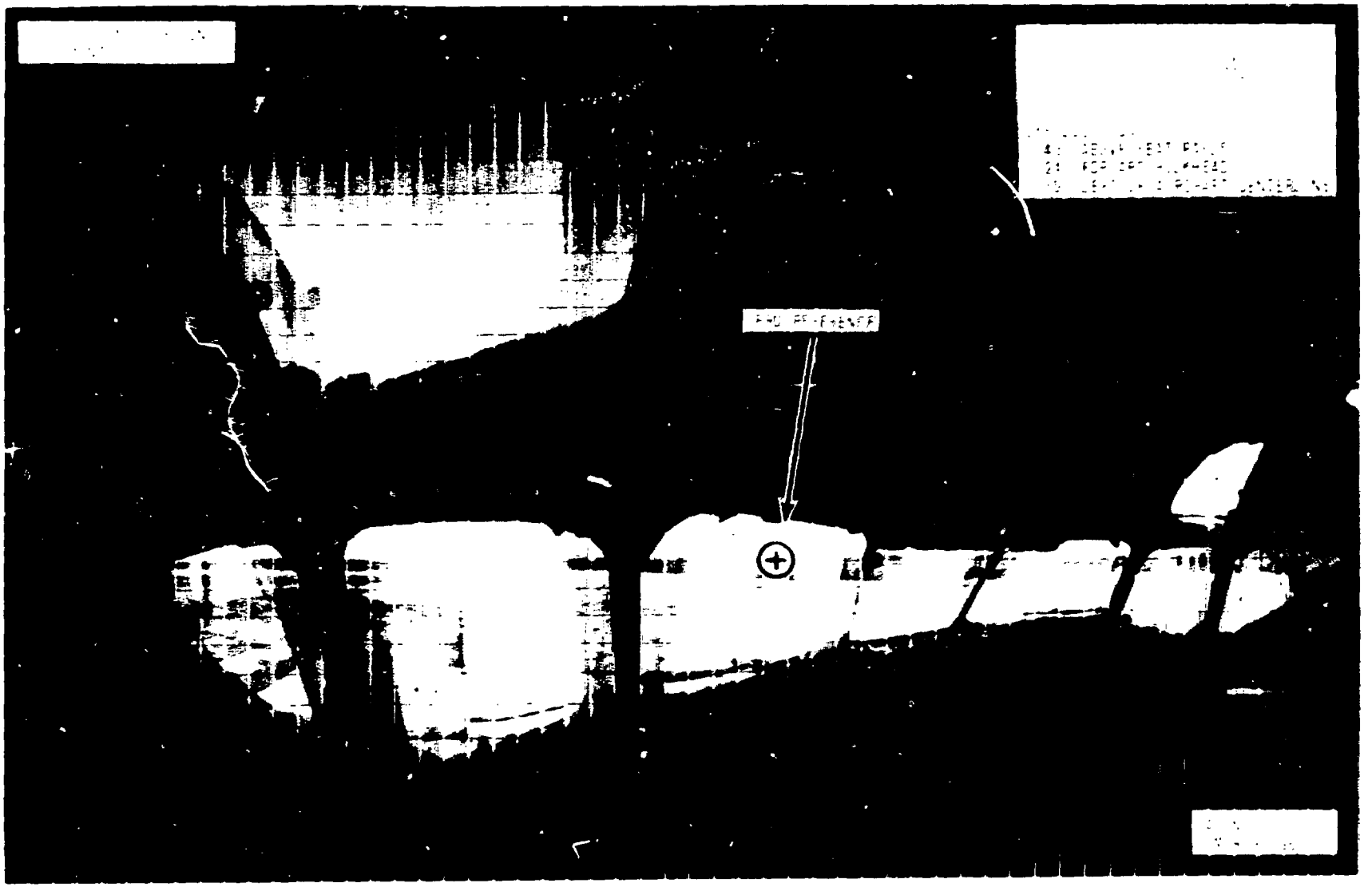


FIGURE 28. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT DOUGLAS DC-9

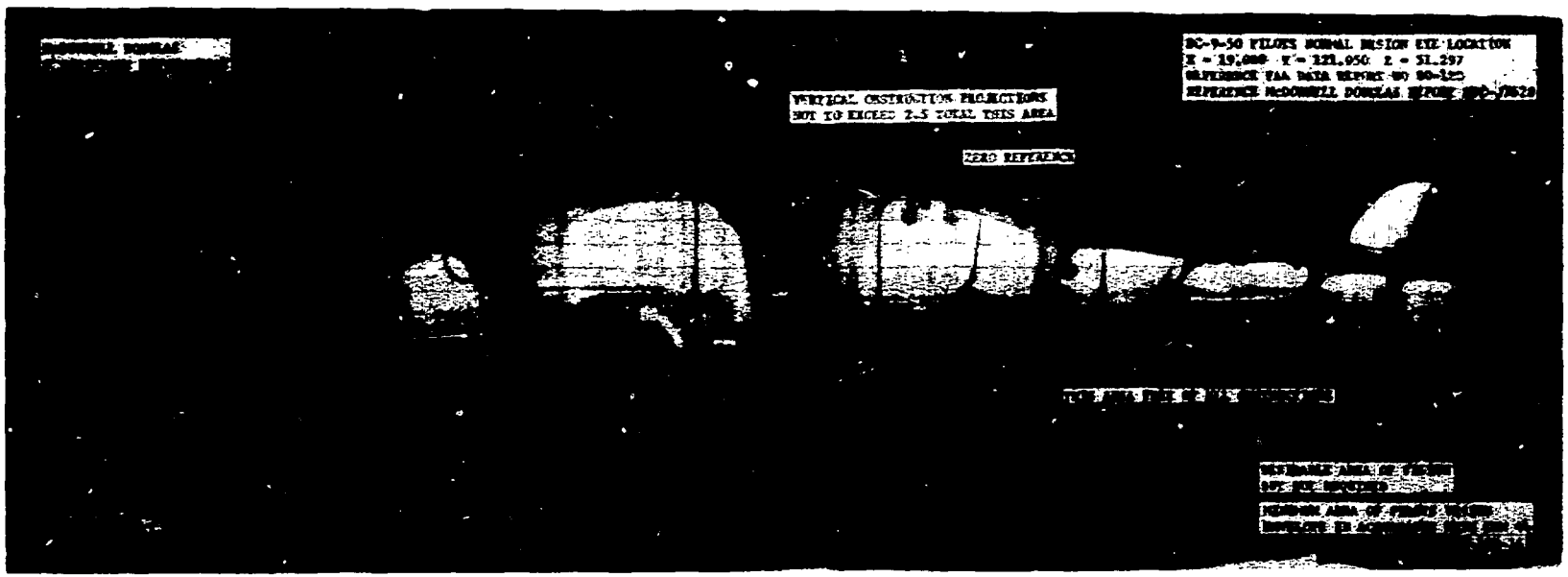


FIGURE 29. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT DOUGLAS DC-9-50

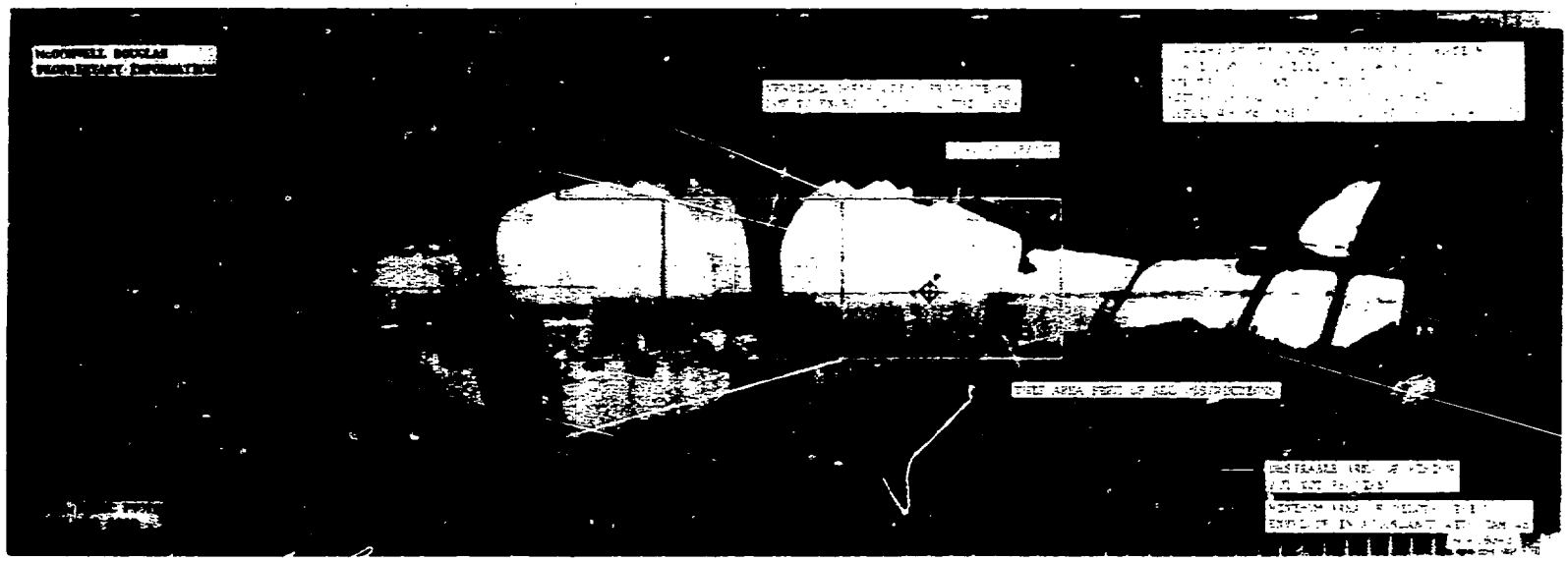


FIGURE 30. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT DOUGLAS DC-9-80

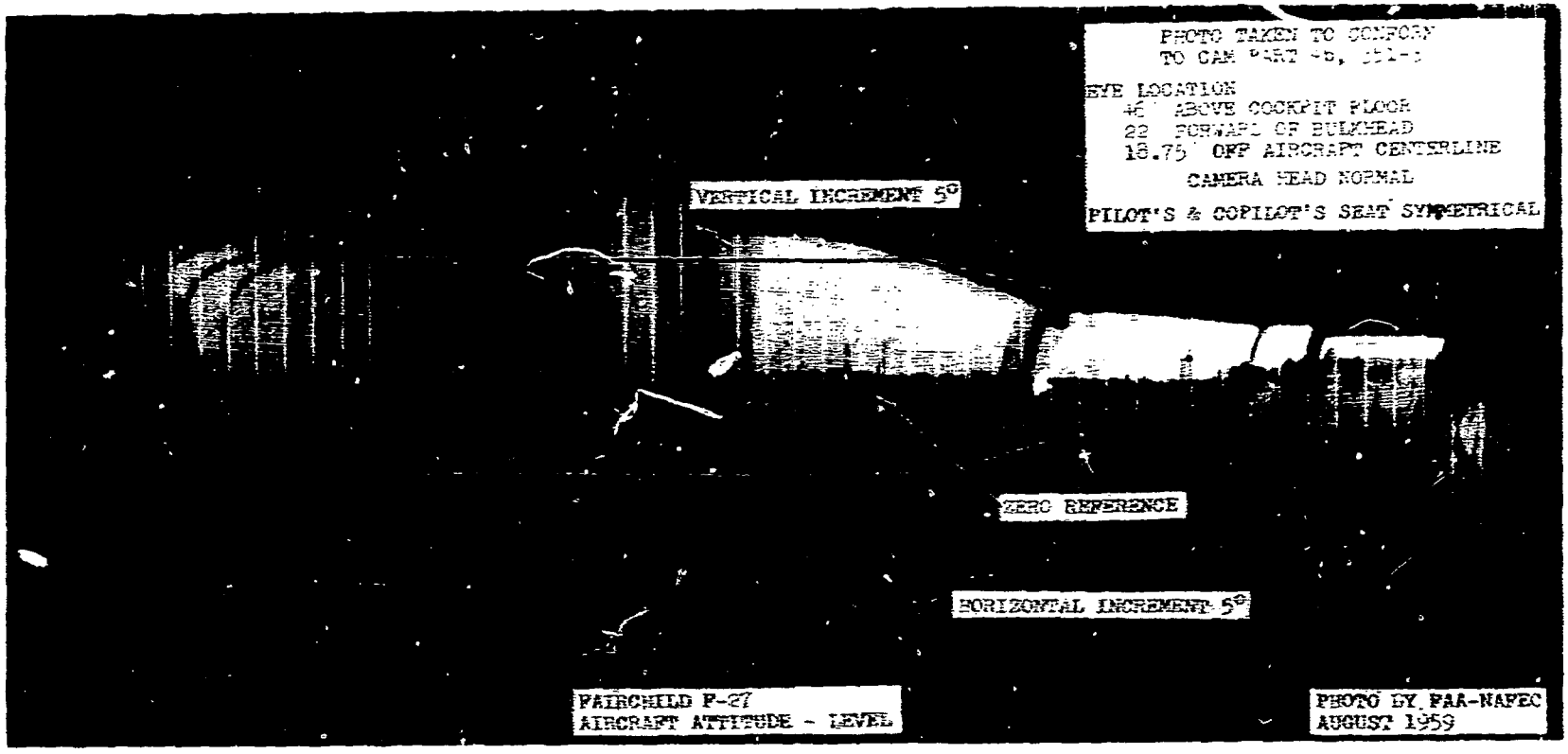


FIGURE 31. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT FAIRCHILD F-27

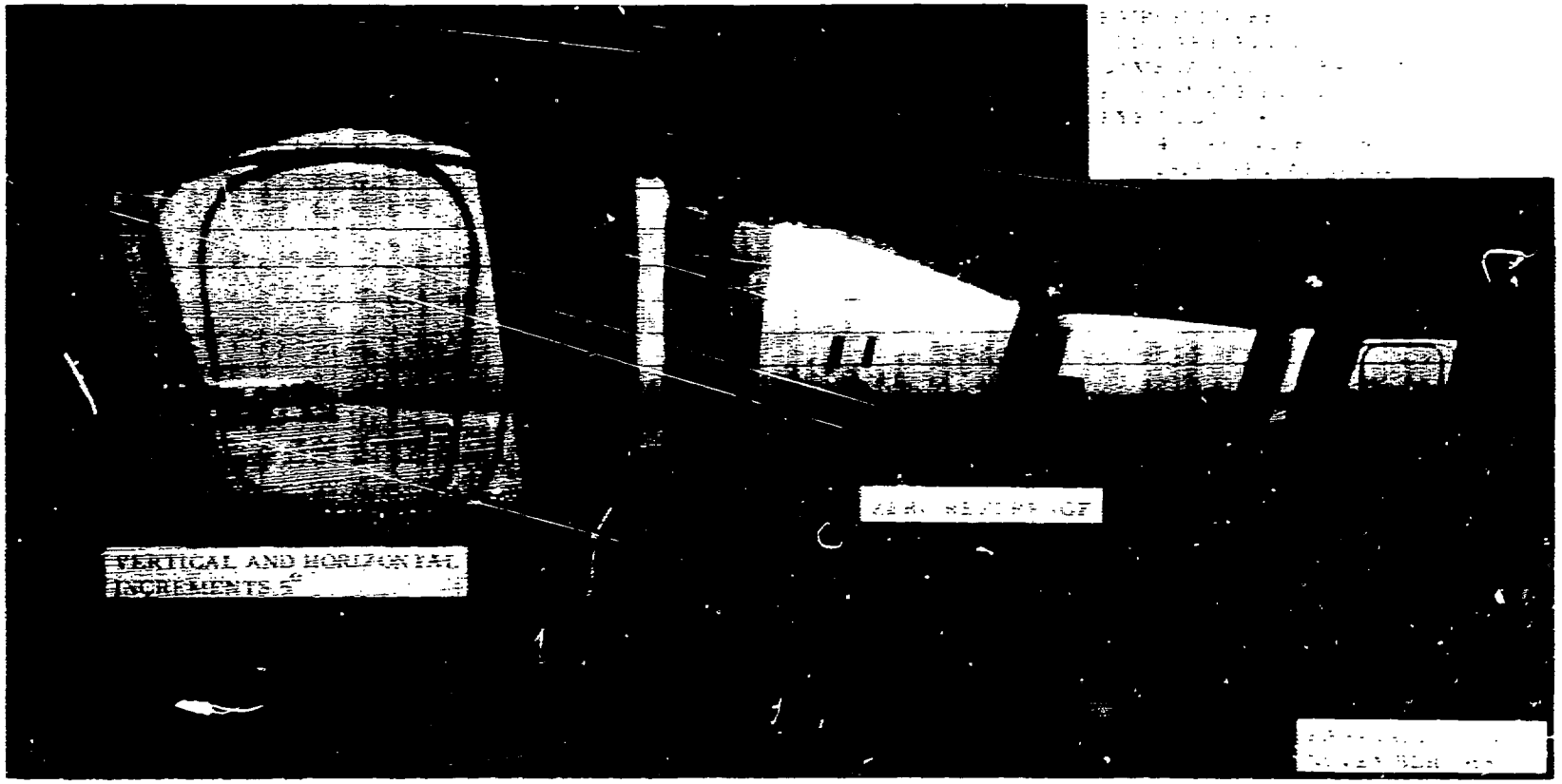


FIGURE 32. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT FAIRCHILD FH-227

FIGURE 33. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT FALCON FAN JET 20

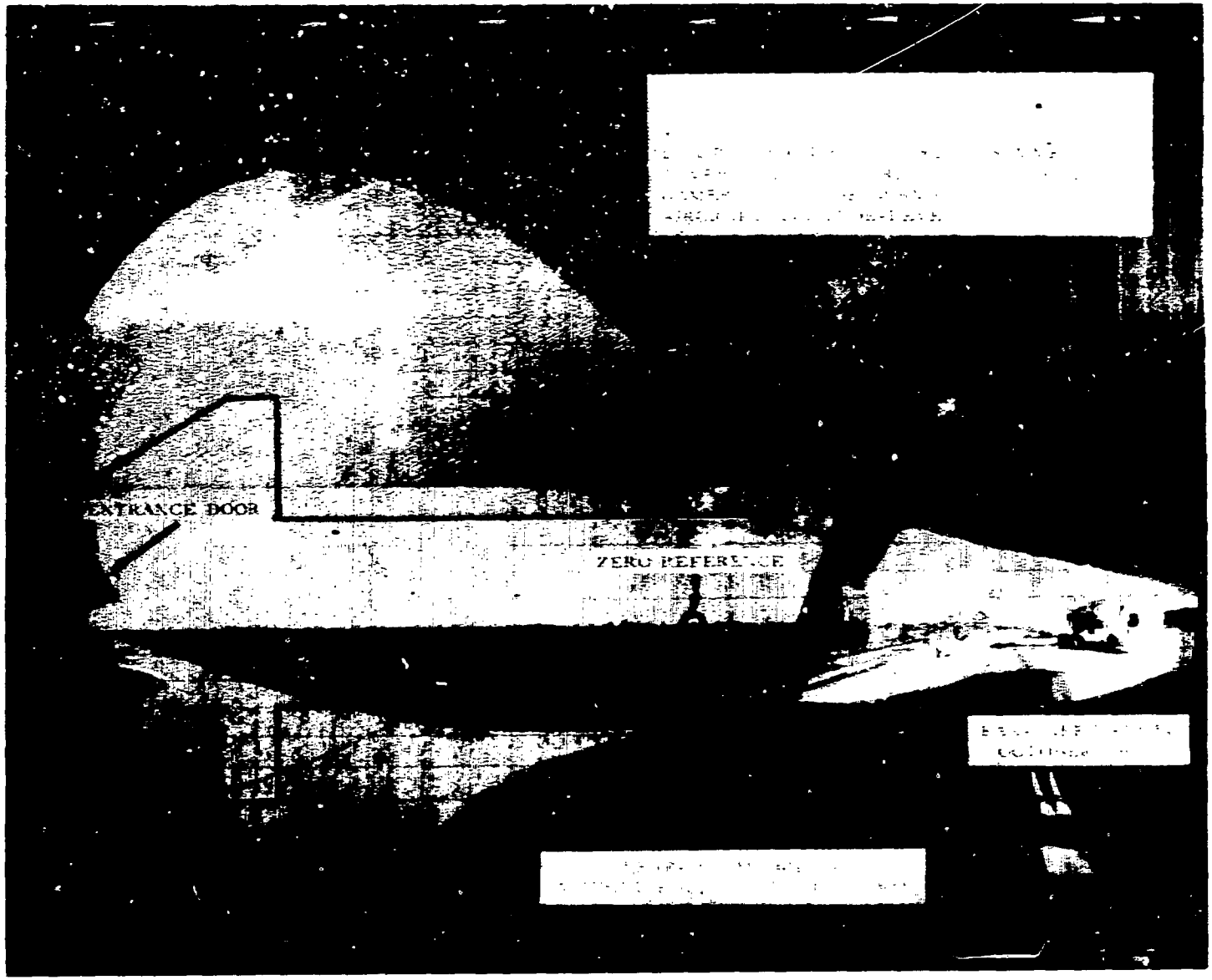


FIGURE 34. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT LEAR JET MODEL 24

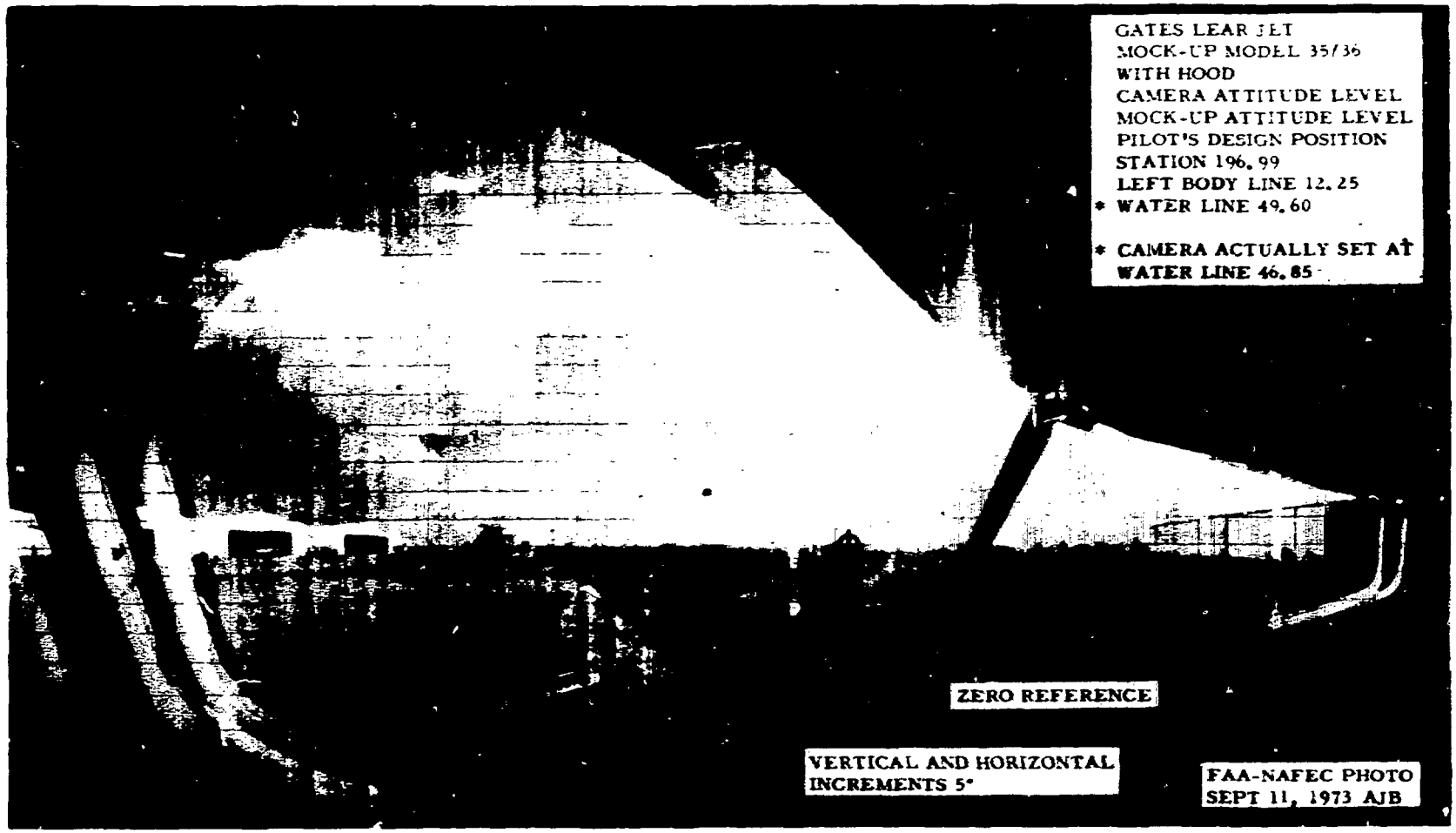


FIGURE 35. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT GATES LEAR JET MODEL 35/36

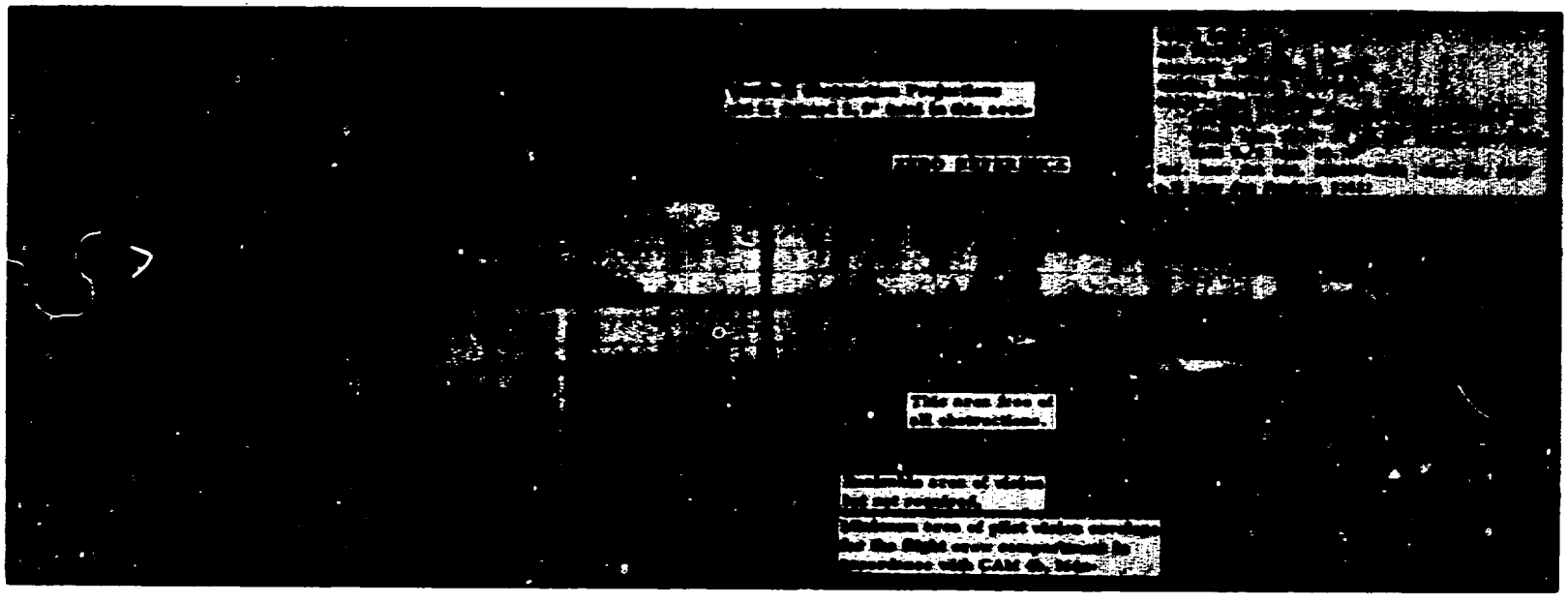


FIGURE 36. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT GATES LEAR JET MODEL 55

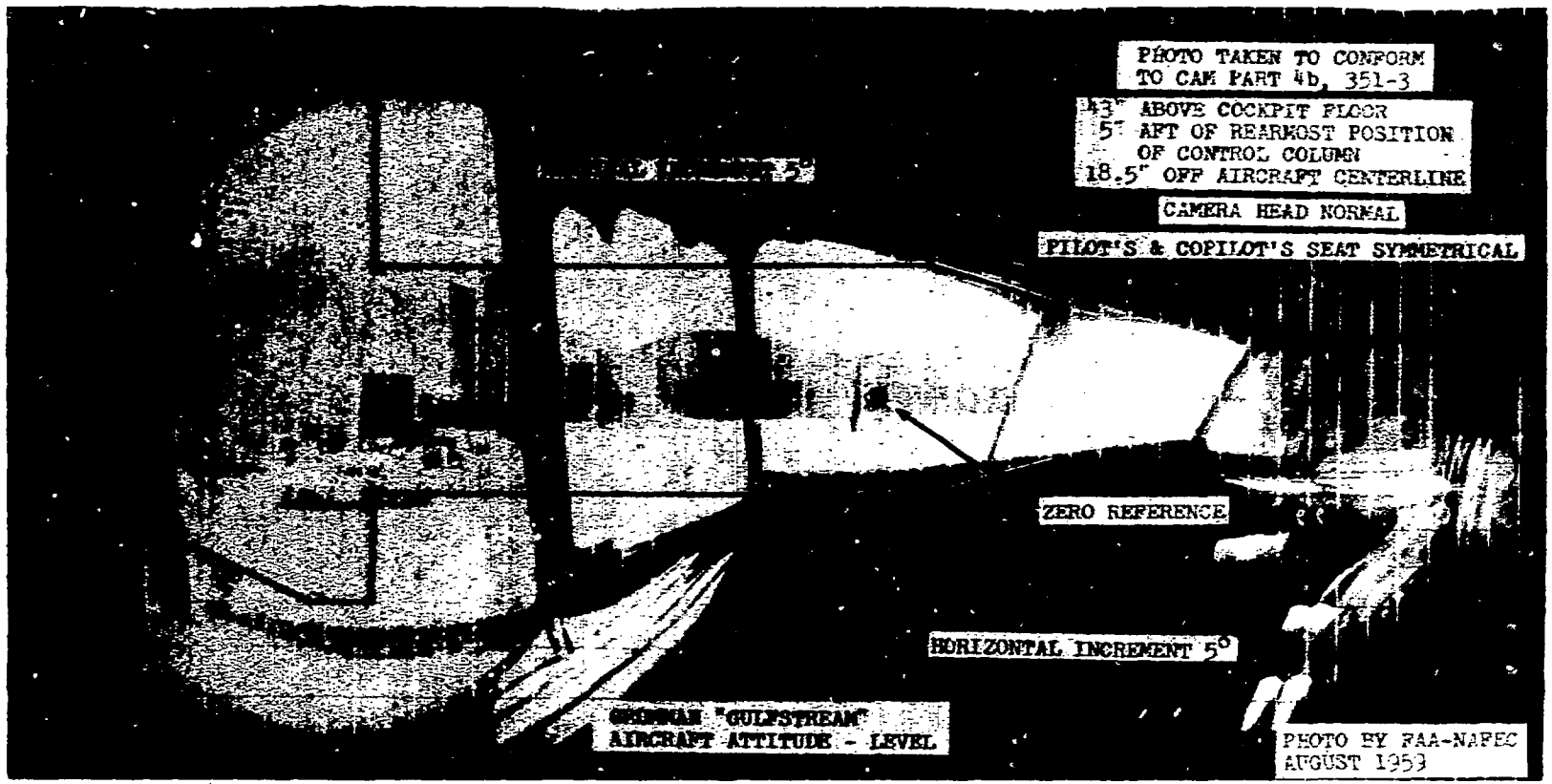


FIGURE 37. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT GRUMMAN GULFSTREAM

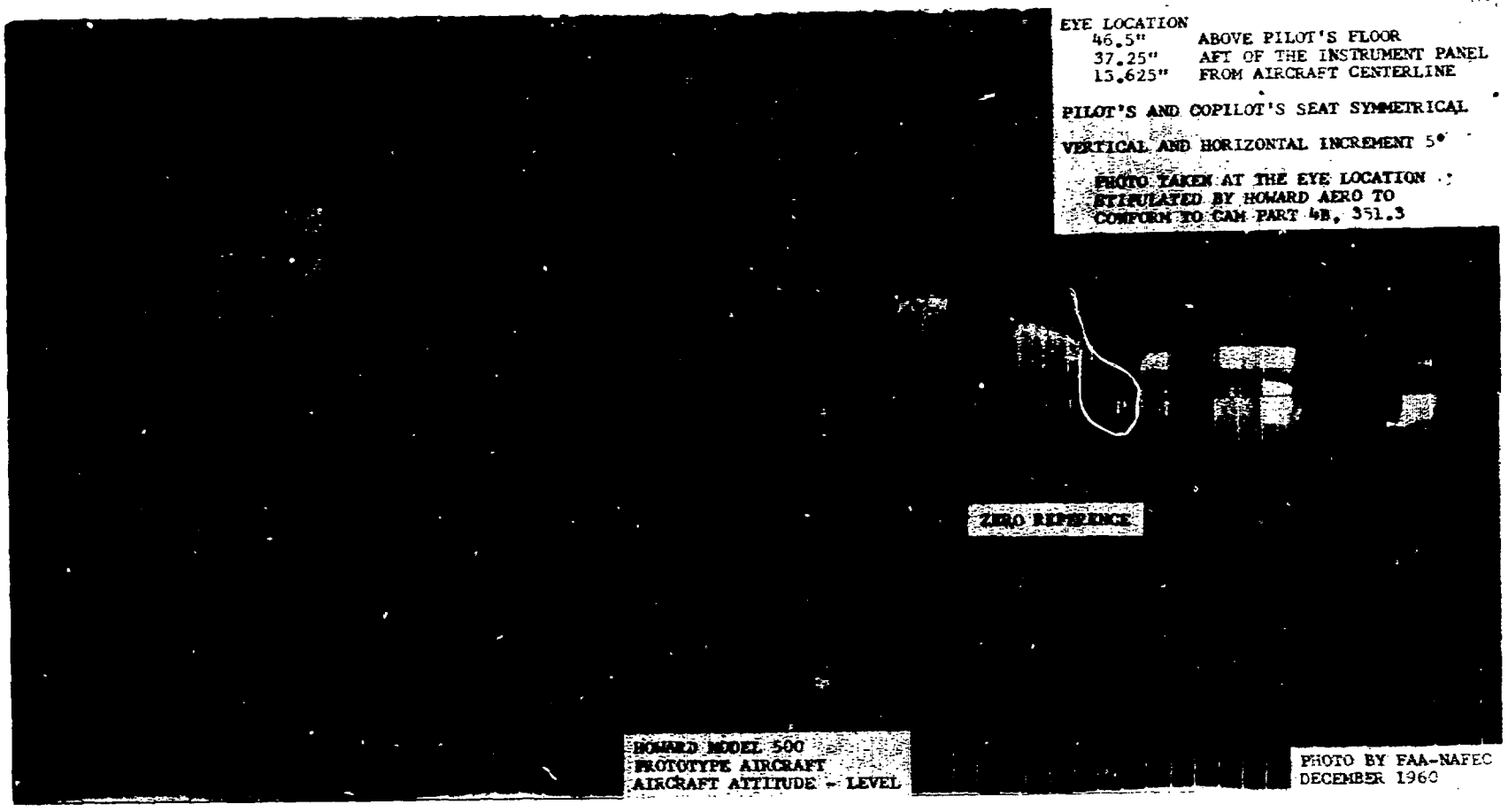


FIGURE 38. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT HOWARD MODEL 500

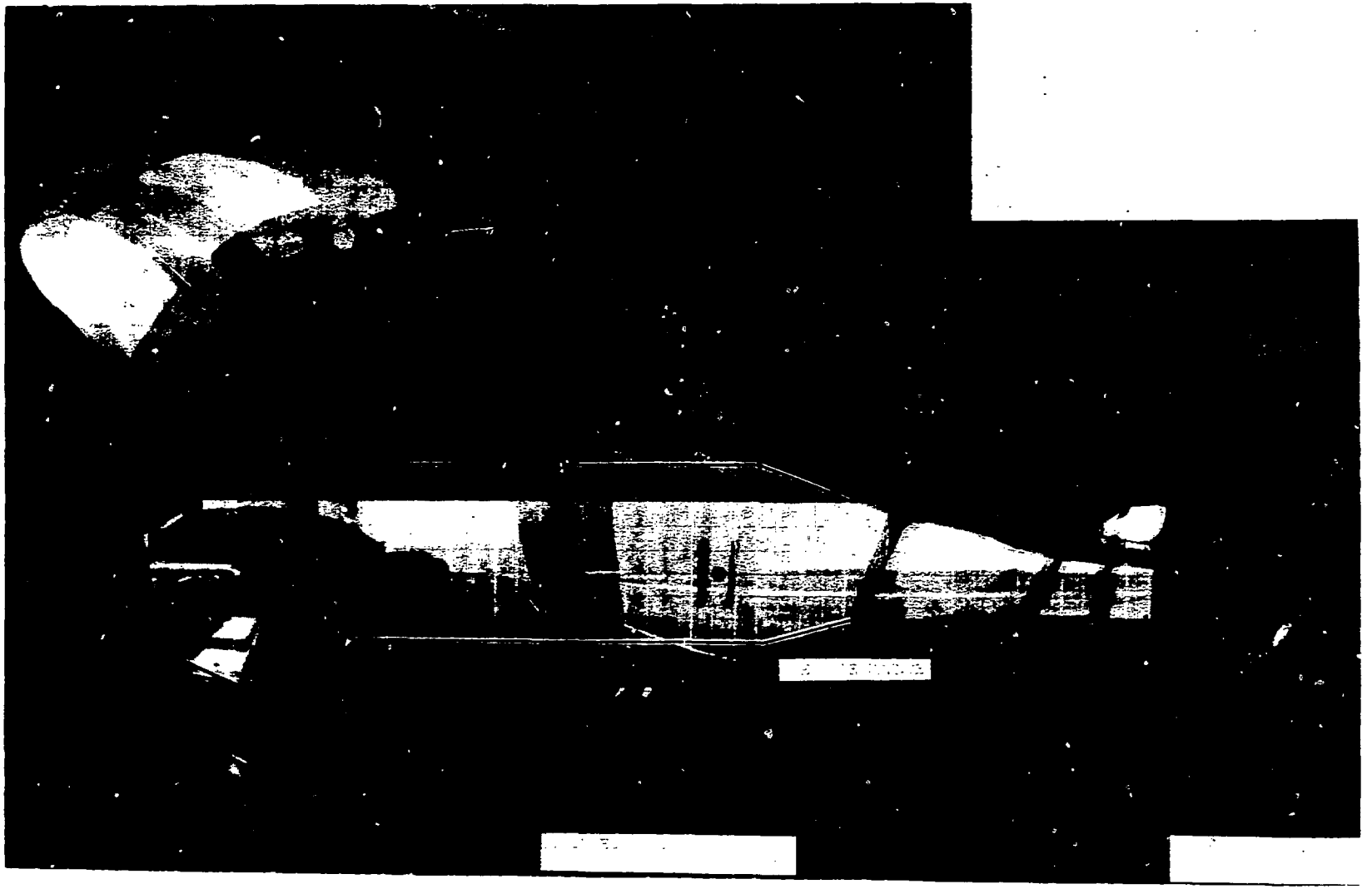


FIGURE 39. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT LOCKHEED ELECTRA

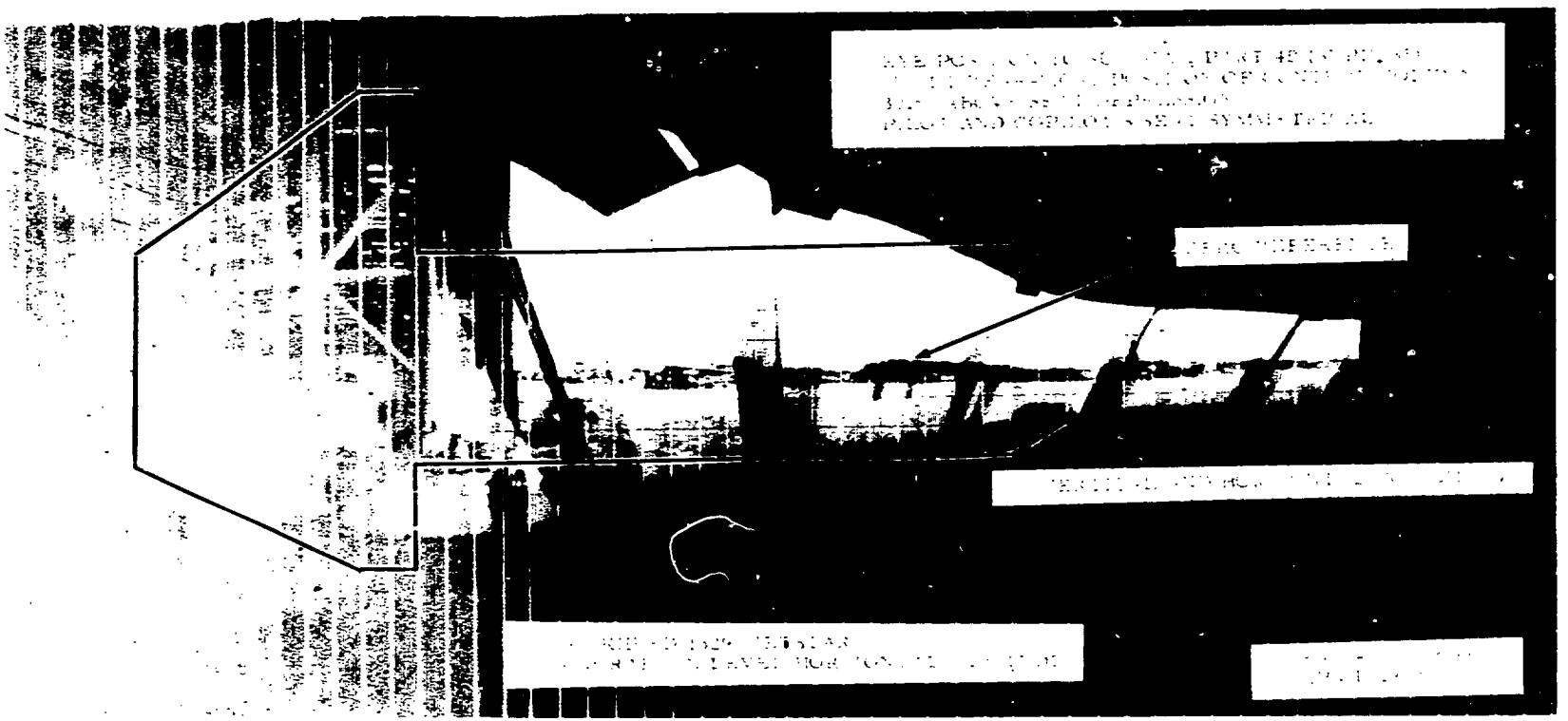


FIGURE 40. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT LOCKHEED 1329

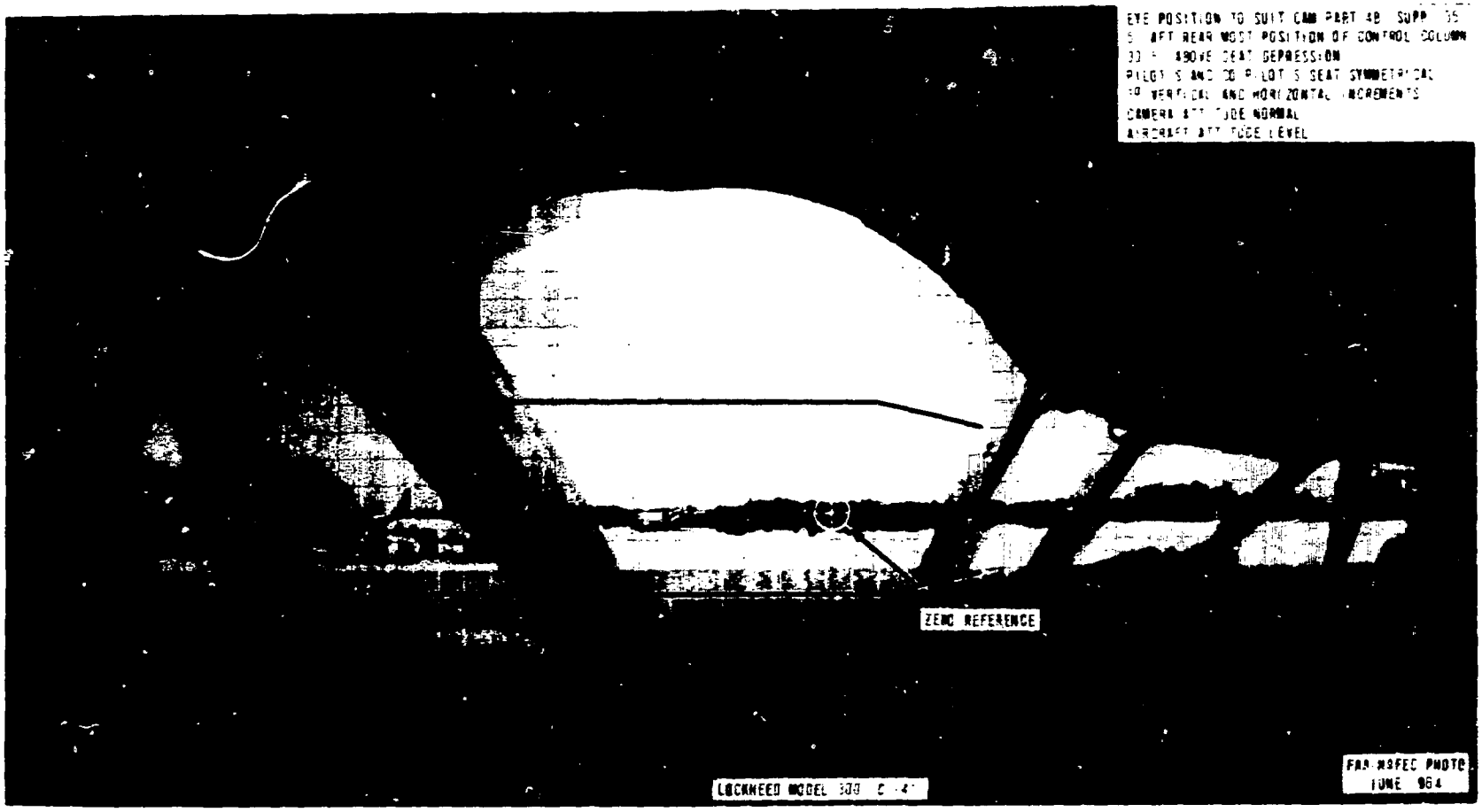


FIGURE 41. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT LOCKHEED MODEL 300

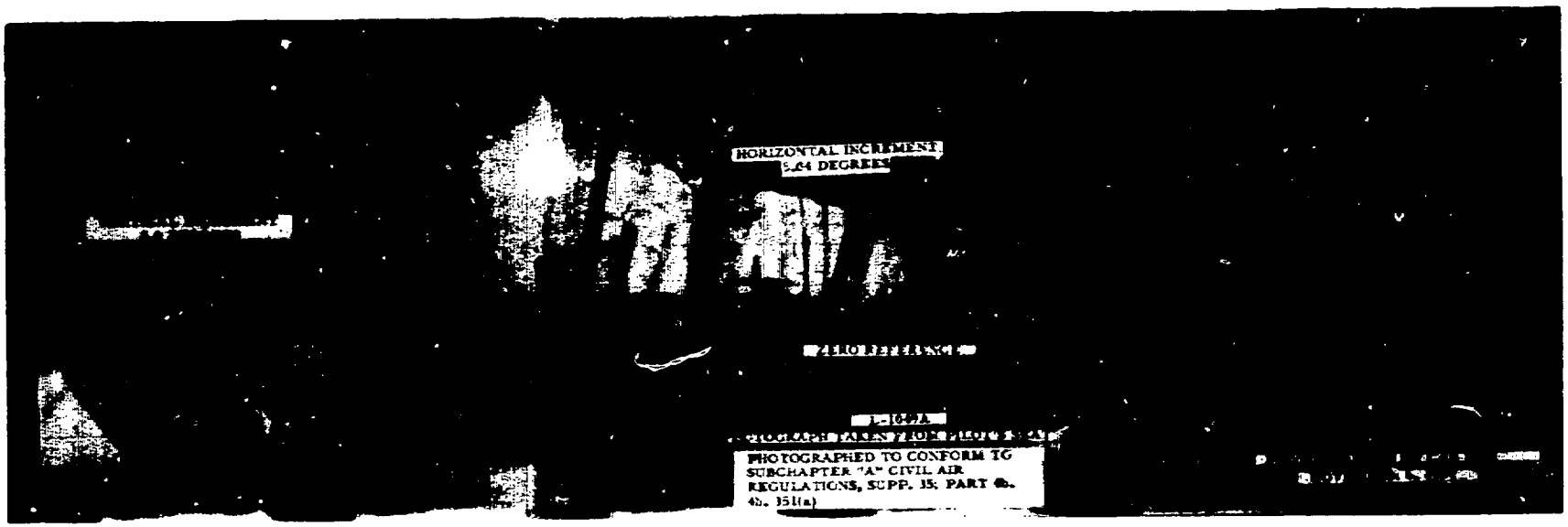
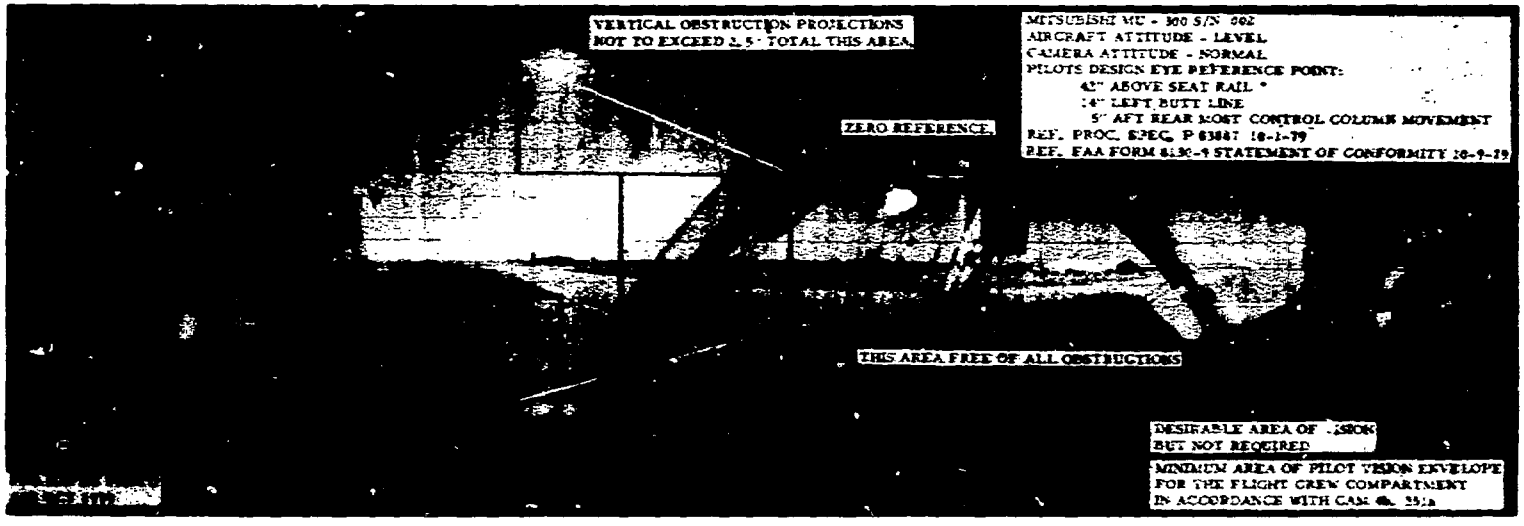


FIGURE 42. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT LOCKHEED L-1049A

FIGURE 43. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT MARTIN MODEL 404



NOTE: This cockpit not in final form, glare shield and other features to improve visibility to be made.

FIGURE 44. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPd OF AIRCRAFT MITSUBISHI MU-300

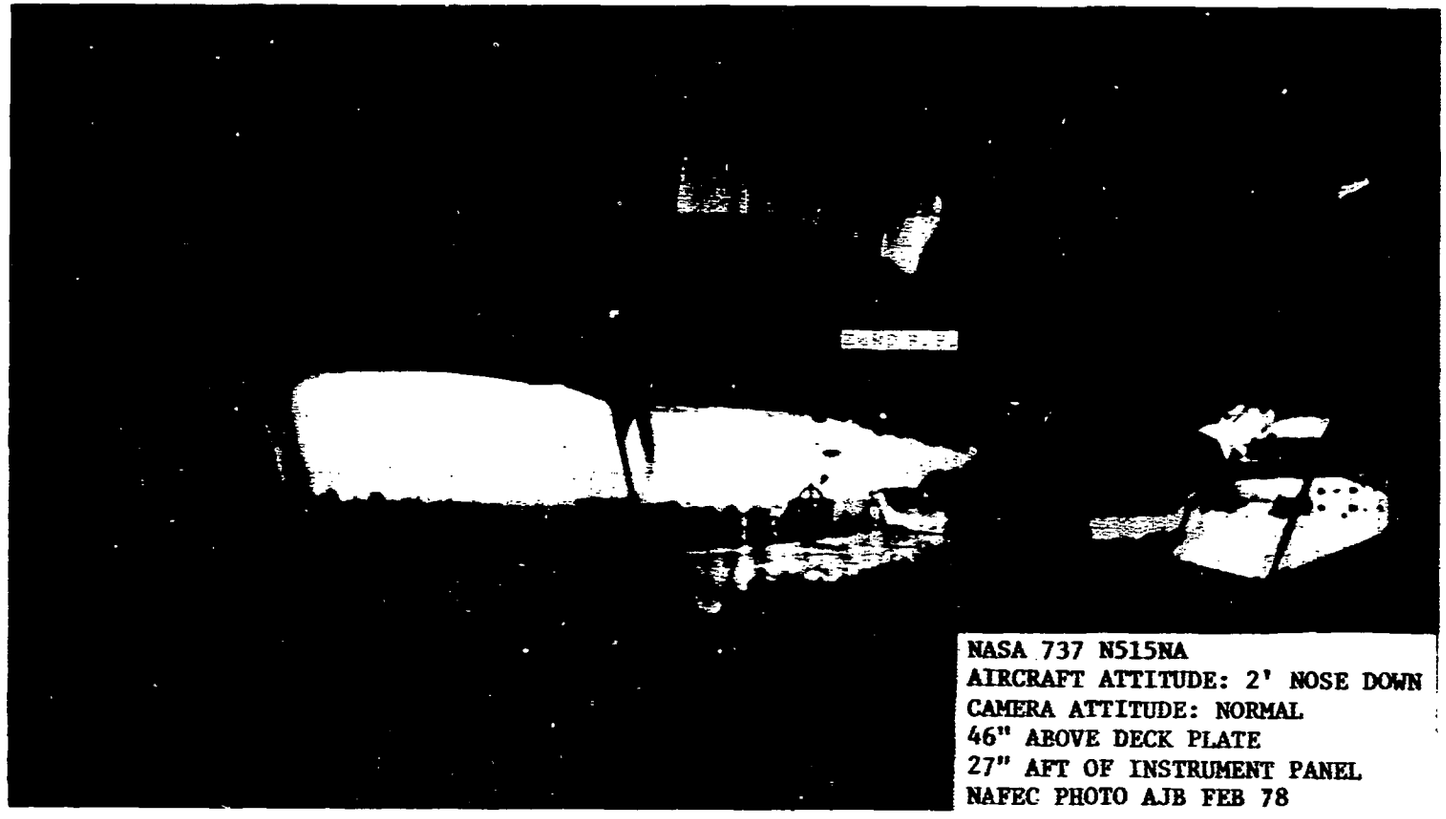


FIGURE 45. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT NASA/BOEING-737

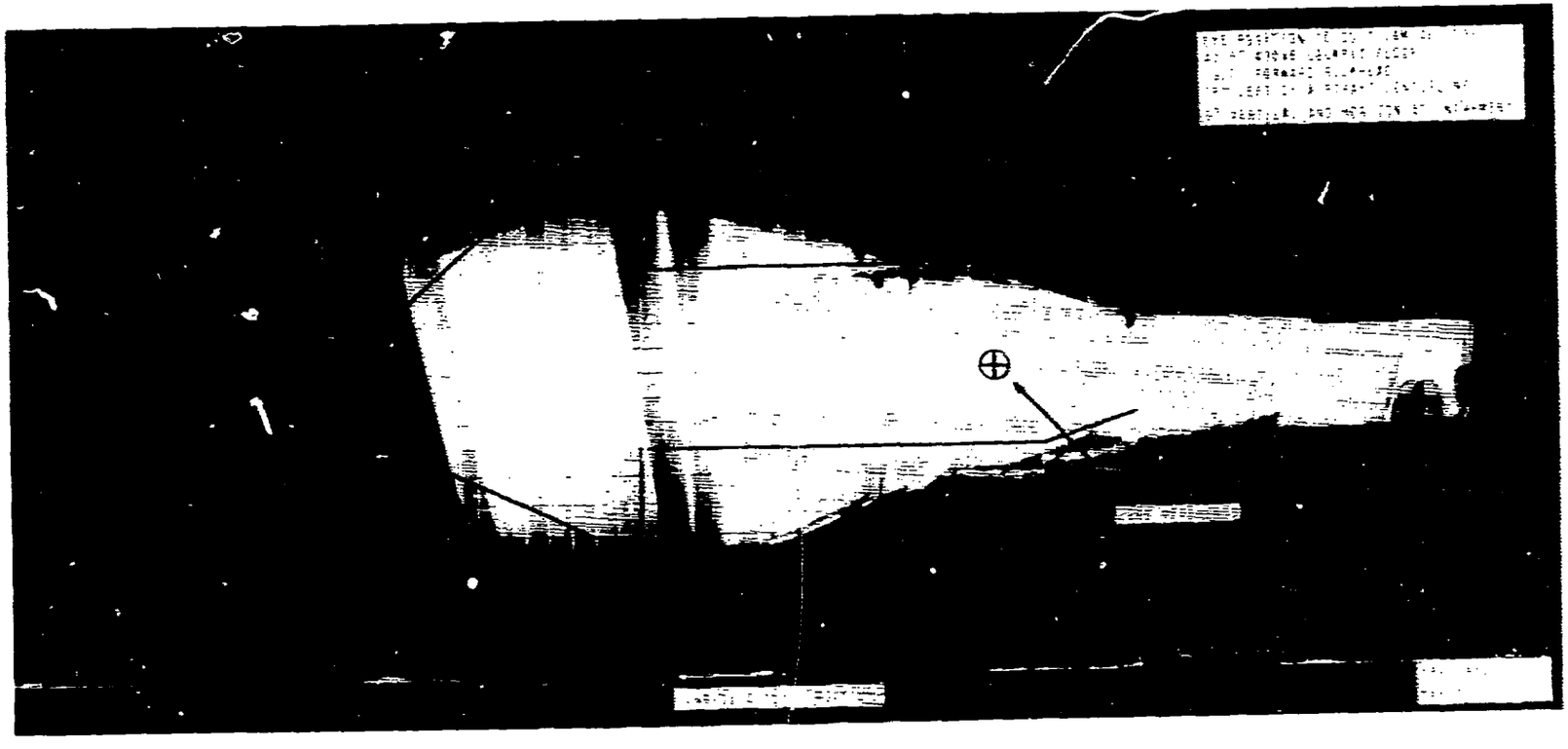


FIGURE 46. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT SUNRISE S-1600

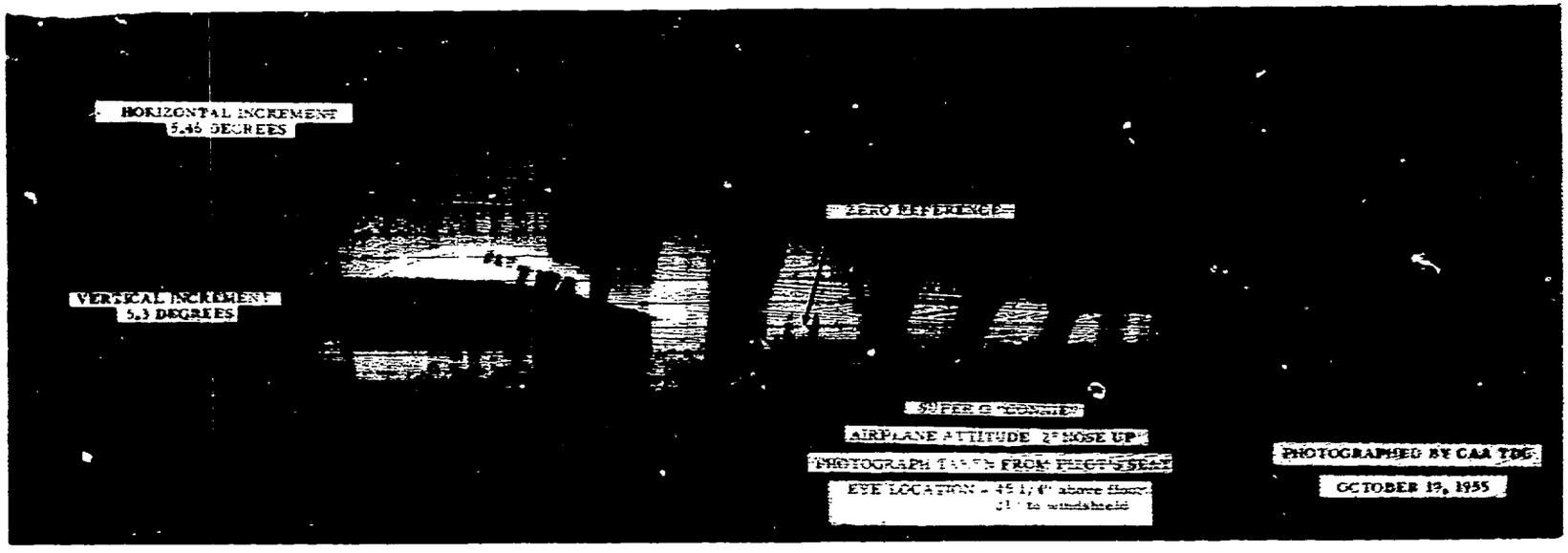


FIGURE 47. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT SUPER G CONSTELLATION

FIGURE 48. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT VICKERS VISCOUNT

CIVILIAN AIRCRAFT
12,500 pounds or less

The aircraft in the following listing are depicted in figures 49 through 74.

Aero 680E

Beech 55
Beech 99

Cessna 140A
Cessna 150F
Cessna 170
Cessna 172
Cessna 177
Cessna 180
Cessna 182
Cessna 206
Cessna 210
Cessna 310
Cessna 337B

DeHavilland DHC-6
Helio Plane
Helio Model 500

Mooney 21

Piper Arrow PA-28R-200
Piper Aztec PA-23
Piper Cherokee Archer PA-28-181
Piper Cherokee 140 PA-28-180
Piper Cherokee 140
Piper Cherokee 6 PA-32-260
Piper Navajo PA-31

Swift 125

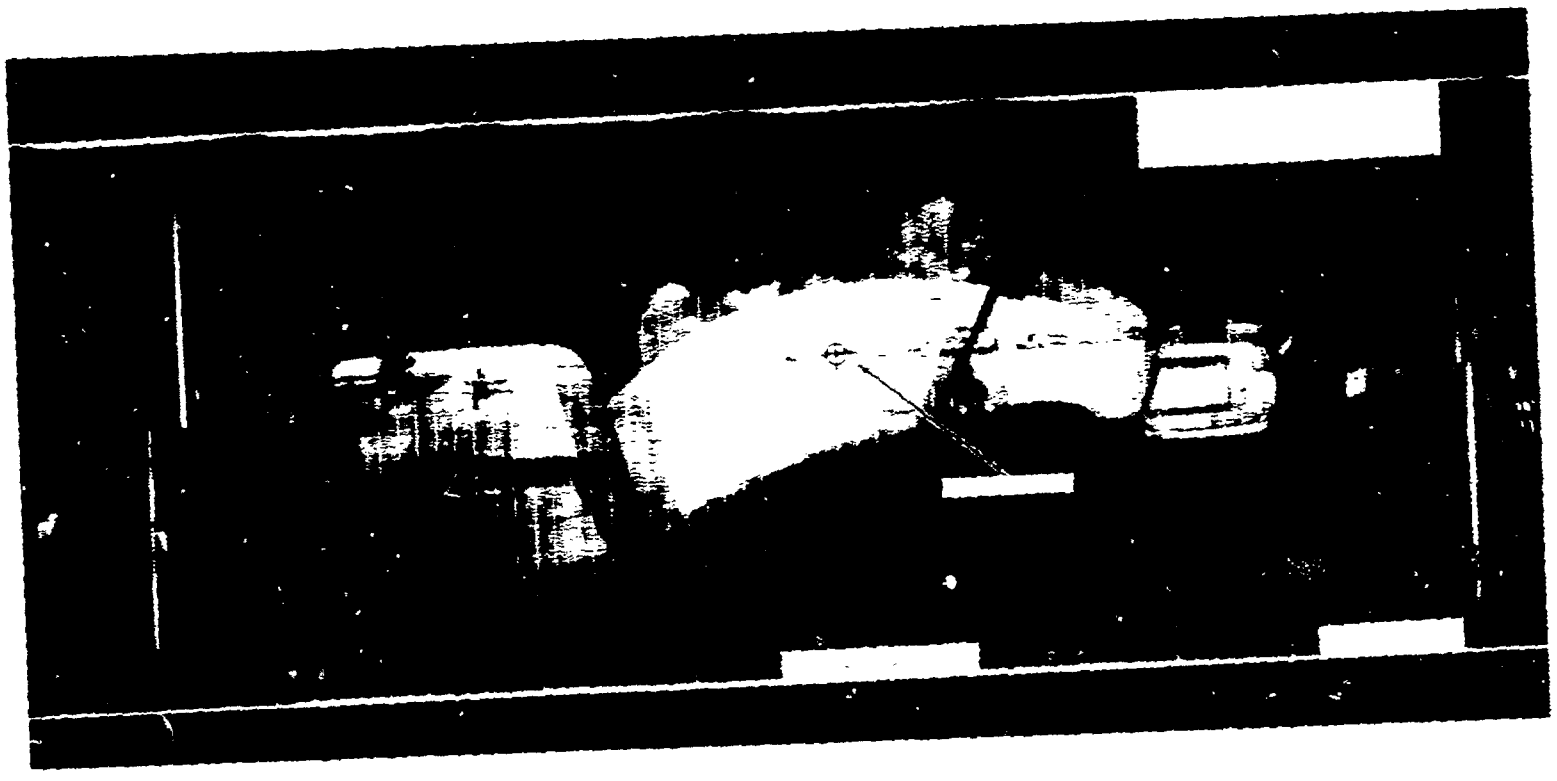


FIGURE 49. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AERO COMMANDER 680E

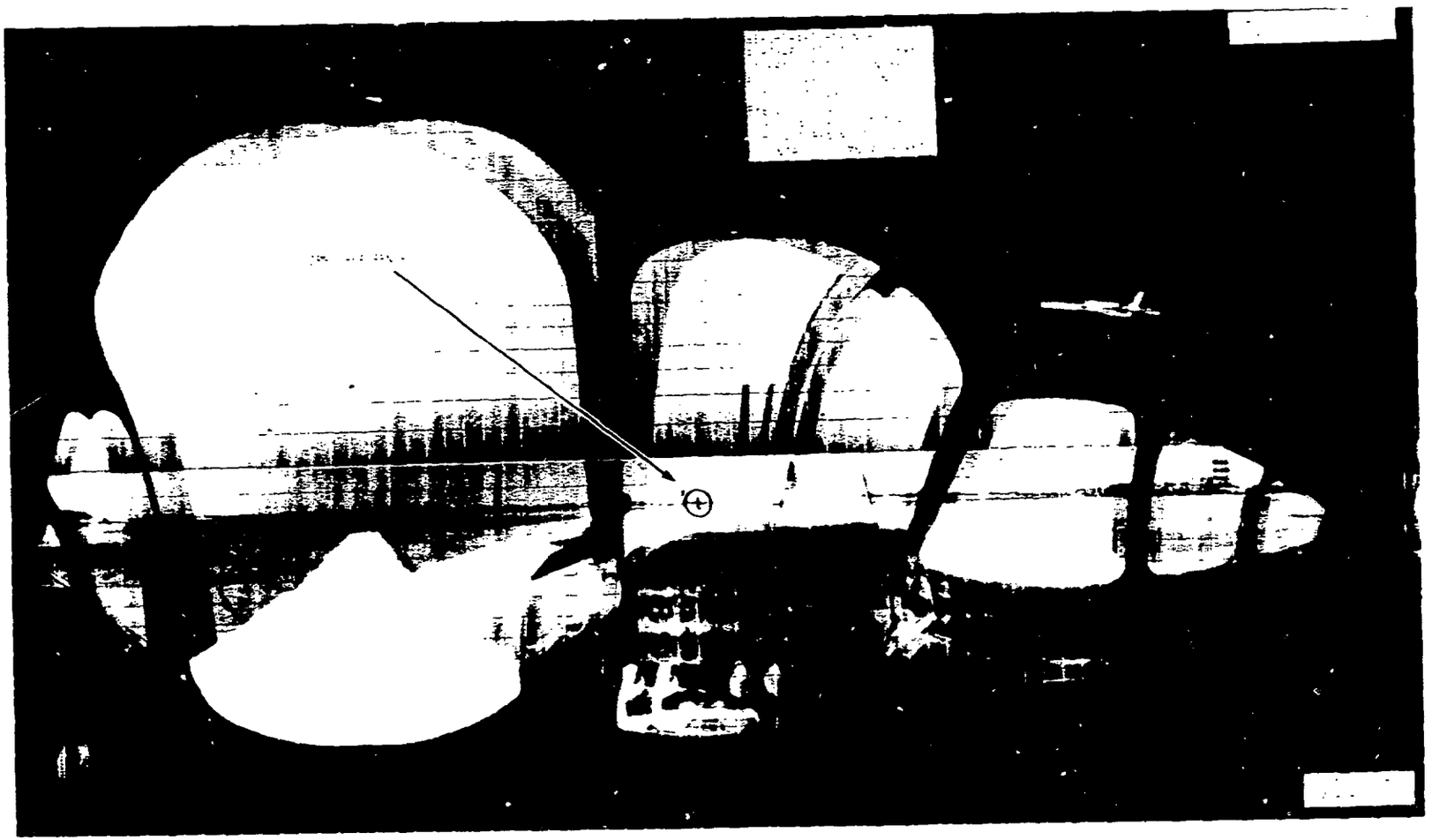


FIGURE 50. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT BEECHCRAFT BARON B-55

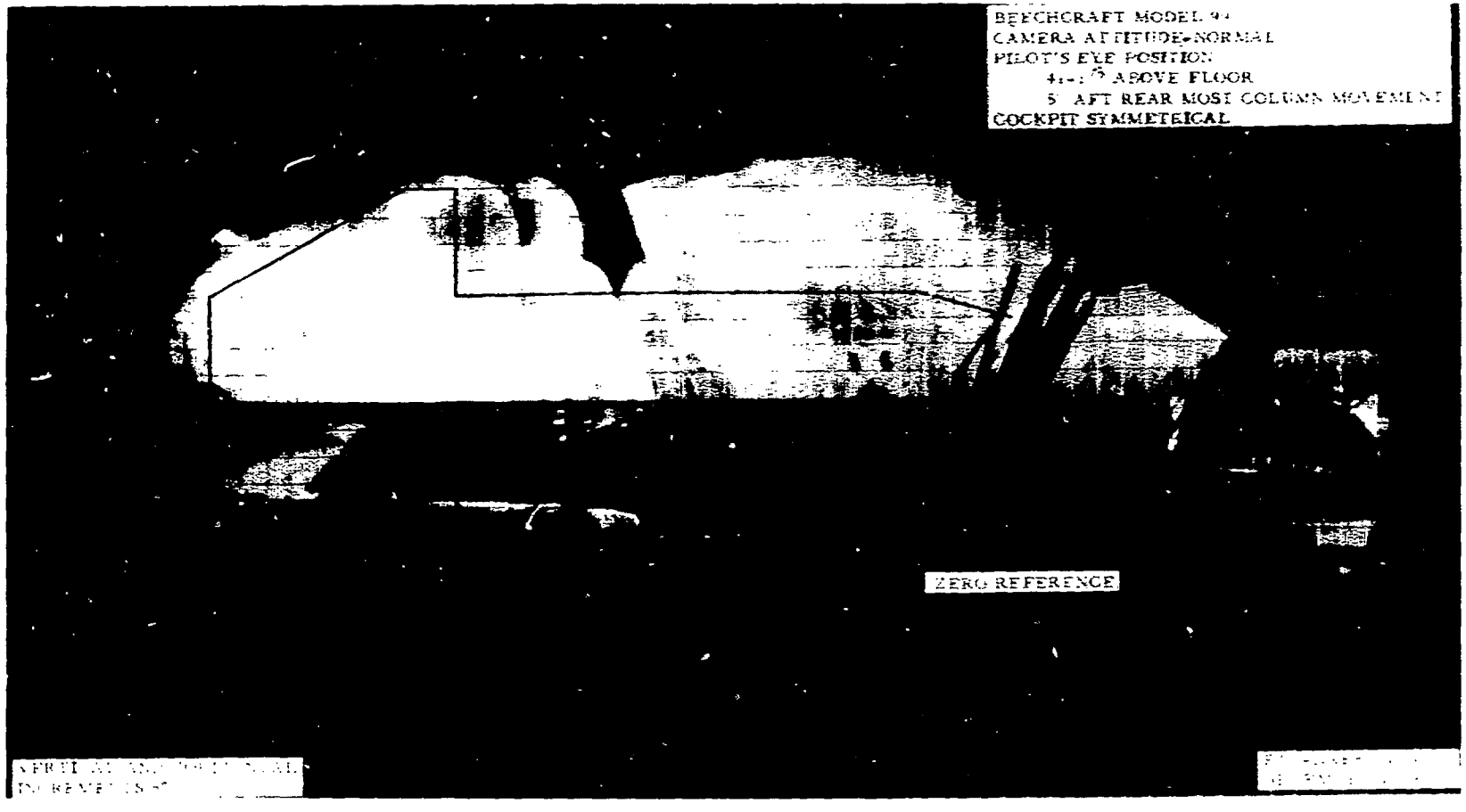


FIGURE 51. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT BEECHCRAFT MODEL 99

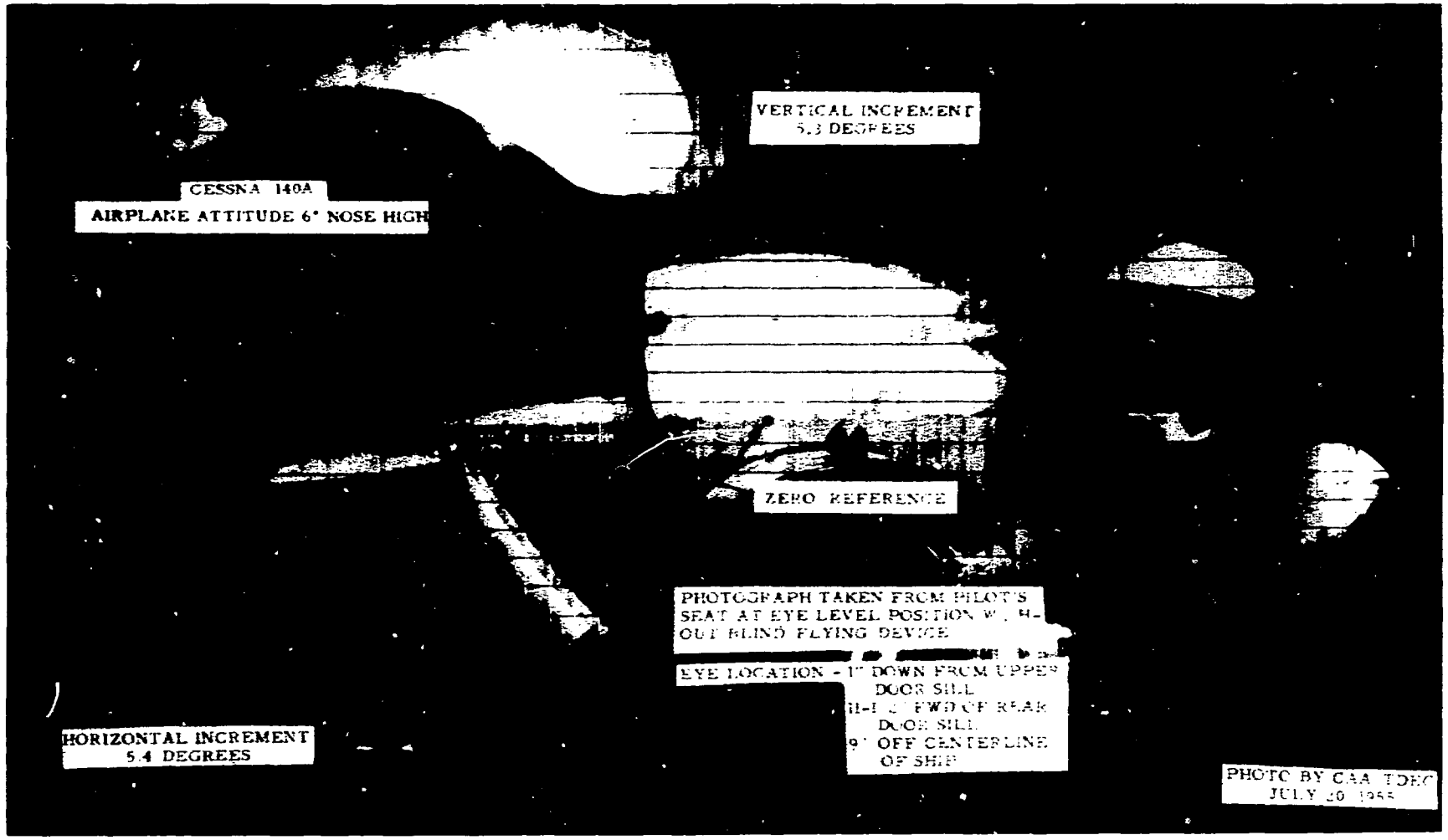


FIGURE 52. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CESSNA 140A

FIGURE 53. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CESSNA 150F

FIGURE 54. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CESSNA 170

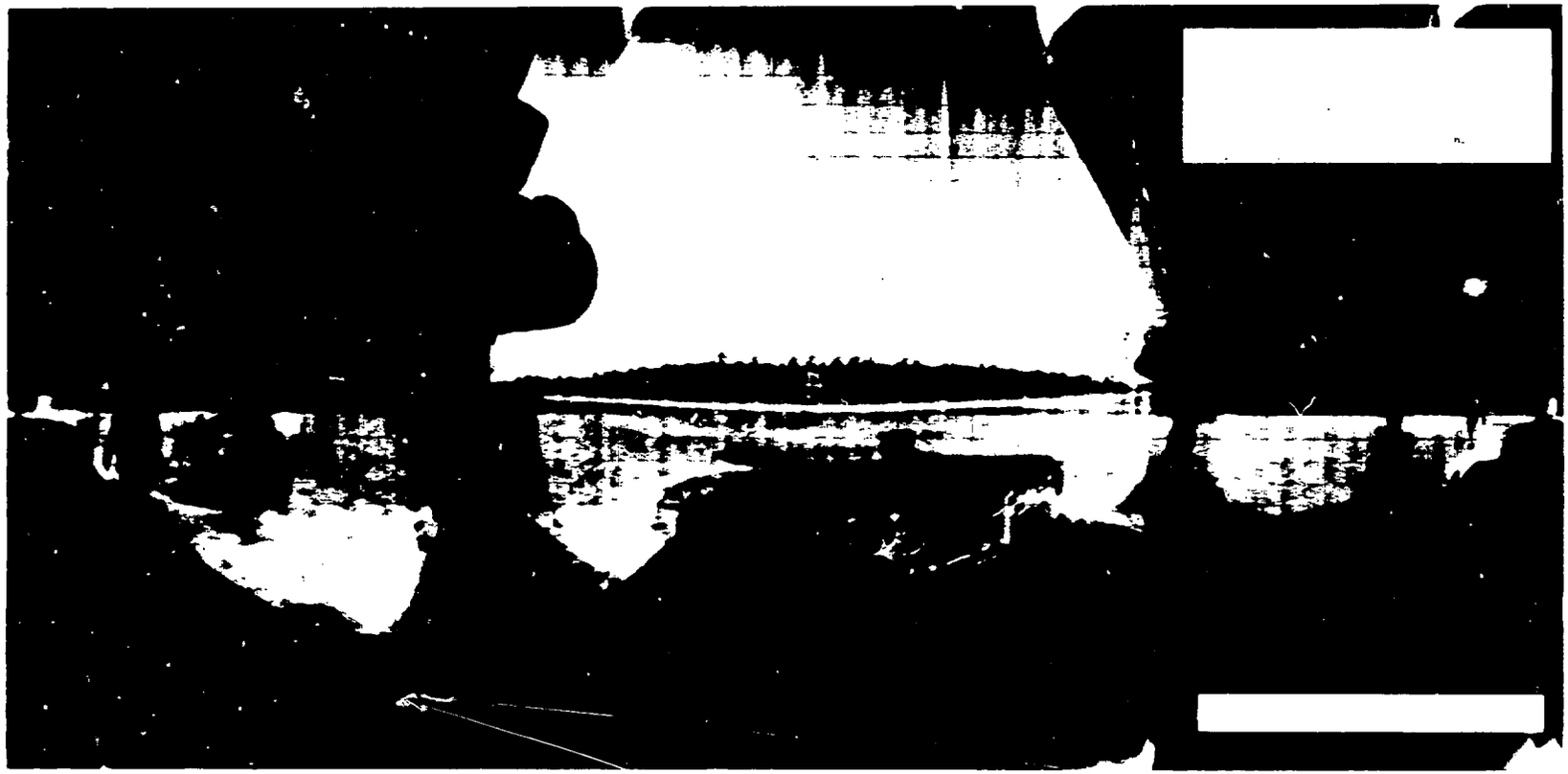


FIGURE 55. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CESSNA 172

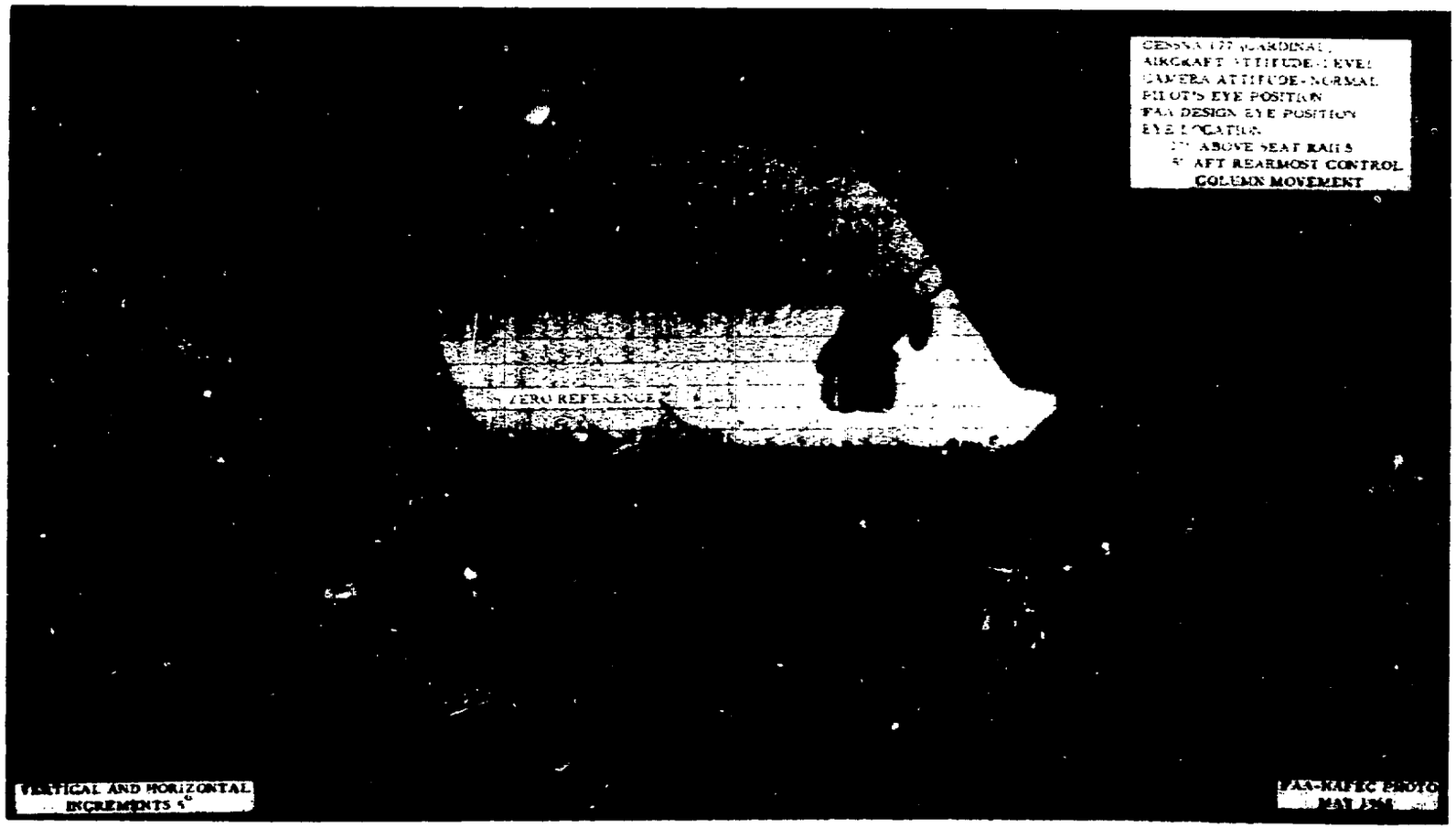


FIGURE 56. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CESSNA 177

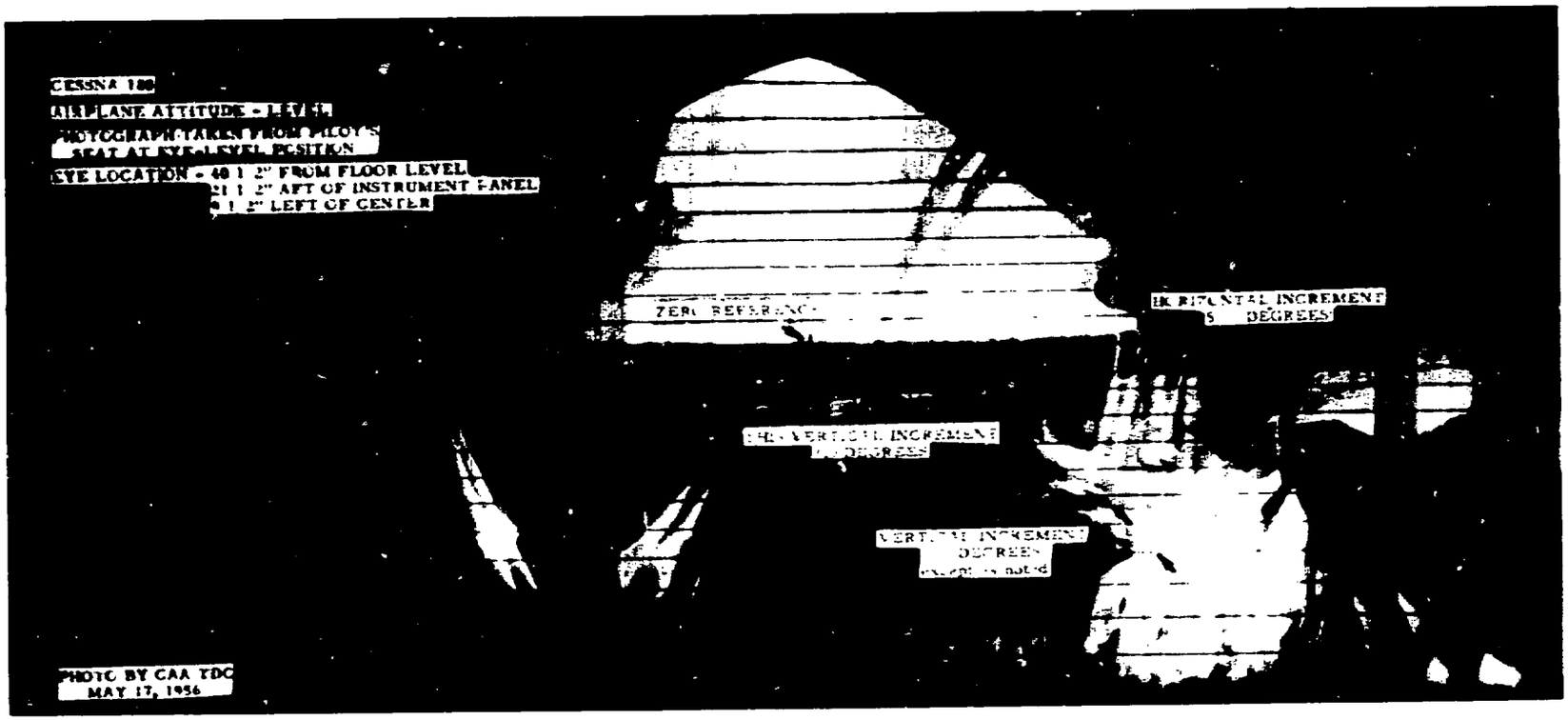


FIGURE 57. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CESSNA 180

FIGURE 58. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CESSNA 182

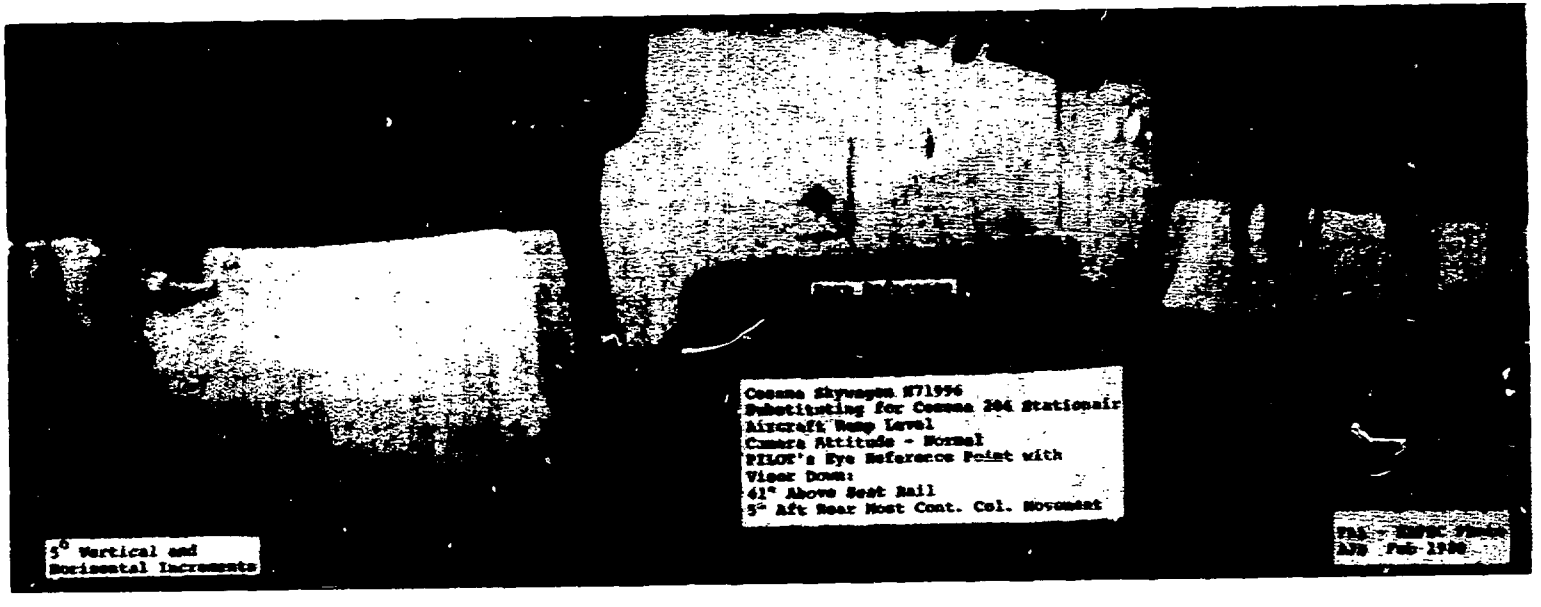


FIGURE 59. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CESSNA SKYWAGON

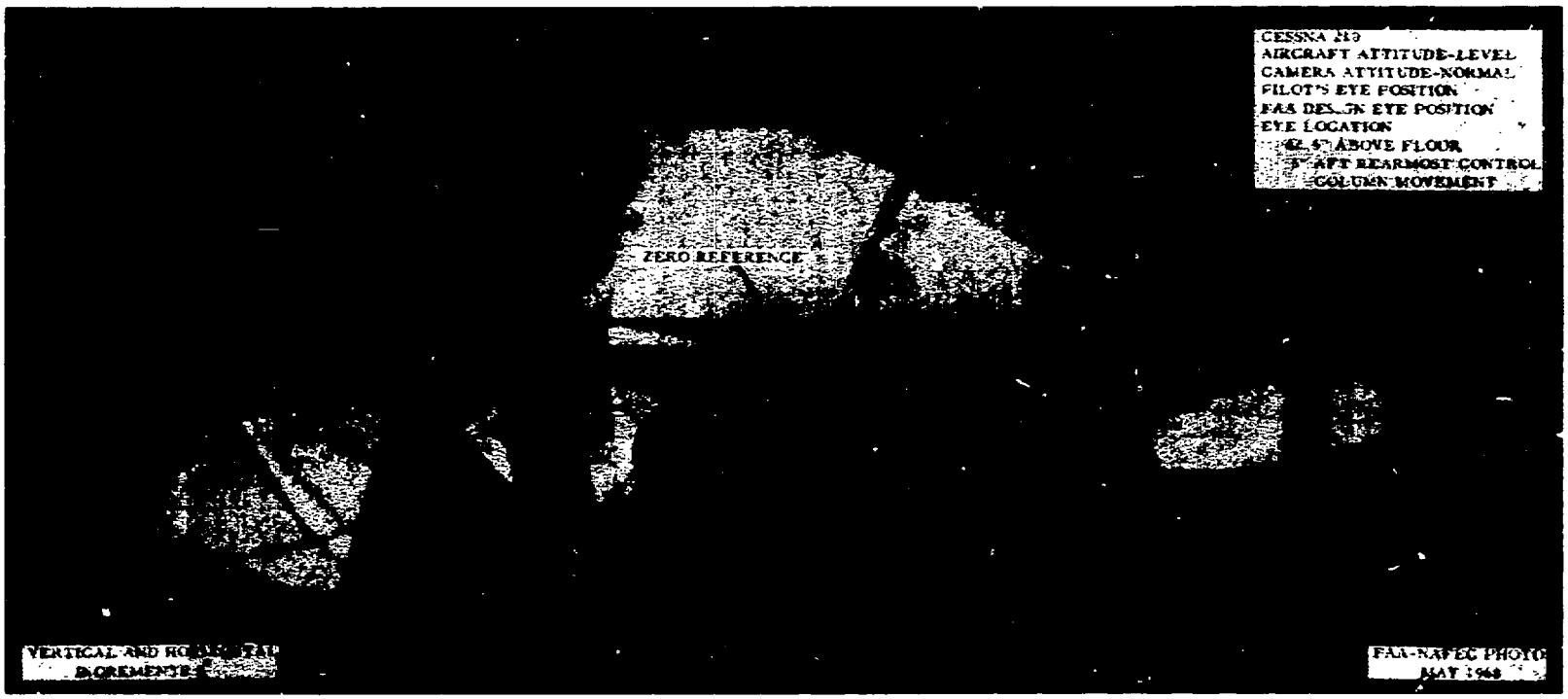


FIGURE 60. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CESSNA 210

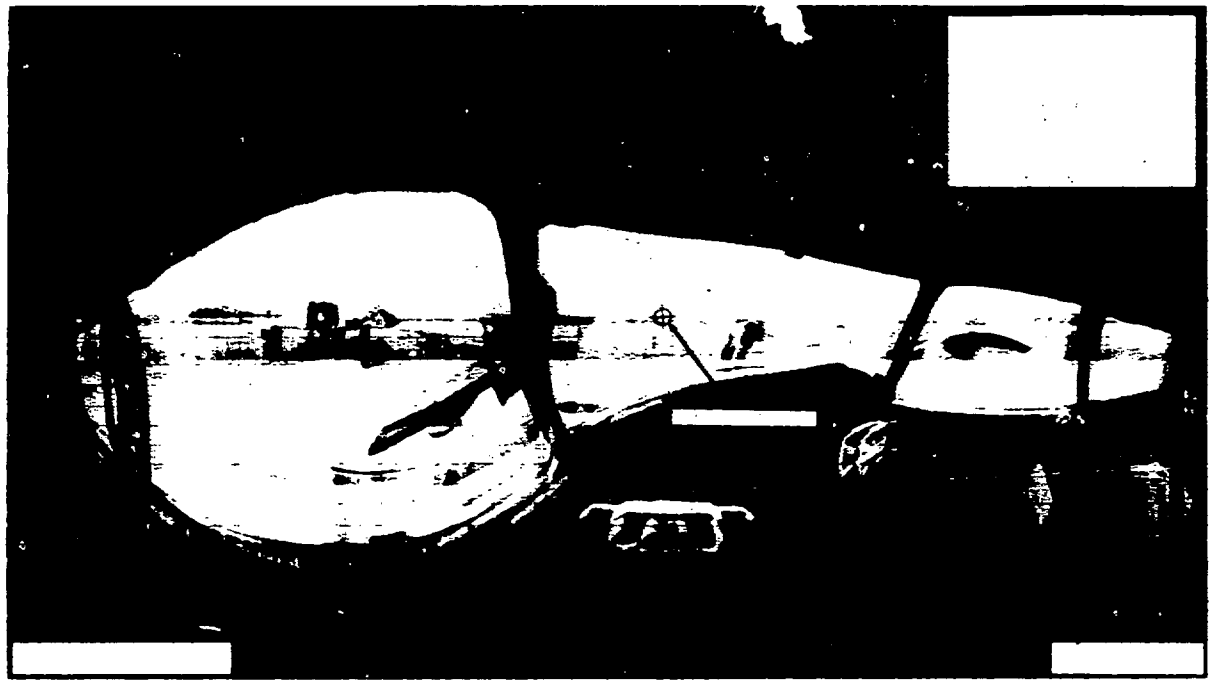


FIGURE 61. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CESSNA 310

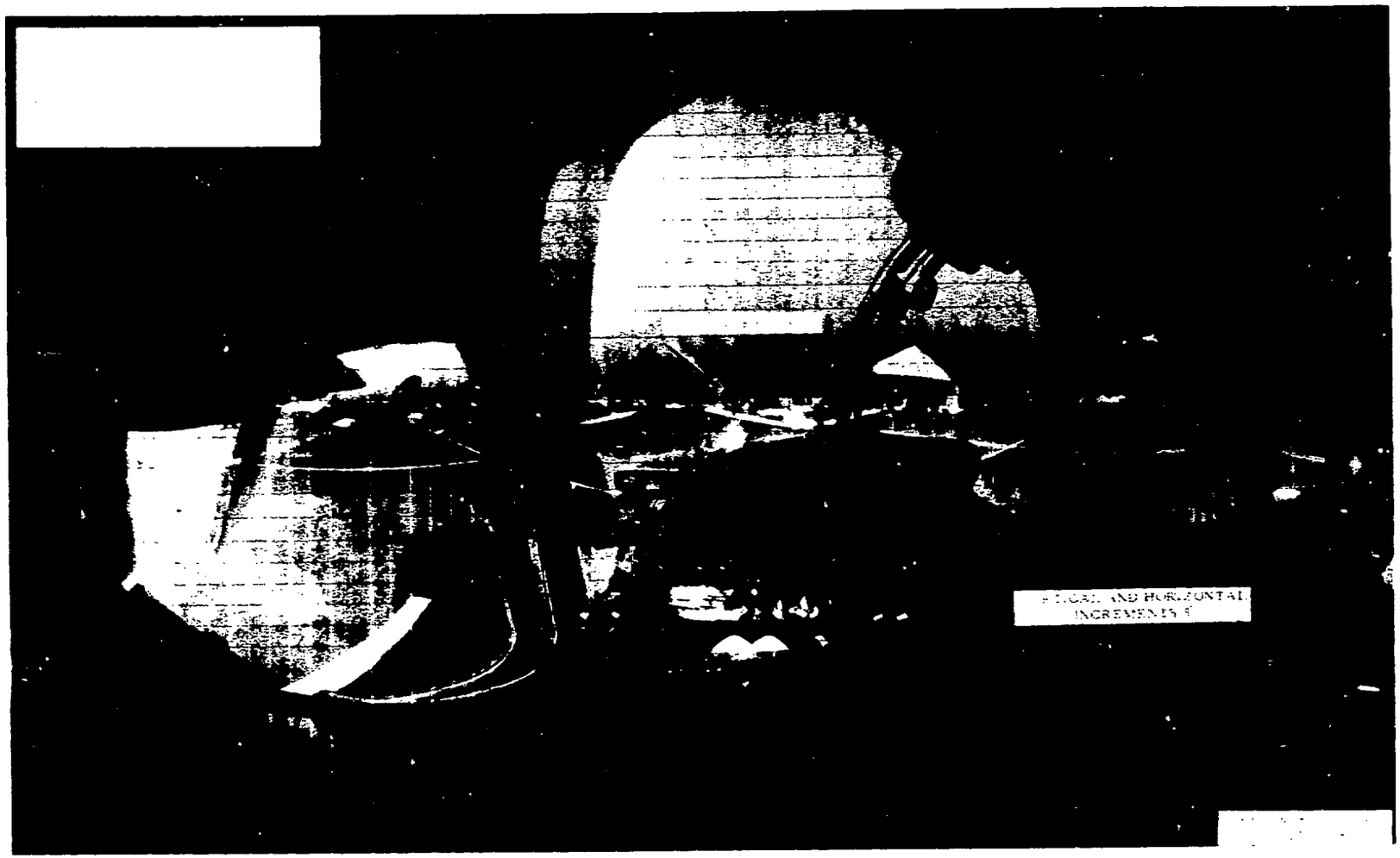


FIGURE 62. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CESSNA 337B

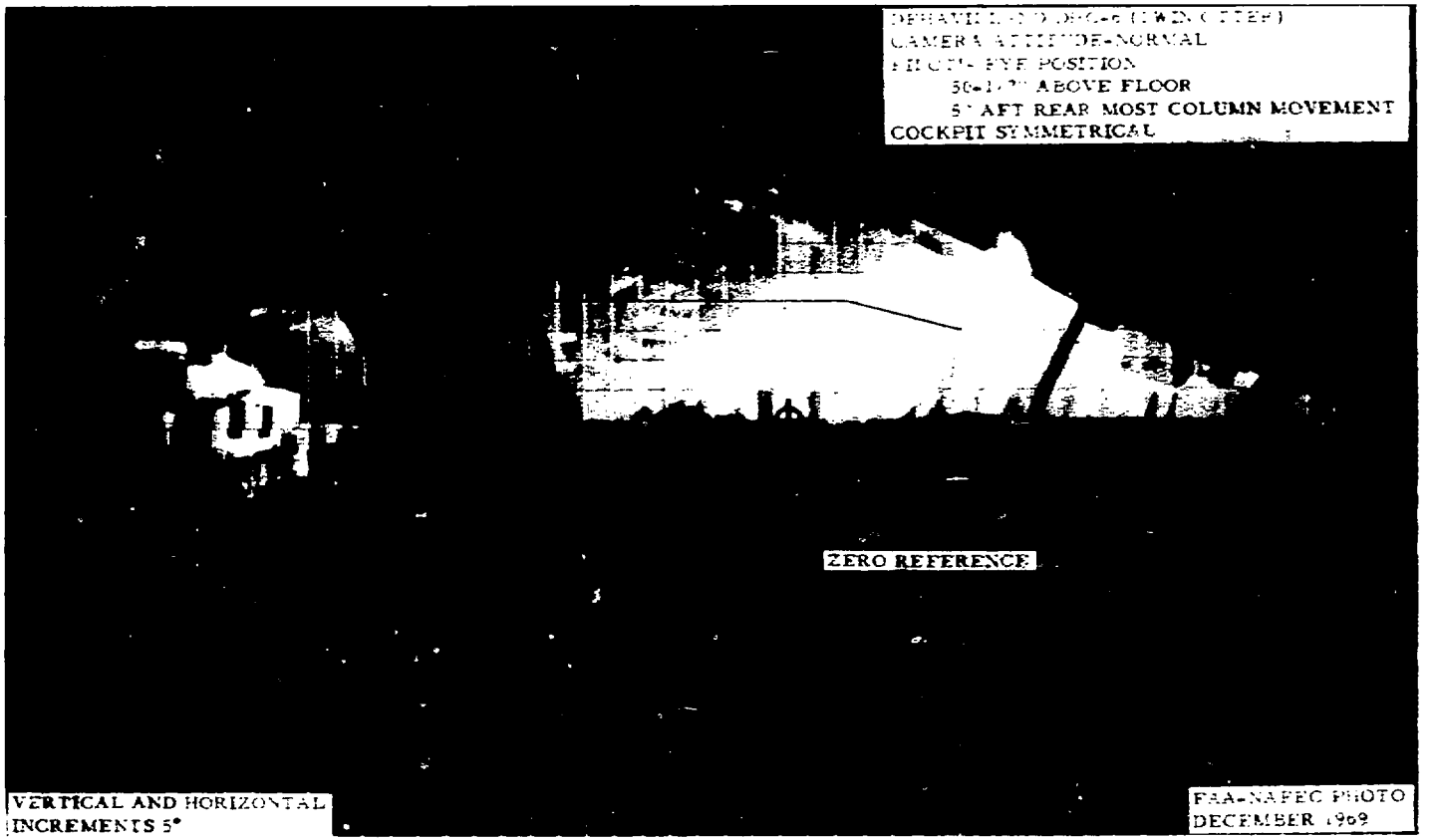


FIGURE 63. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT DEHAVILLAND DHC-6

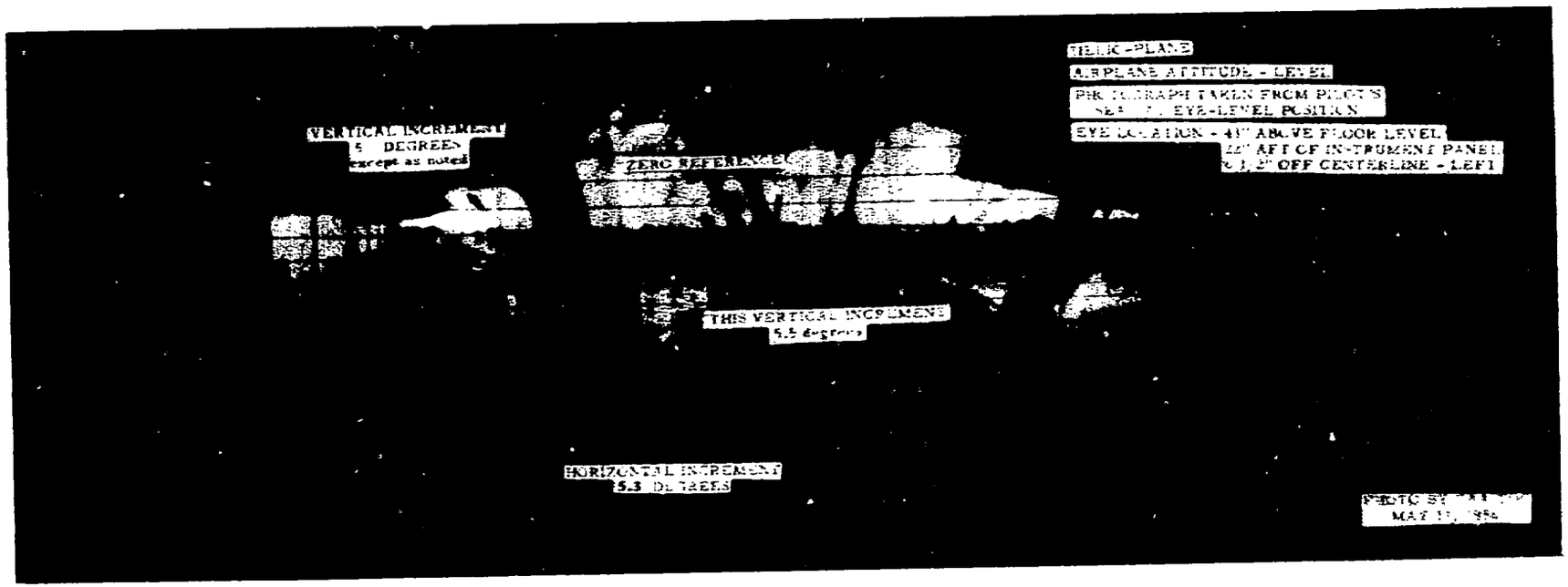


FIGURE 64. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT HELIO-PLANE

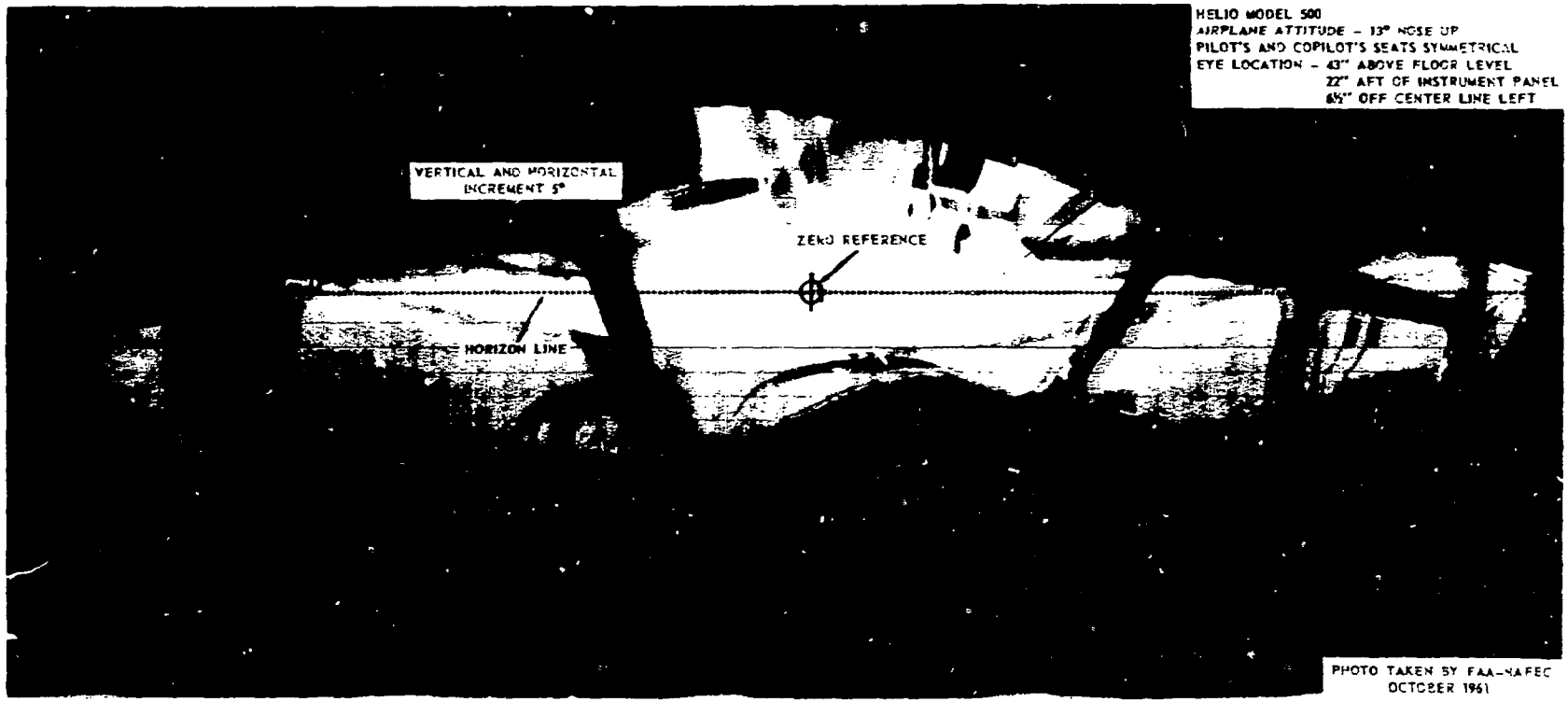


FIGURE 65. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT HELIO MODEL 500

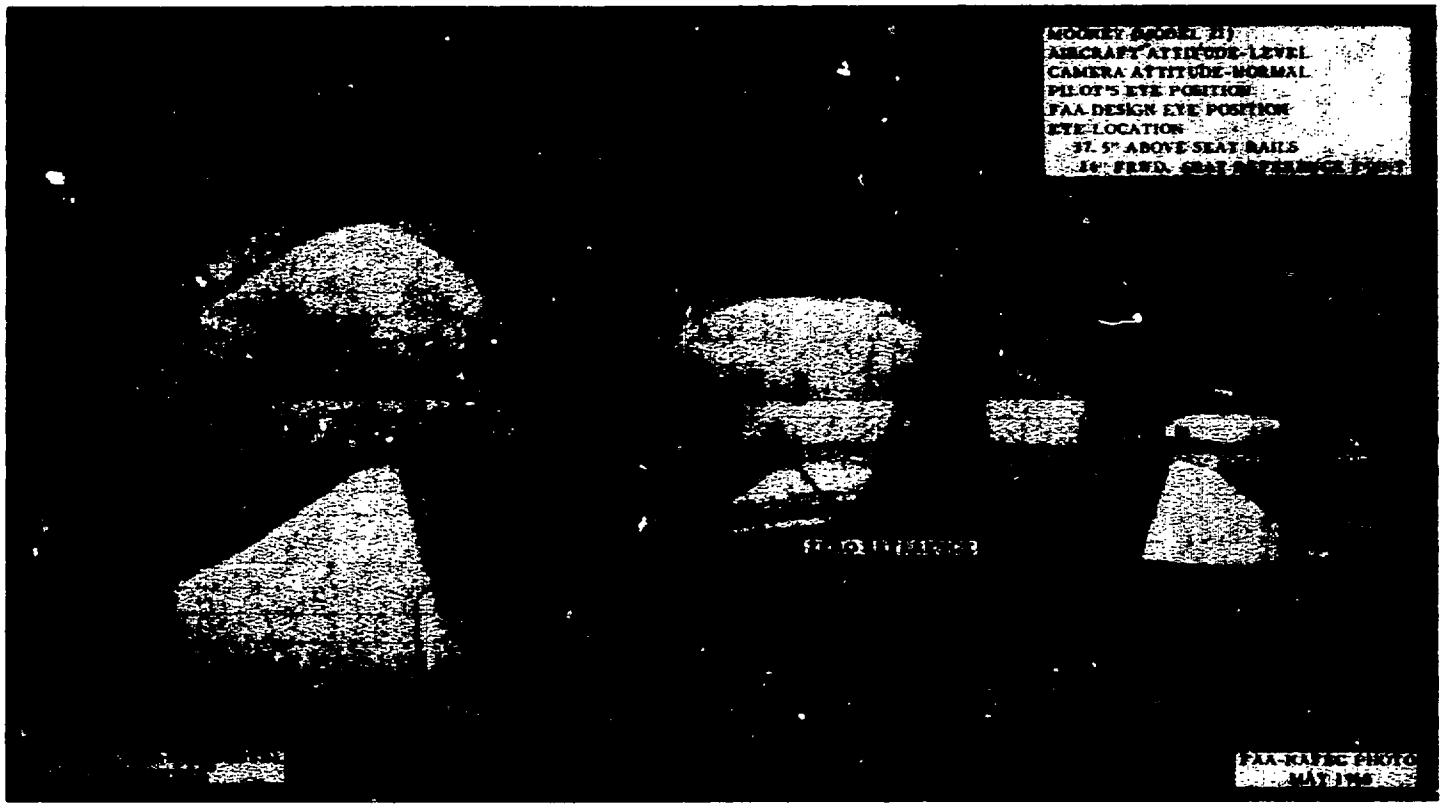


FIGURE 66. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT MOONEY 21

FIGURE 67. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT PIPER ARROW PA-28R-200

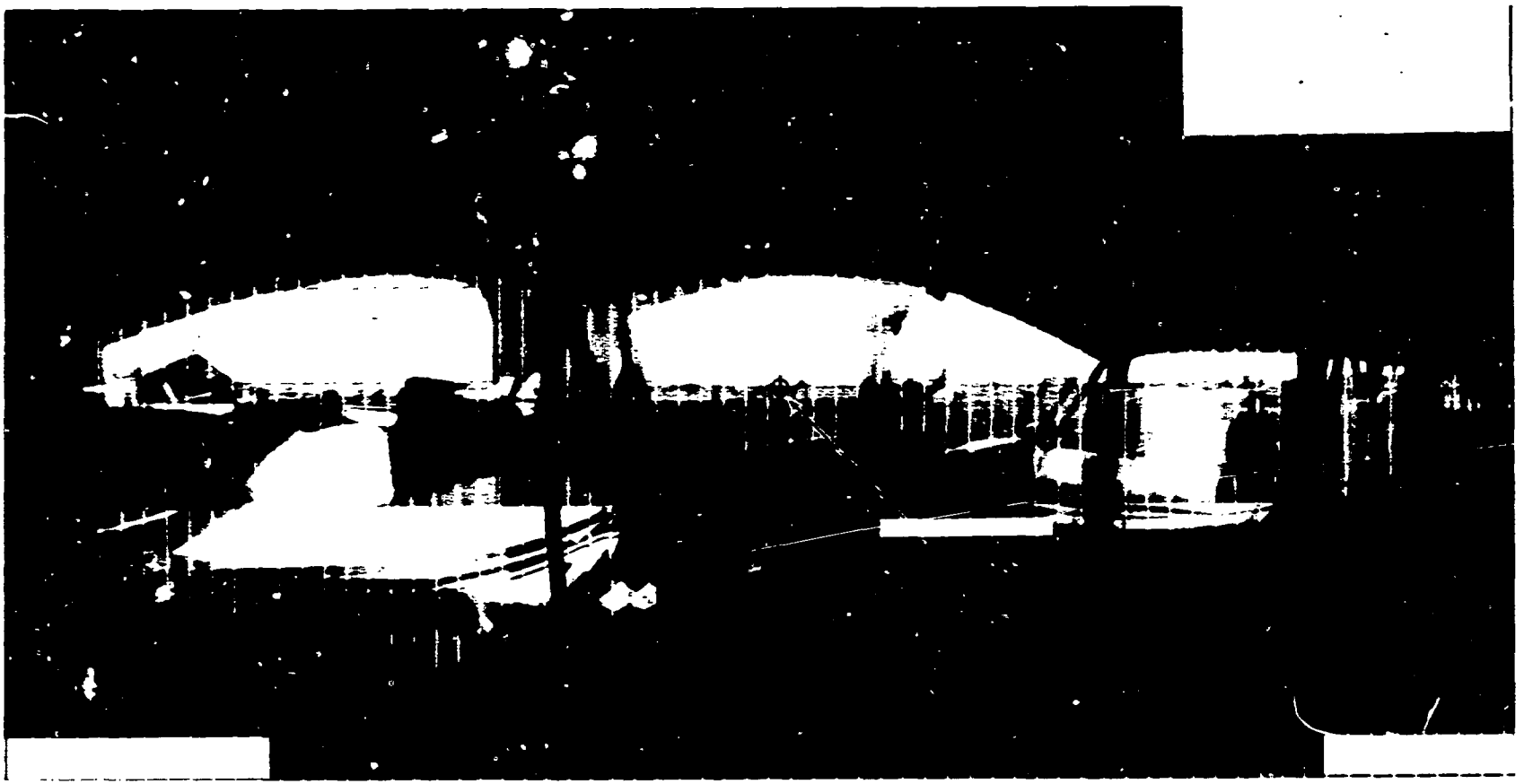


FIGURE 68. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT PIPER AZTEC PA-23

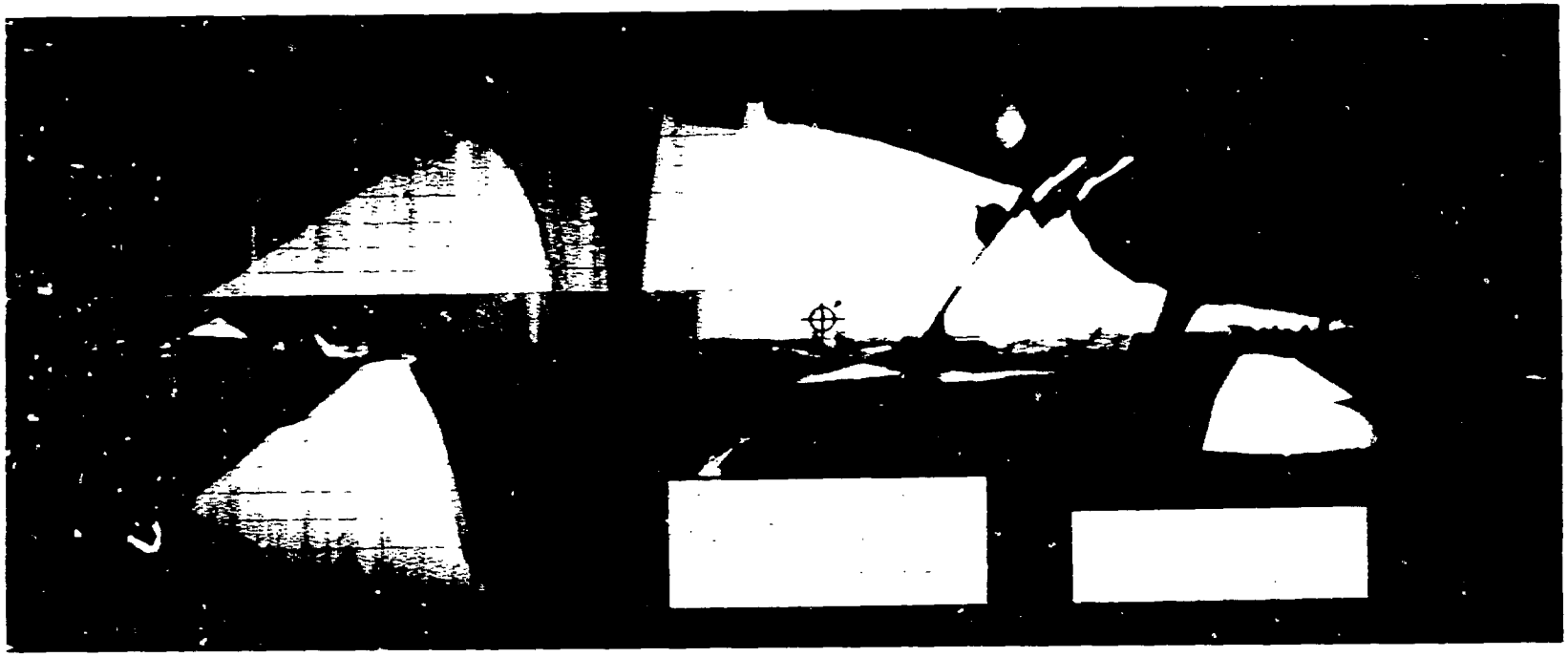


FIGURE 69. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT PIPER CHEROKEE ARCHER PA-28-181

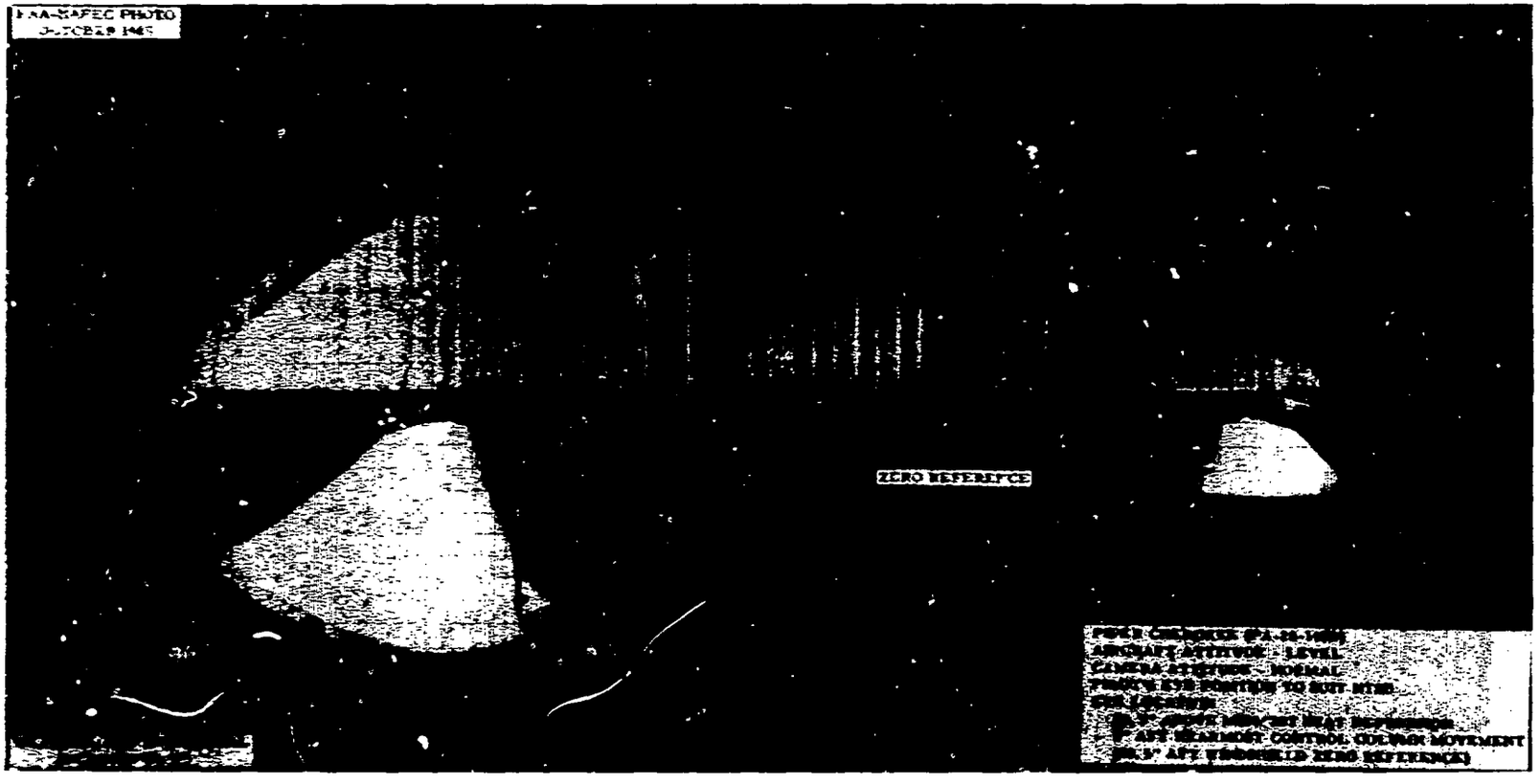


FIGURE 70. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT PIPER CHEROKEE PA-28-140B

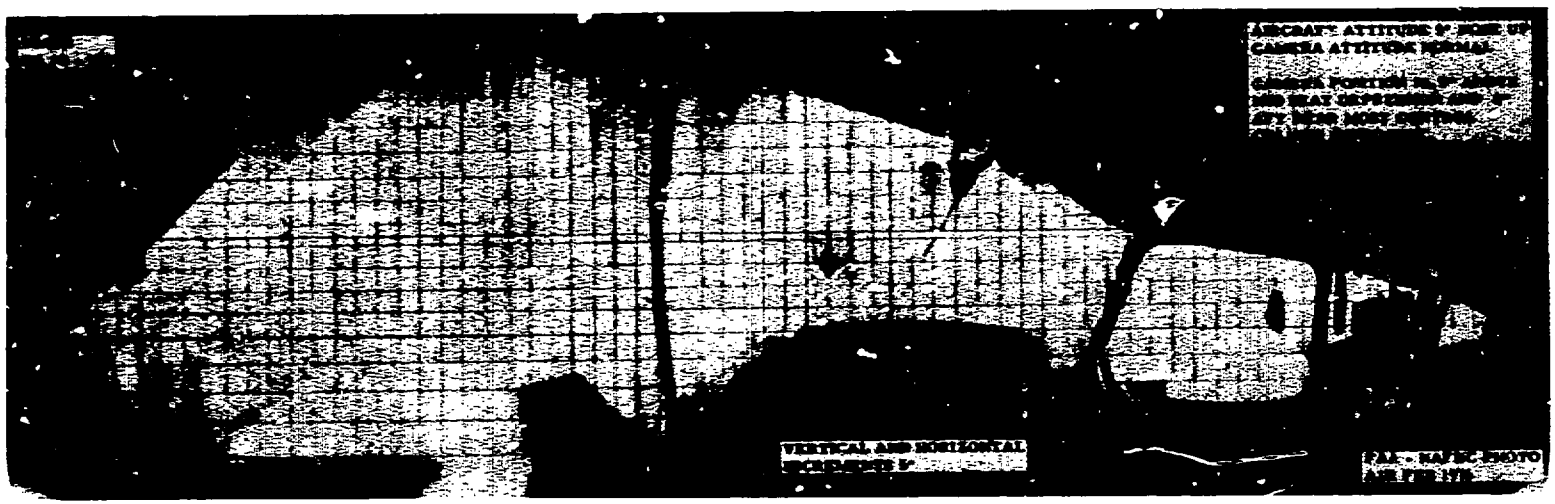


FIGURE 71. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT PIPER CHEROKEE PA-28-180

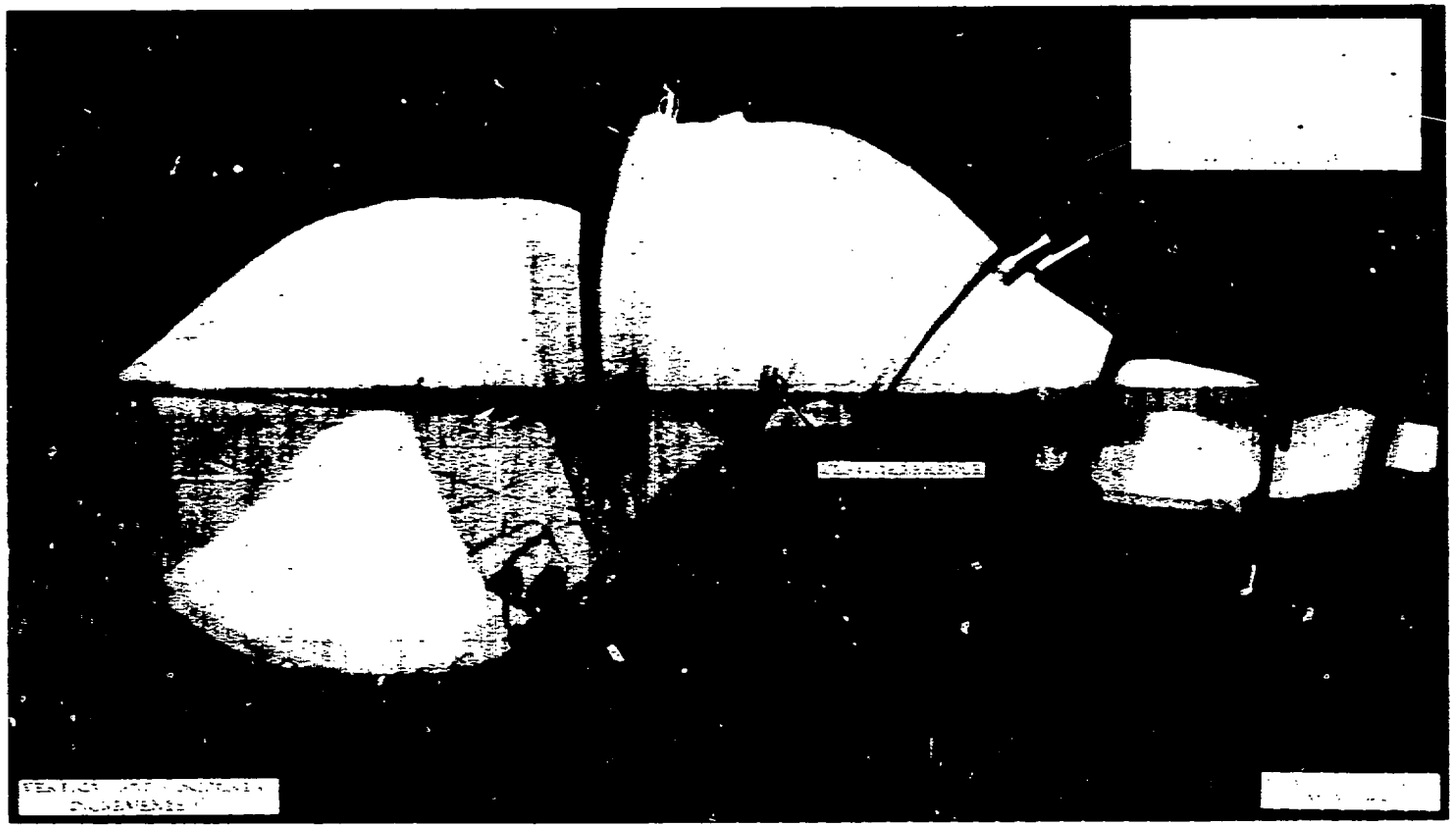


FIGURE 72. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT PIPER CHEROKEE 6 PA-32-260

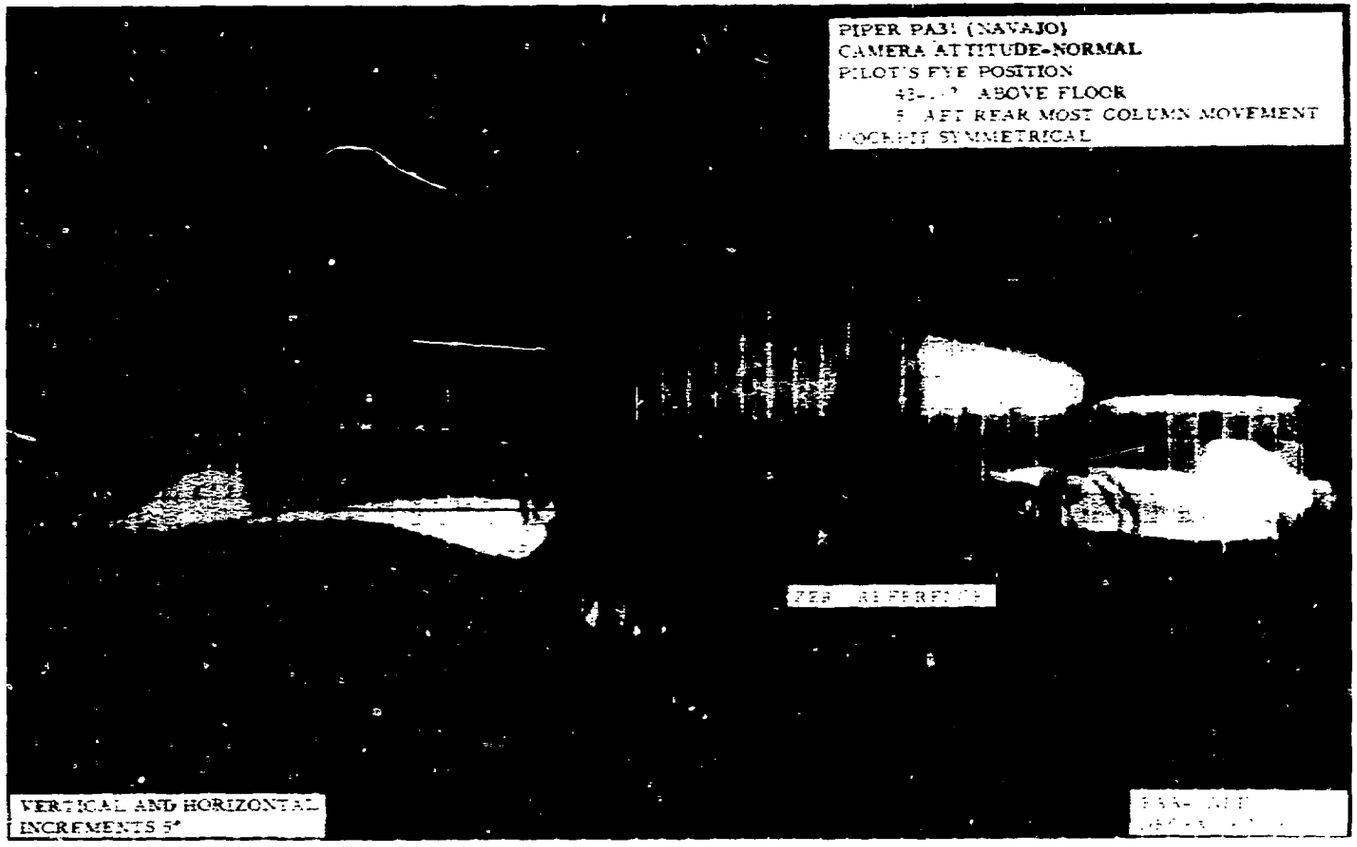


FIGURE 73. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT PIPER NAVAJO PA-31

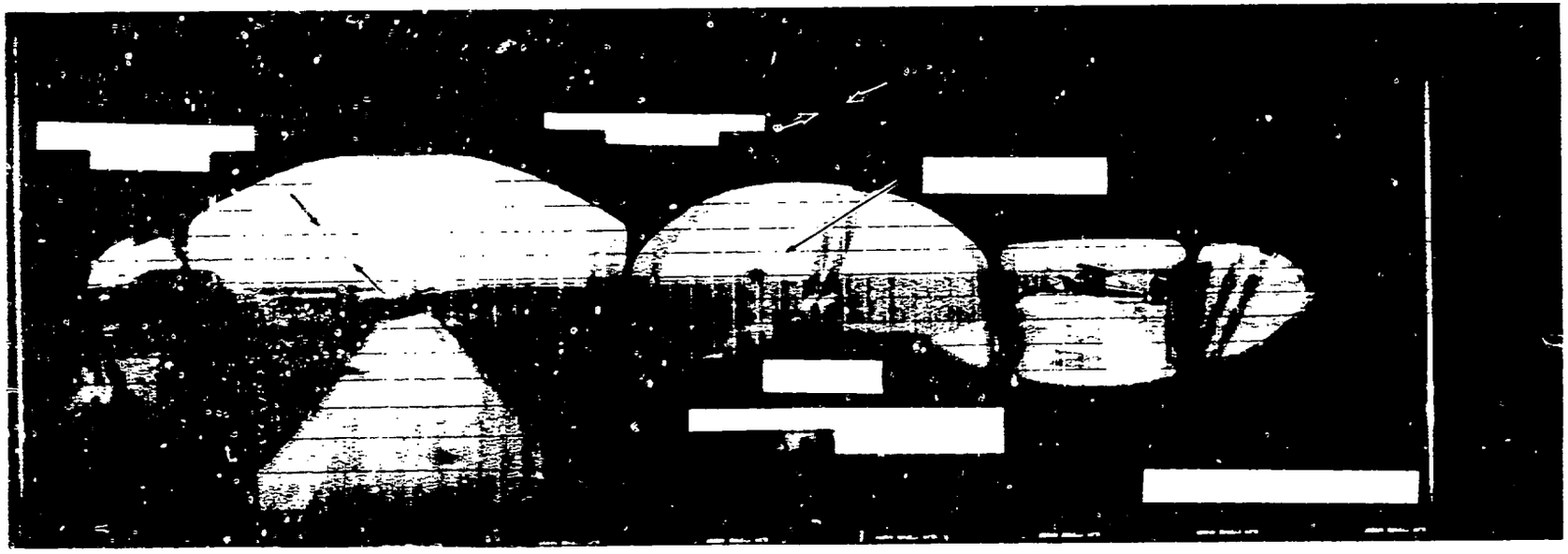


FIGURE 74. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT SWIFT 125

MILITARY AIRCRAFT

The aircraft in the following listing are depicted in figures 75 through 131.

1. B-52A, G
2. B-57E
3. C-124
4. C-130B
5. C-133
6. C-141
7. DeHavilland CV-7A
8. F-4E
9. F-89
10. F-100
11. F-101
12. F-102
13. F-104
14. F-106
15. F-111D
16. FB-111
17. KC-135
18. L-19
19. L-20A
20. L-23
21. LC-26
22. Martin P5M-1
23. Martin XP6M-1
24. Navy F-4D
25. Navy P2V-5F
26. Navy R5D-2Z
27. Navy SNB-5
28. OE-2
29. T-33
30. U-1

HELICOPTERS

1. Bell AH-1G
2. Bell UH-1C
3. CH-1
4. H-13G
5. H-19
6. H-21B, C
7. H-23
8. H-25A
9. H-31
10. H-34
11. H-37
12. HO5-1
13. HOK-1
14. HRS-3
15. Hughes OH-6A
16. Kaman K-20
17. S-61L
18. S-62
19. V-107
20. XH-40
21. YCH-1B
22. Sikorsky YCH-54A

VERTICAL TAKEOFF AND LAND

1. Bell X-22
2. Lockheed XV-4A
3. LTV XC-142A
4. Ryan XV-5A

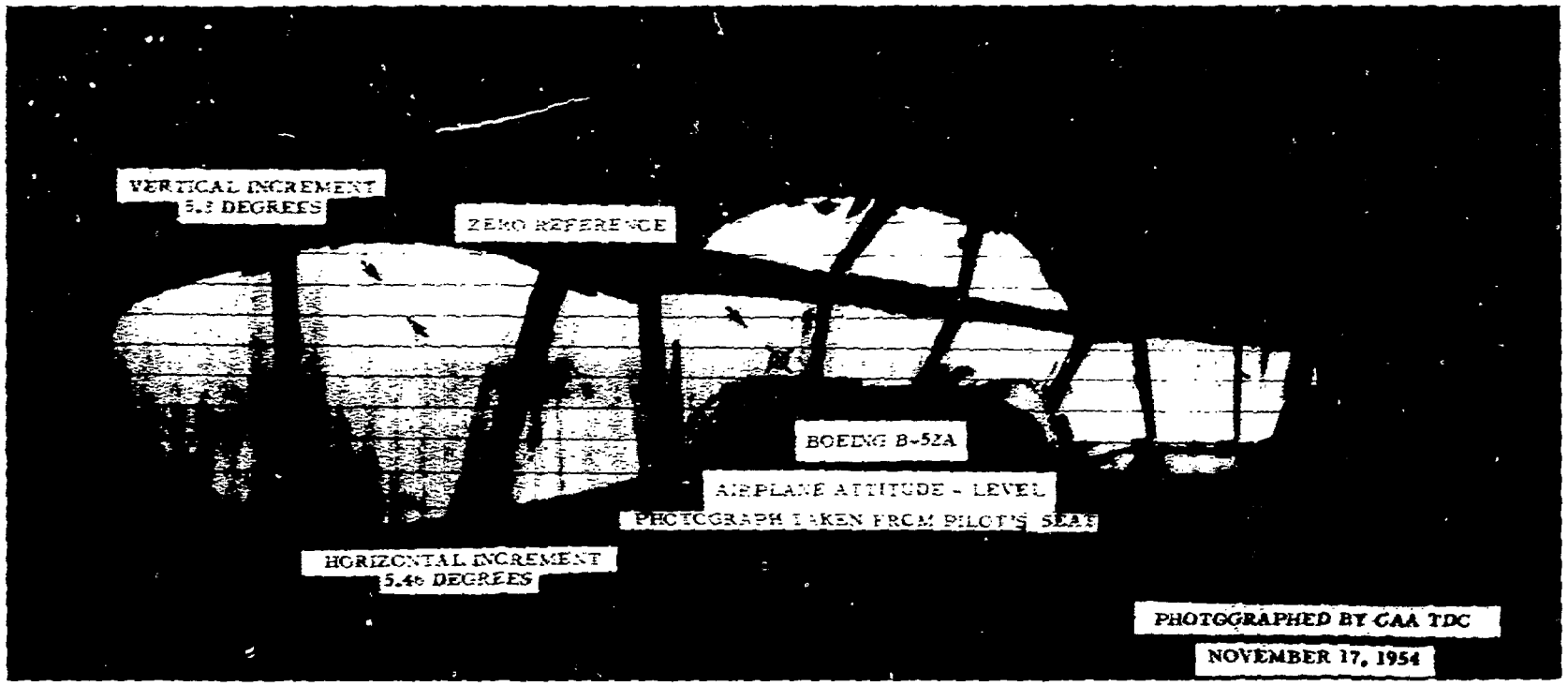


FIGURE 75. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE B-52A

FIGURE 76. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE B-52G

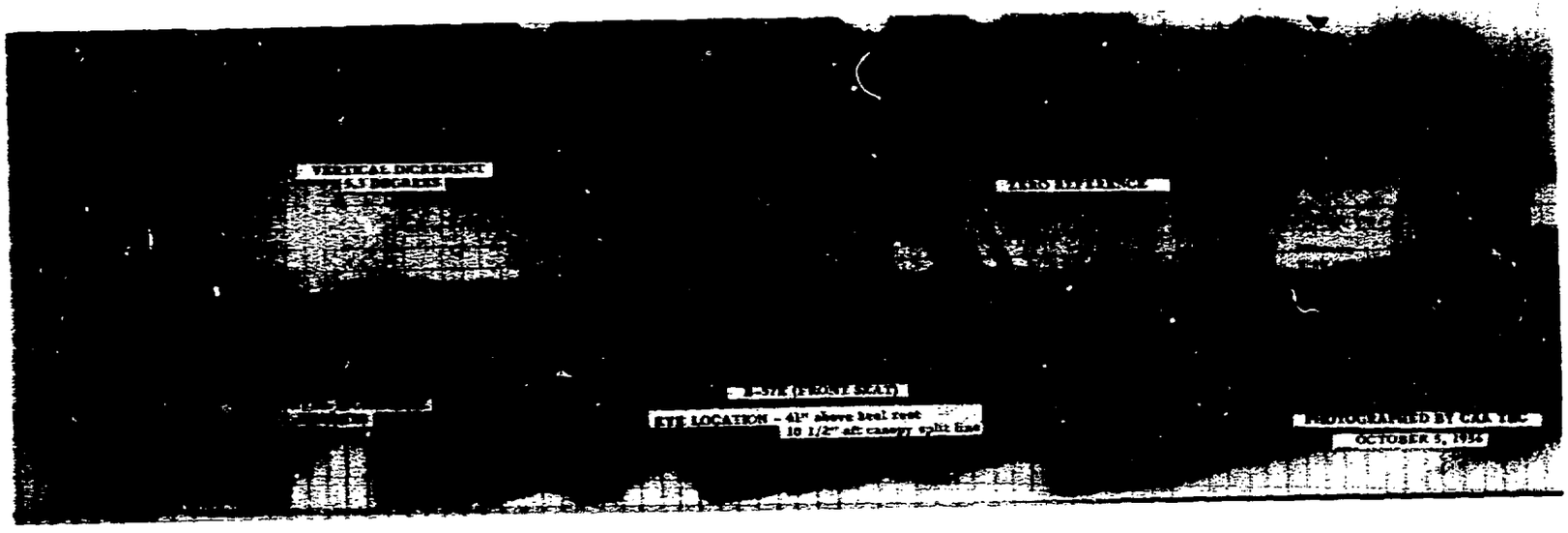


FIGURE 77. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE B-57E

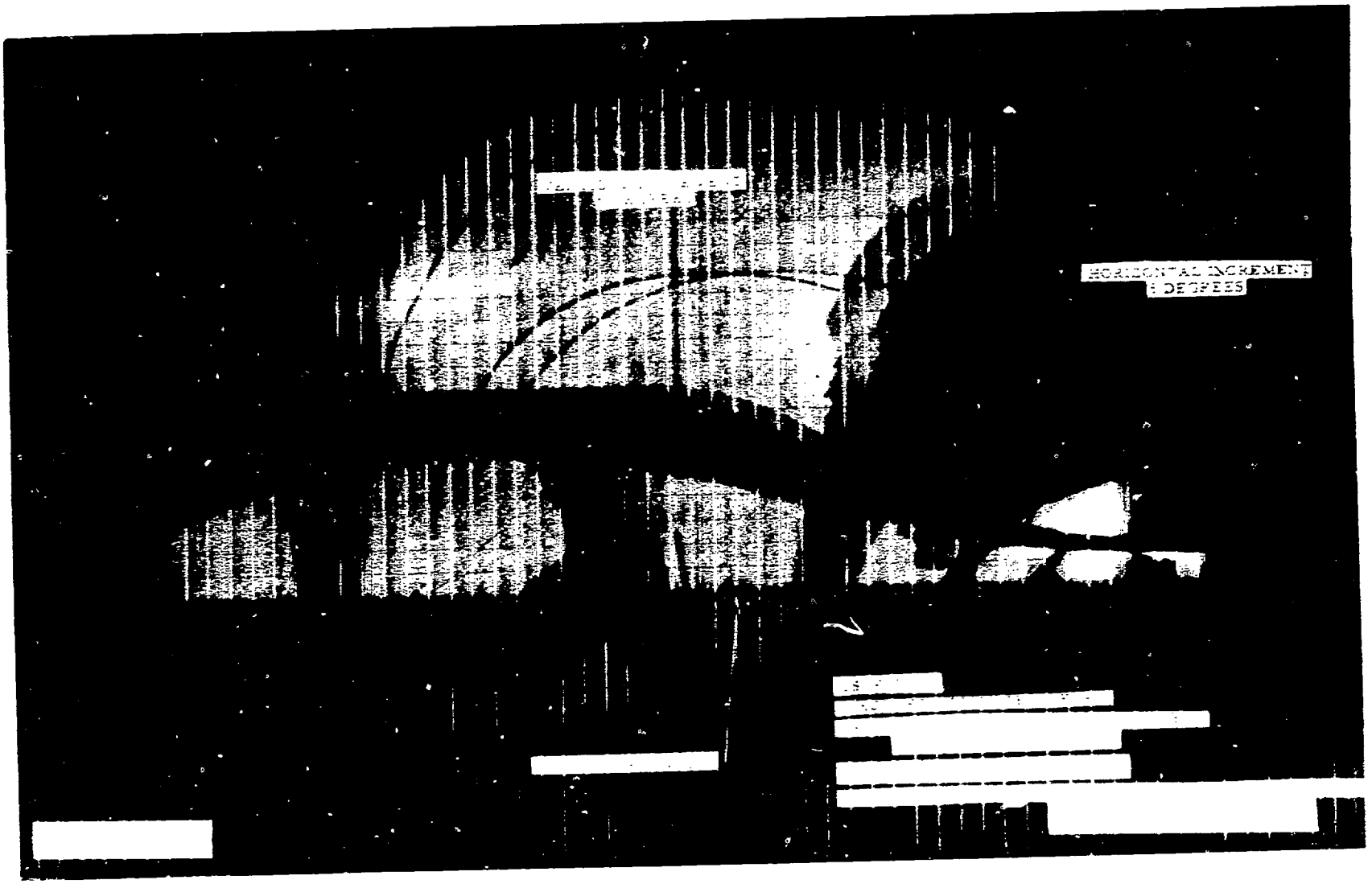


FIGURE 78. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE C-124

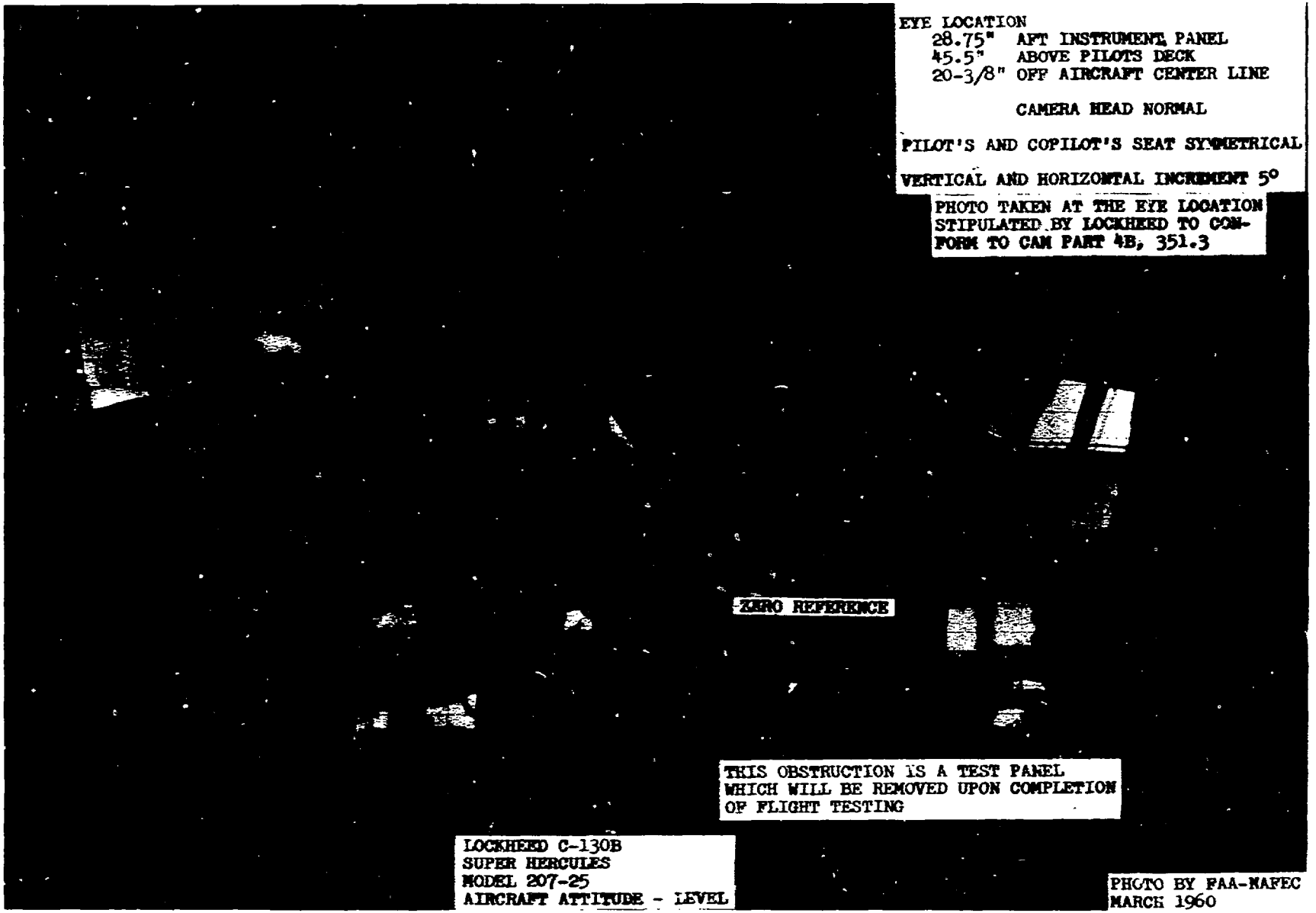


FIGURE 79. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT LOCKHEED C-130B

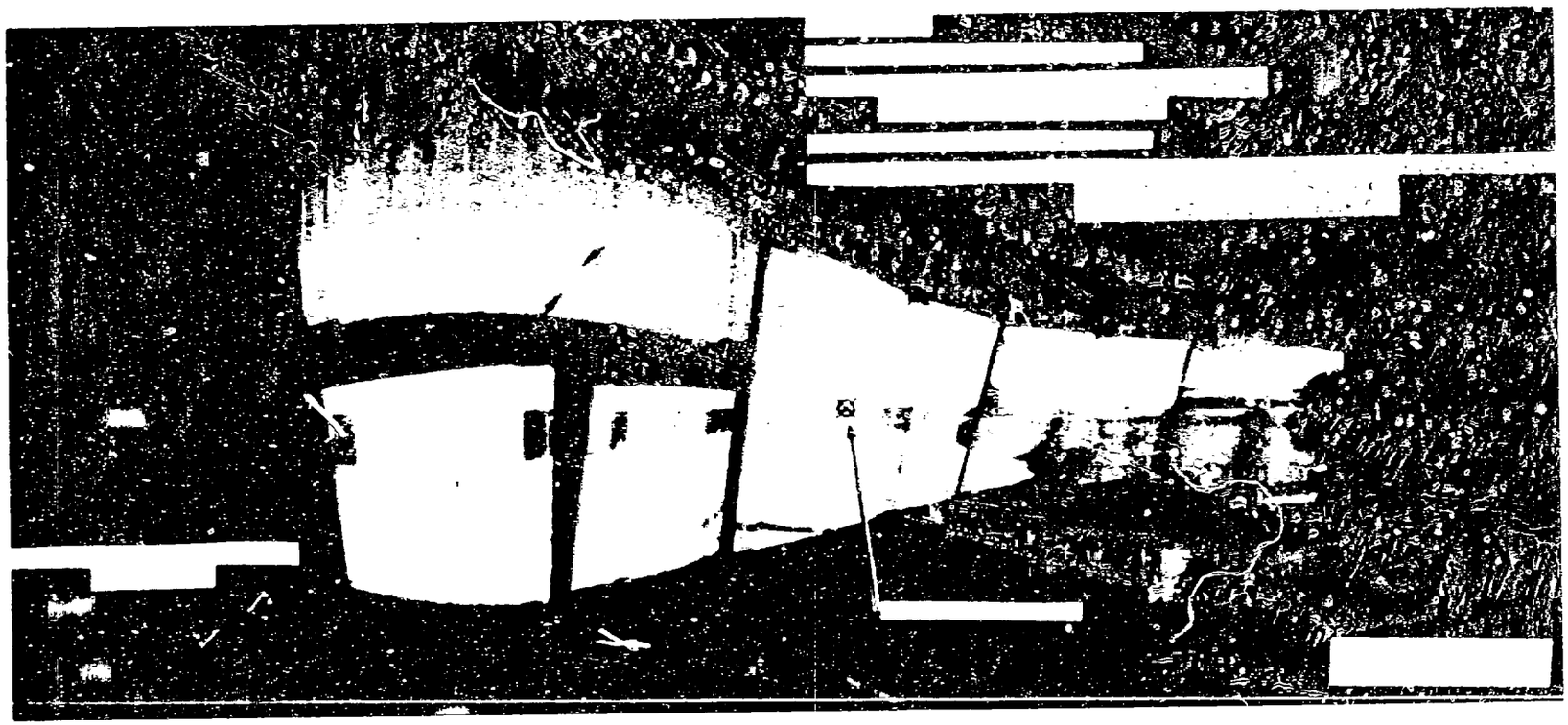


FIGURE 80. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE C-133

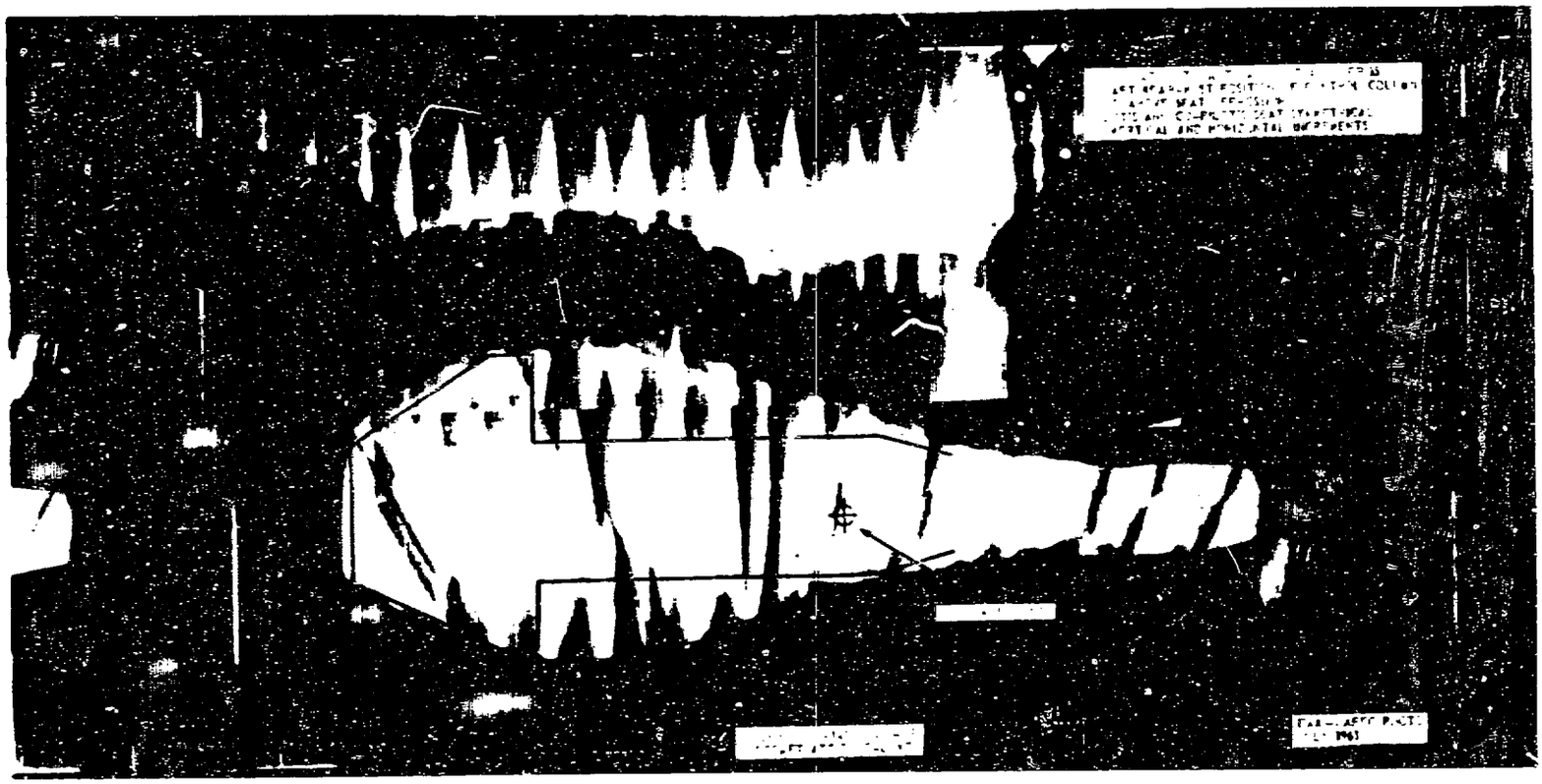


FIGURE 81. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE C-141

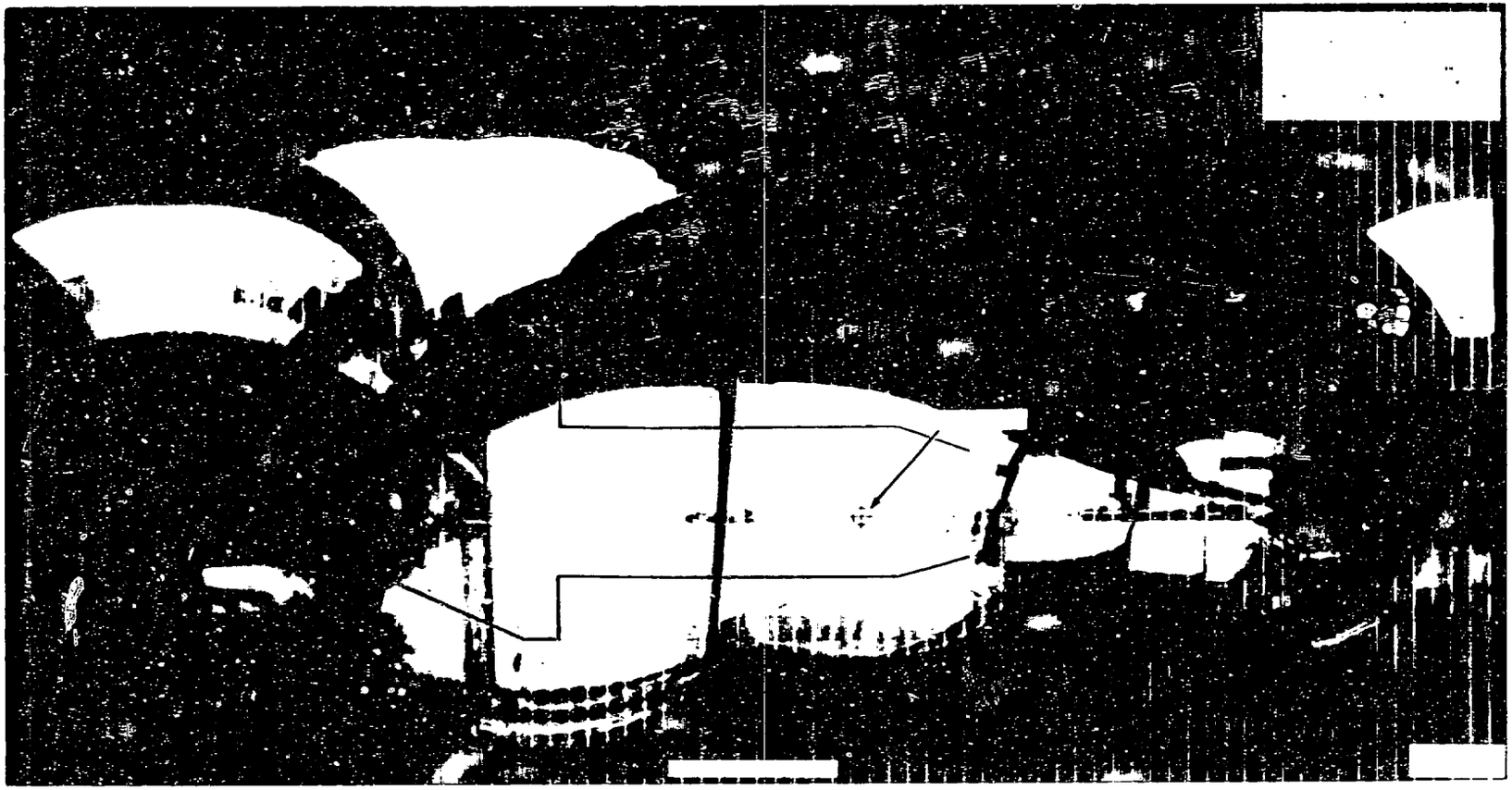


FIGURE 82. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT DEHAVILLAND CV-7A

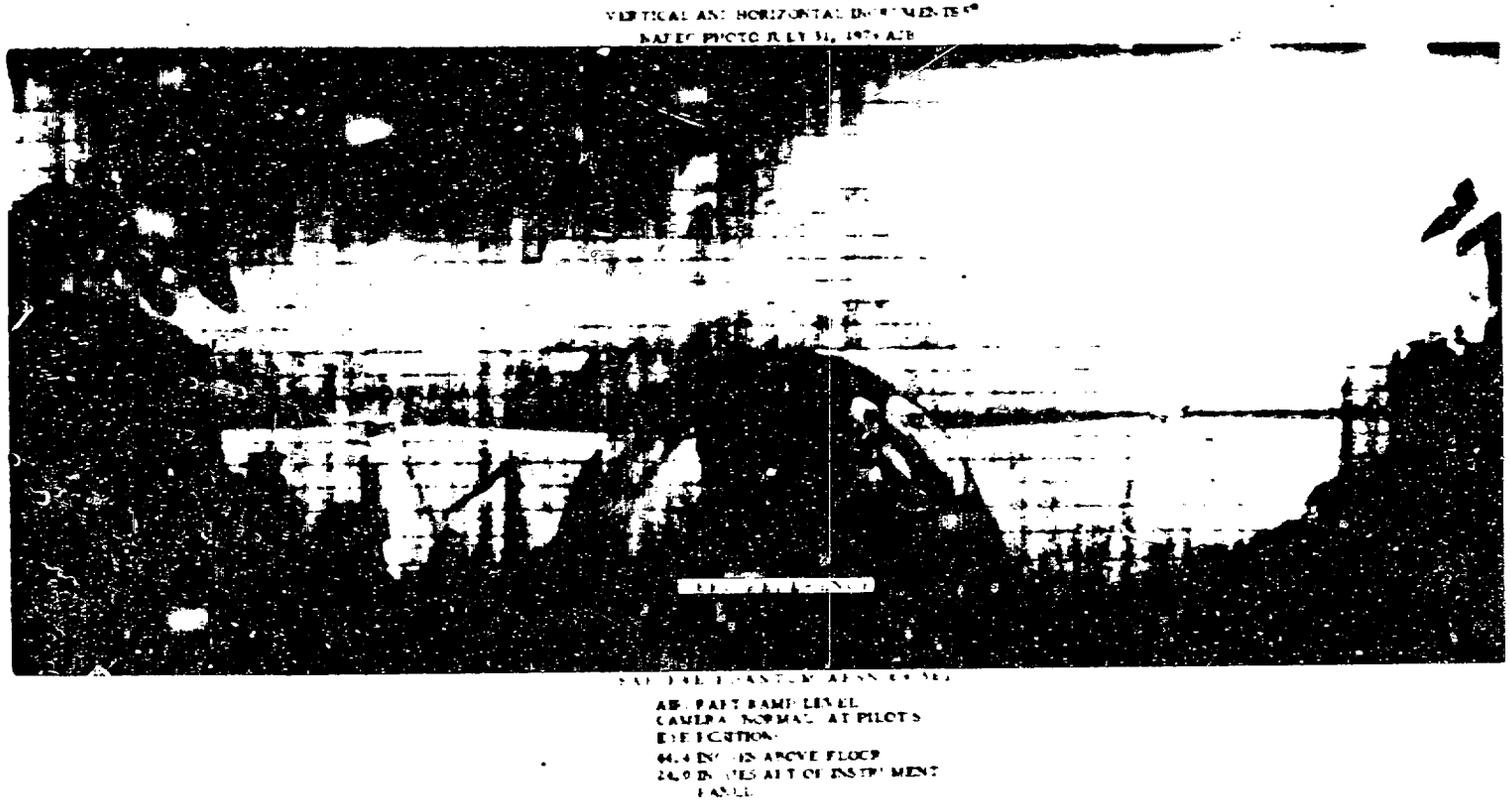


FIGURE 83. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE F-4E

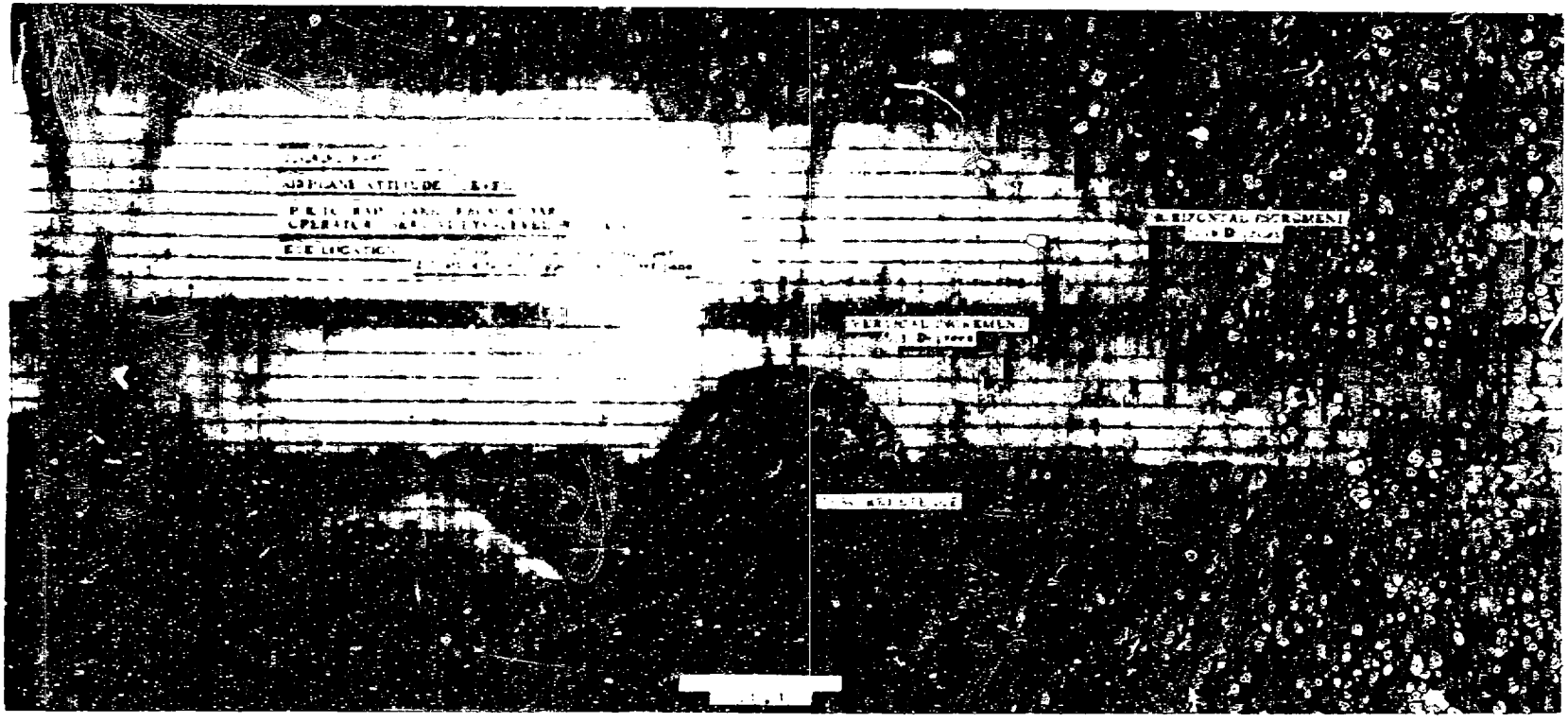


FIGURE 84. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE F-89

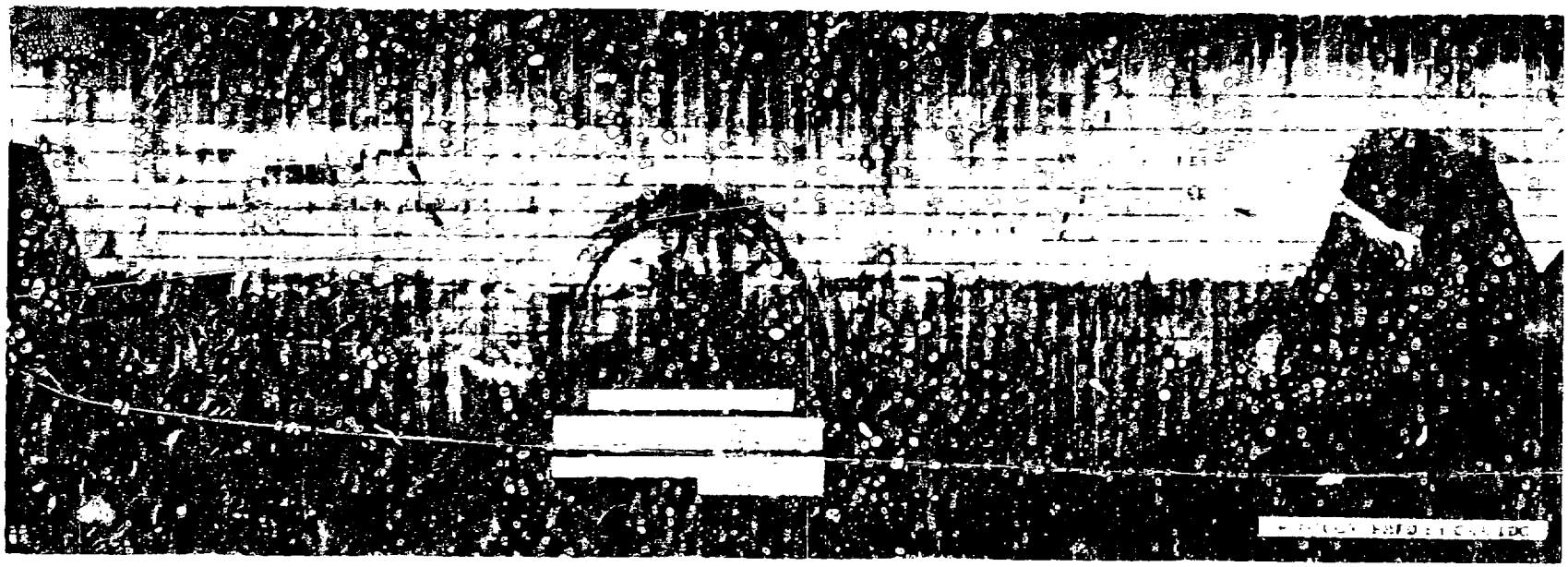


FIGURE 85. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE F-100A

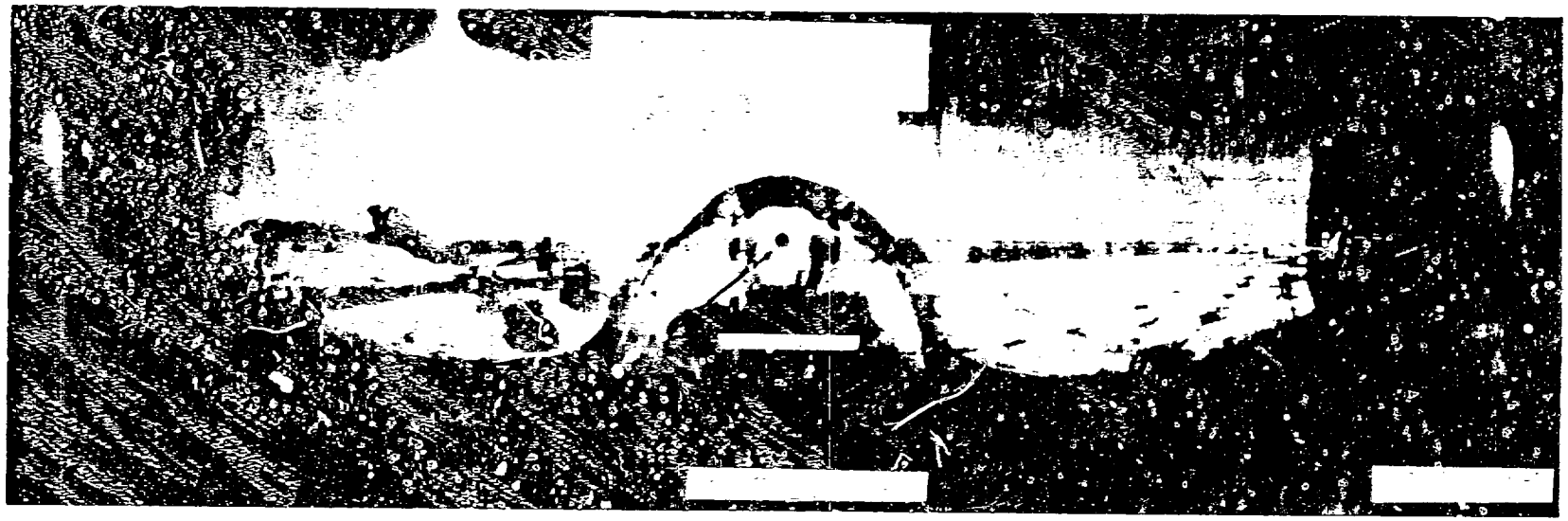


FIGURE 86. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE F-101

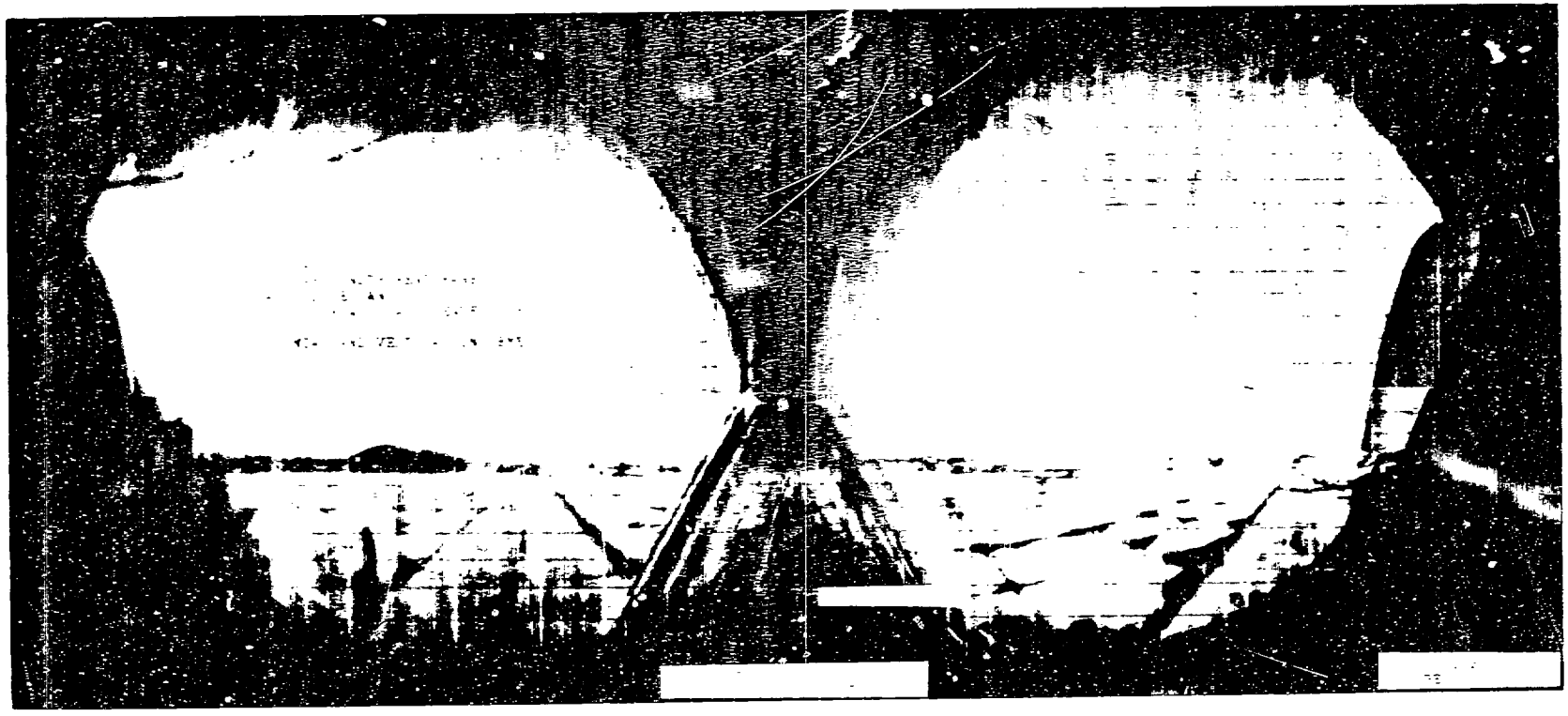


FIGURE 87. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE F-102A

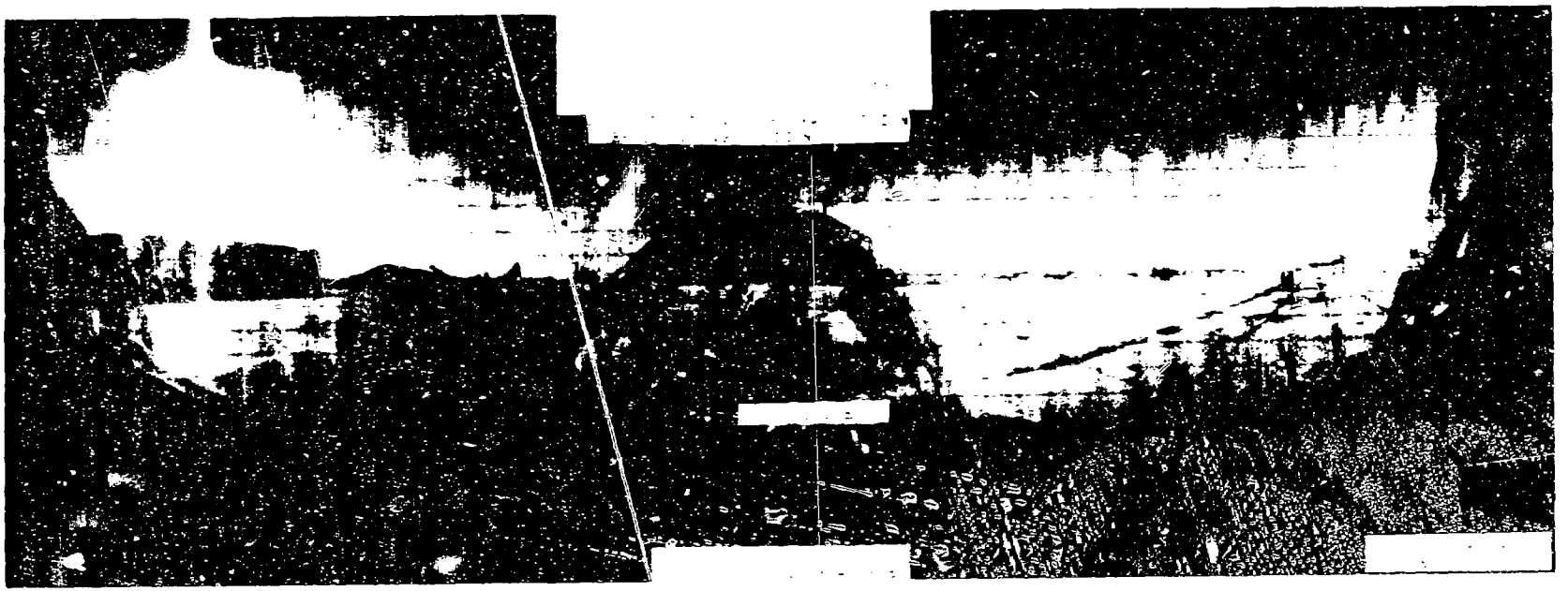


FIGURE 88. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE F-104A

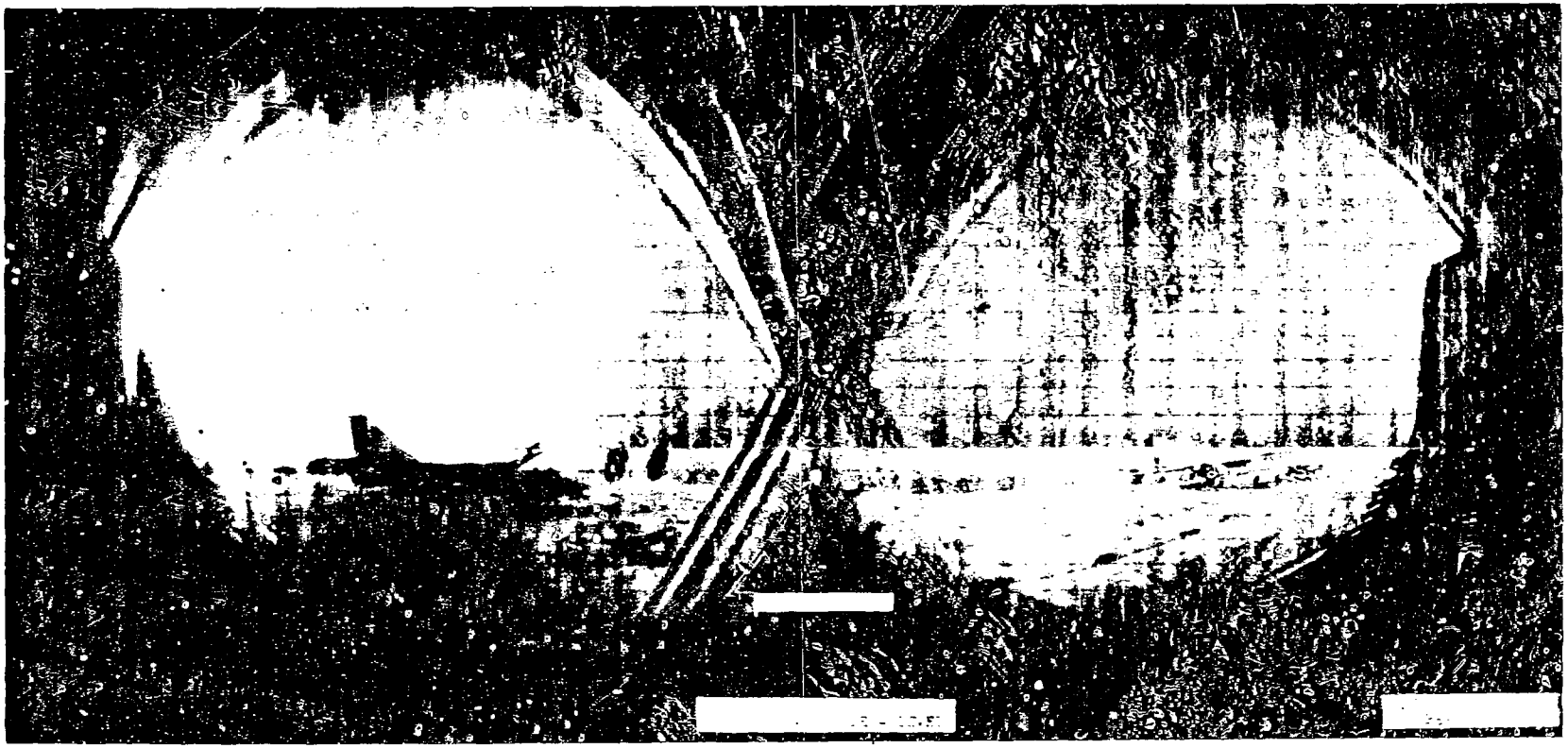


FIGURE 89. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE F-106A

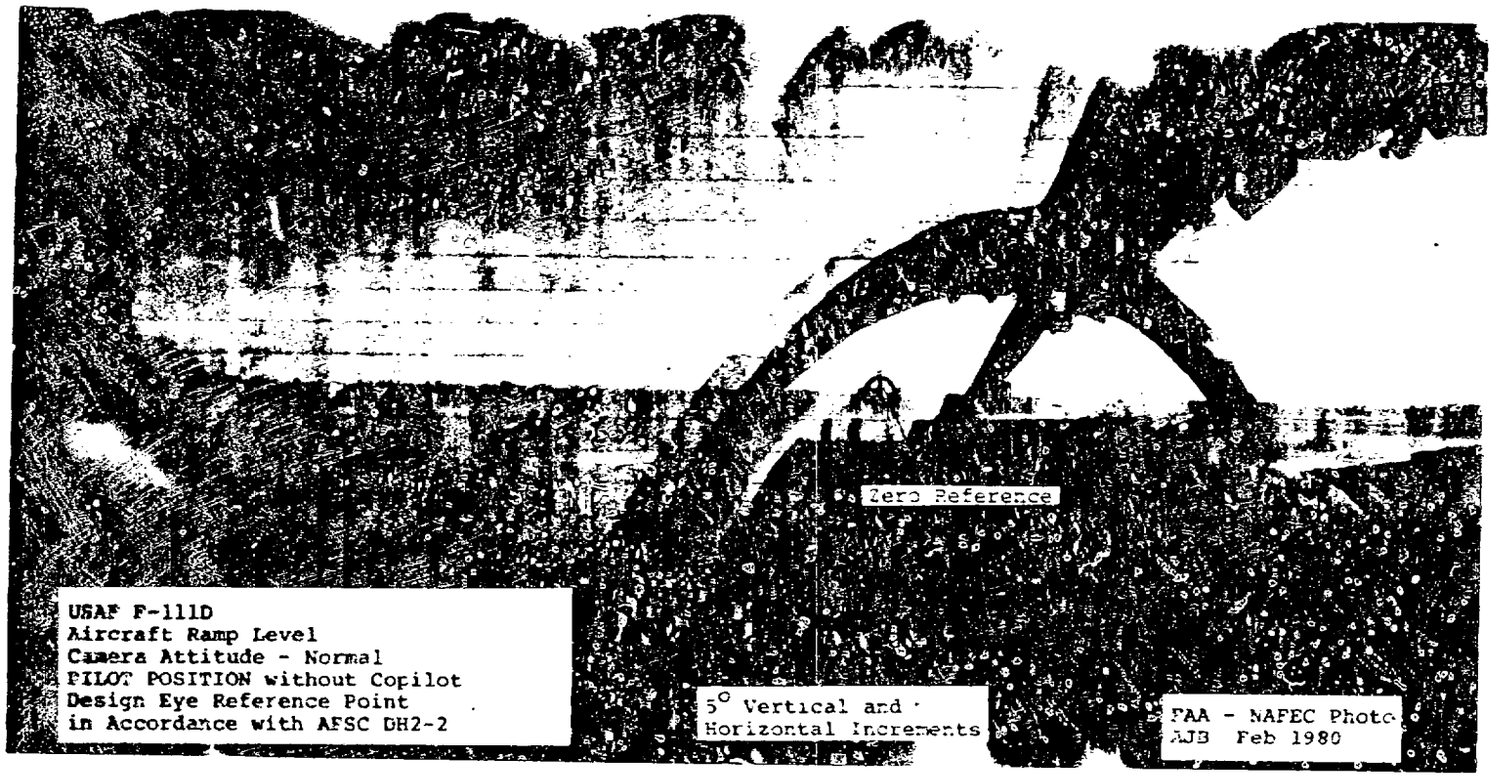


FIGURE 90. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE F-111D

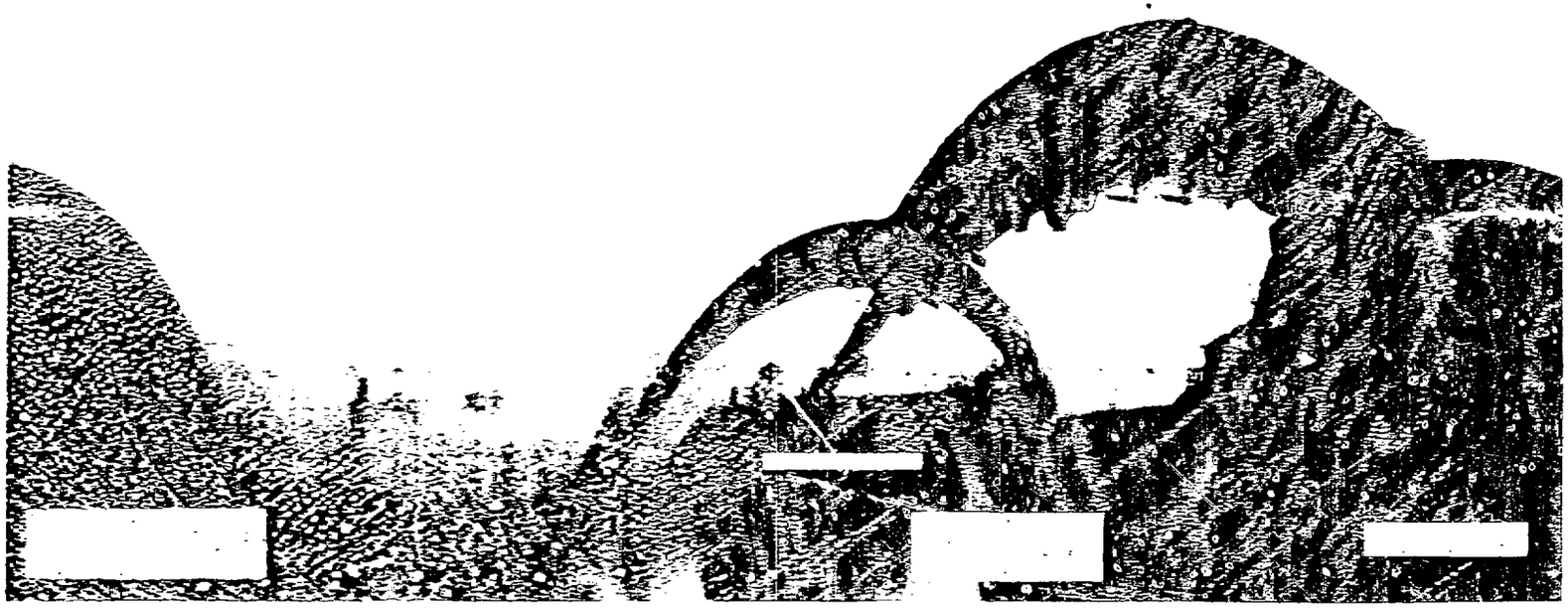


FIGURE 91. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE F/S-111

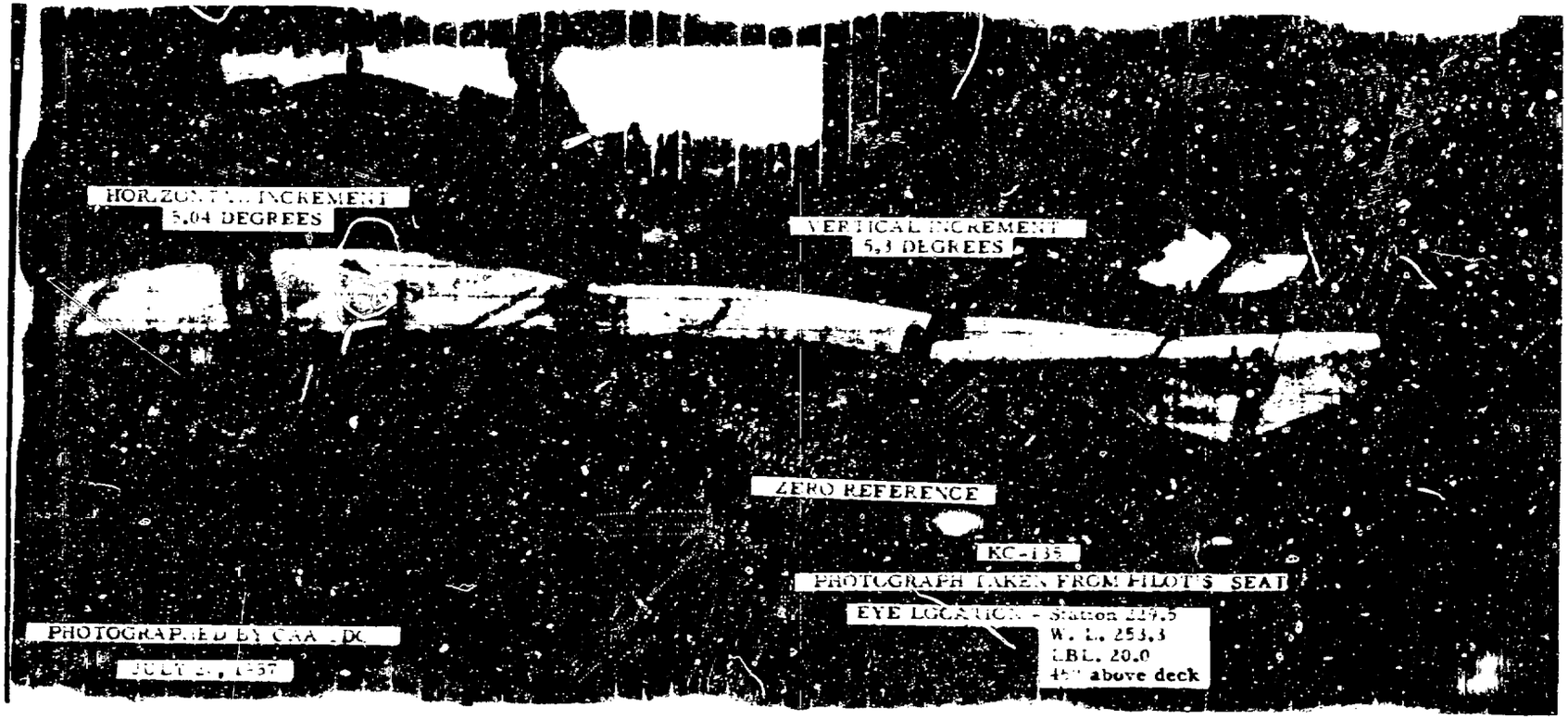


FIGURE 92. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE KC-135

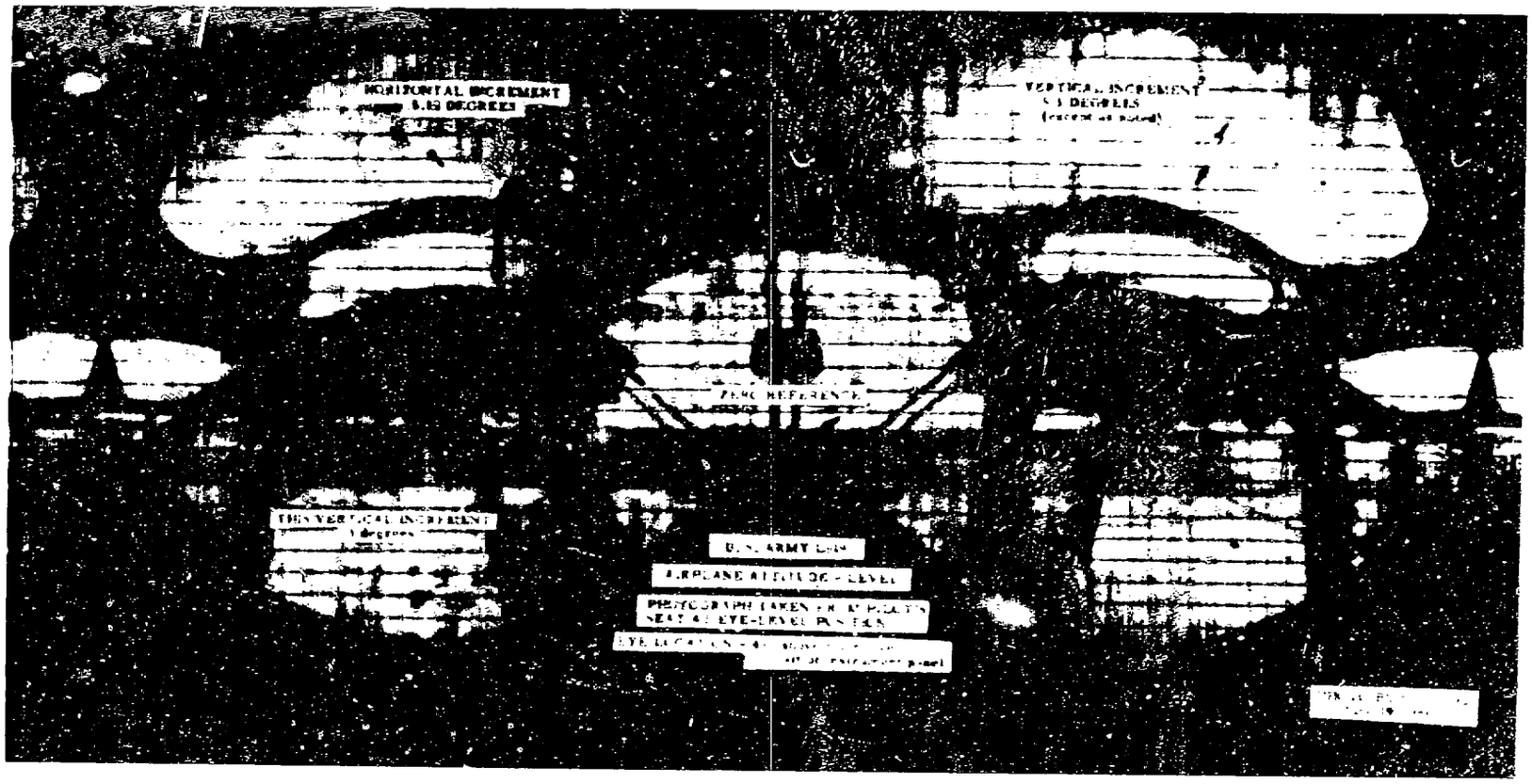


FIGURE 93. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT ARMY L-19

FIGURE 94. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT ARMY L-20A

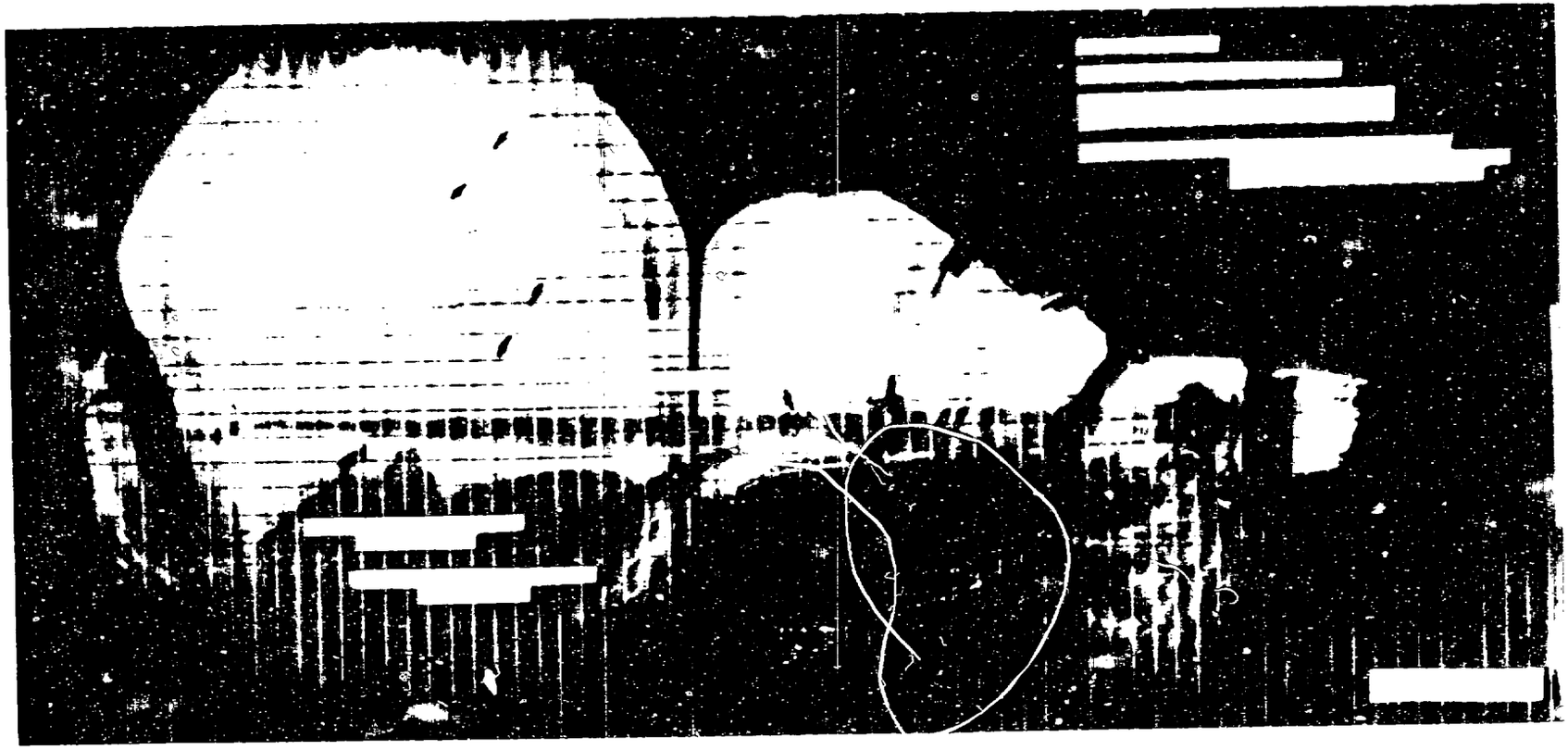


FIGURE 95. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT ARMY L-23

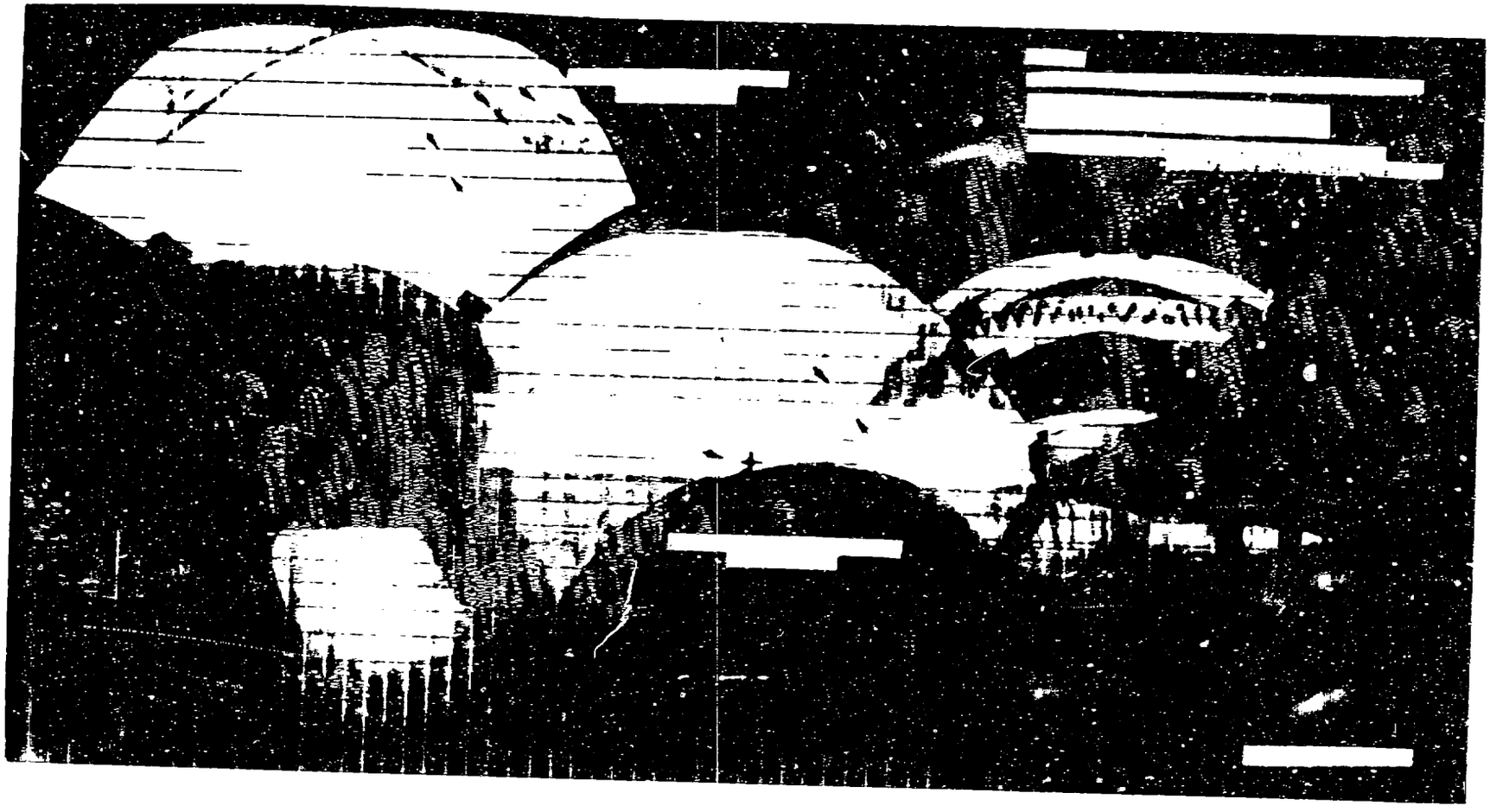


FIGURE 96. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT ARMY LC-126

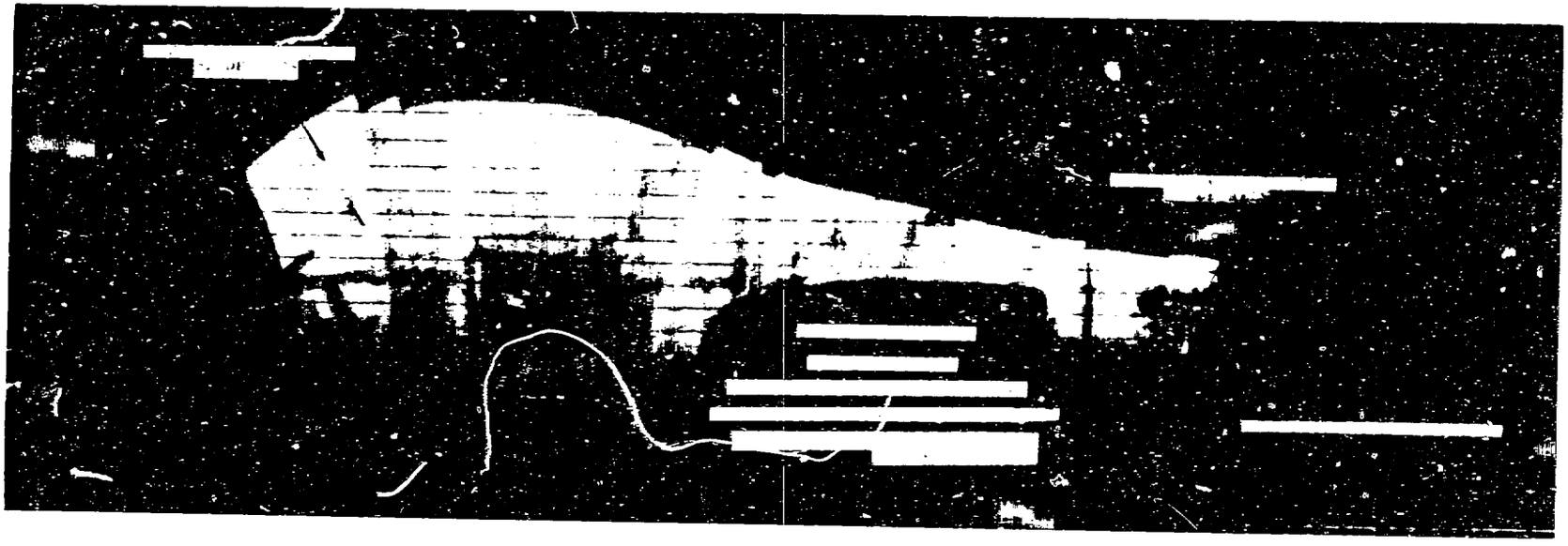


FIGURE 97. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT MARTIN P5M-1

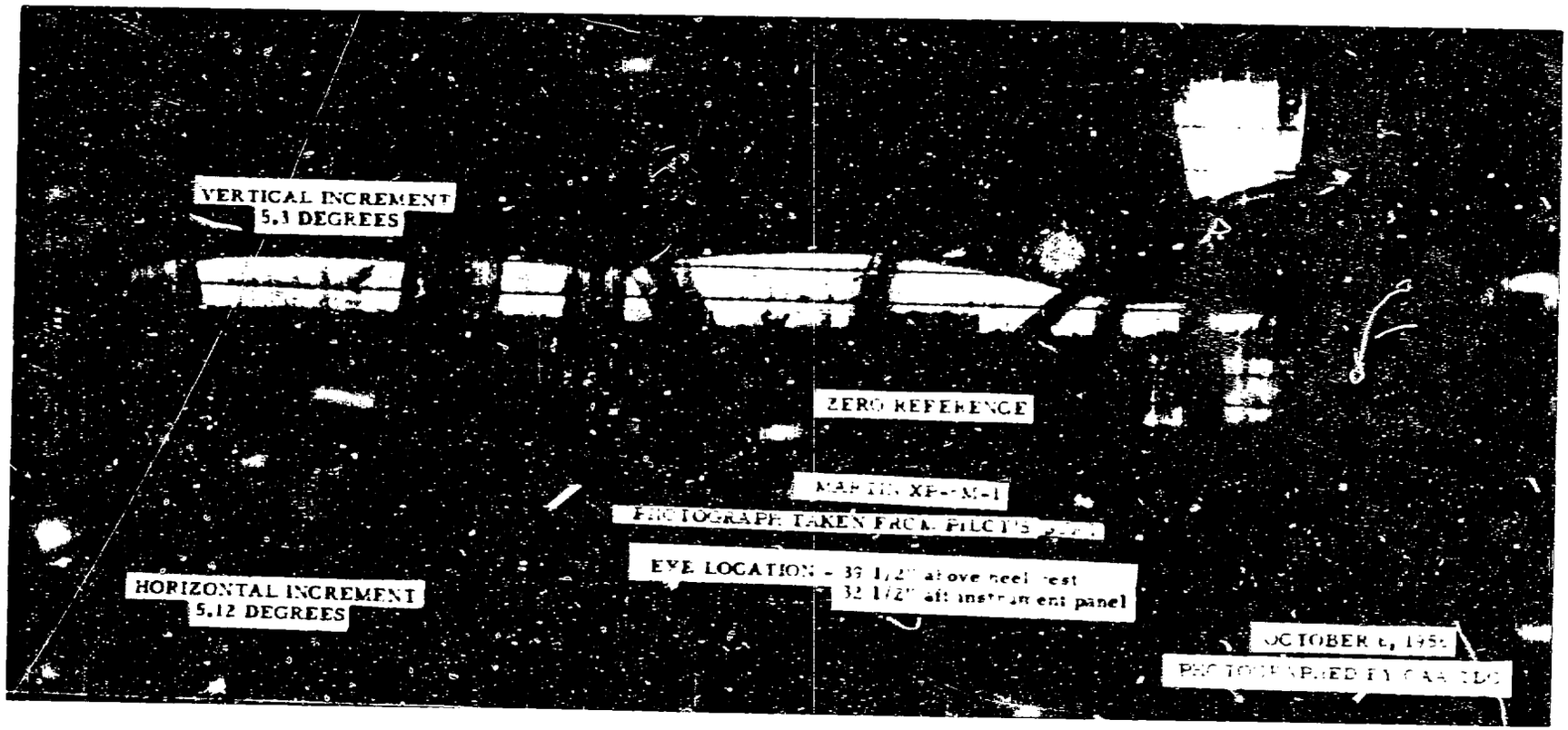


FIGURE 98. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT MARTIN XP-6[illegible]-1

FIGURE 99. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT NAVY F-4D

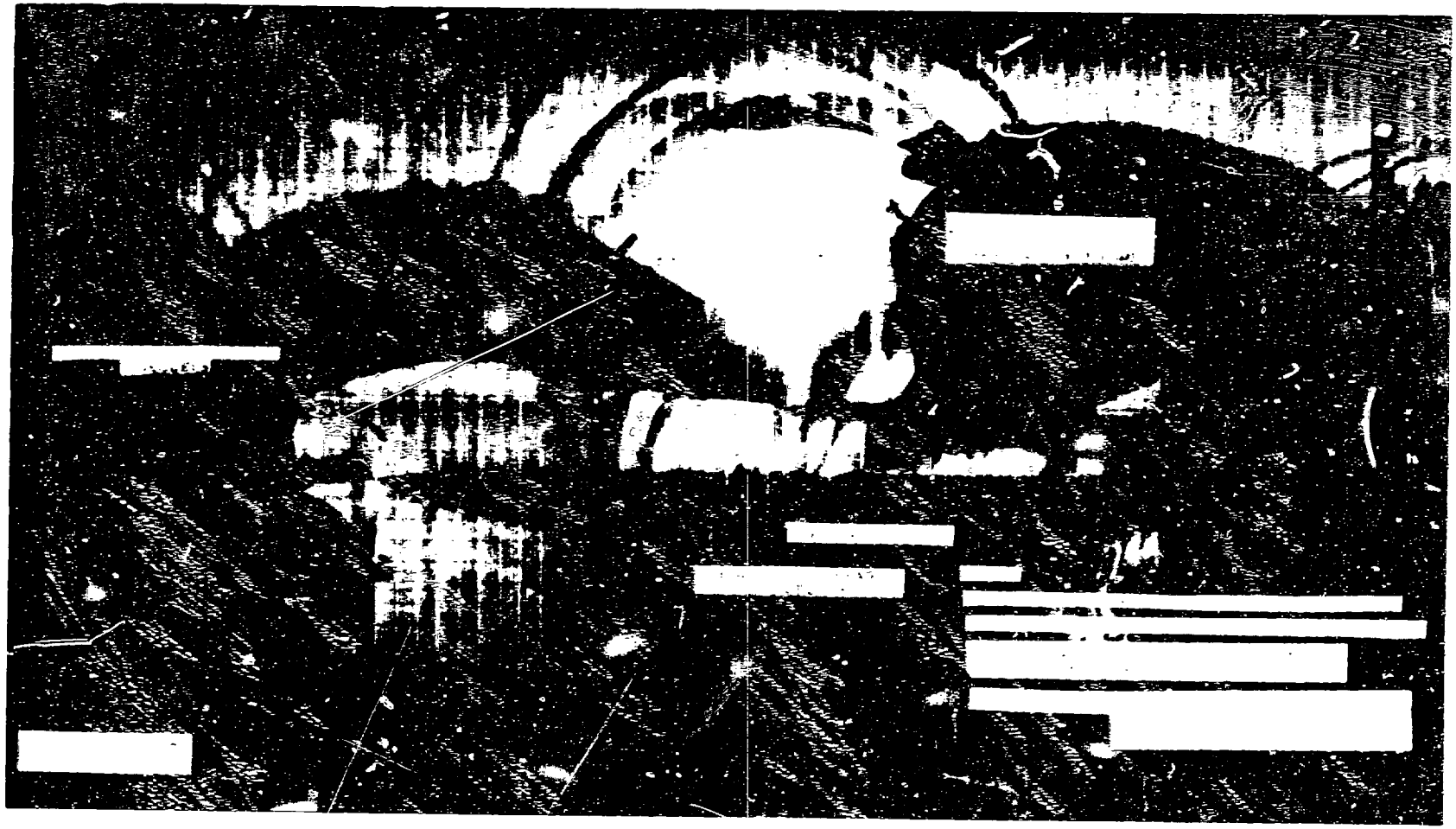


FIGURE 100. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT NAVY P2V-5F

FIGURE 101. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT NAVY R5D-2Z

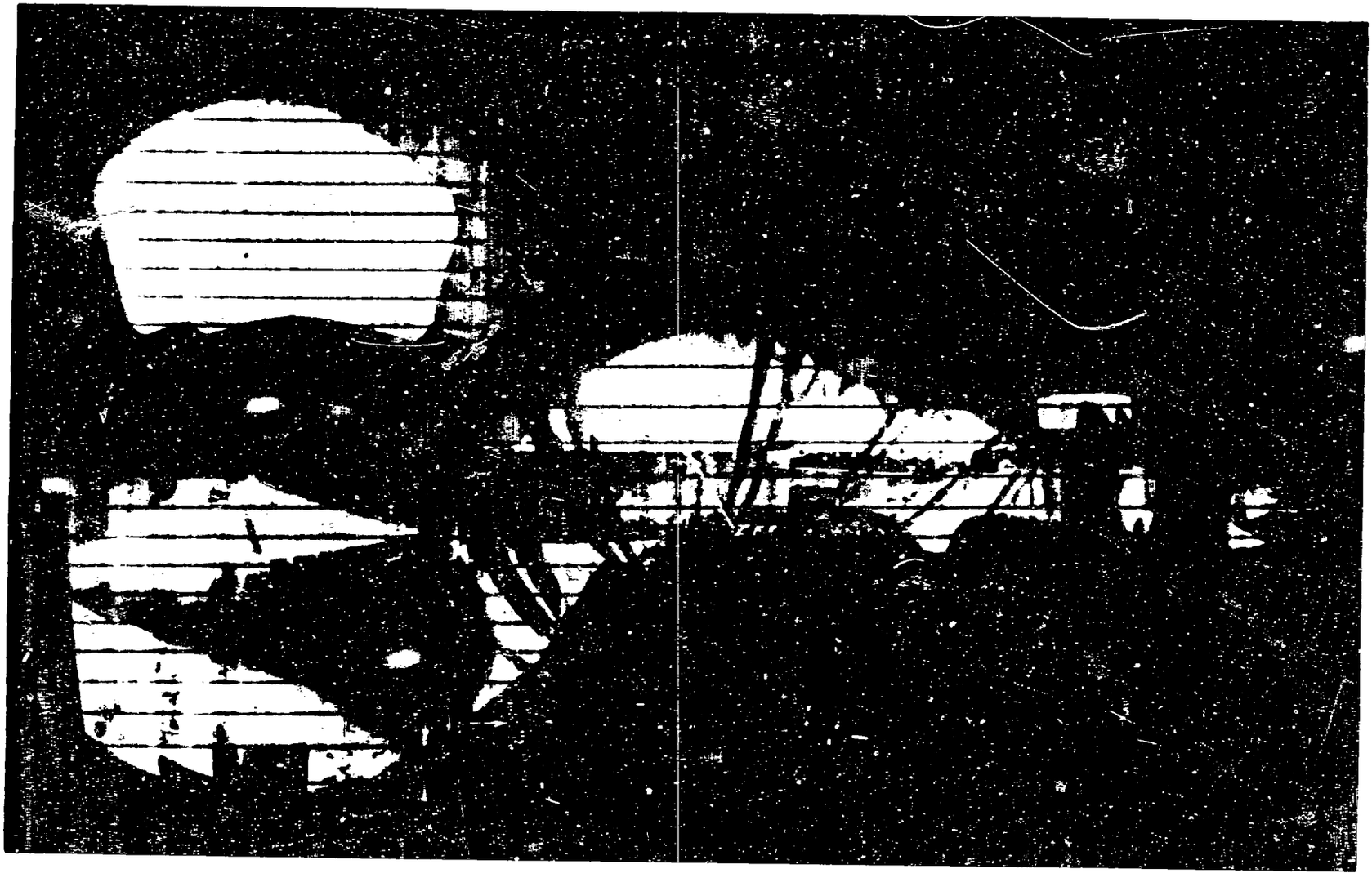


FIGURE 102. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT NAVY SNB-5

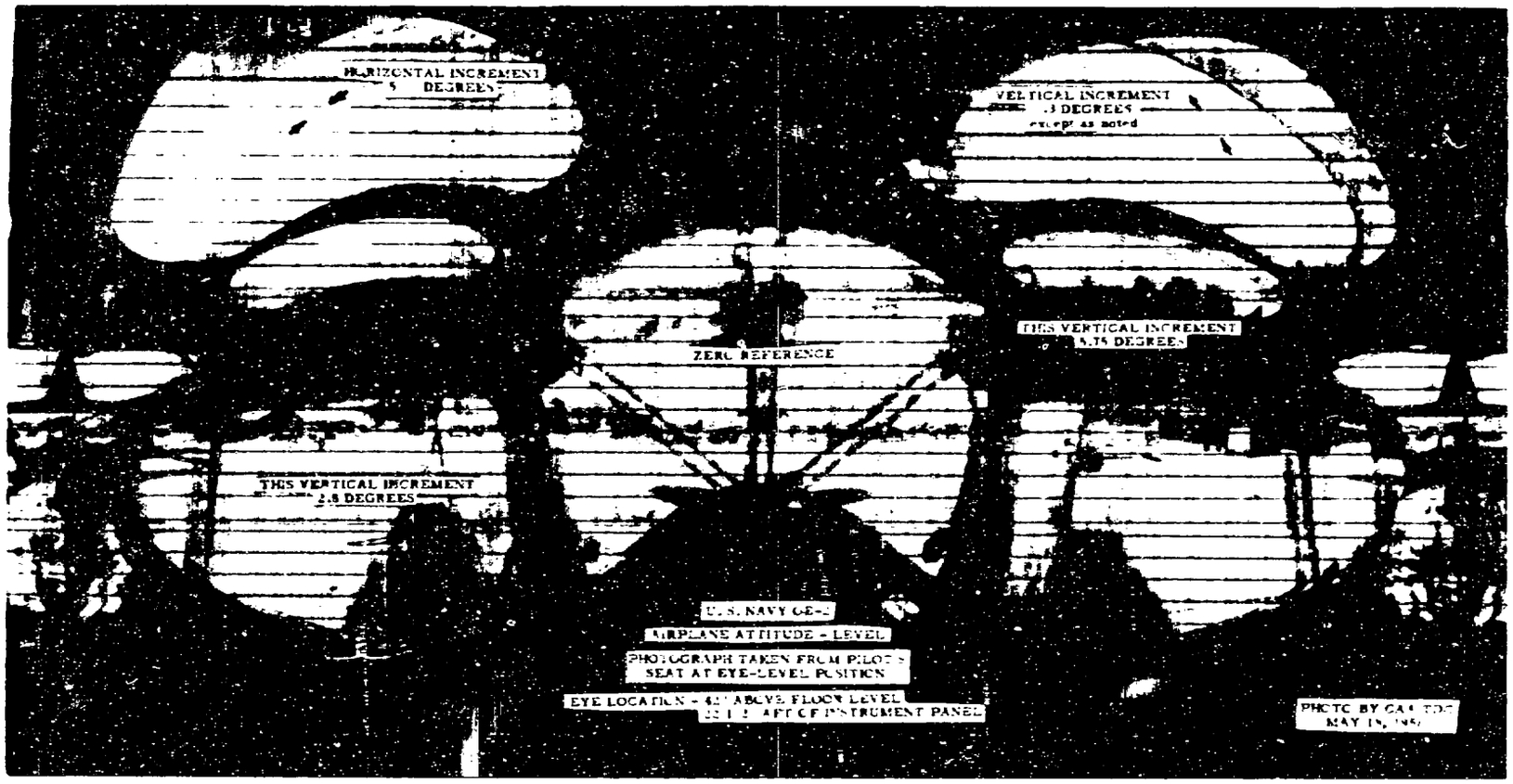


FIGURE 103. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT NAVY OE-2

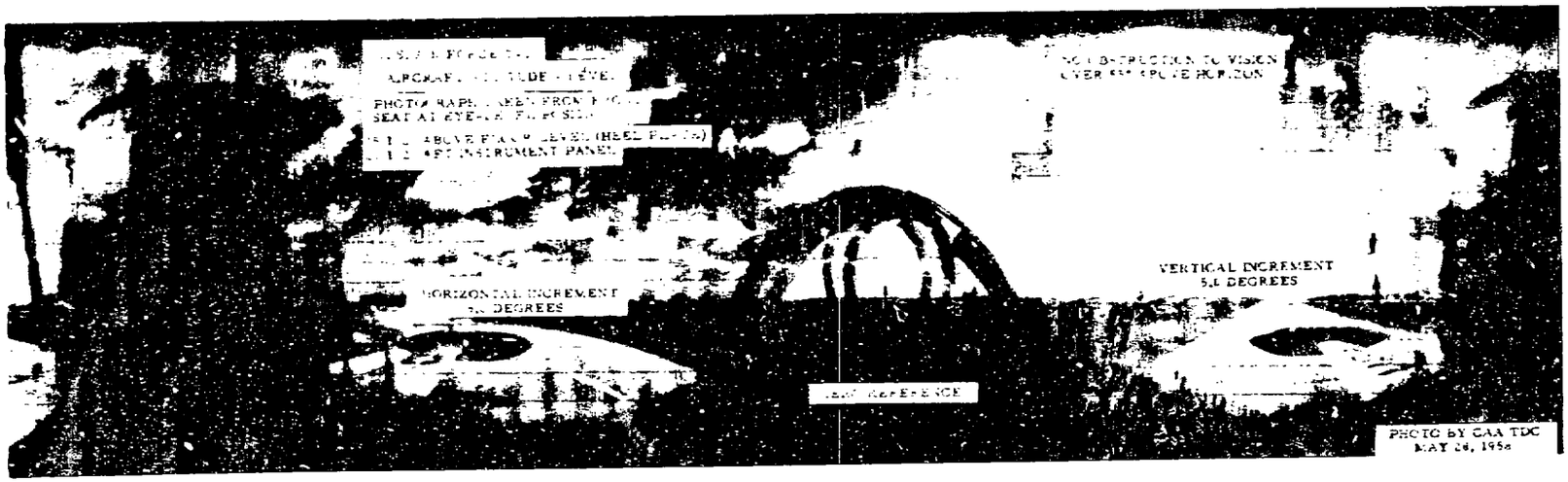


FIGURE 104. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT AIR FORCE T-33

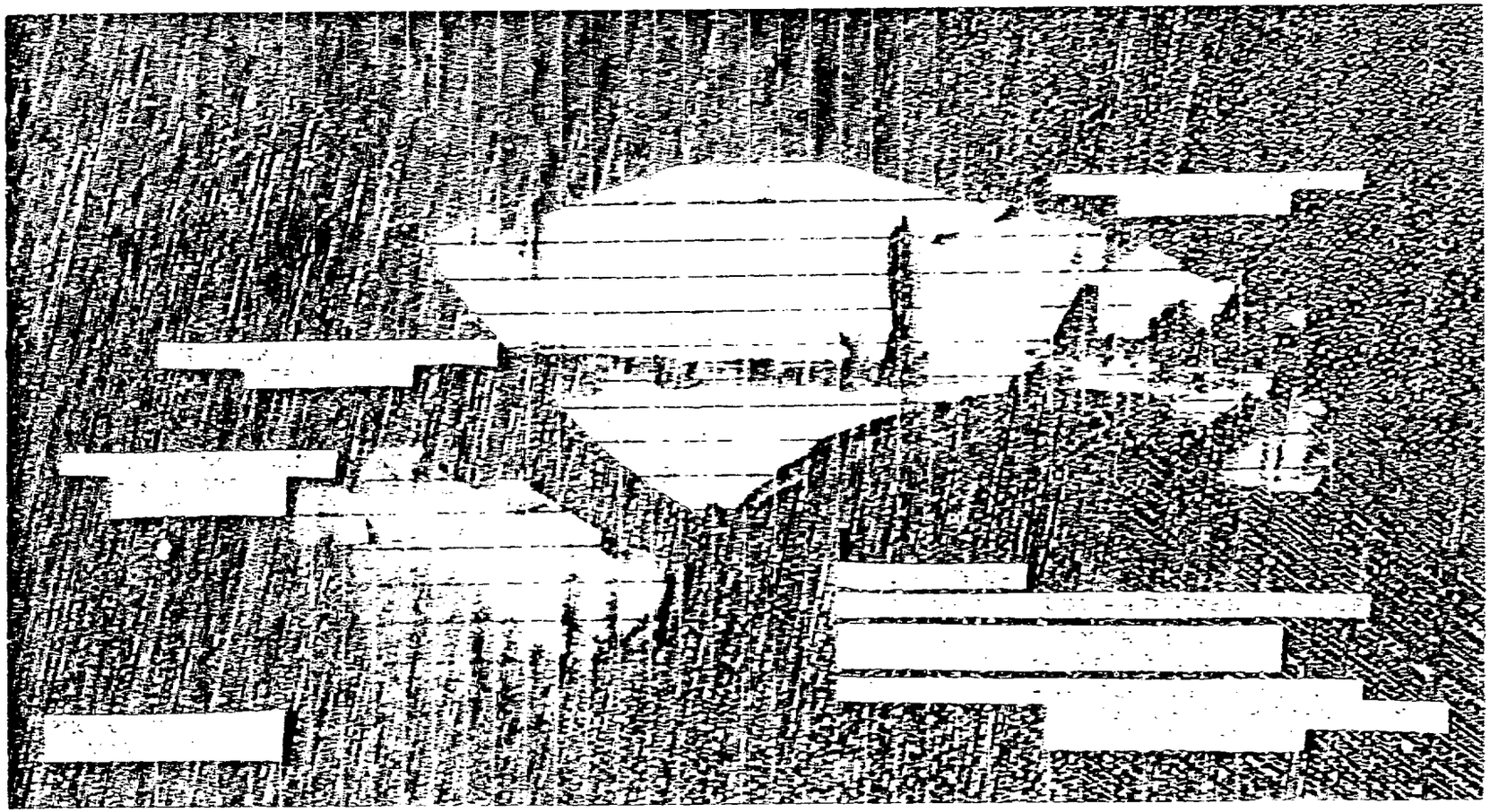


FIGURE 105. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT ARMY U-1

FIGURE 106. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT BELL AH-1G

FIGURE 107. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT BELL UH-1C

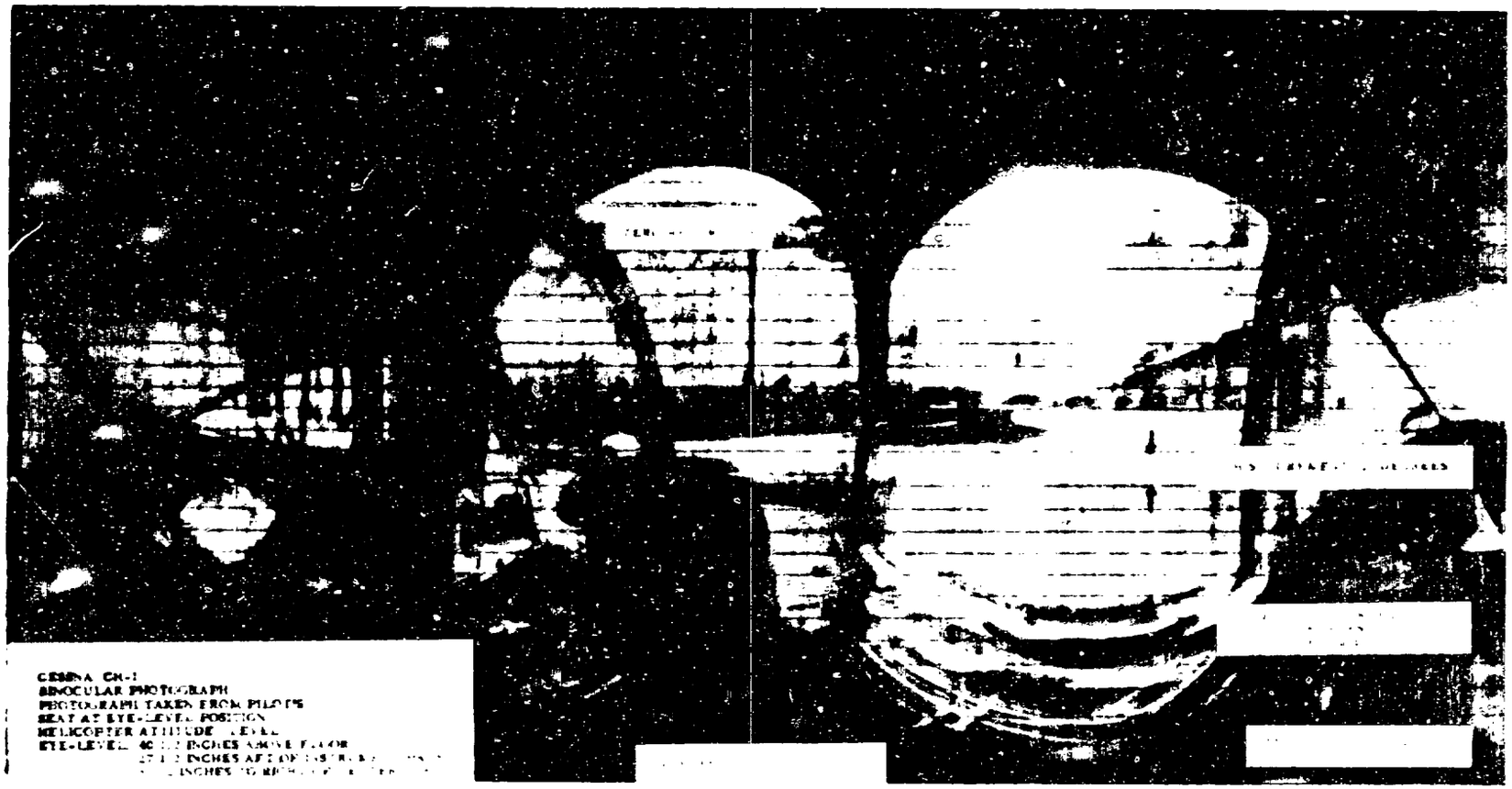


FIGURE 108. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT CESSNA CH-1

FIGURE 109. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT BELL H-13G

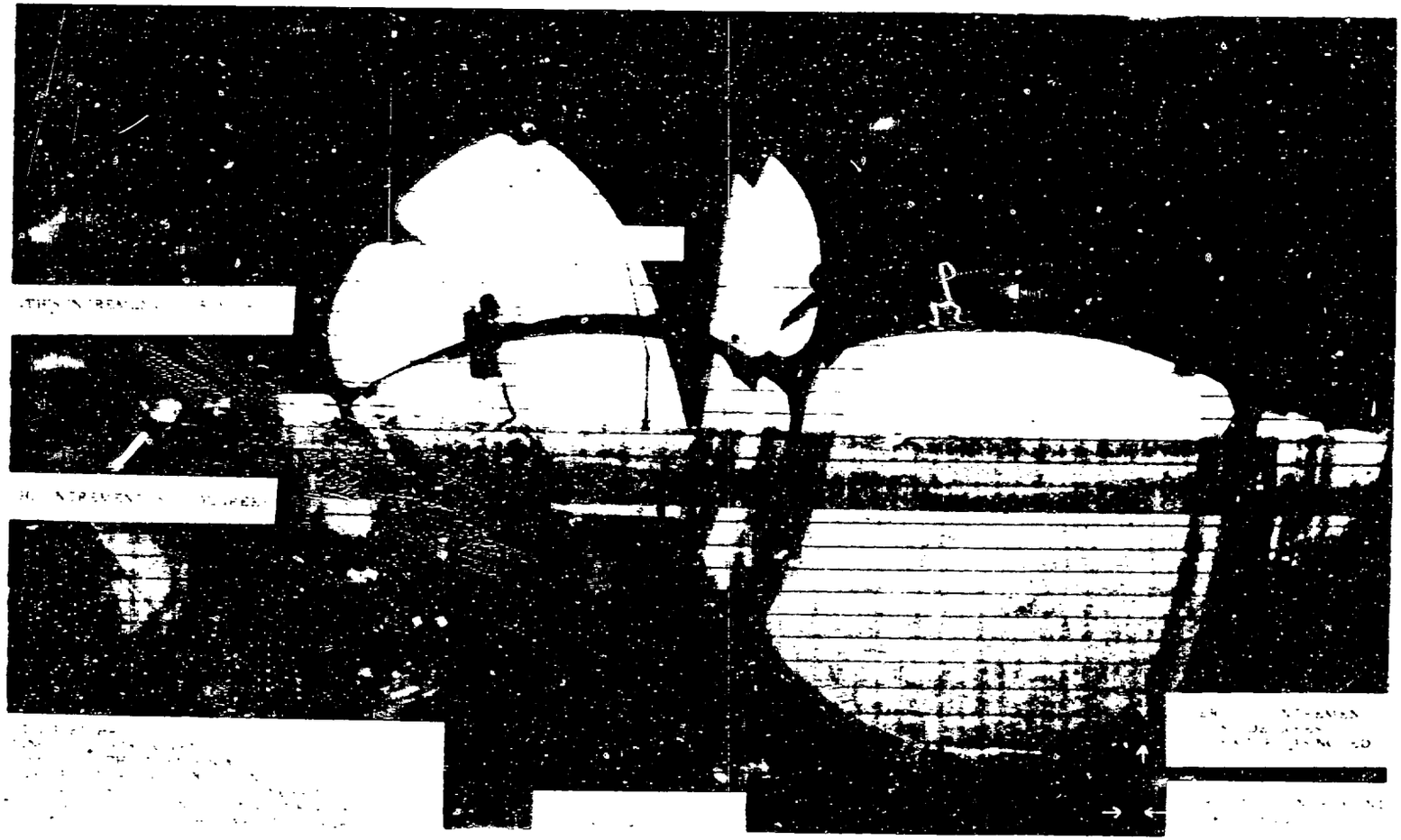


FIGURE 11). BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT SIKORSKY H-19

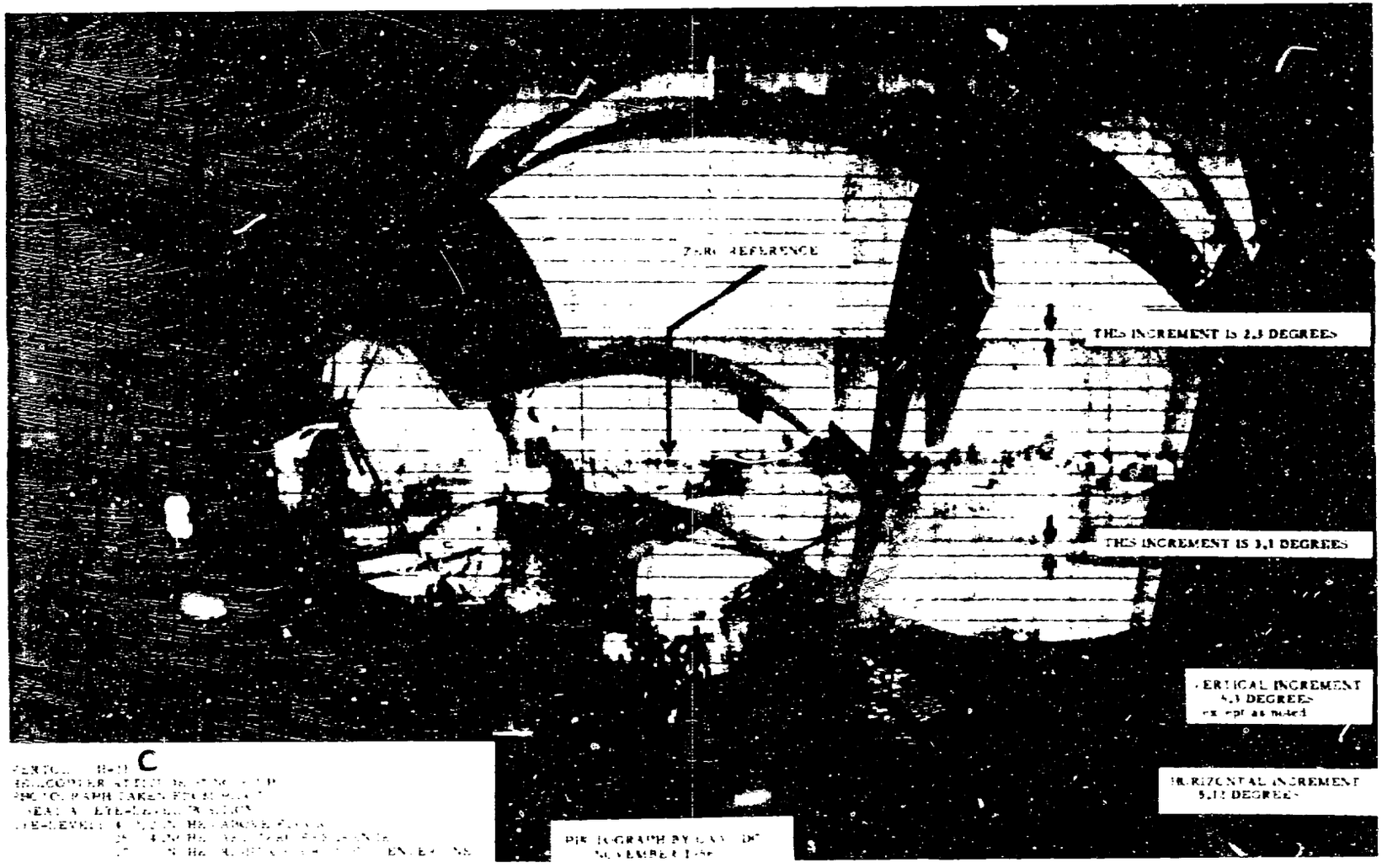


FIGURE 111. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT VERTOL H-21

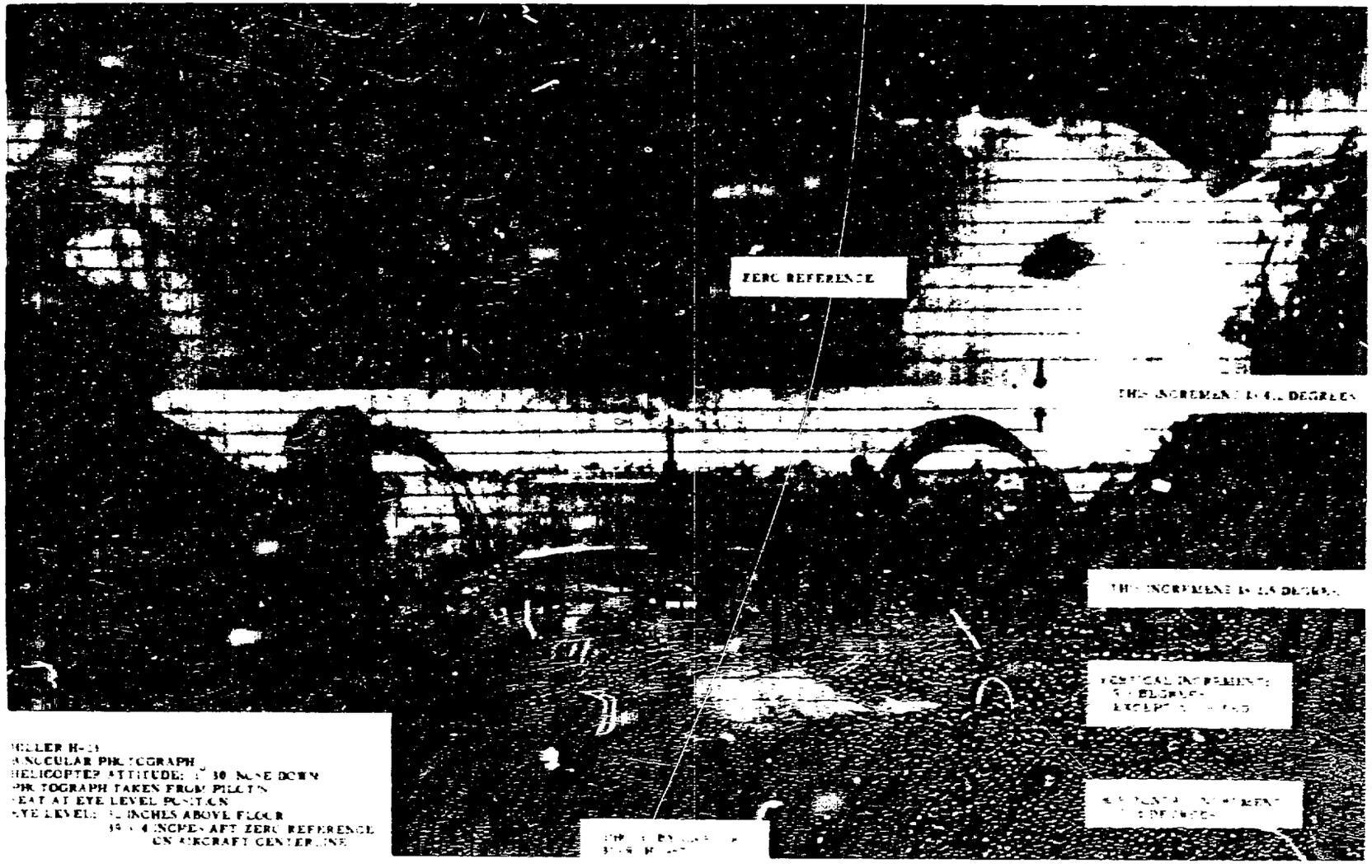


FIGURE 112. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT HILLER H-23

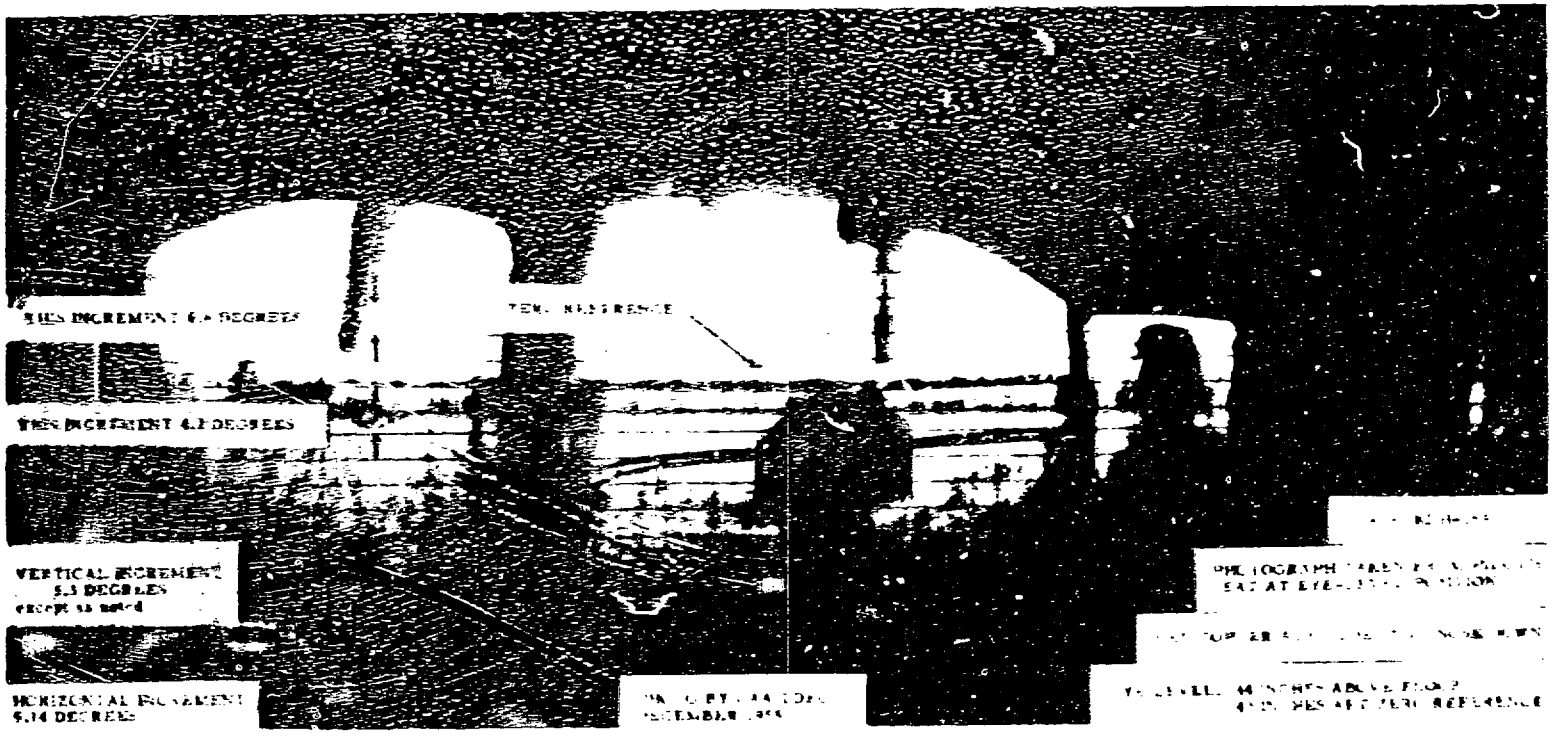


FIGURE 113. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT PIASECKI H-25A

FIGURE 114. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT DOMAN H-31

FIGURE 115. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT SIKORSKY H-34

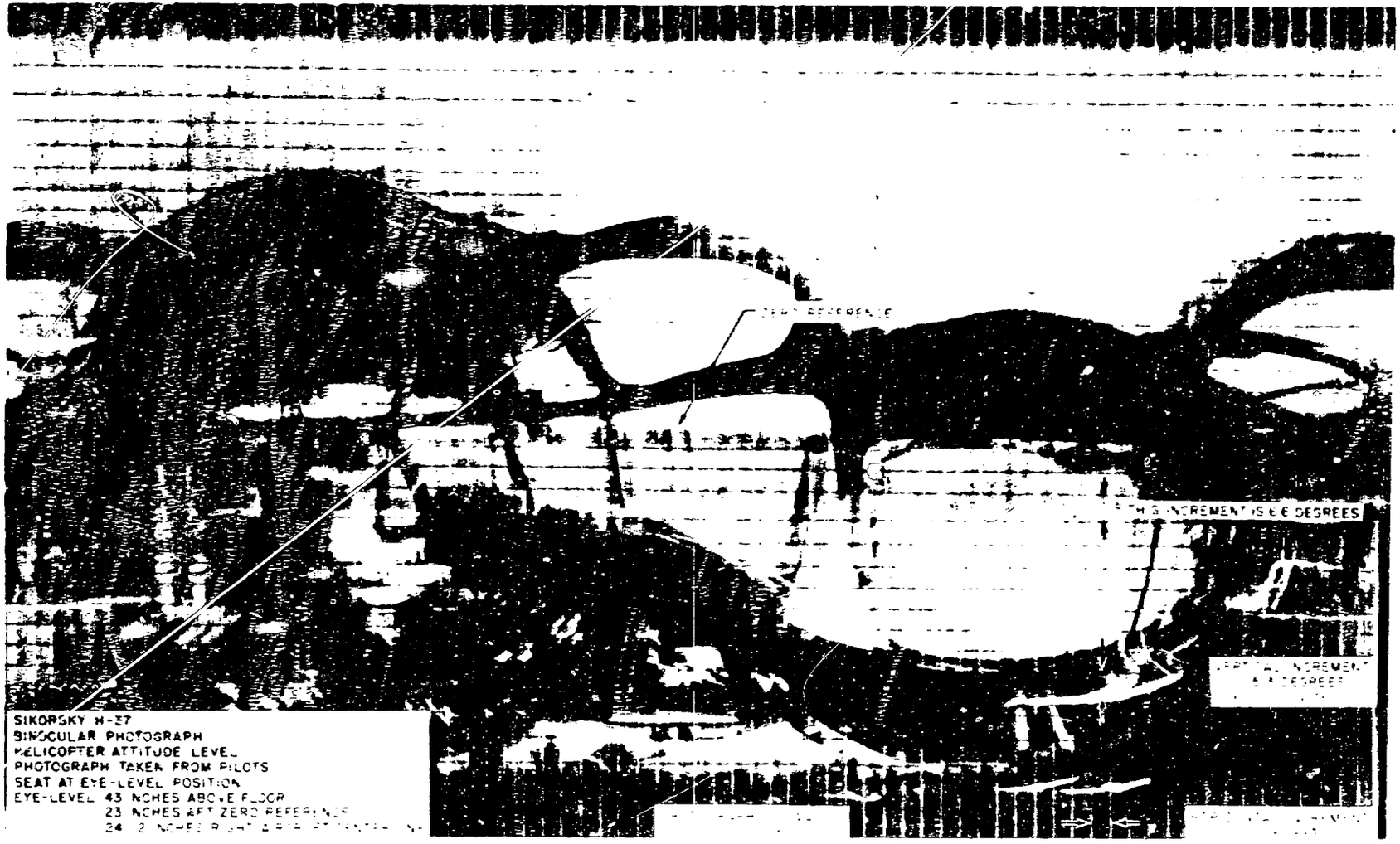


FIGURE 116. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT SIKORSKY H-37

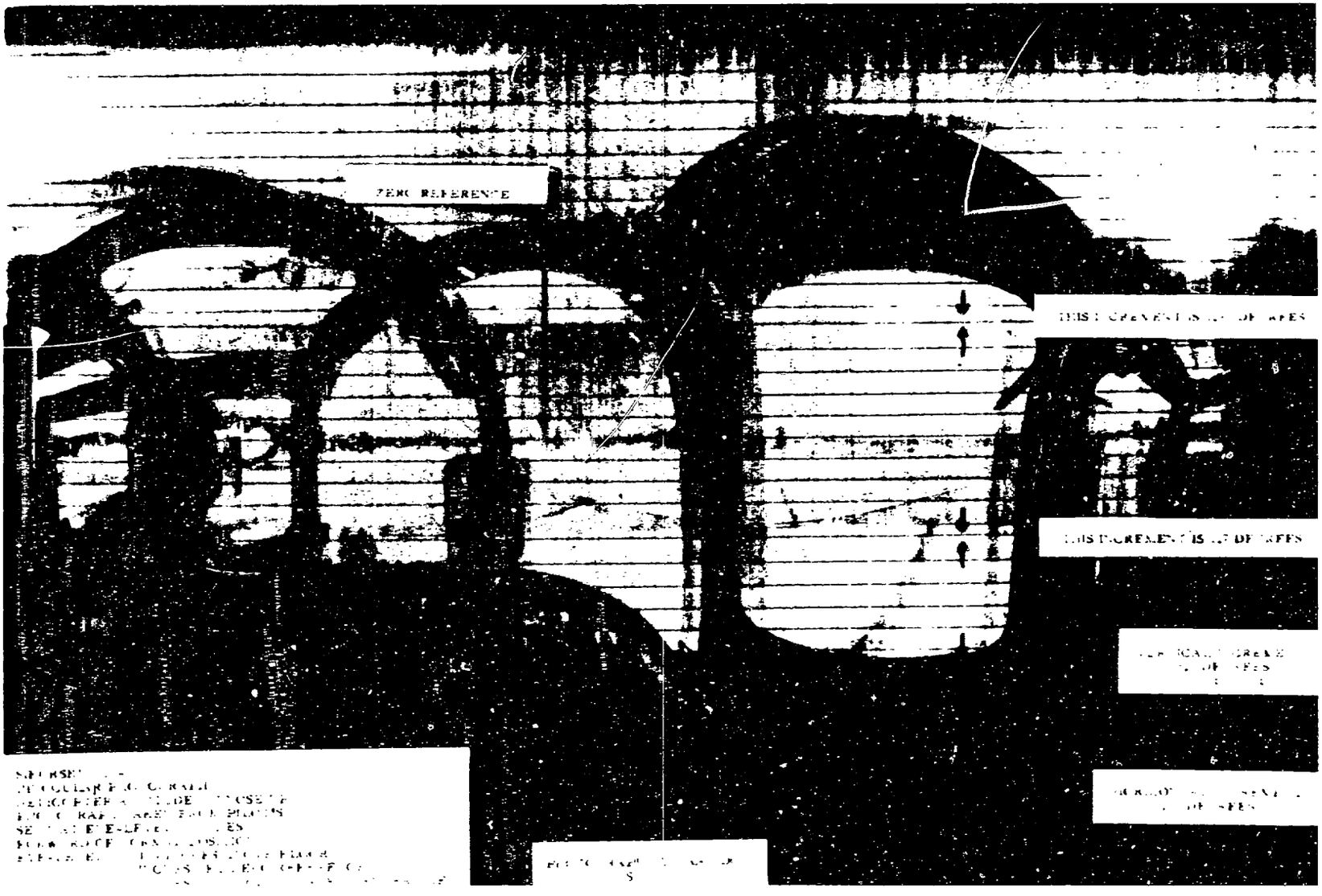


FIGURE 117. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT SIKORSKY HO5-1

FIGURE 118. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT KAMAN HOK-1

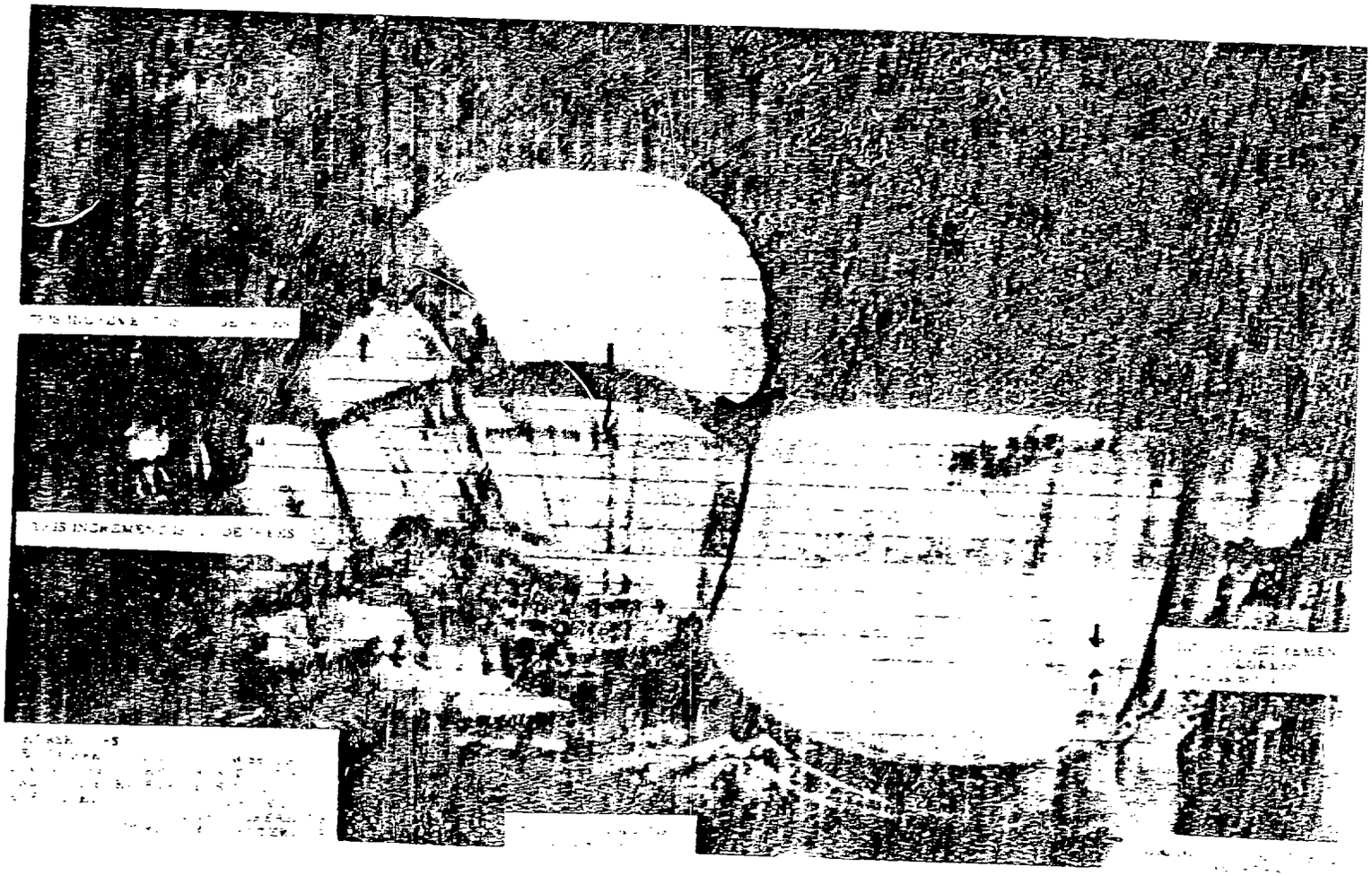


FIGURE 119. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT SIKORSKY HRS-3

FIGURE 120. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT HUGHES OH-6A

FIGURE 121. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT KAMAN K-20

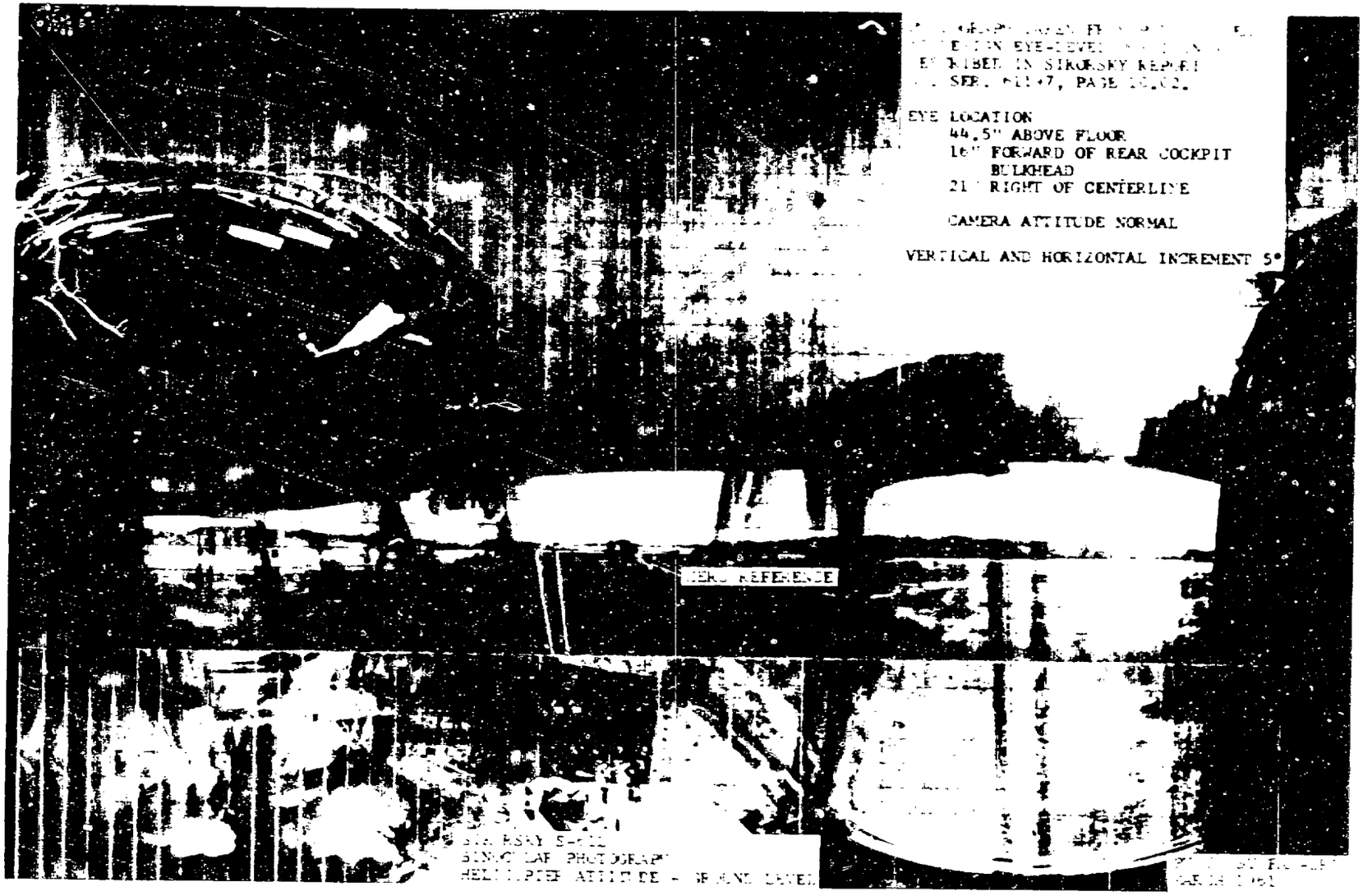


FIGURE 122. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT SIKORSKY S-61L

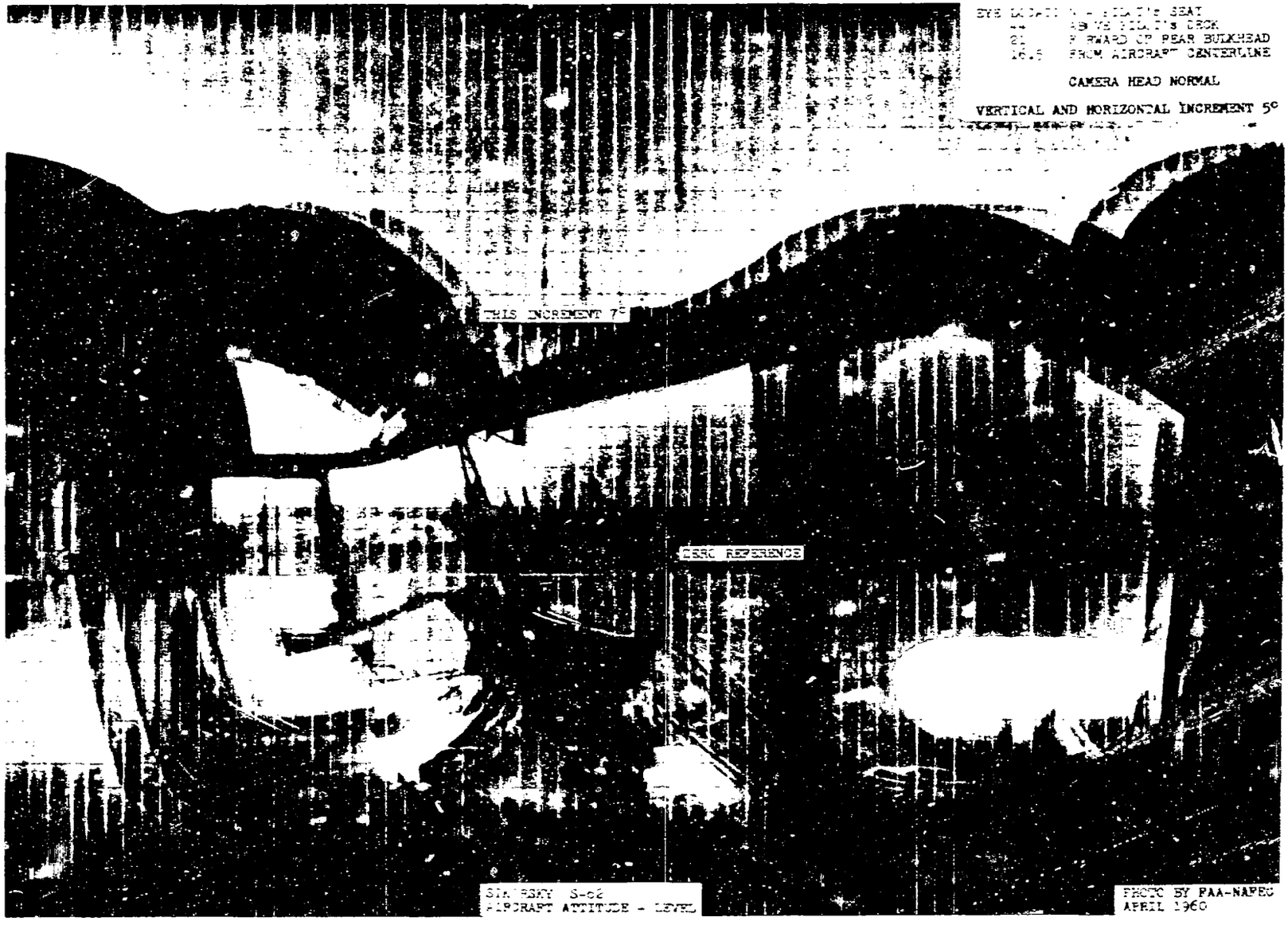


FIGURE 123. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT SIKORSKY S-62

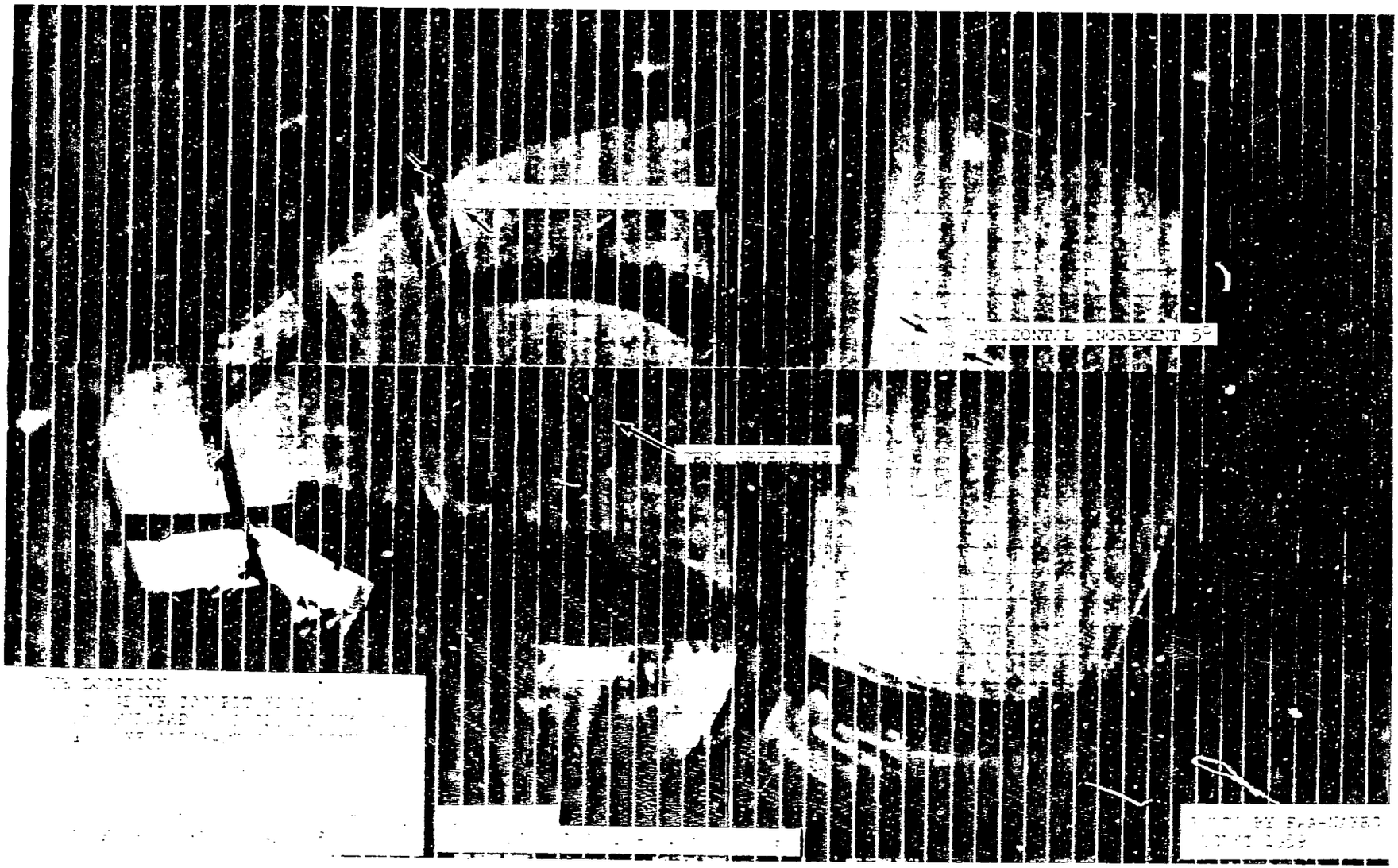


FIGURE 124. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT VERTOL 107

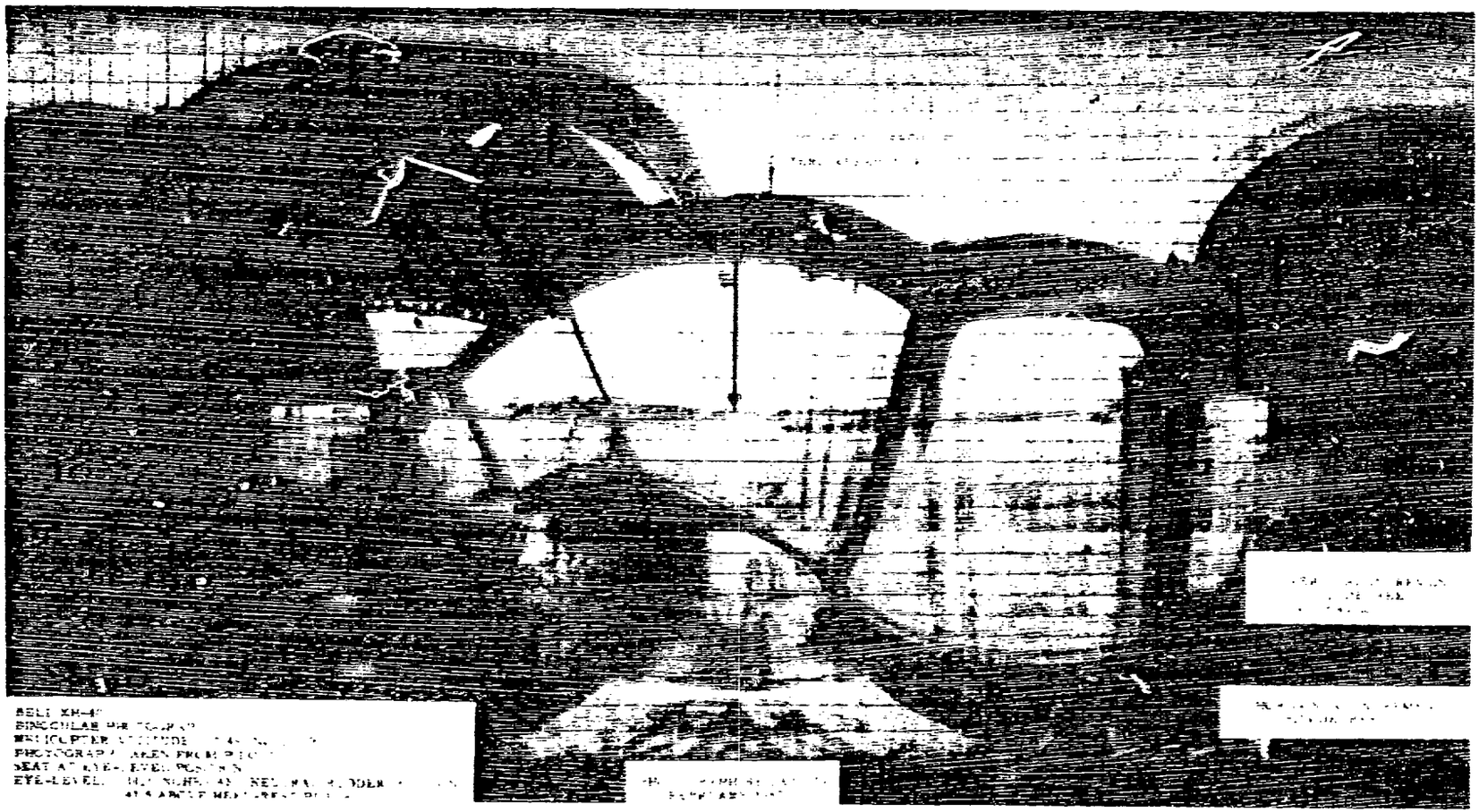


FIGURE 125. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT BELL XH-40

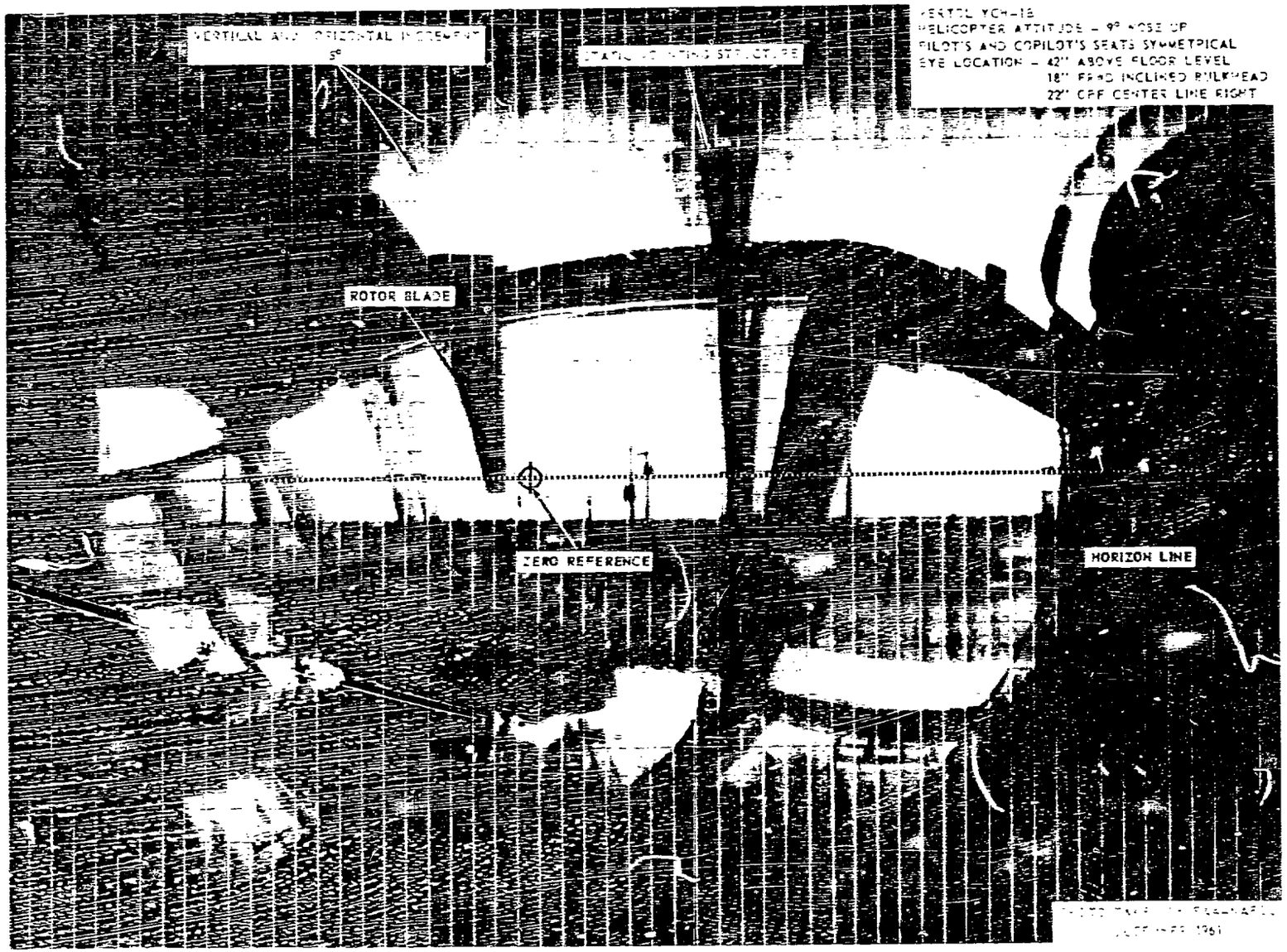


FIGURE 126. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT VERTOL YCH-1B

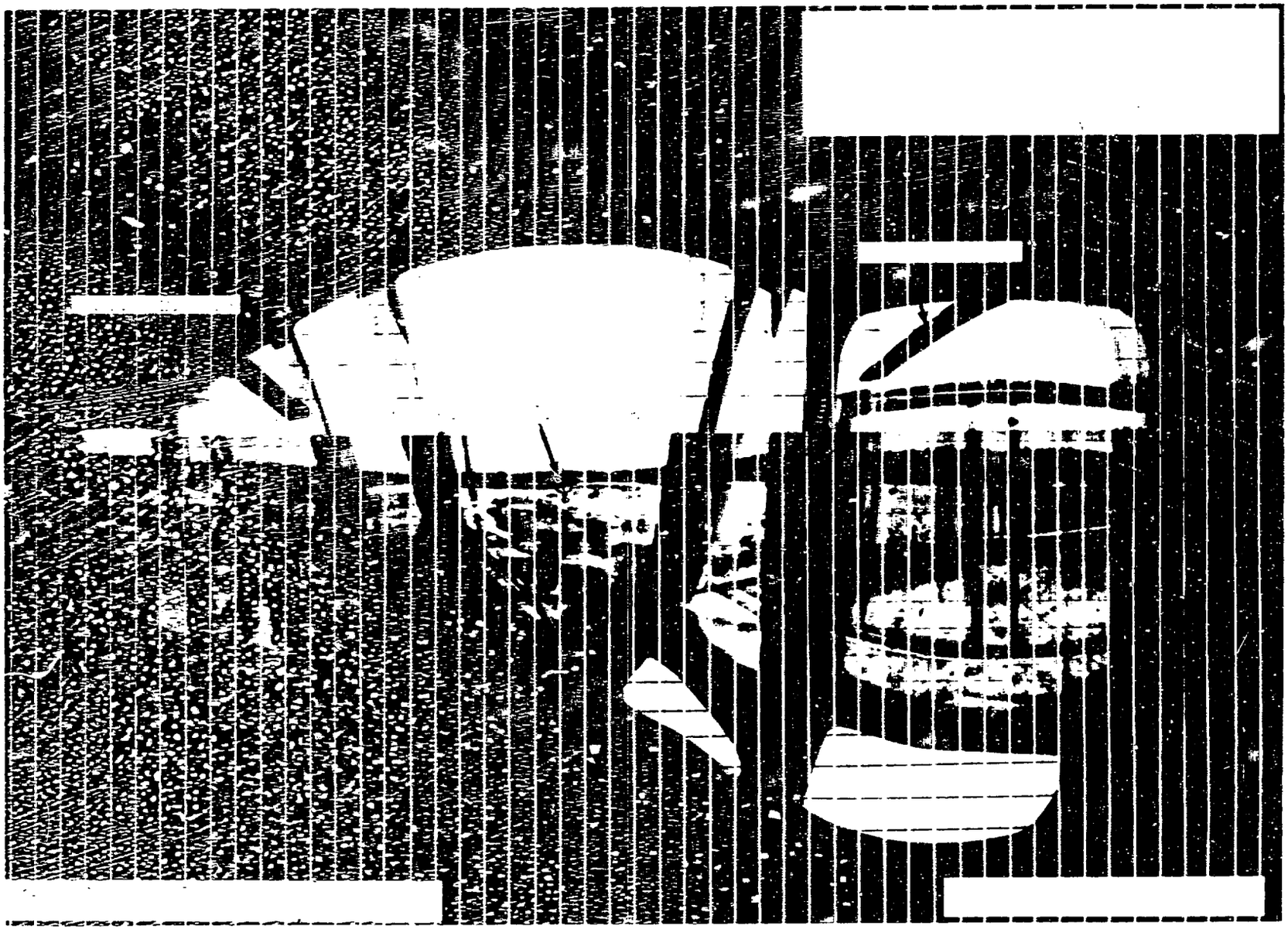


FIGURE 127. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT SIKORSKY YCH-54A

FIGURE 128. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT BELL X-22

FIGURE 129. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT LOCKHEED XV-4A

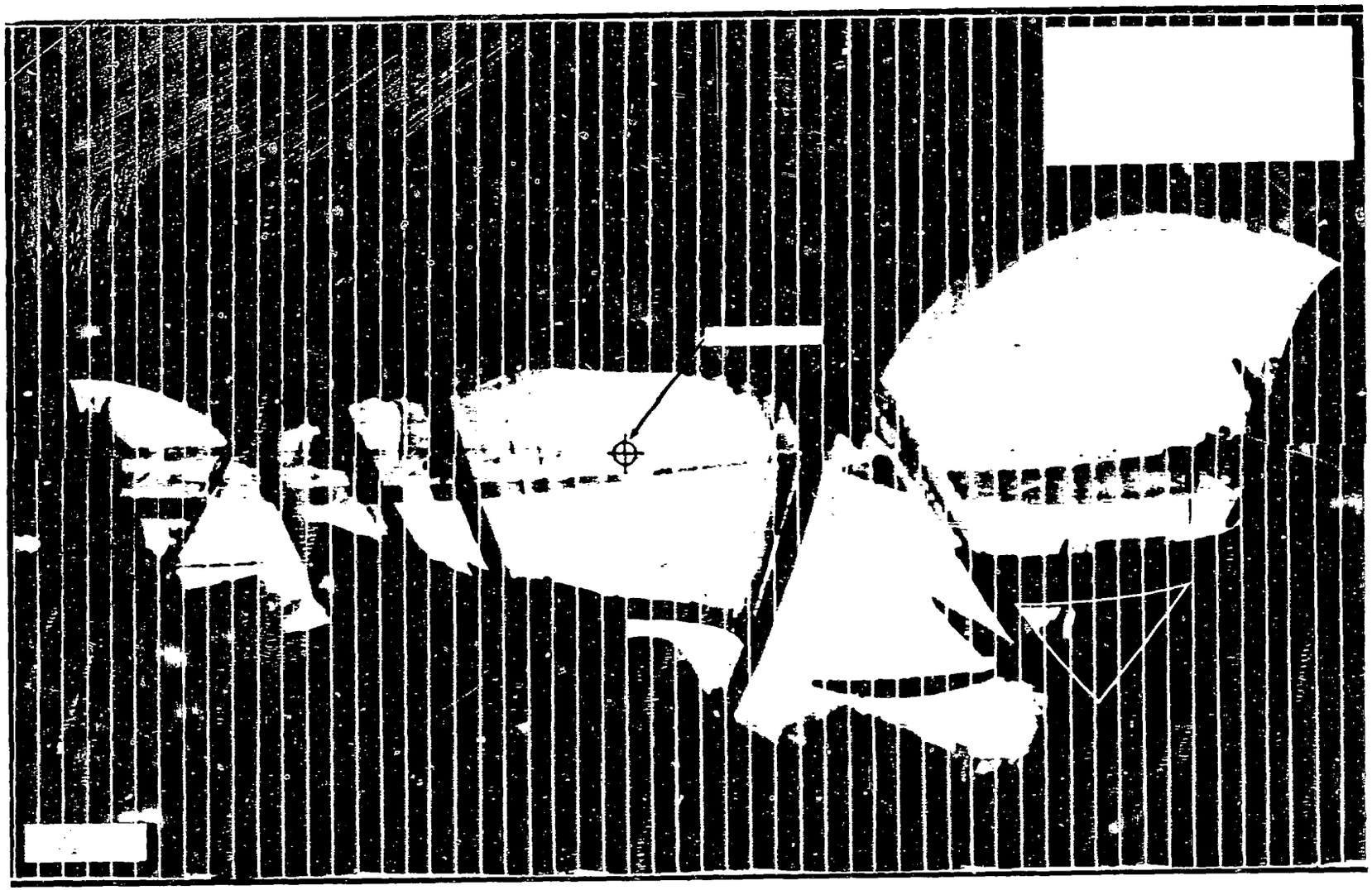


FIGURE 130. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT LTV XC-142A

FIGURE 131. BINOCULAR COCKPIT VISIBILITY PHOTOGRAPH OF AIRCRAFT RYAN XV-5A