DATA REPORT NO. 99

# SMALL-SCALE FIRE TESTS ON SECTIONS OF AIRCRAFT LOADING WALKWAY

Project No. 184 732 02X

Prepared by: S. L. Imbrogno

DECEMBER 1972

DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Aircraft Safety Division
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## Purpose

Small-scale fire tests were conducted on sections of an aircraft loading walkway to determine its ability to provide protection to deplaning passengers in the event of a fuel-spill type fire adjacent to the walkway.

## Background

A series of meetings was held with representatives of the Air Transport Association (ATA), United States Testing Company, Inc., Jetway Equipment Co., and various airlines to discuss plans for conducting full-scale fire tests at the National Aviation Facilities Experimental Center (NAFEC) on an aircraft loading walkway. The goal of these tests was to determine the length of survivable time for passenger egress inside the structure when subjected to a severe external fuel-fed fire.

A need for these tests has been generated by National Fire Protection Association (NFPA) Standard No. 417 issued for aircraft loading structures. Since these structures are considered as part of the air terminal structure by airport officials, the published requirements seem too severe in the expressed opinion of the airlines who provide the walkway as part of the loading platform for airplanes.

Prior to full-scale tests, ATA expressed interest in conducting several small-scale tests on 2-foot-square sections of a walkway. These tests would give an indication of the fire resistance of the complete structure and would point out possible problems that could be encountered during the full-scale test.

## Test Procedures

Each section to be tested was bolted to one end of a closed rectangular steel housing and subjected to a flame from a 2-gallon-per-hour kerosene burner (Figure 1). This burner, described in Federal Aviation Administration (FAA) Power Plant Engineering Report No. 3, produces a flame of 2,000°F ± 100°F with a measured total heat flux of 16.3 Btu/ft$^2$ sec of which 11.7 Btu/ft$^2$ sec is radiative and 4.6 Btu/ft$^2$ sec convective (Reference 1). Conditions produced by this burner closely simulate the severity of an actual free-burning kerosene fire. This can be seen by comparing burn-through times of an unprotected aluminum panel with those predicted based on full-scale fire tests (Reference 2). The burner flame was a 6- by 11-inch ellipse.

Thermocouples were provided for measurement of flame temperature, outer shell and interior surface temperature of the test panel and inside air temperature of the steel housing. Flame temperature measurements were made using 22 AWG chromel/alumel thermocouples. Outer shell, interior surface and inside ambient air temperatures were measured using 30 AWG chromel/alumel thermocouples. Temperature measurements were continuously recorded on four Bristol Model 760 Strip-Chart Dynamaster Recorders.

Smoke density measurements within the housing were made with a smoke meter utilizing a light source and a Weston Model 856 photovoltiac cell with spectral sensitivity in the visual range. This meter measures the percentage of light transmitted across a distance of one foot. In order to minimize the effects of smoke stratification, the meter was hung vertically in the center of the test housing. Smoke measurements were continuously recorded on an Esterline Angus Series "S" Multi-range Recorder.

Criteria for evaluation of the test panels was based on the Port of New York and New Jersey Authority Contract No. JFK-410.067 for Second Level Loading Devices (Reference 3).

## Description of Test Panels

Each panel was a specially made 24- by 24-inch section representative of the construction and materials used in some telescoping walkways.

Panel No. 1 - The first panel tested was of the construction and materials used in the side walls of some loading walkways. This panel consisted of a 1/16-inch-thick corrugated steel outer shell (Figure 2), a 3-inch airspace (Figure 3), a 3/4-inch-thick paper honeycomb, and a 1/8-inch-thick inner asbestos panel. Construction was not the same as that for the side walls of a walkway subsequently tested under full-scale conditions.

On this test panel, the outer steel shell was unpainted whereas the exposed metal in the airspace was painted with what appeared to be a red primer coating.

The interior asbestos panel, backed with paper honeycomb, was secured by means of two aluminum trim strips and a sheet metal retainer (Figure 4).

Panel No. 2A - This second panel, shown in Figures 5 and 6, was similar in construction to the floor section of some loading walkways. It was constructed of a 1/16-inch corrugated steel outer shell, similar to Panel No. 1, a 3-inch-thick enclosed airspace and an approximately 3/4-inch-thick plywood subfloor covered with sponge-backed nylon carpet. The carpet was installed in the conventional manner with metal tack strips nailed to the subfloor and the remaining center section glued down. The entire assembly was riveted to the outer shell.

Panel No. 2B - Panel No. 2B, shown in Figures 7 and 8, was similar in construction to Panel No. 2A except that, in this configuration, the steel outer shell was arranged so that there was direct contact between the outer shell and the plywood subfloor thus, in effect, eliminating the 3-inch insulating airspace and creating a "worst case" situation. This modification was deemed justifiable due to the corrugated nature of the floor and wall sections of the loading walkway. This configuration would alternately create an airspace and an area of direct contact between the subfloor and outer shell lengthwise down the walkway.

Panel No. 3 - Figure 9 shows Panel No. 3 installed on the test housing. This panel was similar in construction to the flexible closure canopy of a loading walkway. Material used in this panel included a weather resistant asbestos outer fabric, a noncombustible inner fabric, and a ceramic high-temperature insulation that contained combustible plastic binders. There was no metal used in this panel as it was not intended to be load bearing.

## Test Results

A summary of test results appears in Table 1.

Panel No. 1 - This panel was exposed to the burner flame for the minimum required time of 5 minutes. Temperature data for this panel is shown in Figure 10. Outer shell temperature exceeded the specified 1000°F for principal structural steel parts at 33 seconds. Interior surface temperature exceeded the specified 320°F for interior surfaces after 3 minutes of flame exposure. Ambient air temperature, due to the small exposure surface and relatively large air volume for the test configuration, did not exceed 95°F for the duration of the test. However in a full-scale test, with the structure surrounded on all sides by flame, this temperature could be expected to be higher.

Although heavy smoke was observed pouring out from the unsealed edges of the test panel, little smoke was measured inside the test chamber. This was mostly due to the asbestos interior paneling acting as a barrier against smoke penetration. Immediately following the development of a crack in the inner panel, smoke was observed entering the test chamber. In a full-scale fire situation, smoke could be expected to enter the interior of the walkway from top or bottom edges where the wall panel meets the ceiling and floor panels, unless these edges were sealed. In this test, however, smoke caused only an 18-percent obscuration of light.

Figure 11 shows the honeycomb reinforcement following flame exposure. As can be seen, the paper honeycomb facing was completely consumed and the core charred. This apparently caused the large amounts of smoke and aided in raising the interior surface temperature.

Figure 12 shows the interior surface of this panel after flame exposure.

Panel No. 2A - This panel was exposed to the burner flame for 15 minutes. Figure 13 shows the temperature data for this panel. Outer shell temperature exceeded the specified 1000°F for principal structural steel parts at 40 seconds. Rear surface temperature remained below the specified 320°F for the entire 15-minute test. Ambient air temperature inside the test chamber did not exceed 85°F for the 15-minute test. Temperatures at 5 minutes for the interior surface and ambient air were 85°F and 80°F, respectively. These rather low temperatures were due mainly to the charring of the 3/4-inch-thick plywood subfloor to a depth of approximately 1/2 inch, as shown in Figure 14, forming a low conductivity thermal insulation and, in part, due to the 3-inch insulating airspace existing in this panel configuration. Figure 15 shows no flame or heat damage to the nylon rug. Temperature measured under the rug at 5 minutes was only 100°F. It should be noted, however, that in an actual in-use fire situation, this charred subfloor would not be able to support deplaning passengers, as indicated by its failure to withstand even light hand pressure after the fire test. Furthermore, any fissures that develop in this subfloor will become a passageway for smoke, toxic gases, and heat.

During this 15-minute test, there was no smoke detected inside the test chamber.

Panel No. 2B - A test on this panel was conducted to determine the insulating effect of the airspace between the outer shell and the subfloor that exists on Panel No. 2A.

Flame exposure for this configuration lasted 10 minutes. As expected, this configuration caused a slightly greater heat flux to the interior surface as indicated by higher surface and ambient air temperatures. However the increased heat flux did not cause these temperatures to exceed those specified in Reference 3.

As shown in Figure 16, interior temperature for this panel reached 100°F at 5 minutes with ambient chamber temperatures reaching 95°F. During the first 5 minutes of the test no smoke entered the chamber. Only a small amount of smoke indicated by less than 5-percent light obscuration developed during the latter half of the test. Figure 17 shows no rug damage after the 10-minute test.

Panel No. 3 - Front and rear views of the panel, after flame exposure, are shown in Figures 18 and 19. This panel was exposed to the burner flame for 10 minutes. Temperature data for this test is shown in Figure 20.

Due to the nonload bearing nature of this material, outer surface temperature measurements were not considered. As can be seen, interior surface temperature exceeded the specified 320°F at 4 minutes. Again, ambient air temperature inside the test chamber remained low reaching only 110°F at 5 minutes and a maximum of 130°F at the end of the 10-minute test.

Figure 21 shows flames and smoke coming from the front surface of the panel at the onset of the test. This was due to the burning of the weather resistant coating on the exterior fabric.

A rapid and large buildup of smoke indicated by 82-percent light obscuration was reached at 5 minutes. This large quantity of smoke was generated by the pyrolysis of plastic binders used in the insulation.

Summary of Evaluation

The test results indicate that, using the criteria set forth in Reference 3, the panel construction did not provide a minimum of 5-minutes protection. In all cases the panels tested failed to remain below the specified temperature limit for either structural steel parts or exposed interior surfaces. Smoke generated by combustible materials used in the fabrication of the sidewall section and flexible closure canopy was sufficient to present a possible hazard to passengers.

Although it did not appear from temperature measurements in the small-scale tests, the potential for a hazardous condition still exists due to the combustible materials used in the floor sections. The charring of the plywood subfloor could weaken it sufficiently to endanger deplaning passengers. In addition, fissures that develop through the subfloor would permit smoke, toxic gases, and heat to enter the interior of the walkway causing a further hazard.

## REFERENCES


1. Sarkos, C. P., "Evaluation of AVCO/NASA Rigid Foam as a Fire Barrier for Cabin Protection," Federal Aviation Administration, Data Report No. 70, April 1970.

2. Geyer, G. B., "Effect of Ground Crash Fire on Aircraft Fuselage Integrity," Federal Aviation Administration, Report NA-69-37, December 1969.

3. The Port of New York and New Jersey Authority, "Contract JFK-410.067 John F. Kennedy International Airport- International Arrival and Airline Wing Buildings - Expansion - Second Level Loading Devices," May 1969.

TABLE 1 - DATA SUMMARY - AIRCRAFT LOADING WALKWAY PANELS

| Panel No. | Description | Burner Exposure Time (min) | Weight (lbs) Before | Weight (lbs) After | Temperature of Significant Points at 5 min: Outer Surface °F | Interior Surface °F | Ambient Air Inside Housing °F | Smoke Obscuration % at 5 min | Meets PNY/NJA * Requirements | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Wall Section<br>Outer Shell - 1/16-in. steel with 3/8-in. reinforcement on top and bottom.<br>Interior Wall - asbestos board with paper honeycomb backing | 5 | 43.1 | 42.8 | 1800 | 520 | 95 | 18 | No | Heavy smoke poured out from between shell and interior panel.<br>Interior panel cracked allowing smoke to enter chamber. |
| 2A | Floor Section<br>Outer Shell - 1/16-in. steel with 3/8-in. reinforcement on outer edges.<br>Interior - red nylon rug backed with neoprene padding.<br>3/4-in. plywood subfloor<br>Approximately 3-in. airspace between outer shell and subfloor. | 15 | 47.5 | -- | 1650 | 100 | 80 | less than 5 | No | Moderate smoke poured from between shell and subfloor. |
| 2B | Modified Floor Section<br>Similar to Panel 2A except modified to simulate an adjacent recessed panel. | 10 | 48.3 | -- | 1700 | 110 | 105 | less than 5 | No | Heavy smoke poured out from between shell and subfloor.<br>Flame on edges of subfloor. |
| 3 | Flexible Closure Canopy<br>Flexible asbestos fabric with weather resistant coating on outer side.<br>High-temperature ceramic insulation with plastic binders approximately 3/4-in. thick between inner and outer fabric. | 10 | 3.2 | 2.5 | N.A. | 350 | 110 | 82 | No | Smoke and flame from front surface of material.<br>Rapid buildup of smoke on inside of chamber after 2 min. |

* NOTE - Port of N.Y. and N.J. Authority Contract No. J.F.K.-410.067 - Specifications for second level loading devices; Fire Protection and Safety Requirements

a. 2300°F fire exposure for 5 minutes....without raising temperature of structural steel parts above 1000°F.

b. 1800°F fire exposure for 5 minutes without raising the temperature of exposed interior surface above 320°F.

c. Keeping ambient air temperature inside the structure under 250°F at the end of 5 minutes of fire exposure.

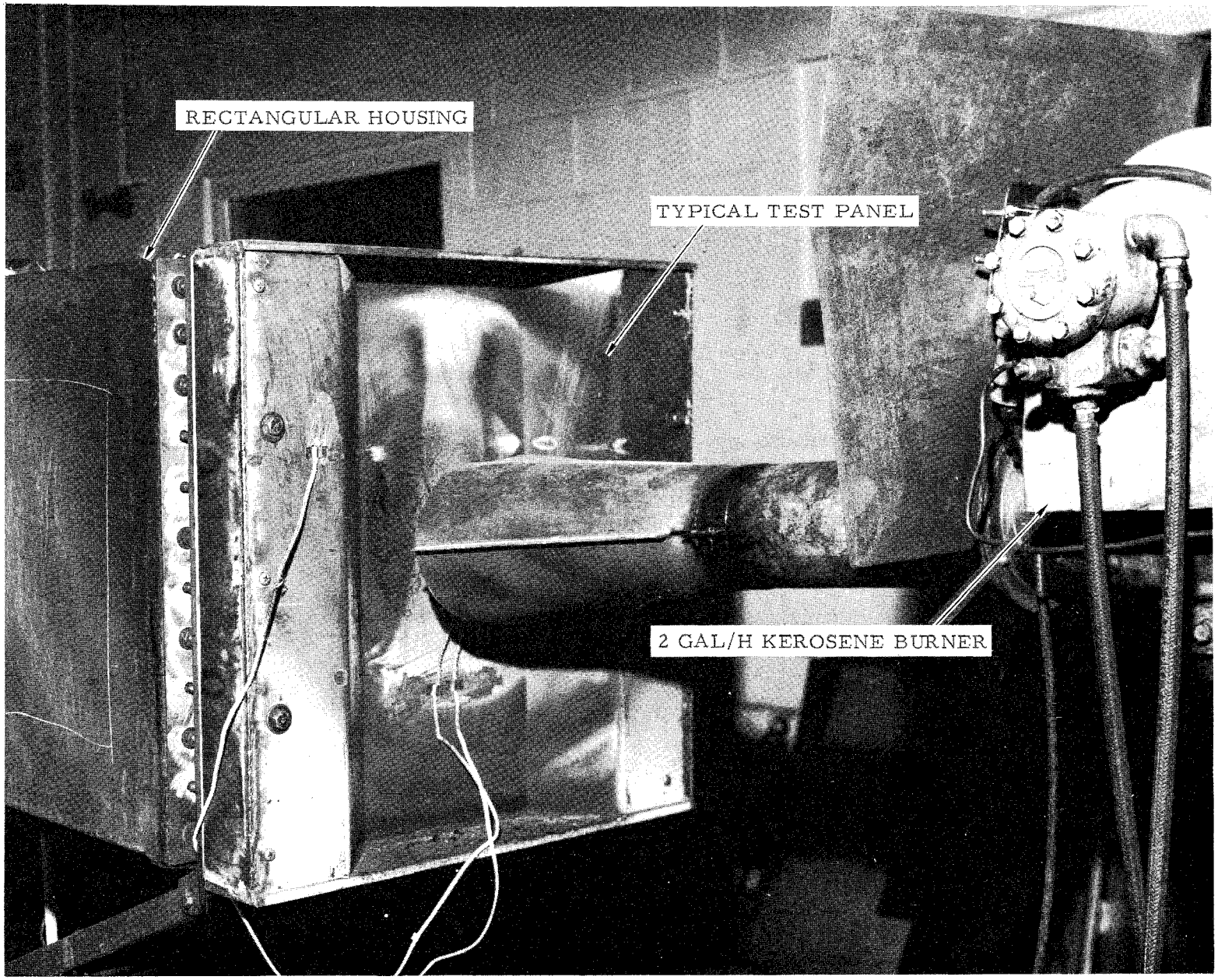


FIGURE 1. FIRE TEST SETUP FOR EVALUATION OF AIRCRAFT LOADING WALKWAY PANELS

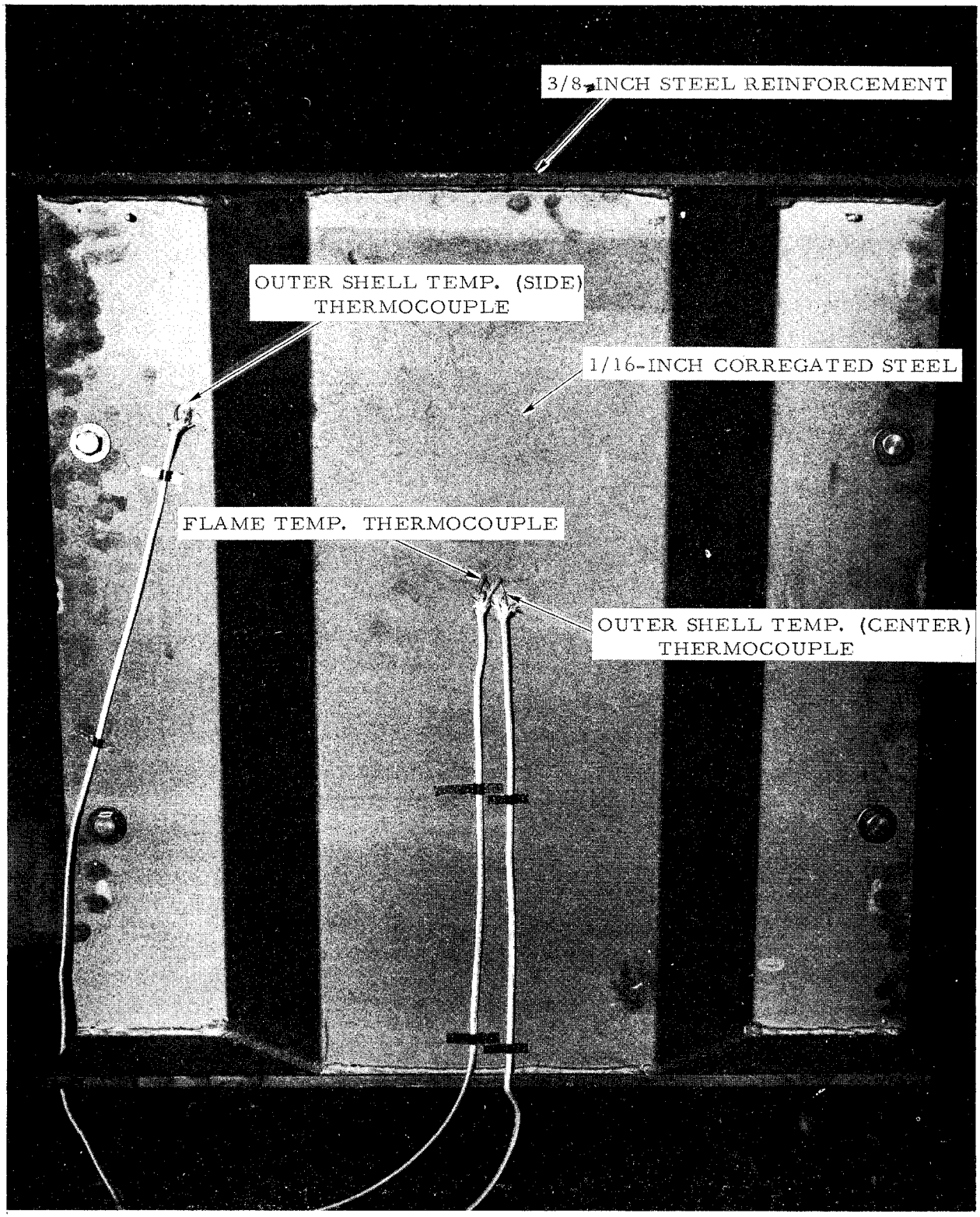


FIGURE 2. OUTER SHELL FOR PANELS NOS. 1 AND 2

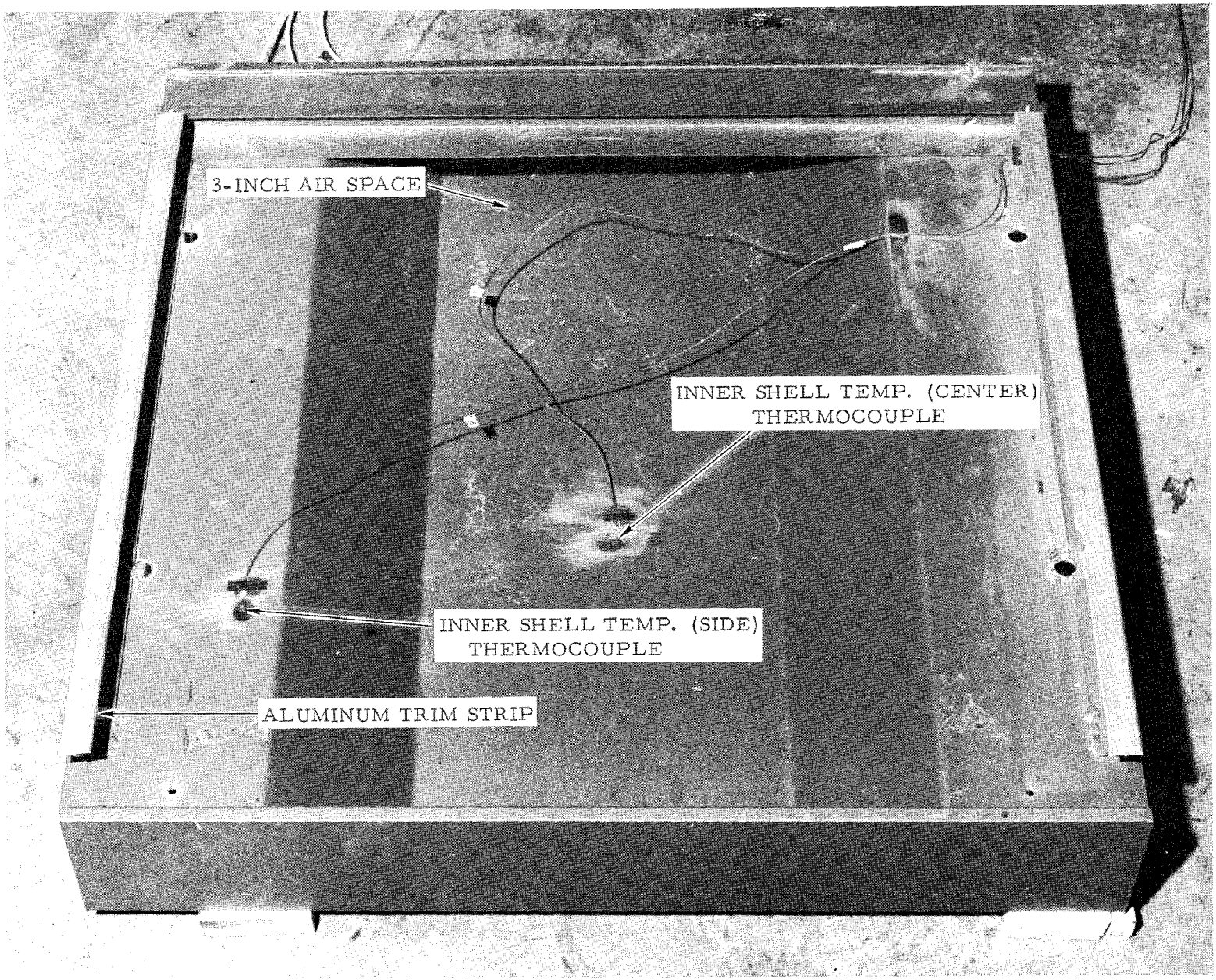


FIGURE 3. PANEL NO. 1 - WALL SECTION WITH INTERIOR ASBESTOS PANEL REMOVED

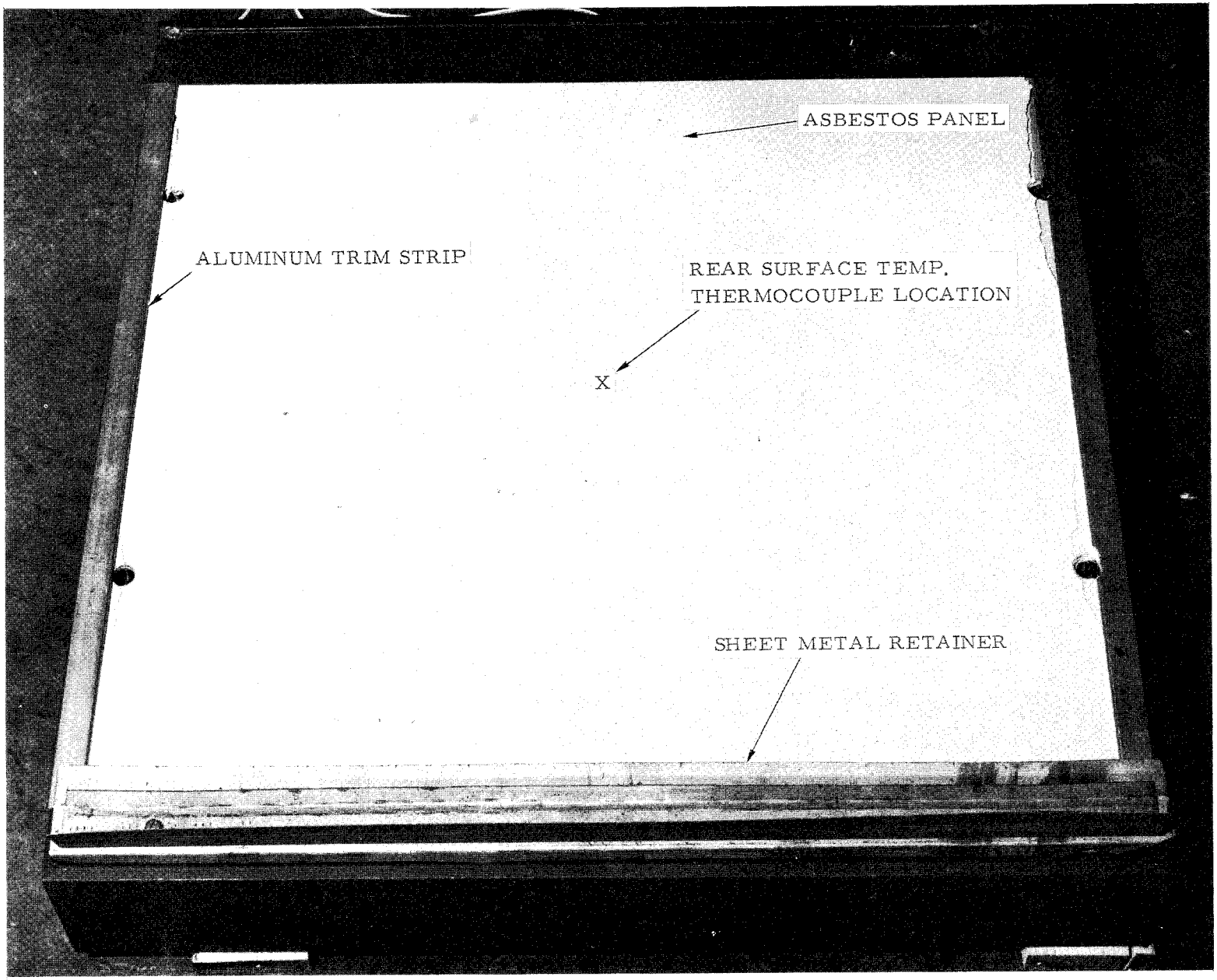


FIGURE 4. PANEL NO. 1 - WALL SECTION INTERIOR ASBESTOS PANEL BEFORE FLAME EXPOSURE

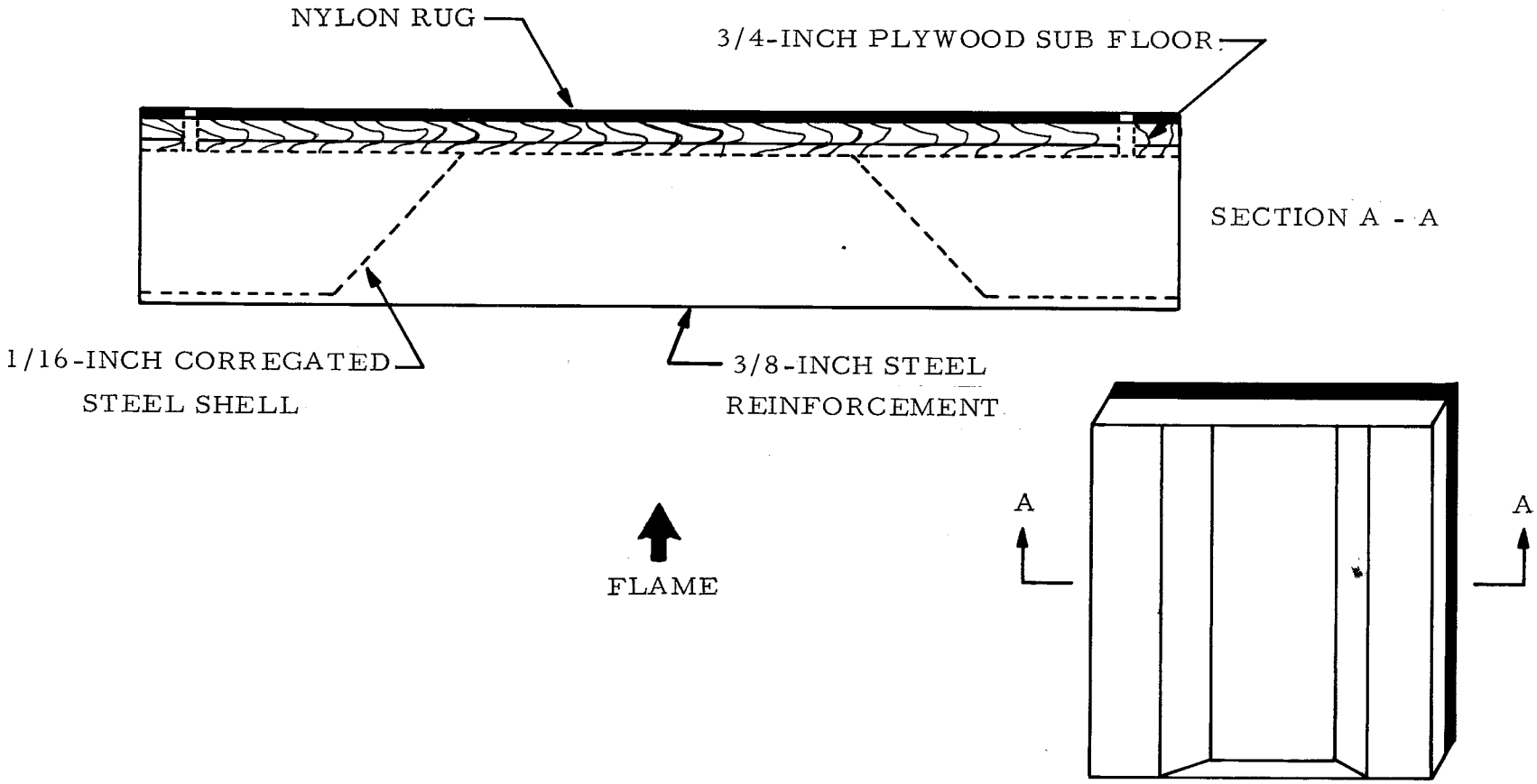


FIGURE 5. PANEL NO. 2A - SECTION VIEW OF FLOOR PANEL AS RECEIVED

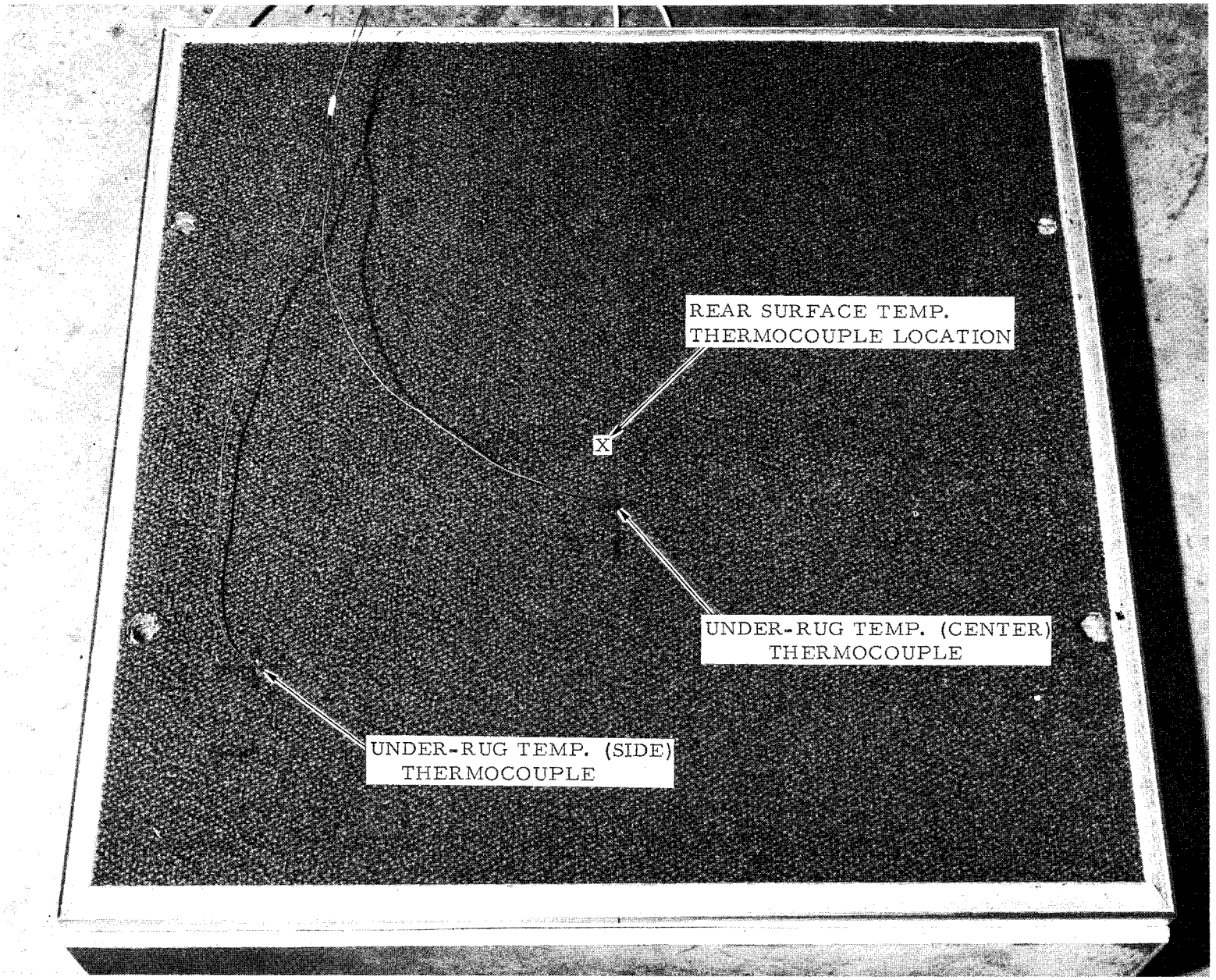


FIGURE 6. PANEL NO. 2A - FLOOR SECTION - NYLON CARPET BEFORE FLAME EXPOSURE

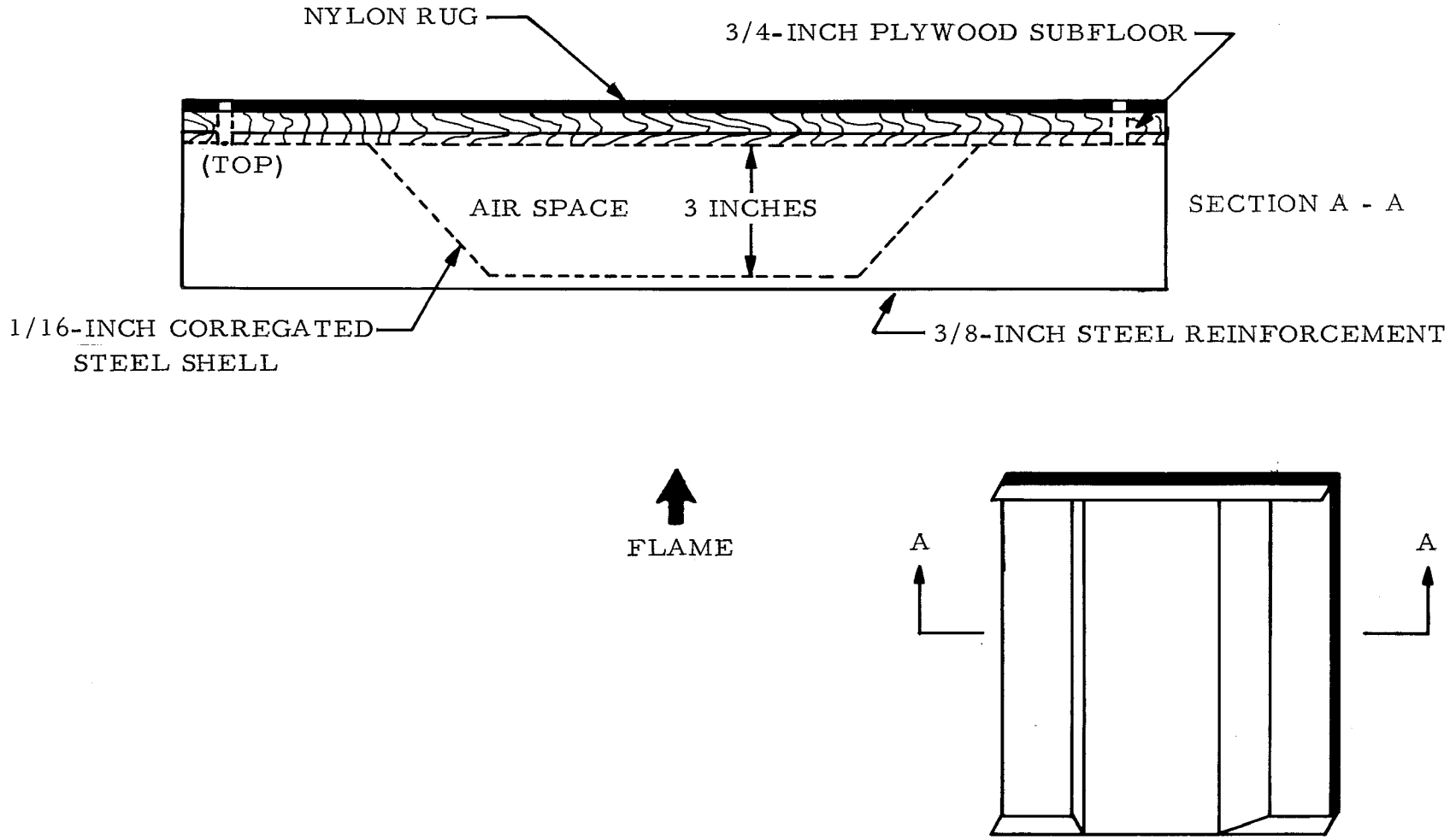


FIGURE 7. PANEL NO. 2B - SECTION VIEW OF MODIFIED FLOOR PANEL

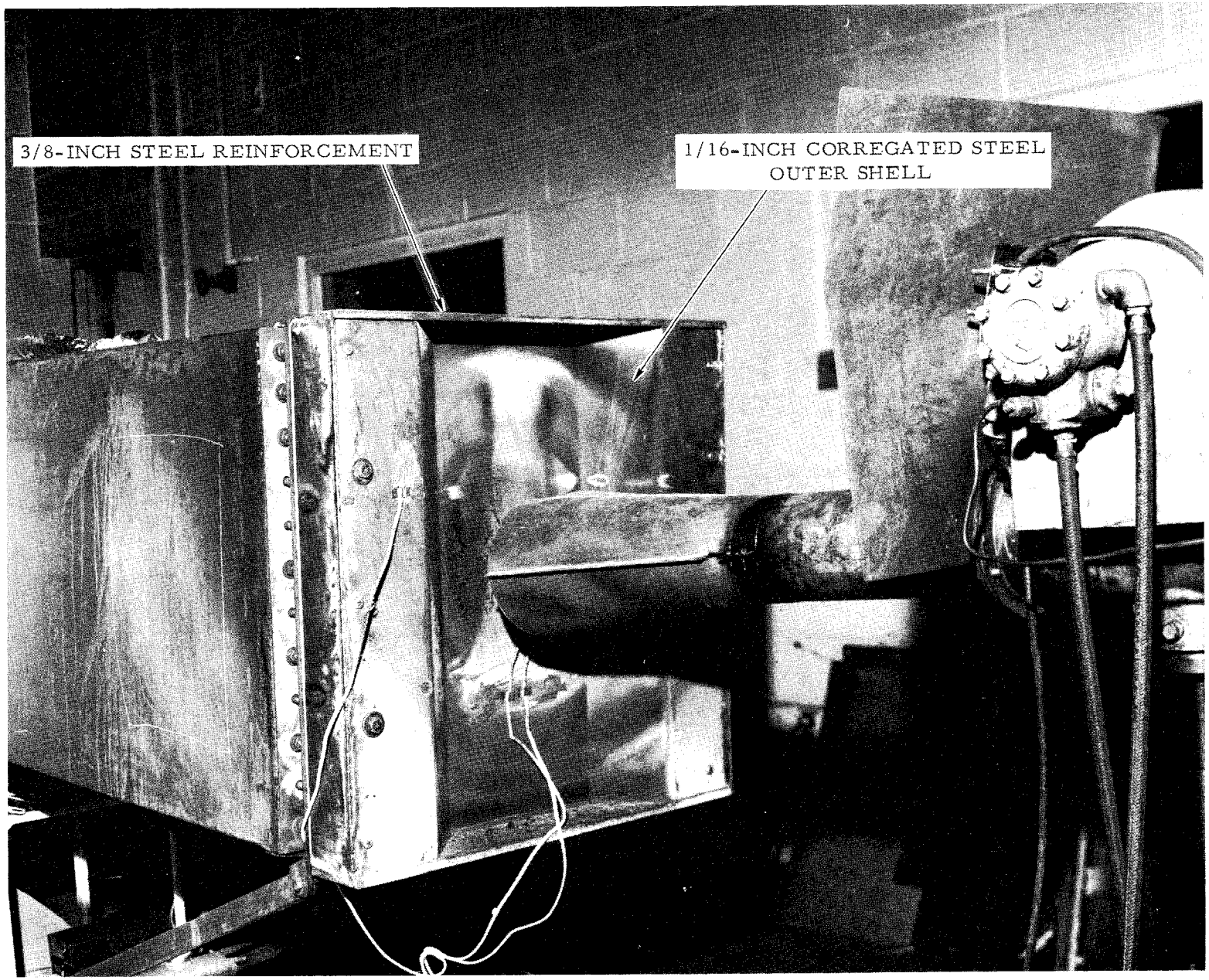


FIGURE 8. PANEL NO. 2B - OUTER SHELL OF MODIFIED FLOOR PANEL

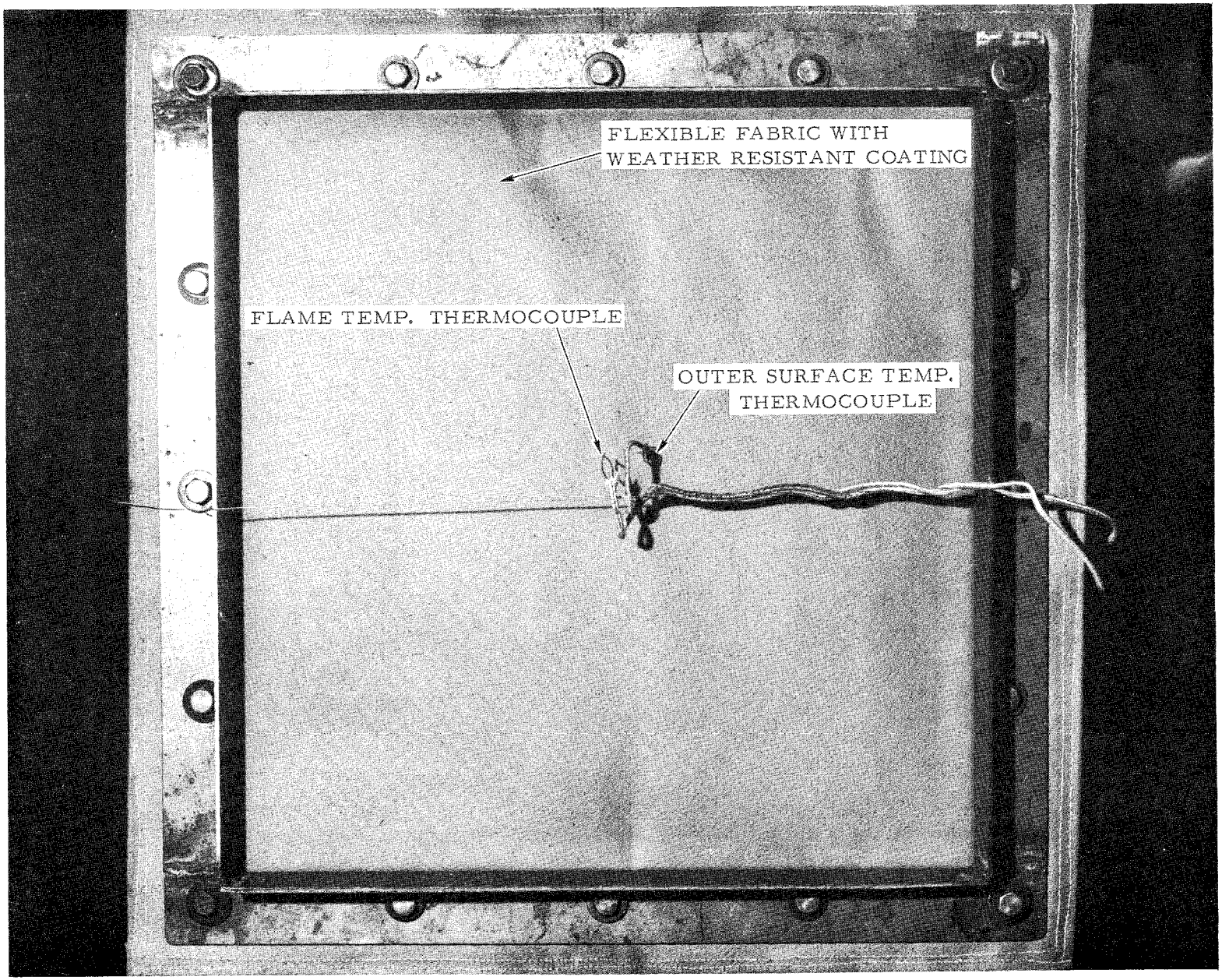


FIGURE 9. PANEL NO. 3 - FLEXIBLE CLOSURE CANOPY BEFORE FLAME EXPOSURE

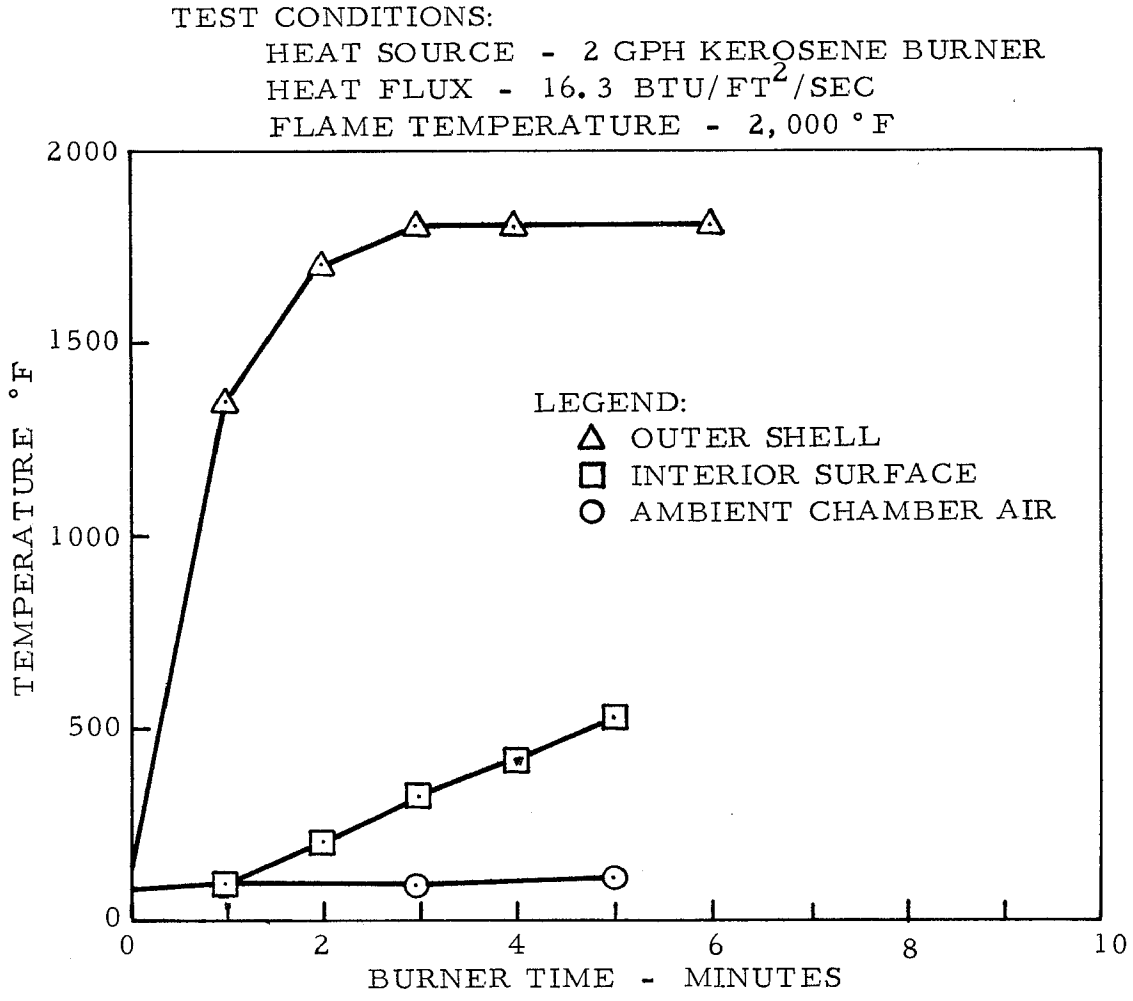


FIGURE 10. TEMPERATURE DATA FOR PANEL NO. 1 - WALL SECTION OF AIRCRAFT LOADING WALKWAY

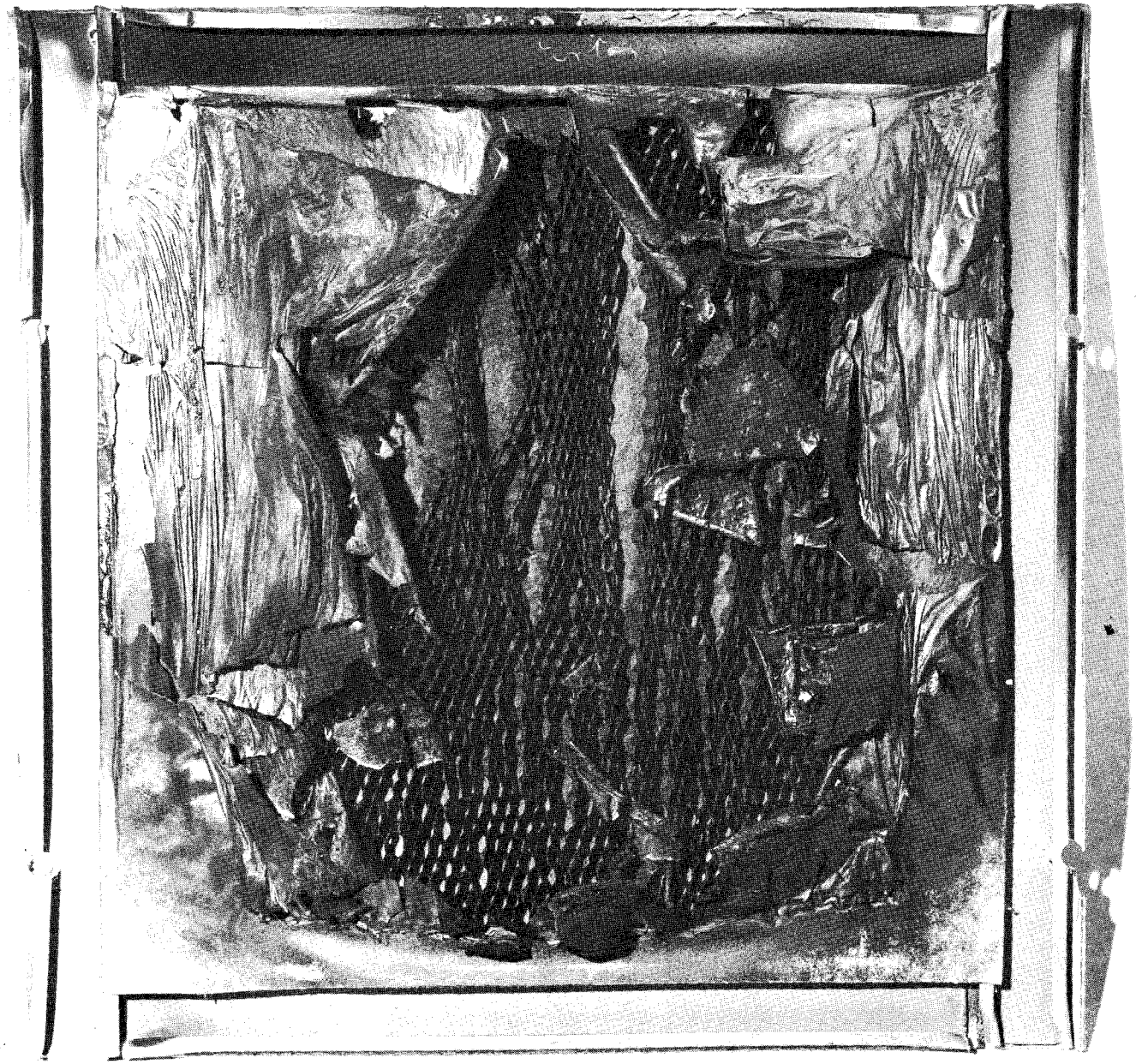

FIGURE 11. PANEL NO. 1 - HONEYCOMB REINFORCEMENT AFTER FIVE MINUTES FLAME EXPOSURE

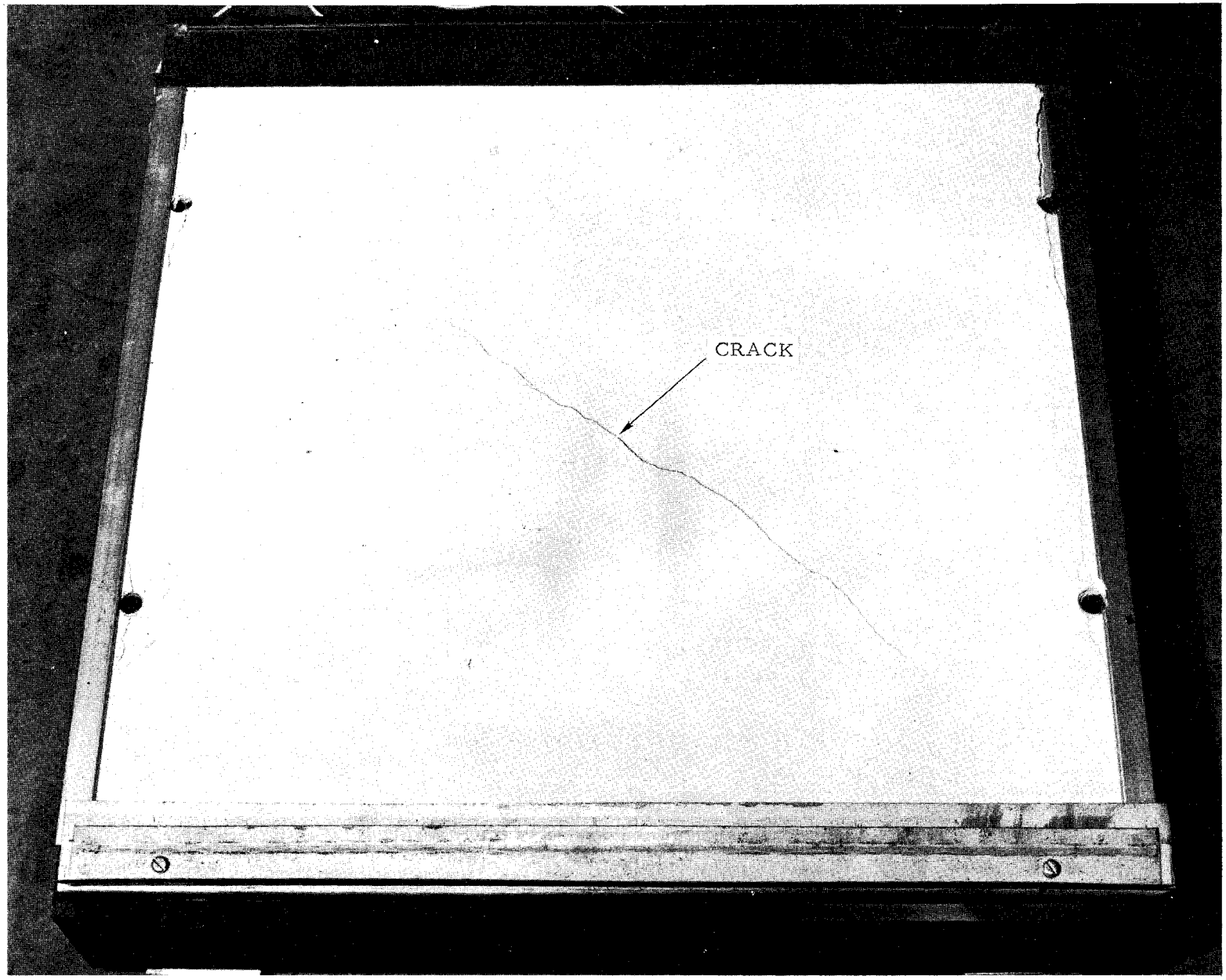


FIGURE 12. PANEL NO. 1 - WALL SECTION - INTERIOR ASBESTOS PANEL AFTER FIVE MINUTES FIRE EXPOSURE

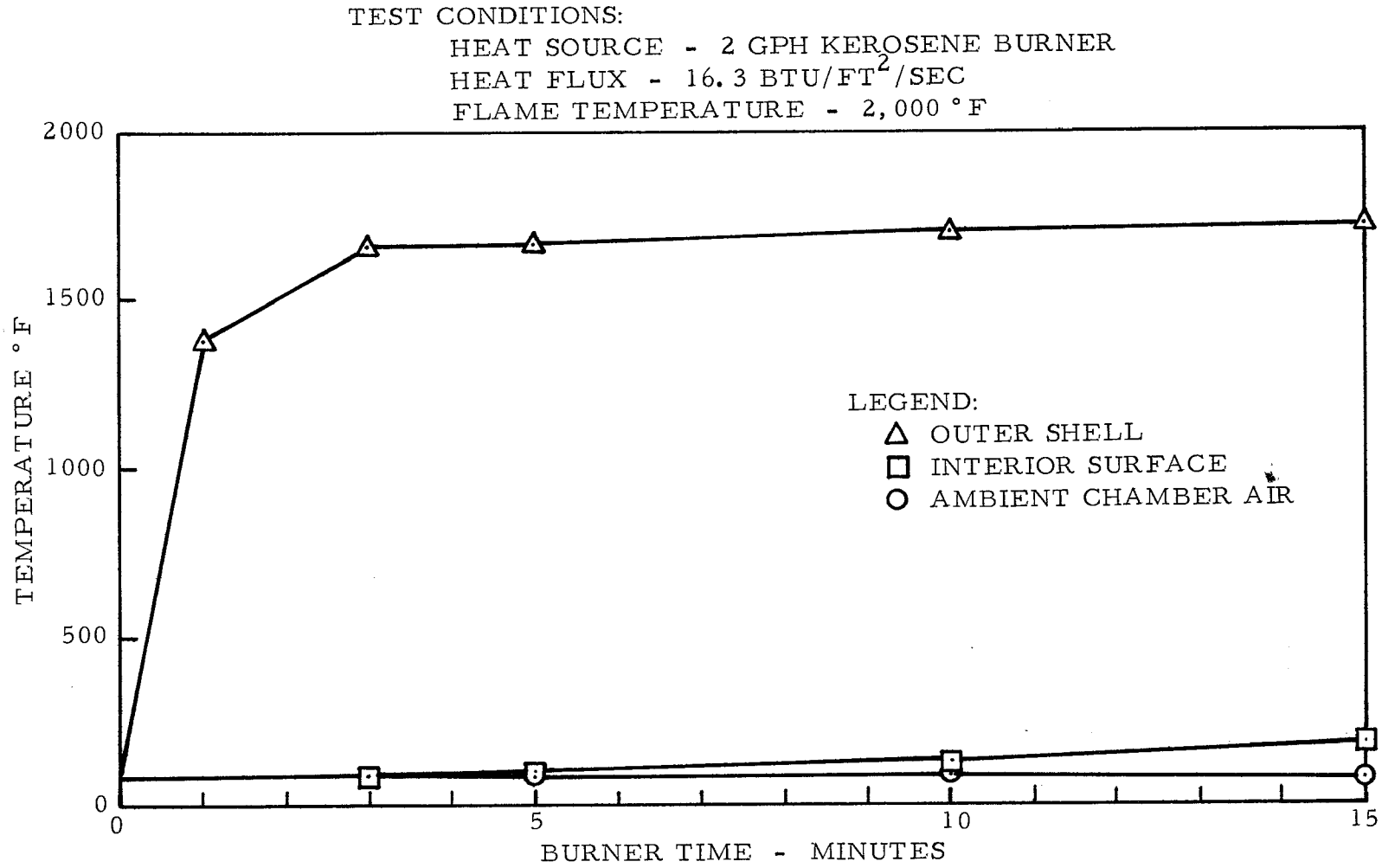


FIGURE 13. TEMPERATURE DATA FOR PANEL NO. 2A - FLOOR SECTION OF AIRCRAFT LOADING WALKWAY

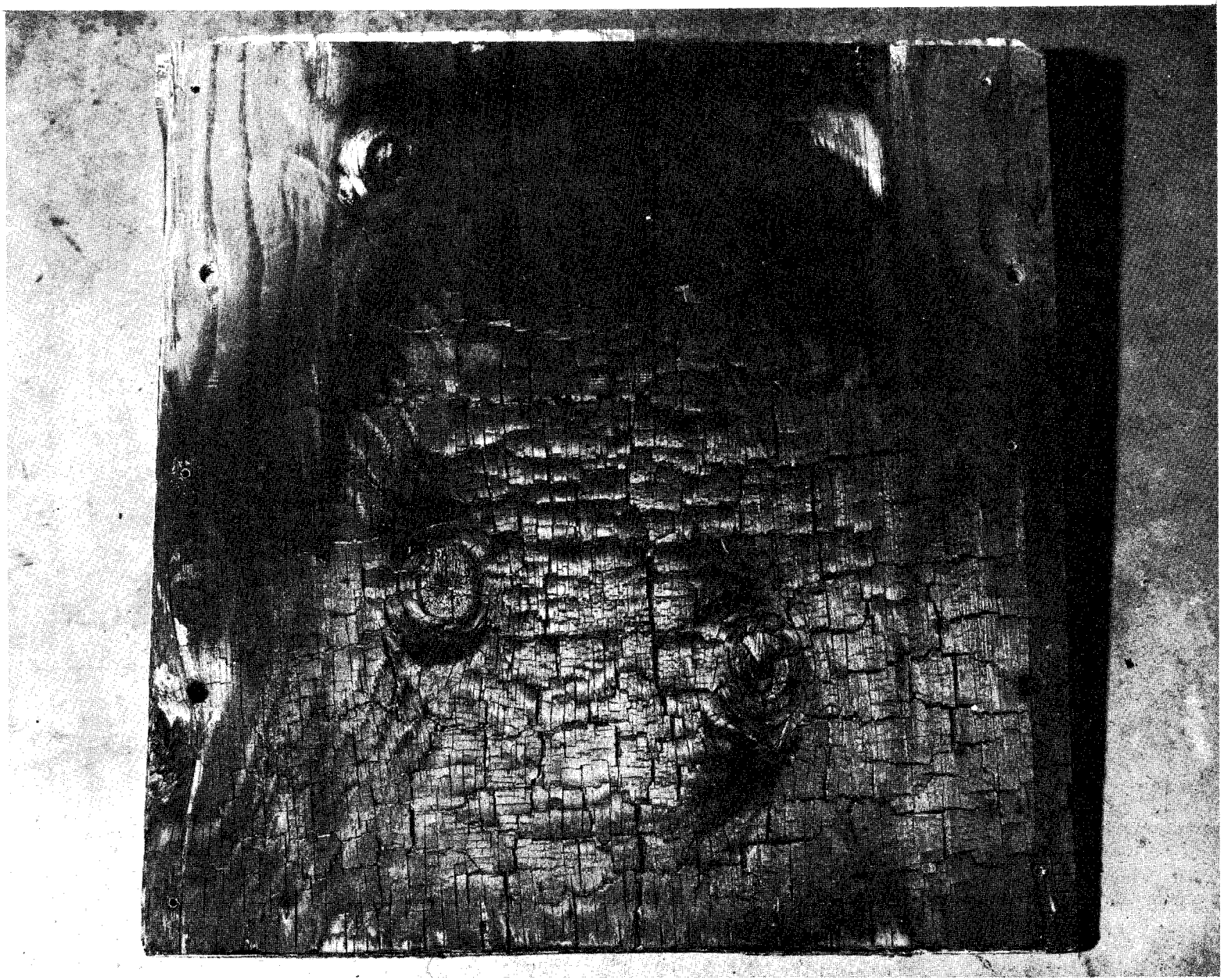

FIGURE 14. PANEL NO. 2A - 3/4-INCH-THICK PLYWOOD SUBFLOOR AFTER 15 MINUTES FIRE EXPOSURE

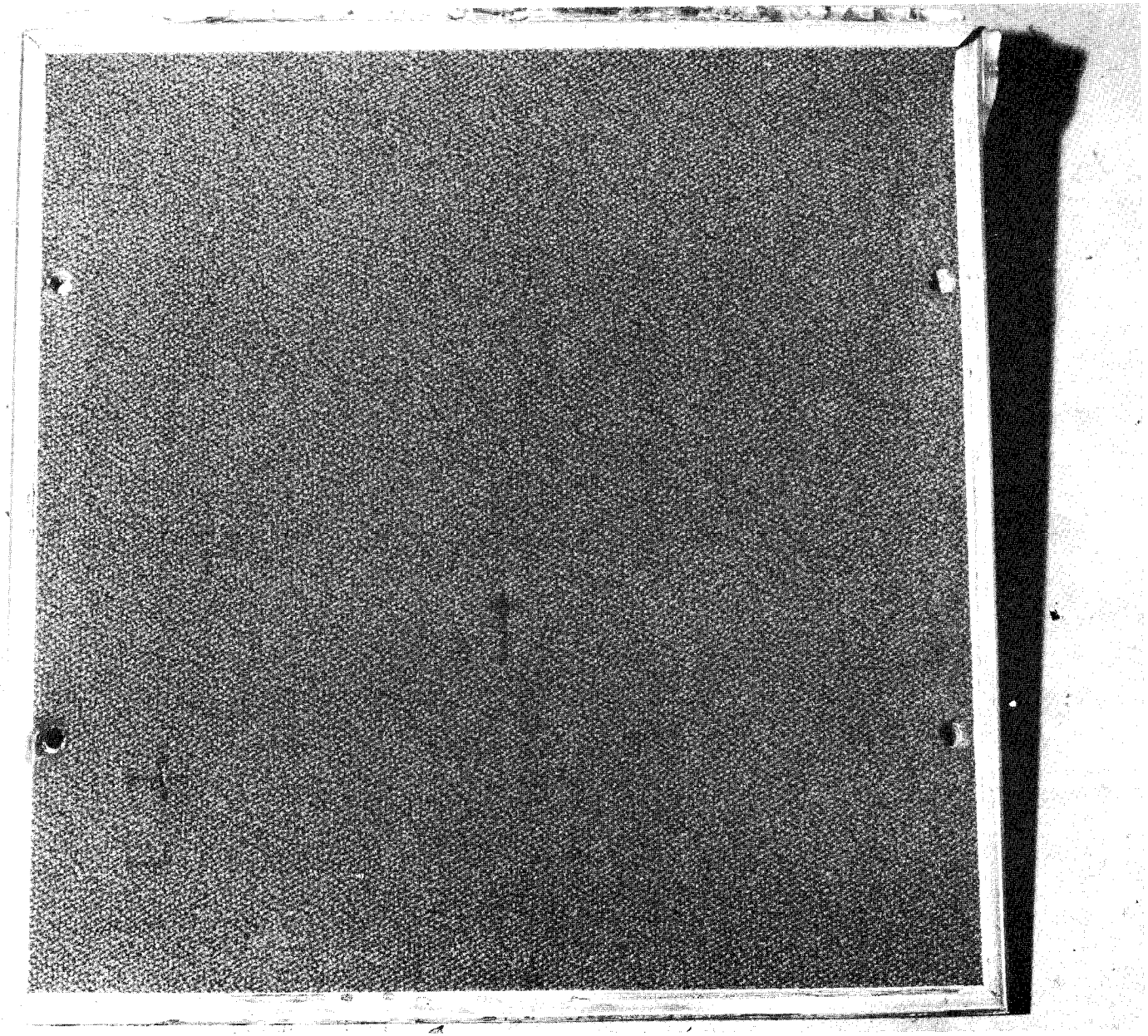

FIGURE 15. PANEL NO. 2A - FLOOR SECTION - NYLON RUG AFTER 15 MINUTES FLAME EXPOSURE

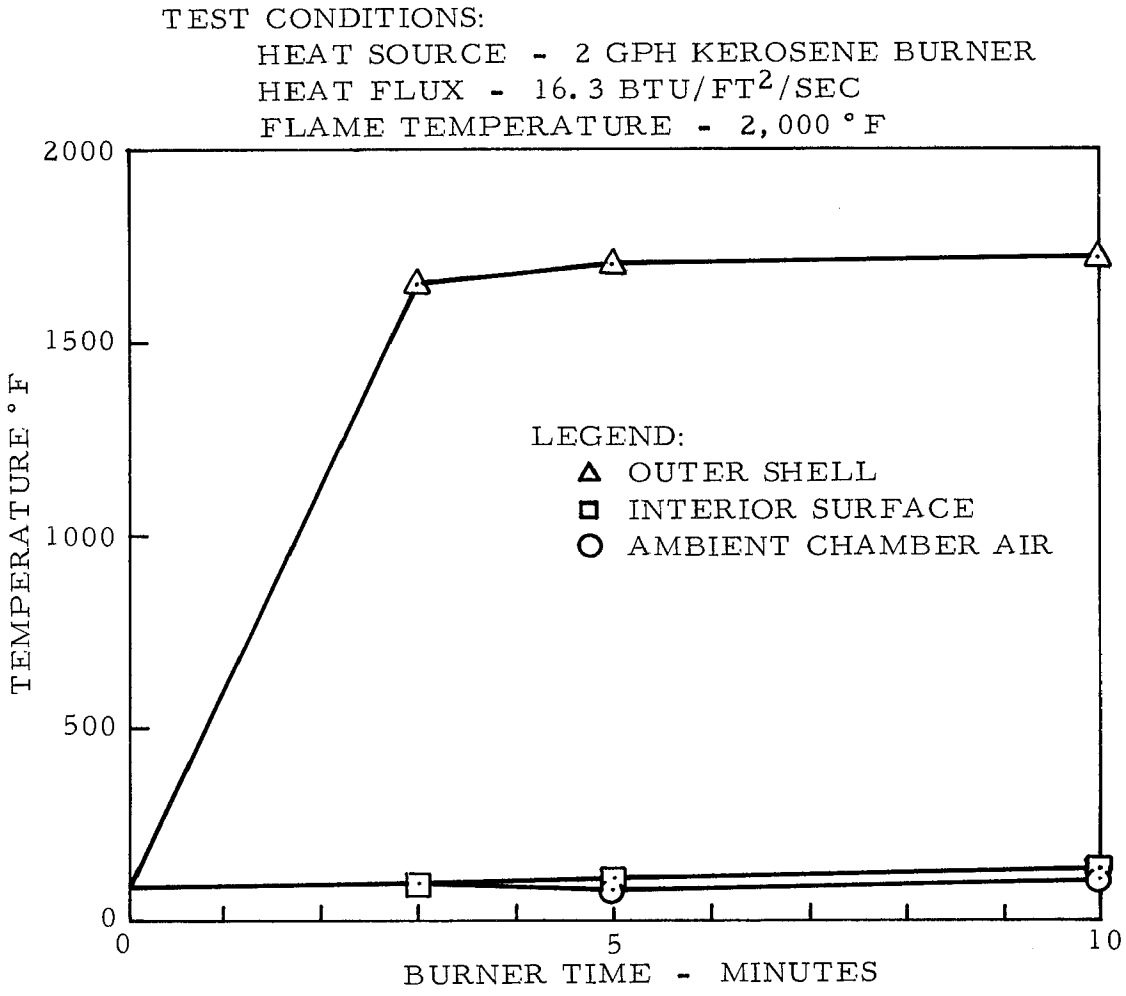


FIGURE 16. TEMPERATURE DATA FOR PANEL NO. 2B - MODIFIED FLOOR SECTION OF AIRCRAFT LOADING WALKWAY

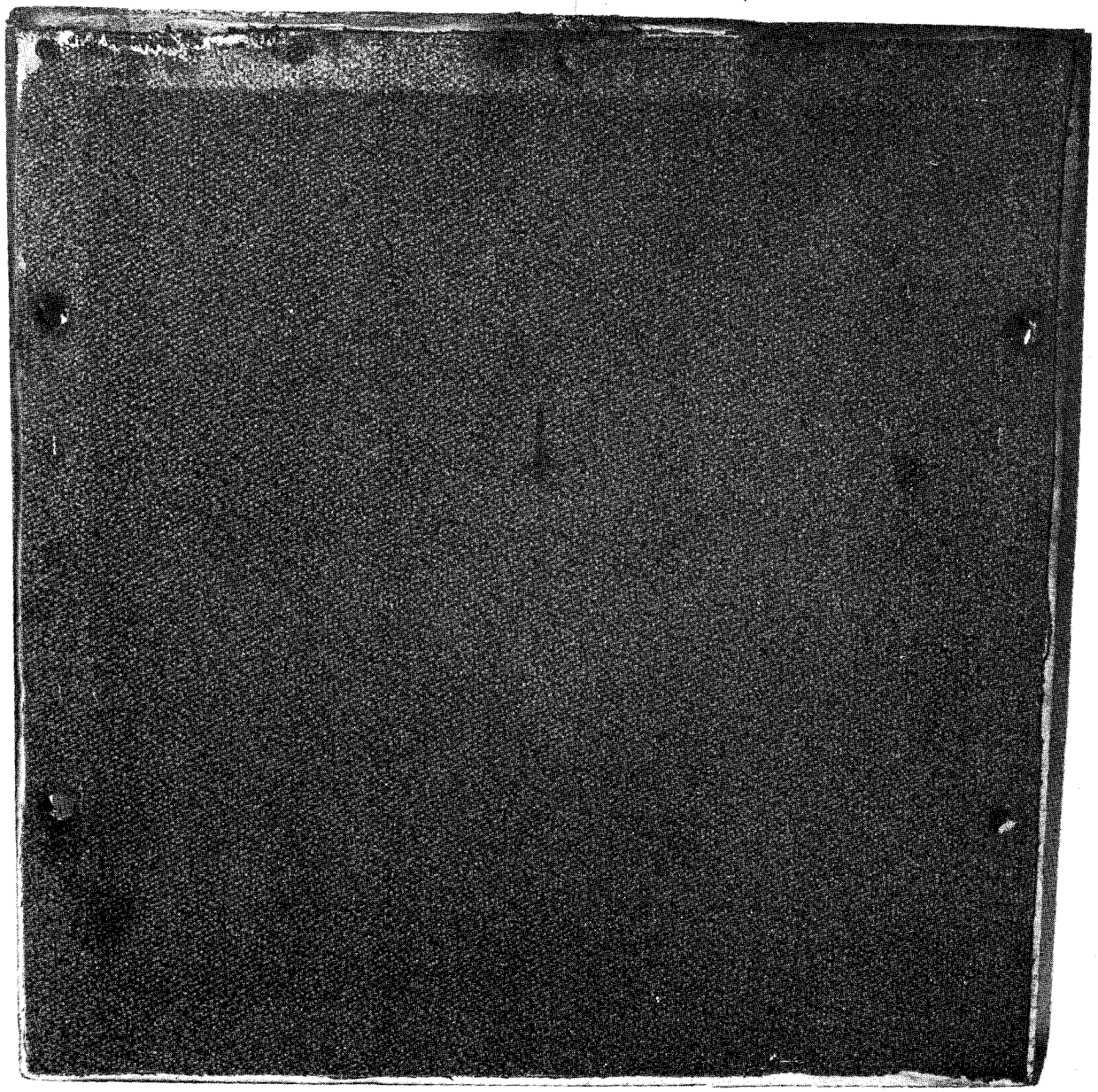

FIGURE 17. PANEL NO. 2B - MODIFIED FLOOR SECTION - NYLON RUG AFTER TEN MINUTES FLAME EXPOSURE

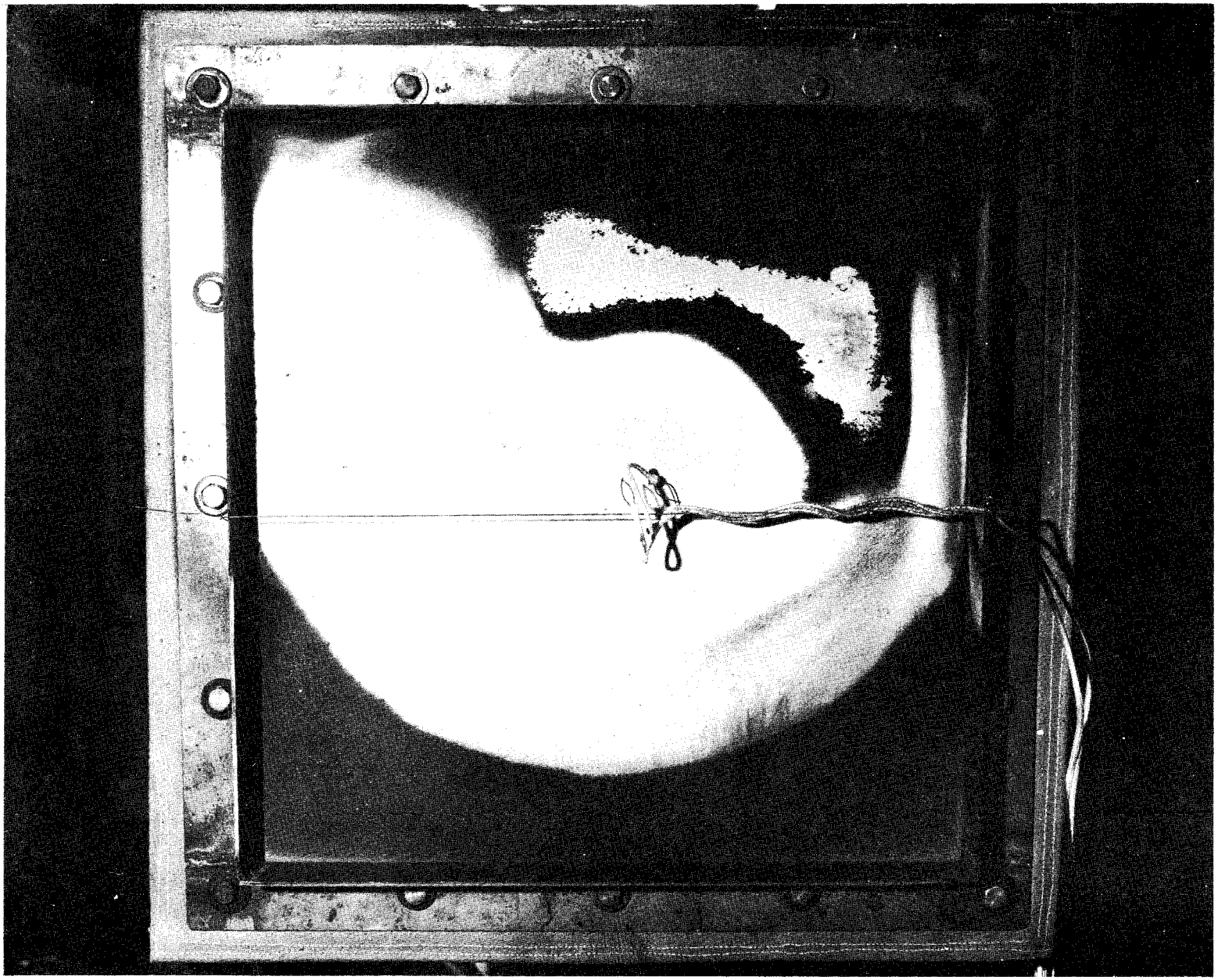

FIGURE 18. PANEL NO. 3 - FLEXIBLE CLOSURE CANOPY - FRONT VIEW AFTER TEN MINUTES FLAME EXPOSURE

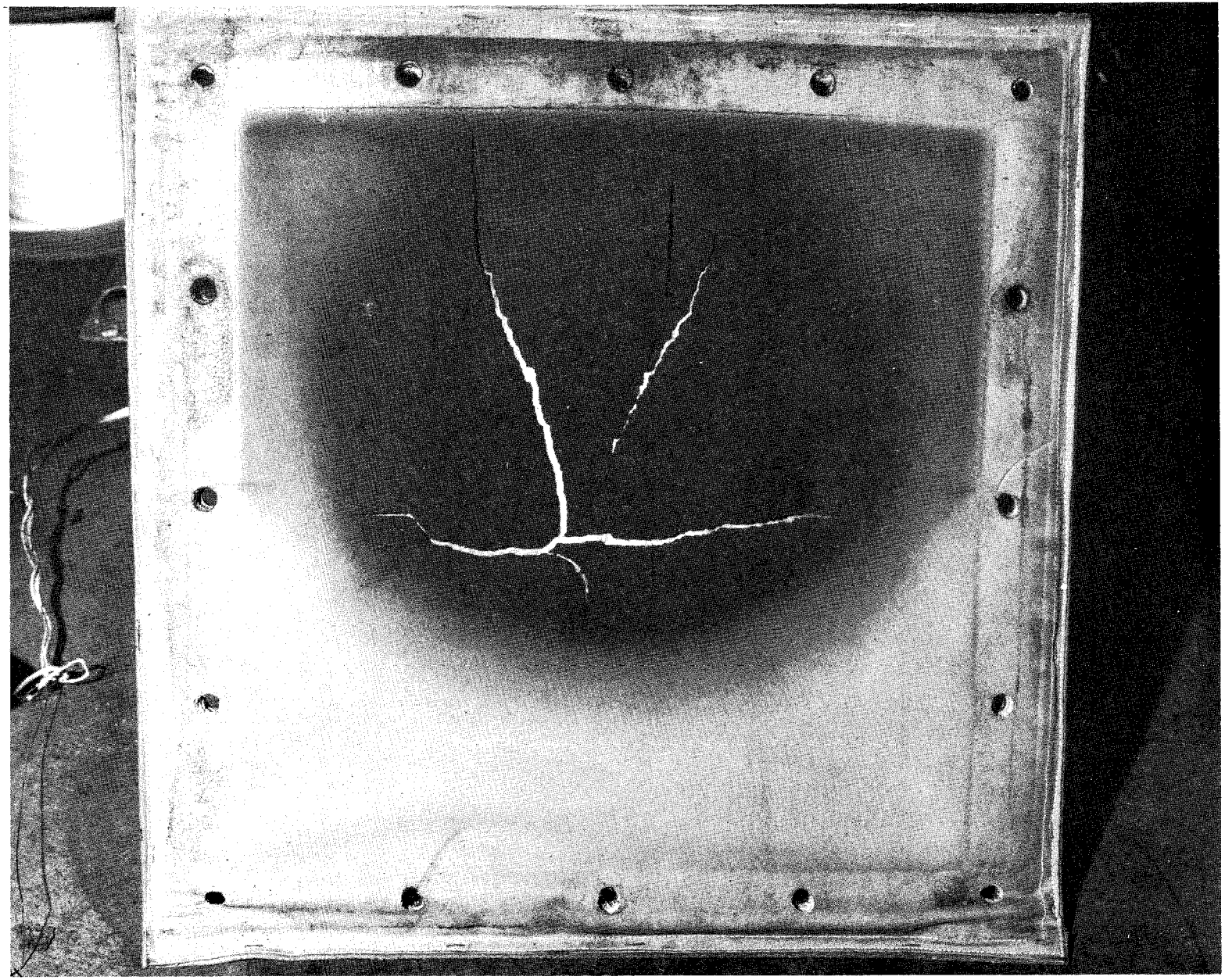

FIGURE 19. PANEL NO. 3 - FLEXIBLE CLOSURE CANOPY - REAR VIEW AFTER TEN MINUTES FLAME EXPOSURE

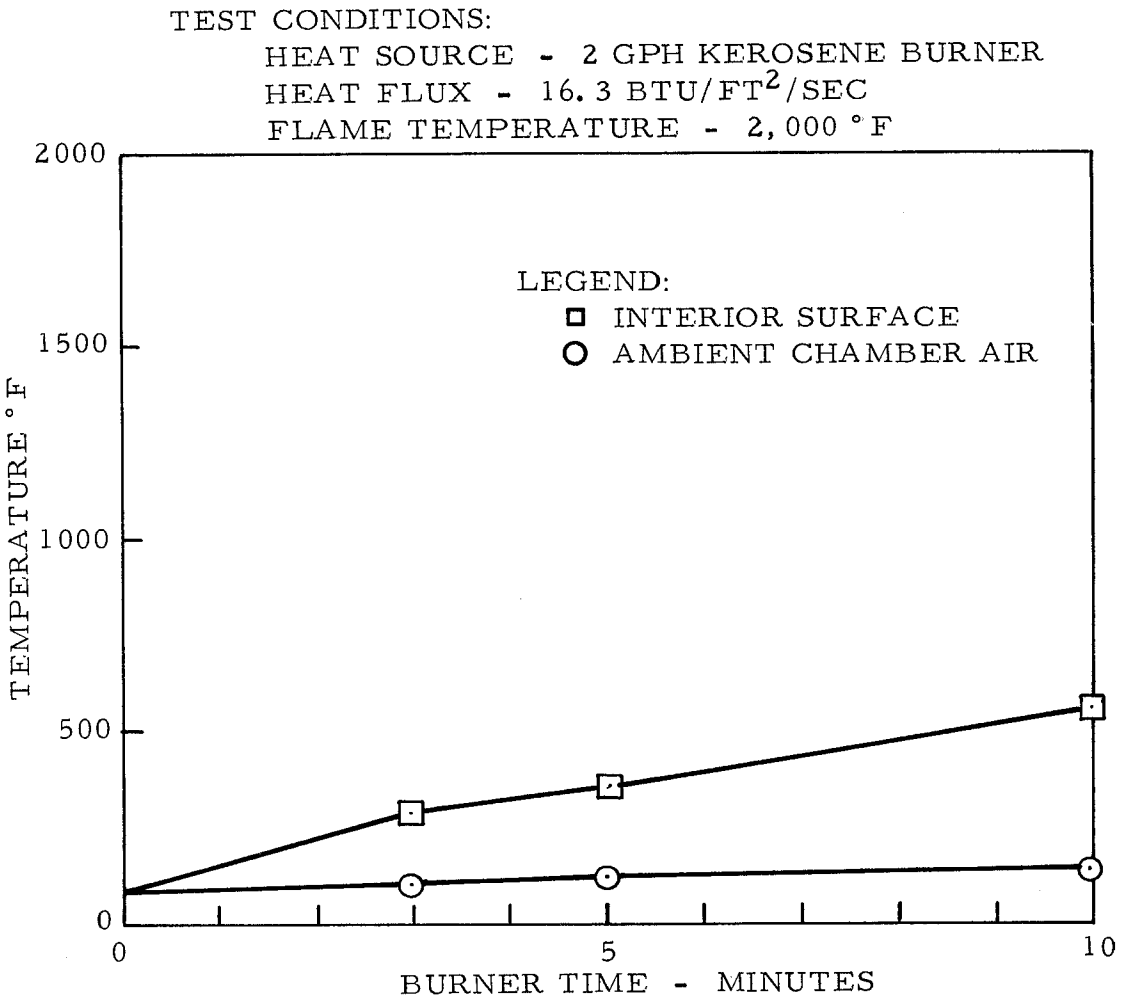


FIGURE 20. TEMPERATURE DATA FOR PANEL NO. 3 - FLEXIBLE CLOSURE CANOPY OF AIRCRAFT LOADING WALKWAY

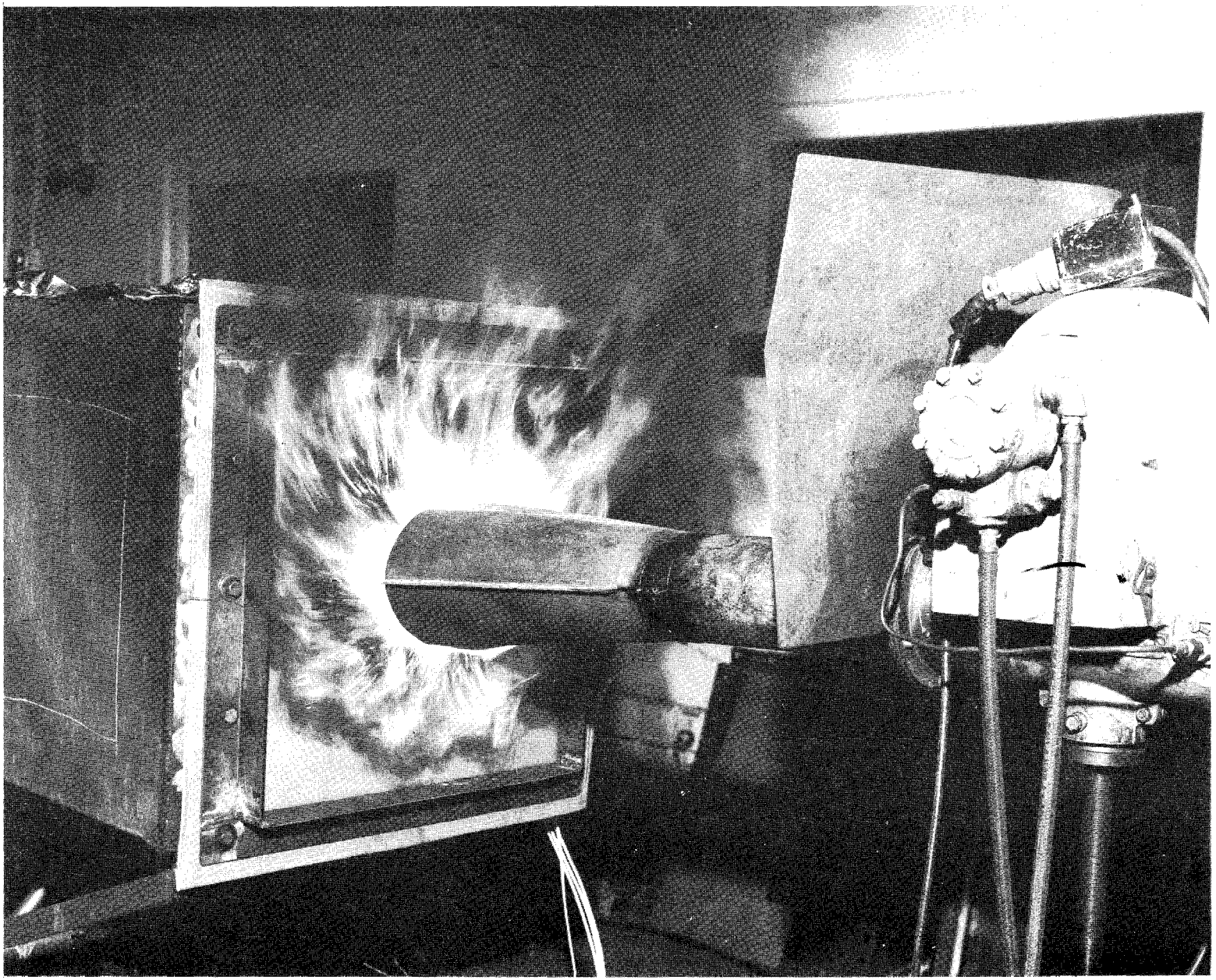

FIGURE 21. PANEL NO. 3 - FLEXIBLE CLOSURE CANOPY AT APPROXIMATELY 30 SECONDS INTO TEST