AD-779 503

ARTIFICIAL ICING TESTS UH-1H HELICOPTER. PART II. HEATED GLASS WINDSHIELD

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Army Aviation Systems Test Activity
Edwards Air Force Base, California

January 1974

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The United States Army Aviation Systems Test Activity conducted a limited evaluation of a heated glass UH-1H helicopter windshield from 3 January through 8 January 1974. The evaluation was performed at Edwards Air Force Base, California using the helicopter icing spray system and consisted of two productive flights for a total of 1.1 productive flight hours. One shortcoming was noted: restricted upward and downward forward field of view through the heated

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20. Abstract

UH-1H windshield after exposure to an artificial icing environment. Within the scope of this test, the heated portion of the heated glass UH-1H windshield provides a satisfactory anti-ice/deice capability when flying in an icing environment. Further evaluation should be conducted to determine the optimum size, shape, and location of the heated portion of the windshield and to determine if electrical requirements for two windshields are compatible with UH-1H mission electrical loads.

PREFACE

Two heated windshields were generously provided by Bell Helicopter Company of Fort Worth, Texas, to conduct this evaluation.

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INTRODUCTION

BACKGROUND

1. Icing tests completed on the UH-1H helicopter in Alaska (ref 1, app A) revealed a major deficiency, in that forward vision was obscured due to formation of ice on the windshield. In an effort to correct this deficiency, Bell Helicopter Company (BHC) provided two heated glass windshields to the United States Army Aviation Systems Command (AVSCOM) for evaluation. The proffered windshields were manufactured by Pittsburgh Plate Glass (PPG) Industries, using BHC-provided data for the placement and size of the heating elements. The AVSCOM directed the United States Army Aviation Systems Test Activity (USAASTA) to conduct the evaluation of these windshields in an artificial icing environment (ref 2).

TEST OBJECTIVE

2. The objective of this test was to determine the capability of the PPG heated glass windshield to provide adequate windshield anti-ice/deice protection for the UH-1H helicopter.

DESCRIPTION

3. The test aircraft was a UH-1H helicopter, serial number 67-17145, manufactured by BHC. A detailed description of the standard UH-1H helicopter is contained in the operator's manual (ref 3, app A). Nonstandard equipment installed on the helicopter during this evaluation included the heated glass windshield for the copilot's side only, an ice accretion indicator probe (visual probe) located on the cabin roof above the pilot's overhead plexiglass panel, and a heated total temperature probe located between the pilot and copilot chin bubbles. The standard windshield was installed on the pilot's side for comparison with the PPG windshield installed on the copilot's side.

4. The heated glass windshield was manufactured by PPG. Heating elements are provided to deice a viewing area of approximately 10 x 34 inches in the center of the windshield. The heated part of the windshield requires 28 volts direct current and 2.5 watts of power per square inch. A detailed description of the heated windshield system is contained in appendix B.

TEST SCOPE

5. The evaluation of the UH-1H heated glass windshield was conducted in an artificial icing environment provided by a CH-47C helicopter icing spray system (HISS) (app C) and under night visual conditions without ice. Tests were accomplished at Edwards Air Force Base, California from 3 January through 8 January 1974 by USAASTA personnel. A total of 2 flights consisting of 1.1 productive hours were conducted. Flight limitations contained in the operator's manual for the UH-1H helicopter and in the safety-of-flight release (ref 4, app A) were observed during the testing. The tests were accomplished at an average gross weight of 7200 pounds, an aft center-of-gravity location of 143 inches, pressure altitude of 6000 feet, 90 knots indicated airspeed (KIAS), and a rotor speed of 324 rpm.

TEST METHODOLOGY

6. To evaluate the UH-1H heated glass windshield, it was necessary only to ice the test helicopter's fuselage. All normal anti-ice/deice systems, to include the heated windshield, were activated prior to entering the spray cloud. The test aircraft was next positioned in the spray cloud to accumulate a predetermined amount of ice (1/4 inch) and then moved to a position clear of the spray cloud for photographic documentation.

7. A USAASTA-fabricated ice accretion measuring device was used to measure the incremental accumulation of ice. In-flight and postflight photography was used to document the functioning of the heated windshield. A voice recorder was used to document pilot comments. The type of ice (glime) and severity (moderate) encountered during this evaluation were determined by using the definitions presented in appendix D.

RESULTS AND DISCUSSION

GENERAL

8. The evaluation of the heated glass UH-1H windshield to provide anti-ice/deice capability was conducted using the CH-47C HISS. This evaluation included investigation of the basic characteristics of the glass windshield under day and night conditions in a nonicing environment. During this evaluation, one shortcoming was noted: restricted upward and downward forward field of view through the heated windshield after exposure to the artificial icing environment. Within the scope of this test, the heated portion of the heated glass UH-1H windshield provides a satisfactory anti-ice/deice capability when flying in an icing environment. Further evaluation should be conducted to determine the optimum size, shape, and location of the heated portion of the windshield and to determine if electrical requirements of two windshields are compatible with UH-1H mission electrical loads.

ANTI-ICE/DEICE CAPABILITY

9. The heated glass UH-1H windshield was qualitatively evaluated to determine its capability to effectively operate as an anti-ice/deice system. The test was conducted in two parts, during which a total of 1/4 inch of glime ice was accumulated in 6 minutes. Pressure altitude was 6000 feet, airspeed 90 KIAS, and average outside air temperature -5.5°C. During the first part of the test, the windshield was turned on prior to entering the artificial icing environment (spray cloud). Photo A shows the windshield after the helicopter was repositioned outside of the spray cloud. The heated part of the windshield was completely effective in preventing the accumulation of ice when the system was activated prior to entry into the spray cloud. During the second part of the test, the windshield was not turned on prior to entering the spray cloud. Entry into the cloud without prior activation of the heated windshield resulted in the windshield becoming completely iced over within approximately 15 seconds. However, after turning the system on, the heated section was completely deiced of a 1/8-inch layer of ice in approximately 45 seconds. Within the scope of this test, the heated portion of the heated glass windshield provides satisfactory anti-ice/deice capability.

FIELD OF VIEW

10. The field of view provided by the heated glass UH-1H windshield was qualitatively evaluated during flight behind the HISS, during normal in-flight maneuvers, visual approach to landing, and hover taxi. Photo B shows the clear part of the iced windshield. Additional forward viewing area was provided by the heated moisture of the spray cloud flowing upward approximately 1/2 inch from the upper edge of the heated section. The forward field of view provided by the heated windshield was adequate to maintain position relative to the HISS. The

Photo A. UH-1H Deiced Copilot's Windshield.

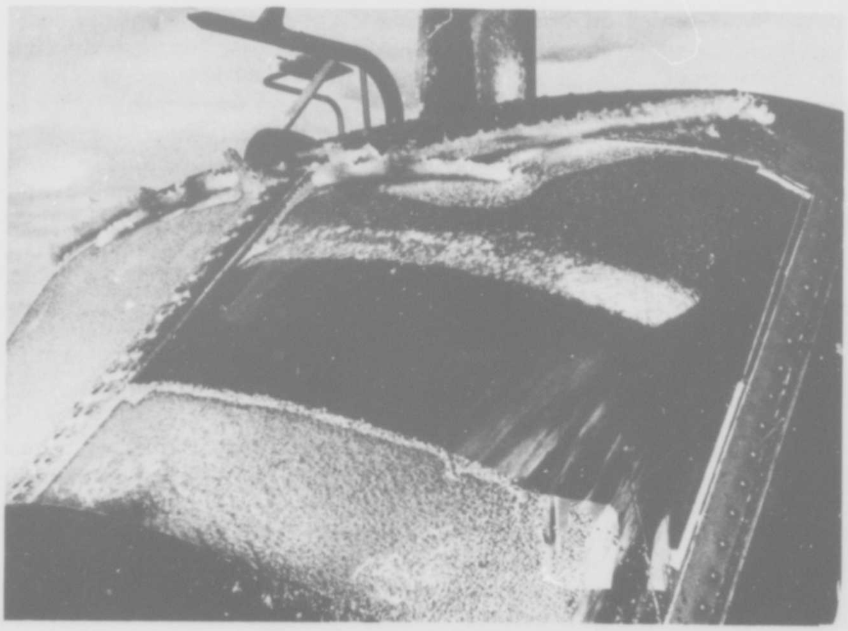

Photo B. Field of View, UH-1H Heated Glass Windshield.

field of view was adequate for the copilot to visually fly the helicopter in level flight. However, when making right turns, the only clear field of view for the copilot to the right side of the helicopter was through the pilot's door window. This characteristic should be improved by addition of the heated windshield on the pilot's side. In addition, the steepness of climbs and descents was limited because of restricted upward and downward forward field of view. To ensure a safe approach and landing, the angle of approach to landing was limited to approximately 5 degrees because of the restricted field of view. The copilot's field of view during hover taxiing was satisfactory except to the right front of the helicopter because of the obscured pilot's windshield. Mission maneuvers such as nap-of-the-earth flight and takeoffs and landings in confined areas or under snow conditions would be hazardous if attempted after exposure to an icing environment because of the restricted forward field of view provided by the heated glass windshield. Within the scope of this test, the restricted upward and downward forward field of view of the heated glass UH-1H windshield after exposure to an icing environment is a shortcoming. Further evaluation should be conducted to determine the optimum size, shape, and location of the heated portion of the windshield for the UH-1H helicopter.

OPTICAL CHARACTERISTICS

11. The heated glass UH-1H windshield was qualitatively evaluated to determine if any unusual optical characteristics exist. The windshield was evaluated in flight under daylight, twilight, and night conditions, with and without electrical power applied in a nonicing environment. Photographs comparing the night optical characteristics of the pilot's plexiglass windshield and the copilot's glass windshield are presented in photos E-1 through E-3, appendix E. The light sources are two mercury vapor-type lights.

12. No unusual optical characteristics were present under daylight conditions when looking through either the heated or nonheated parts of the copilot's windshield. The heated part of the windshield was not noticeable under daylight conditions. Under twilight conditions, the presence of the heated part of the windshield became distinct from the nonheated part as if there were a tinted band of glass across the width of the windshield. However, this characteristic was not objectionable and was only present during twilight conditions. During night flight, the optical characteristics of the pilot's standard windshield and the nonheated part of the copilot's windshield were essentially the same (photos E-1 and E-2). However, as shown in photo E-3, the optical characteristics of the heated part of the windshield are different from those observed with the nonheated part. When viewing a point light source through the heated part, the light scattered into four rays in the approximate shape of an X. The light scattering increased when viewing lights of greater intensity. This characteristic is noticeable but not objectionable. When viewing unlighted objects through the heated or nonheated parts of the windshield, the optical characteristics were essentially the same. All observed optical characteristics were the same with and without electrical power applied to the heated section of the windshield. Within the scope of this test, the optical characteristics of the heated glass UH-1H windshield are satisfactory.

MISCELLANEOUS

13. Location of the cockpit control panel for the heated windshield was easily accessible to both the pilot and copilot. Functioning of the indicator lights and control switches was easily understood. However, only two functions are provided by the three-position control switch: down position, ON; center position, OFF; and up position, OFF. The extra OFF position of the control switch used in this test installation should be eliminated from any production version of this system. Additionally, the direction of moving the windshield control switch to activate the system is opposite to the direction of other switches located on the center console of the helicopter. Direction of movement of the control switch should conform with other helicopter switches for any production version.

14. Electrical power to heat the wire elements in the copilot's windshield is taken from the essential bus of the helicopter. The normal generator load factor observed with the heated windshield off was 0.3. With the heated windshield activated, the generator load factor increased 0.1. On the ship's service electrical load meter, 1.0 represents 100 percent of the main generator load (300 amperes). The increase in load factor caused by the heated windshield represents an increase of 30 amperes. Further evaluation should be conducted to determine if the added electrical requirements of two heated glass windshields are compatible with UH-1H mission electrical loads.

CONCLUSIONS

GENERAL

15. The following conclusions were reached upon completion of the heated glass UH-1H windshield evaluation:

a. The heated portion of the heated glass windshield provides satisfactory anti-ice/deice capability (para 9).

b. The optical characteristics of the heated glass UH-1H windshield in a nonicing environment were satisfactory during flight in daylight, twilight, and night conditions (para 12).

c. The addition of electrical power to the heated section of the windshield did not change the optical characteristics of the windshield (para 12).

d. One shortcoming was noted during this evaluation.

SHORTCOMING

16. The restricted upward and downward field of view of the heated UH-1H windshield after flight in the artificial icing environment is a shortcoming (para 10).

RECOMMENDATIONS

17. The shortcoming should be corrected.

18. Further evaluation should be conducted to determine the optimum size, shape, and location of the heated portion of the windshield for the UH-1H helicopter (para 10).

19. The extra OFF position of the control switch should be eliminated (para 13).

20. Direction of movement of the control switch should conform with other helicopter switches (para 13).

21. Further evaluation should be conducted to determine if the added electrical requirements of two heated glass windshields are compatible with UH-1H mission electrical loads (para 14).

APPENDIX A. REFERENCES

1. Final Report, USAASTA, Project No. 73-04-4, *Artificial Icing Tests, UH-1H Helicopter, Part I*, January 1974.

2. Letter, AVSCOM, AMSAV-EFT, 26 November 1973, subject: Army Helicopter Simulated Icing Tests (Project 73-04).

3. Operator's Manual, TM 55-1520-210-10, *Army Model UH-1D/H Helicopter*, 25 August 1971.

4. Message, AVSCOM, AMSAV-EFT, R281955Z December 1973, unclas, subject: Safety-of-Flight Release for UH-1H Icing Test with Heated Glass Windshield and IR Scoop Installed.

5. Final Report, USAASTA, Project No. 72-35, *Helicopter Icing Spray System Qualification*, October 1973.

6. Technical Manual, All American Engineering Company, SM 280A, *Installation, Operation and Maintenance Instructions, Icing Conditions Simulation Equipment*, July 1973.

APPENDIX B. WINDSHIELD DESCRIPTION

1. The UH-1H heated glass windshield is manufactured by PPG Industries, Inc. The windshield is of three-ply construction with glass inboard and outboard plys and a polyvinyl plastic interply. Inboard and outboard fiberglass "straps" are bonded around the windshield to facilitate mounting to the UH-1H windshield frame. The net weight increase after installation of the glass windshield is 13 pounds (one side).

2. The heated part of the windshield provides a center viewing area of 10 inches high by 34 inches wide (photo B-1). Heat to the windshield is provided electrically by wire elements imbedded in the interlayer. Heat emission is approximately 2.5 to 2.6 watts per square inch using 28 volts direct current as the power source.

3. The heated windshield control system consists of a cockpit-mounted control box (photo B-2), a controller unit with integral timer, power relay, and two temperature sensors imbedded in the windshield surface (photo B-3). Electrical power is supplied to the controller unit by a pilot-operated switch located on the control box. The controller interfaces with the two windshield temperature sensors and the output of the controller controls the power relay. The power relay when activated supplies the power to the windshield wire heating elements.

4. When electrical power is applied to the controller, the integral timer (externally adjustable from 1 to 5 minutes) starts and the power relay activates. Electrical power is applied to the windshield until the windshield temperature reaches 110°F or until the timer runs out, whichever occurs first. When the windshield temperature reaches 110°F, the controller deactivates the power relay, thus removing electrical power. When the windshield temperature drops to 100°F, electrical power is restored and the timer resets and starts.

5. Temperature protection is provided by an over-temperature control circuit in conjunction with an over-temperature sensor. At 130°F windshield temperature, the over-temperature control circuit deactivates the power relay and illuminates the abnormal condition warning indicator light on the cockpit control box. The over-temperature control circuit functions until the windshield temperature drops to 120°F.

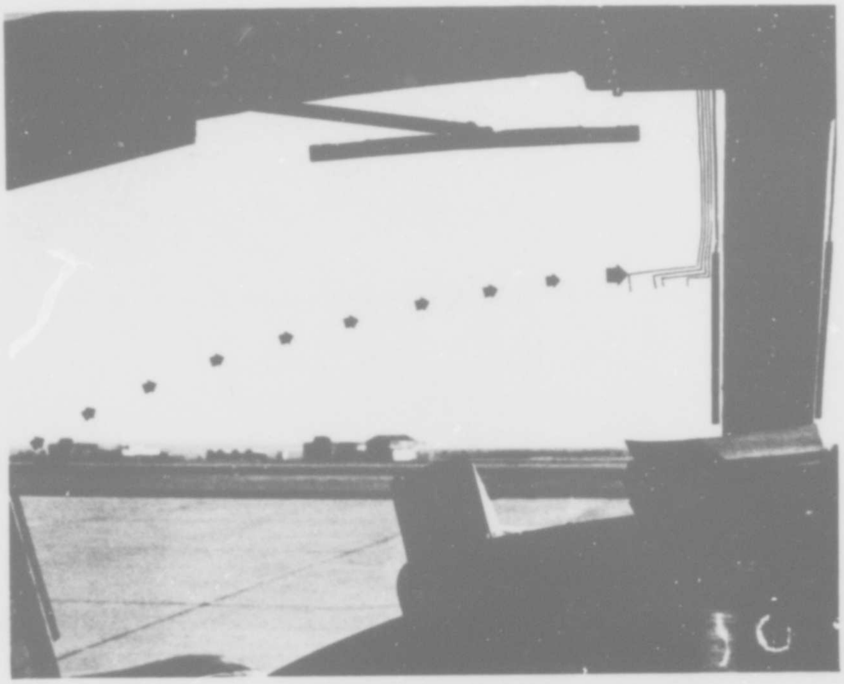

Photo B-1. UH-1H Heated Glass Windshield.

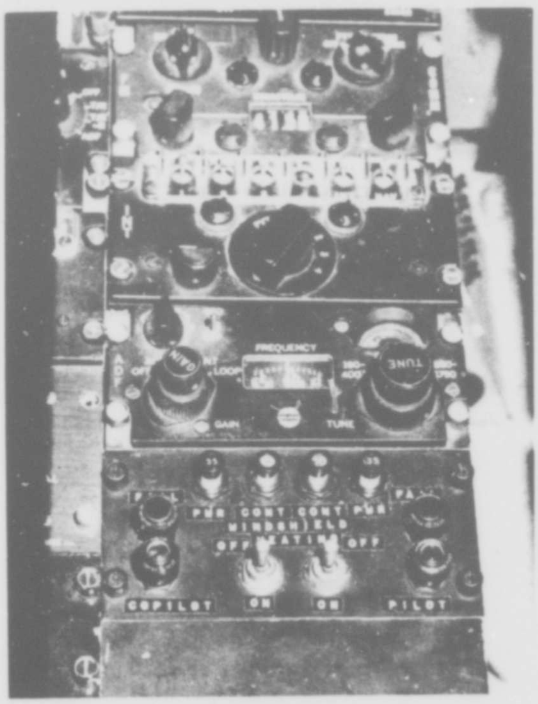

Photo B-2. Cockpit-Mounted Control Box.

APPENDIX C. CH-47C HELICOPTER ICING SPRAY SYSTEM DESCRIPTION

The icing spray system equipment consists of a 75-foot spray boom, boom supports, boom hydraulic actuators, an 1800-gallon water tank, and spray system control equipment weighing approximately 4700 pounds (fig. 1). The icing spray boom, which is located in a horizontal plane 15 feet below the aircraft during operation, is jettisonable in both the fully extended and stowed positions. The internal water is also jettisonable. The desired liquid water content and droplet size distribution are obtained by controlling the water flow rate and air pressure from the spray system control equipment mounted inside the CH-47C aircraft. Detailed spray system characteristics are contained in references 5 and 6, appendix A.

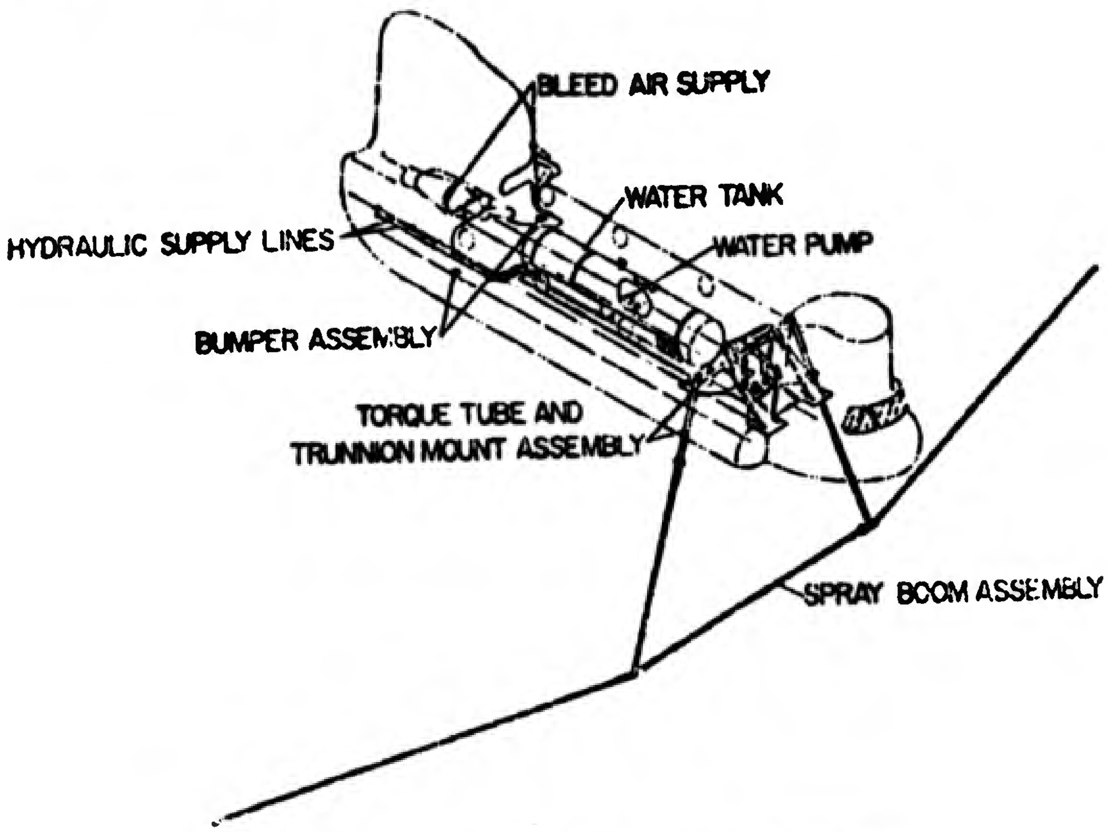

Figure 1. Icing Condition Simulation Equipment in CH-47C Aircraft.

APPENDIX D. ICING DEFINITIONS

1. Icing type definitions are as follows:

a. Rime ice: An opaque ice formed by the instantaneous freezing of small supercooled droplets.

b. Clear ice: A semitransparent ice formed by the slower freezing of larger supercooled droplets.

c. Glime ice: A mixture of clear ice and rime ice which is very common.

2. Icing severity definitions are as follows:

a. Trace icing: Accumulation of 1/2 inch of ice on a small probe each 80 miles. The presence of ice on the airframe is perceptible but the rate of accretion is nearly balanced by the rate of sublimation. Therefore, this is not a hazard unless encountered for an extended period of time. The use of deicing equipment is unnecessary.

b. Light icing: Accumulation of 1/2 inch of ice on a small probe each 40 miles. The rate of accretion is sufficient to create a hazard if flight is prolonged in these conditions but insufficient to make diversionary action necessary. Occasional use of deicing equipment may be necessary.

c. Moderate icing: Accumulation of 1/2 inch of ice on a small probe each 20 miles. On the airframe, the rate of accretion is excessive, making even short encounters under these conditions hazardous. Immediate diversion is necessary or use of deicing equipment is mandatory.

d. Heavy icing: Accumulation of 1/2 inch of ice on a small probe each 10 miles. Under these conditions, deicing equipment fails to reduce or control the hazard and immediate exit from the icing condition is mandatory.

3. The liquid water content under various icing conditions is shown in table 1.

Table 1. Liquid Water Content.

Icing Condition	Liquid Water Content[1] (gram/meter^3)
Trace	Zero to 0.1
Light	0.1 to 0.5
Moderate	0.5 to 1.0
Heavy	Greater than 1.0

[1]Based on a mean drop size of 25 microns.

APPENDIX E. PHOTOGRAPHS

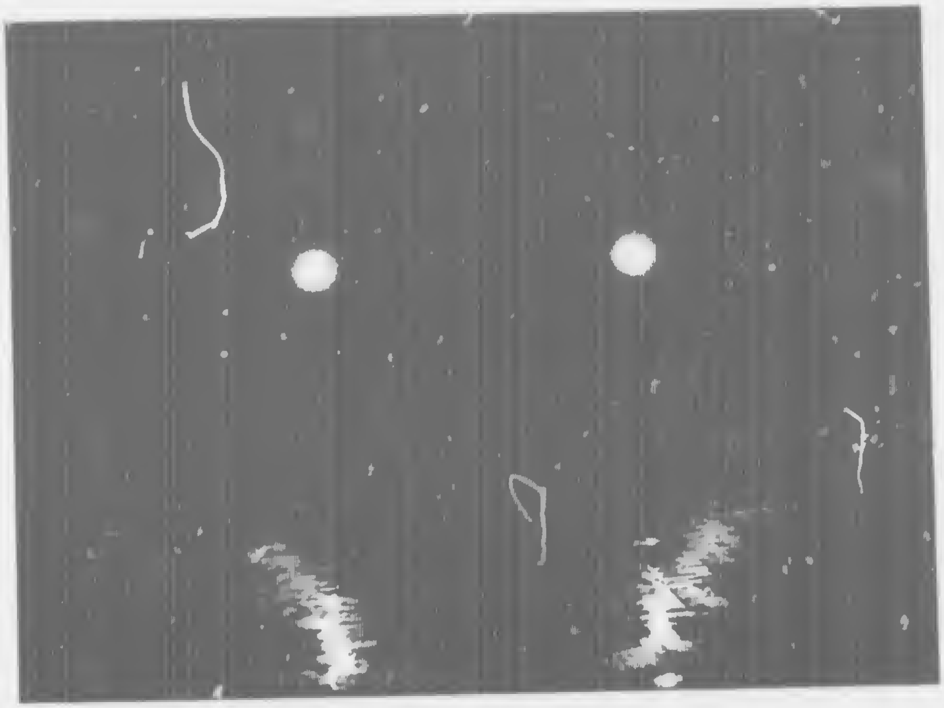

Photo E-1. Mercury Vapor Lights Through Standard Windscreen.

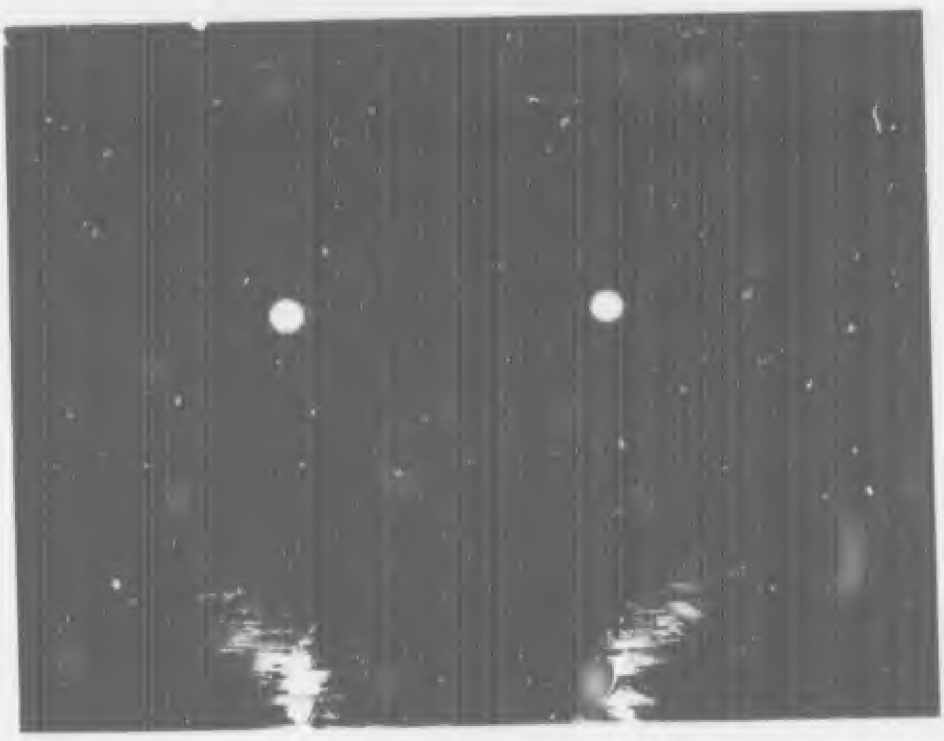

Photo E-2. Mercury Vapor Lights Through PPG Windscreen Above Heating Elements.

Photo E-3. Mercury Vapor Lights Through PPG Windscreen Through Heating Elements.