NATIONAL BUREAU OF STANDARDS REPORT

10 340

SIMULATED SOLAR HEAT TEST OF MUST WARD CONTAINERS

Report to

U. S. Army Natick Laboratories
Natick, Massachusetts

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

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THE INSTITUTE FOR BASIC STANDARDS provides the central basis within the United States of a complete and consistent system of physical measurement; coordinates that system with measurement systems of other nations; and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. The Institute consists of an Office of Measurement Services and the following technical divisions:

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> Reactor Radiation—Linac Radiation—Nuclear Radiation—Applied Radiation.

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> Office of Standard Reference Data—Clearinghouse for Federal Scientific and Technical Information [3]—Office of Technical Information and Publications—Library—Office of Public Information—Office of International Relations.

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Located at Boulder, Colorado 80302.
[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

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SIMULATED SOLAR HEAT TEST OF MUST WARD CONTAINERS

J. W. Grimes, W. J. Mulroy and T. W. Reichard
Building Research Division
Institute for Applied Technology

Report to

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Simulated Solar Heat Test of MUST Ward Containers

by

J. W. Grimes, W. J. Mulroy and T. W. Reichard

1. Introduction

The Building Research Division of the National Bureau of Standards was requested by the Army Natick Laboratories (NLABS) through Project Order No. AMXRED 70-180 dated June 10, 1970, part (b) Test Plan dated June 4, 1970, to determine if heating of the exterior skins to 180 °F will induce delamination in the sandwich panels of two MUST (Medical Unit, Self-Contained, Transportable) Ward Container Units. The temperature of 180 °F was selected to represent conditions that could occur under solar heating.

2. Background

The Army has procured a number of these Ward Containers which have exhibited delamination in the sandwich panels shortly after acceptance. Figure 1 is a picture of a Ward Container found to be delaminated after delivery to the Atlanta Army Depot. The chalk marks outline the areas found, by tapping, to be delaminated. It was suggested that solar heating of the exterior facings probably triggered the delamination of poorly bonded panels in these containers, as shown in figure 2.

Exterior surface temperatures as high as 180 °F and even higher have been reported for structures under certain climatic conditions. This study was initiated in an effort to determine if solar heating might trigger delamination in containers with apparently well bonded panels.

3. Description of Specimens

Two Ward Containers, supplied by Natick Laboratories, were tested. The two wards were of slightly different construction and will be referred to in this report as Ward A, fig. 3 and 4, and Ward B, fig. 3 and 5. The nominal size of each ward was 7 ft high x 7 ft wide x 13 ft long.

Ward A was a prototype which had seen extensive field use. The nameplate data are as follows:

Container-Shelter
Ward

Zero P/N 10221

Stock No.
Serial No. 005
Part No. 697946-1 Model
Contract No. DADA 17-67-C-7075
Series No.
Manufacturer - Zero Mfg. Co.
Burbank, California, U. S.

Ward B was a new unused production sample. The nameplate data are as follows:

Ward Container

FSN 5410-809-6634
Part No. MRL-890331-1
Mod. MR68 Ser. No. 219
DAAK01-68-C-8162 (C2)
MO. Research Labs, Inc.
St. Charles, Missouri
U. S. Property

4. Test Apparatus and Procedure

The two containers were tested simultaneously in an environmental chamber in which the ambient temperature was varied from 70 °F to 100 °F on a 24 hr. cycle similar to a typical solar day. Humidity was not controlled. The temperatures of the interiors of the containers were maintained at approximately 75 °F. The temperatures of the exterior skins of the fixed roof and the folding roof and floor panels, were controlled at approximately 180 °F for about three hours during the 100 °F portion of the simulated solar day. The containers were exposed to six 24-hour cycles.

The surfaces of the fixed roofs and the folding roofs and floors were symmetrically divided into eight areas and thermocouples were attached to the exterior skin at the center of each area. These exterior thermocouples were bonded to the surface with epoxy and covered with olive drab tape. Interior surface temperatures of the heated panels were measured by six thermocouples bonded to the surface with epoxy and covered with tape. The interior air temperature of each ward was measured with a single, centrally located thermocouple. The ambient temperature of the chamber was measured around each container by averaging four thermocouples placed approximately 30 inches above each top corner. All thermocouples were made from 24 gage copper-constantan thermocouple wire.

All thermocouple output signals were recorded on punched cards by an automated data acquisition system at 10 minute intervals during the four hours of highest ambient temperature and hourly for the remainder of the 24 hour cycle.

The interior temperature of each container was maintained at about 75 °F using a package air conditioning unit (5000 Btu/hr) plus non-thermostated cooling coils (see figure 17) for use during the high ambient temperature periods of the daily cycle. These coils were cooled with 42 °F chilled water.

The interior surface of the two vent covers in the fixed roof of both wards were insulated with expanded polystyrene, 2 in. thick, to reduce the cooling load.

Infrared heat lamps were used to heat the exterior surface skins on the roofs and folding wall sections of the containers to the nominal 180 °F. Temperature was controlled by varying the supply voltage to the heat lamps. Racks of heat lamps were placed on 18 in. centers with the bulb surfaces 17 inches from the surfaces of the roof and folding wall sections.

Figure 3 shows installation of Ward B and Ward A (left to right in picture) as they were tested in the environmental chamber.

The heated areas of the skins were inspected for delamination prior to the test and at least once each temperature cycle. The inspection was made using the tapping method.

The edge of an ordinary flat steel washer (5/8 in. bolt size) was used to tap by hand the exterior facing. Tapping on bonded areas produced clear tones while unbonded areas produced dull tones.

For tapping the areas under the heat lamps on the fixed roof a 6 ft. extension was attached to the washer. The extension was a piece of 5/8 in. OD light aluminum tubing.

5. Results

Upon receipt the two wards were tap tested to locate delaminated areas. None were found on Ward B. Two areas were found on the folding roof panel of Ward A. They were circled and dated 6/29 with a marking pen (fig. 4, 8, 9).

There were indications that the delamination at these two areas was caused by corrosion of the skins. The corrosion, which appeared to have started from the interior of the panel, had eaten all the way through the skin at the second of the two delaminated areas (see figure 9). These corroded areas were approximately opposite screw-inserts potted in the honeycomb core.

After the tapping test was completed the heat lamp bulbs were installed, their operating voltage determined, and sufficient cooling installed in the wards to maintain their interior temperature near the desired value. During the checkout period for this apparatus the average fixed roof ward skin temperature was raised to approximately 165 °F for short periods of time on several days (1 hr on the July 2nd, 2 hrs on the 6th, 5 hrs on the 7th, 3 hrs on the 8th, 1 hr on the 9th, and 5 hrs on the 10th). During the remainder of the checkout period the ward skins were exposed to a laboratory ambient temperature which ranged from 70 °F to 100 °F. Another tapping test was then performed on 7/13. Large areas on the roof of Ward B were found to be delaminated and were marked, see figure 15.

Testing under controlled cyclic conditions was then begun. Fig. 6 and 7 show the time-temperature data on the two wards for a typical cycle. Testing was continued for six of these cycles (July 14, 15, 16, 17, 21, and 22). During the low temperature portion of each daily cycle a tapping test was performed, the new boundaries for delamination areas were marked, and the date was written in the newly delaminated areas. The results of these tap tests are shown in figures 4, 5 and 8 through 15. Table 1 lists the total areas of these individual delaminations.

It was observed that the skins of the delaminated areas would rise during heating and return during cooling. See figure 14.

It was also observed during the checkout period that the single cooling coil in Ward B (same size as in Ward A) did not provide enough cooling effect and an additional coil of the same size was added to Ward B.

6. Conclusions

Exposure to solar temperature cycle on the roof and folding panels of the two Ward Containers resulted in the following delamination:

1. No delamination was observed on the folding floor panel of either ward
2. Minor delamination occurred on the folding roof panel of both wards

3. No delamination was observed on the fixed roof of the prototype ward (Ward A) whereas extensive delamination (20%) occurred on the fixed roof of the production sample (Ward B)

4. Delamination of the fixed roof of the production sample, Ward B, tended to start at the roof vents and spread progressively towards the roof edges with the daily temperature cycles. This differs from the pattern of delamination indicated on the ward container of figure 1.

It is evident from the above that the prototype ward, which had seen extensive use in the field with only minor delamination prior to laboratory testing, was clearly superior to the production ward in delamination resistance under temperature cycling. Two of the three delaminations which did occur in the prototype were apparently caused by a corrosive agent within the panel.

Further investigation would be desirable to determine the heat leakage of the two wards. The production sample required two cooling coils in addition to the 5000 Btu/hr package unit for cooling but the prototype required only one cooling coil. This indicates that there was a performance difference between the two samples in cooling load. This indication is supported by the interior skin temperature data shown on figure 6 and 7.

7. Acknowledgment

The authors acknowledge with appreciation the assistance of several people who contributed to this project, especially Mr. Dave Ward, Mr. Boyd Shomaker and Mr. James Allen who were responsible for day to day operations and Mr. T. W. Watson who coordinated and monitored the work.

Table 1

Delaminated Areas

Ward	Location[1/]	Size sq. in.
A	Area 1 - Folding Roof	38*
A	Area 2 - Folding Roof	94*
A	Area 3 - Folding Roof	19
B	Area 1 - Folding Roof	48
B	Area 2 - Folding Roof	17
B	Vent 1 - Fixed Roof	1090
B	Vent 2 - Fixed Roof	1030

1/ See figures 8, 9, and 10 for Ward A.
See figures 11-16 for Ward B.

* 23 sq. in. of Area 1 and 78 sq. in. of Area 2 were delaminated on Ward A as received at NBS.

FIGURES

Figure 14. View of delaminated area around Vent 2, Ward B. See figure 13 for location.

Figure 15. View of delaminated area around Vent 2, Ward B. See figure 13 for location.

Figure 16. View of delaminated area around Vent 2, Ward B. See figure 13 for location.

Figure 17. View of Ward A showing the auxiliary cooling coil used to help maintain the interior temperature of 75 °F.

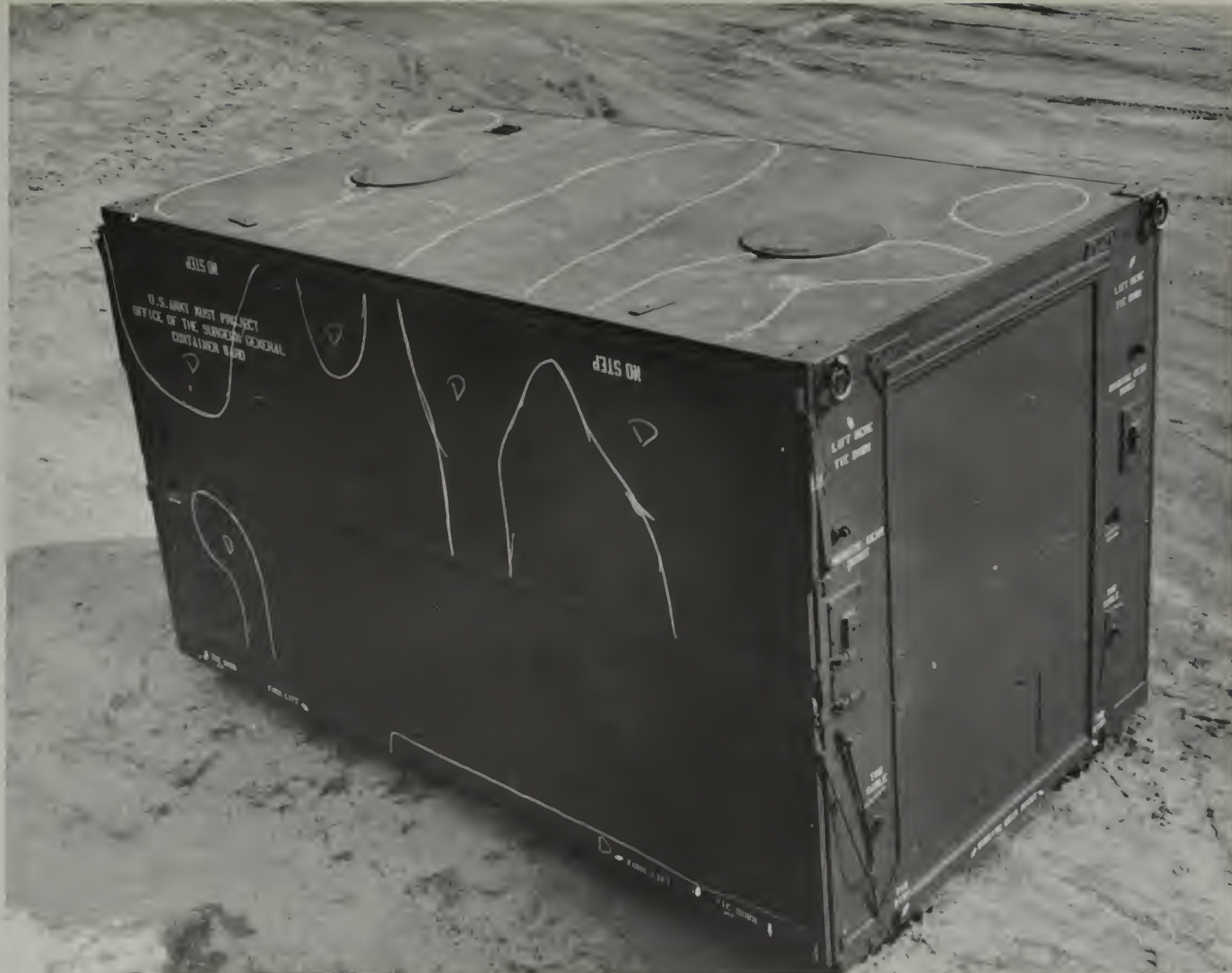

Figure 1. Overall view of a typical delaminated Ward Container. Chalk marks outline the delaminated areas as determined by tapping (NLABS Photo).

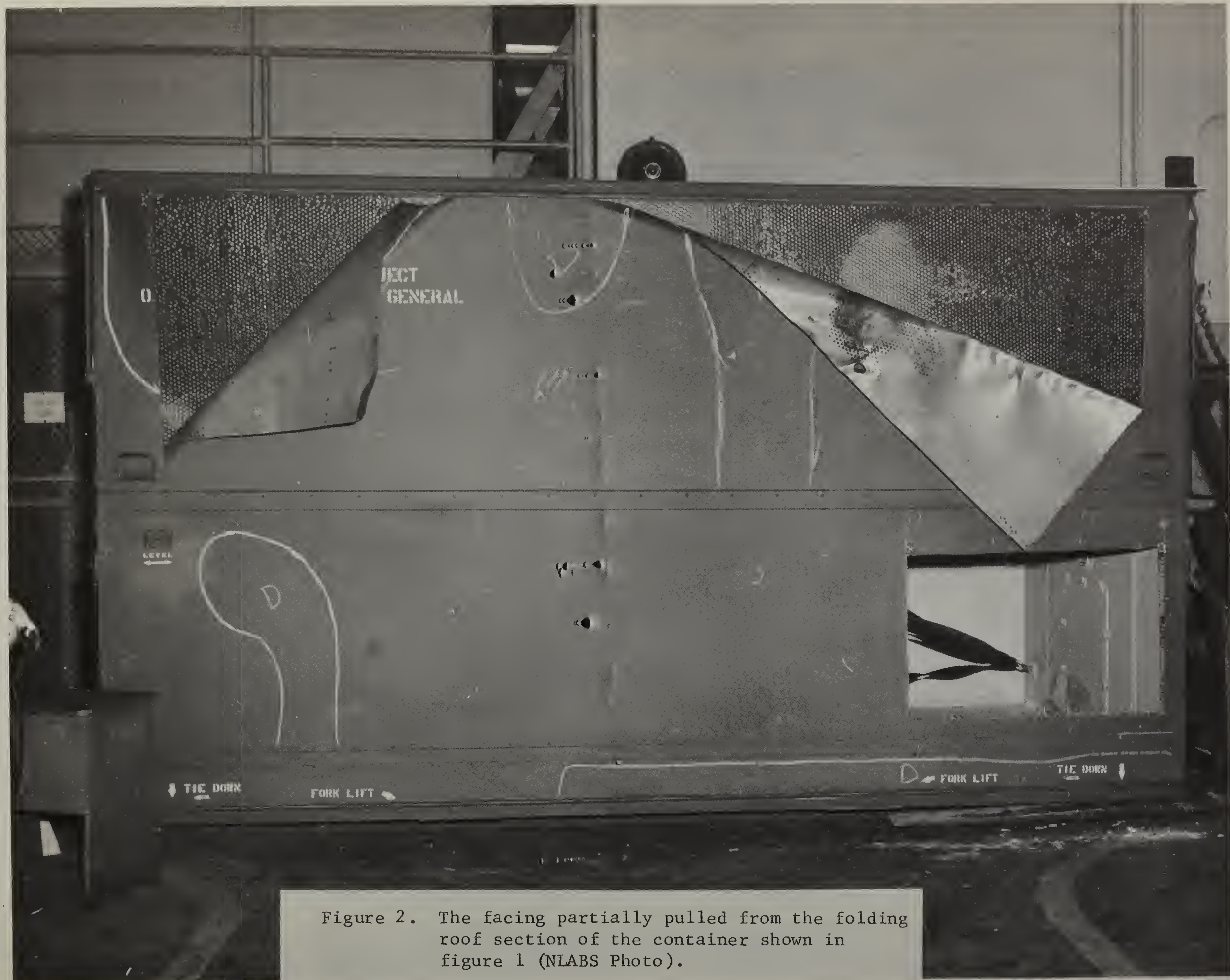

Figure 2. The facing partially pulled from the folding roof section of the container shown in figure 1 (NLABS Photo).

Figure 3. Overall view of the two test wards in the test chamber.

Figure 4. Overall view of Ward A as tested. Circles on folding roof section indicate areas found to be delaminated.

Figure 5. Overall view of Ward B as tested.

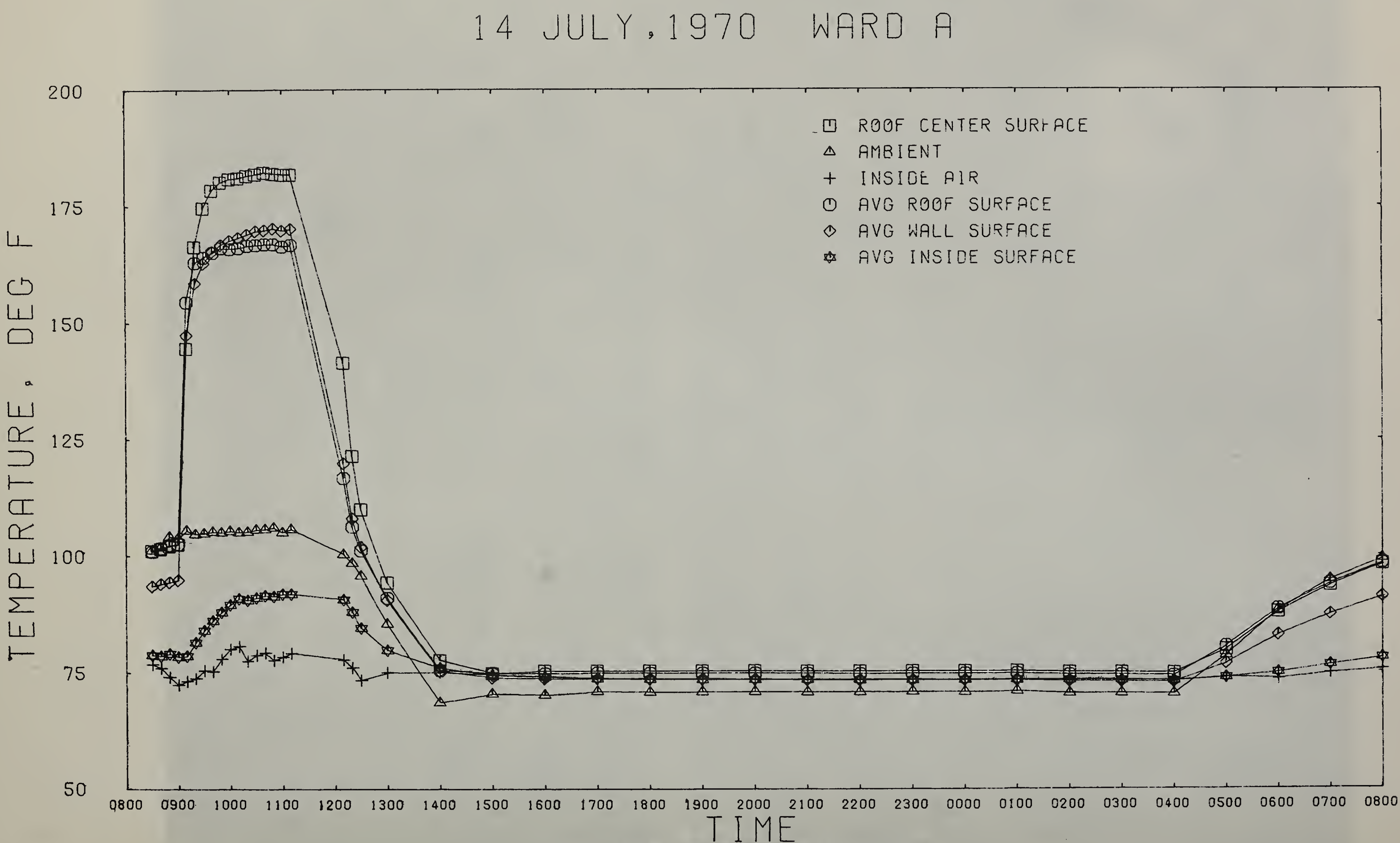

Figure 6. Typical time-temperature data for one cycle on Ward A.

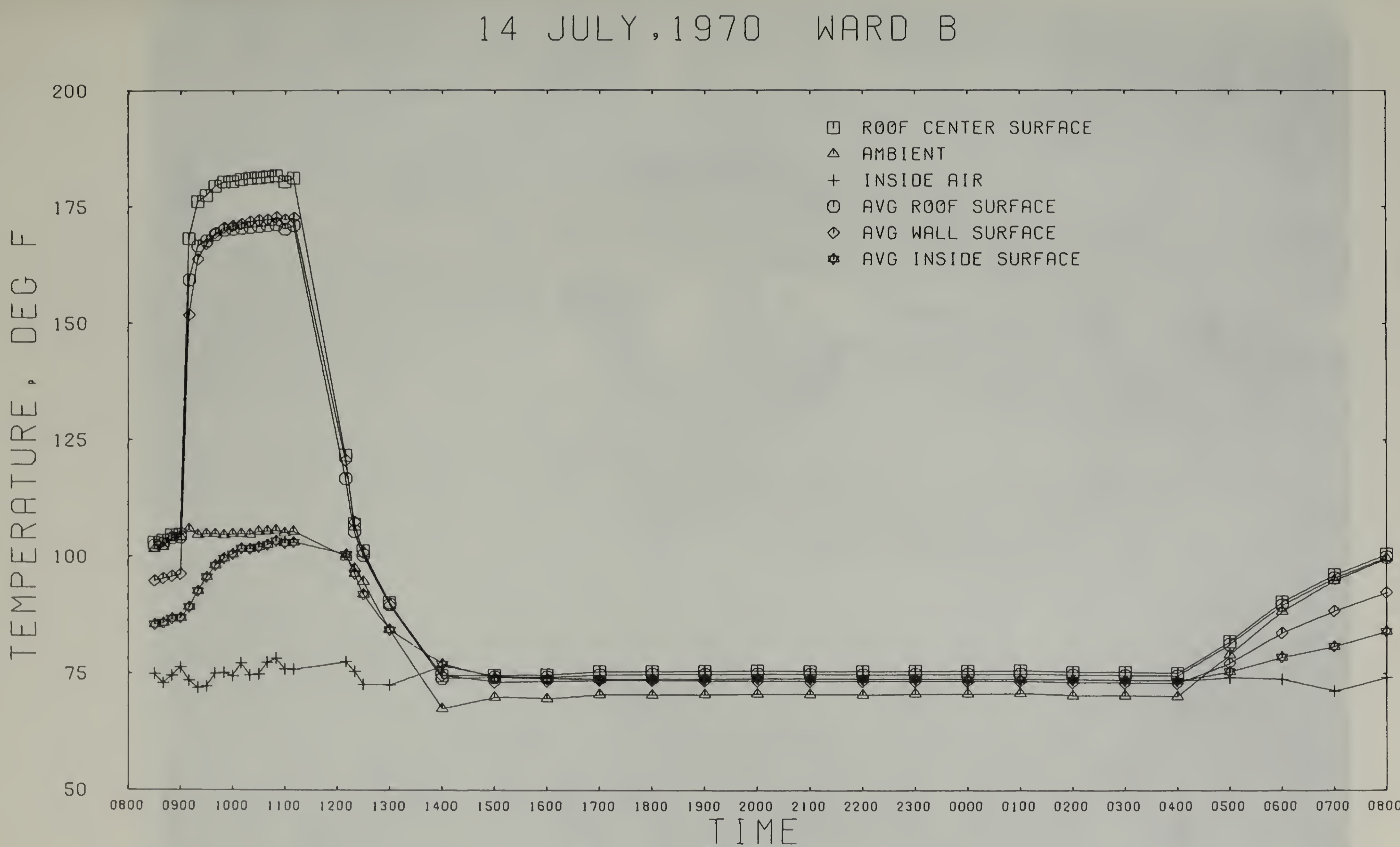

Figure 7. Typical time-temperature data for one cycle on Ward B.

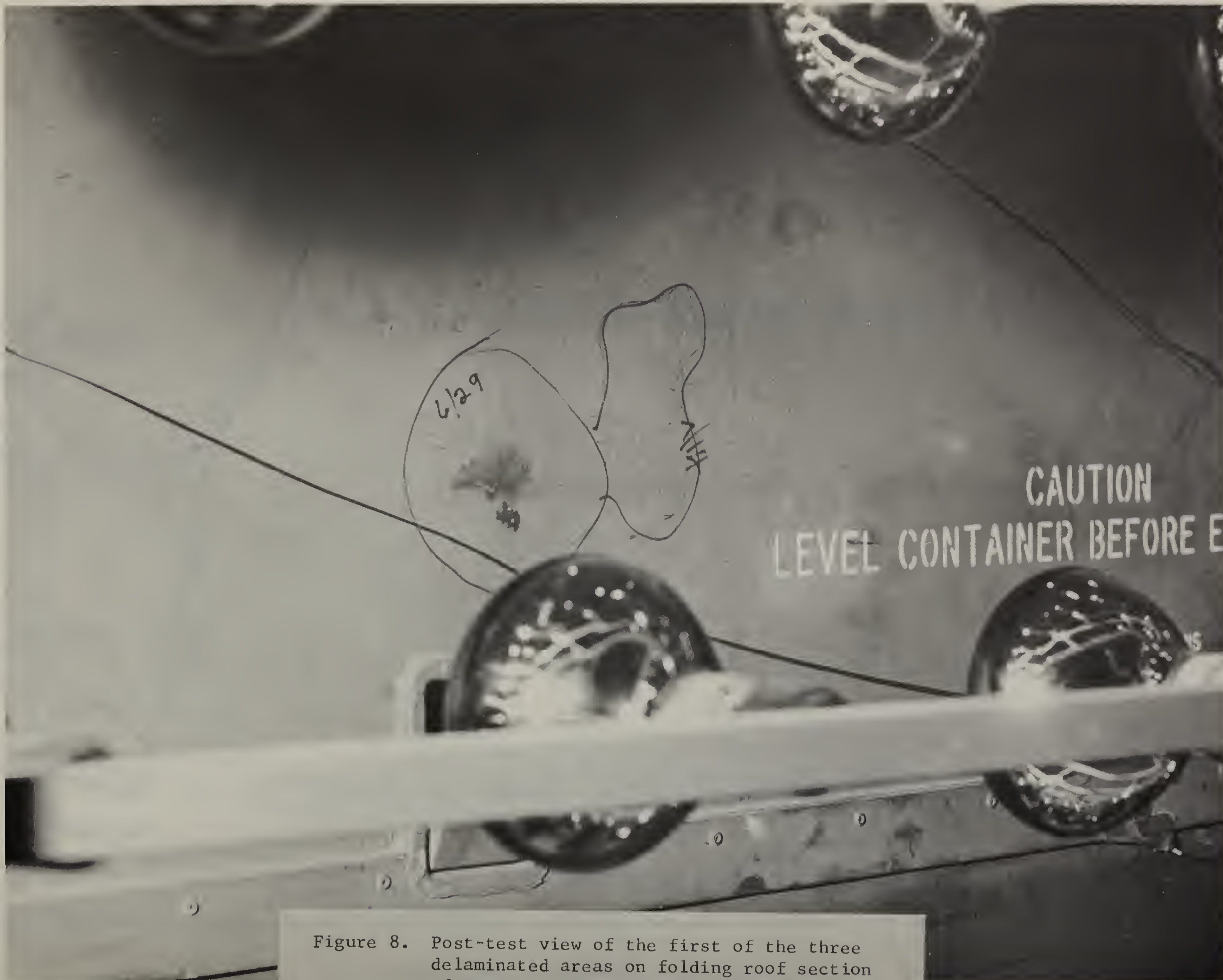

Figure 8. Post-test view of the first of the three delaminated areas on folding roof section of Ward A. (See figure 4). The area enclosed by the 6/29 circle was delaminated prior to test.

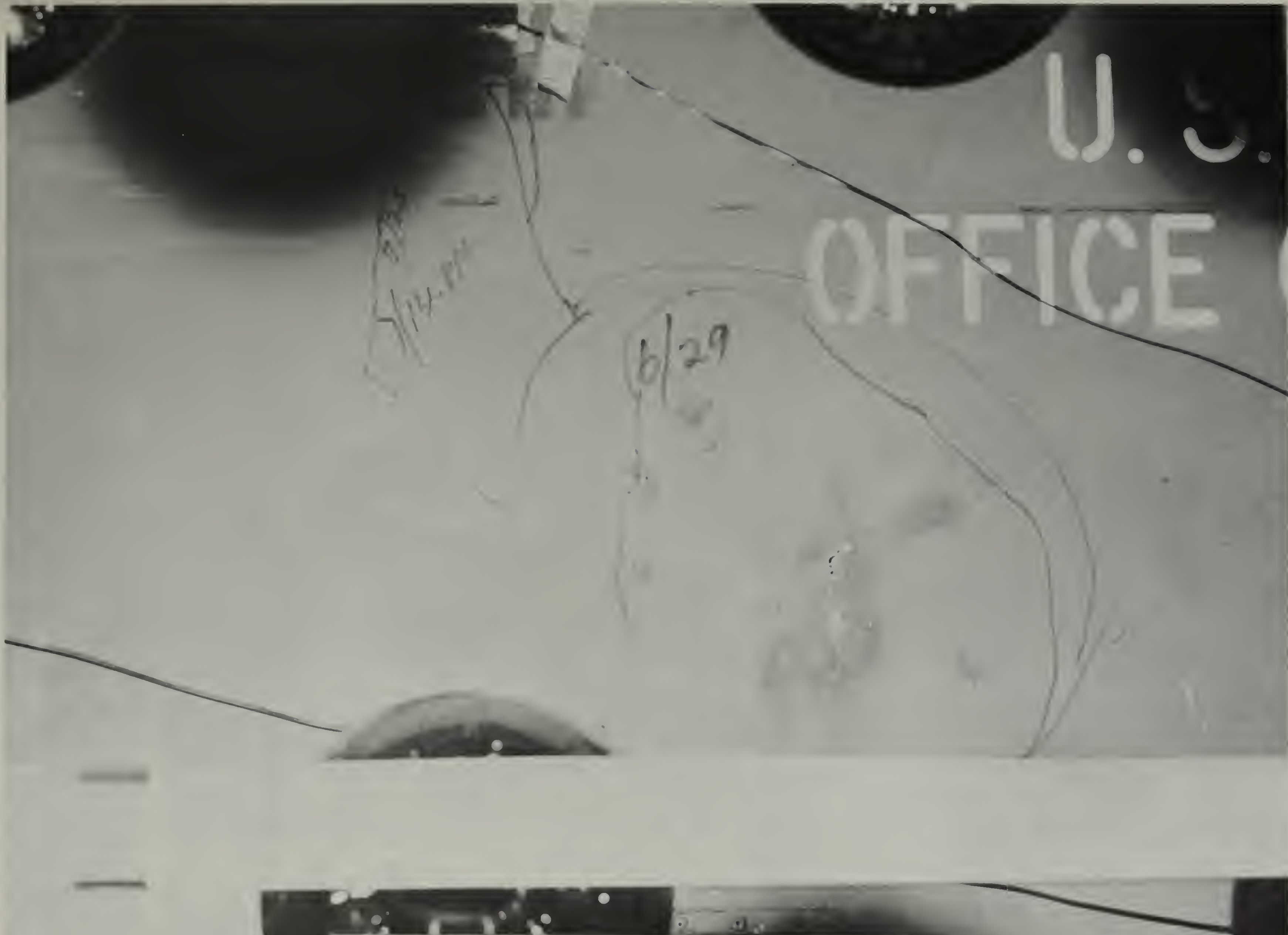

Figure 9. Post-test view of the second of three delaminated areas on folding roof section of Ward A. (See figure 4). The area enclosed by the 6/29 circle was delaminated prior to test.

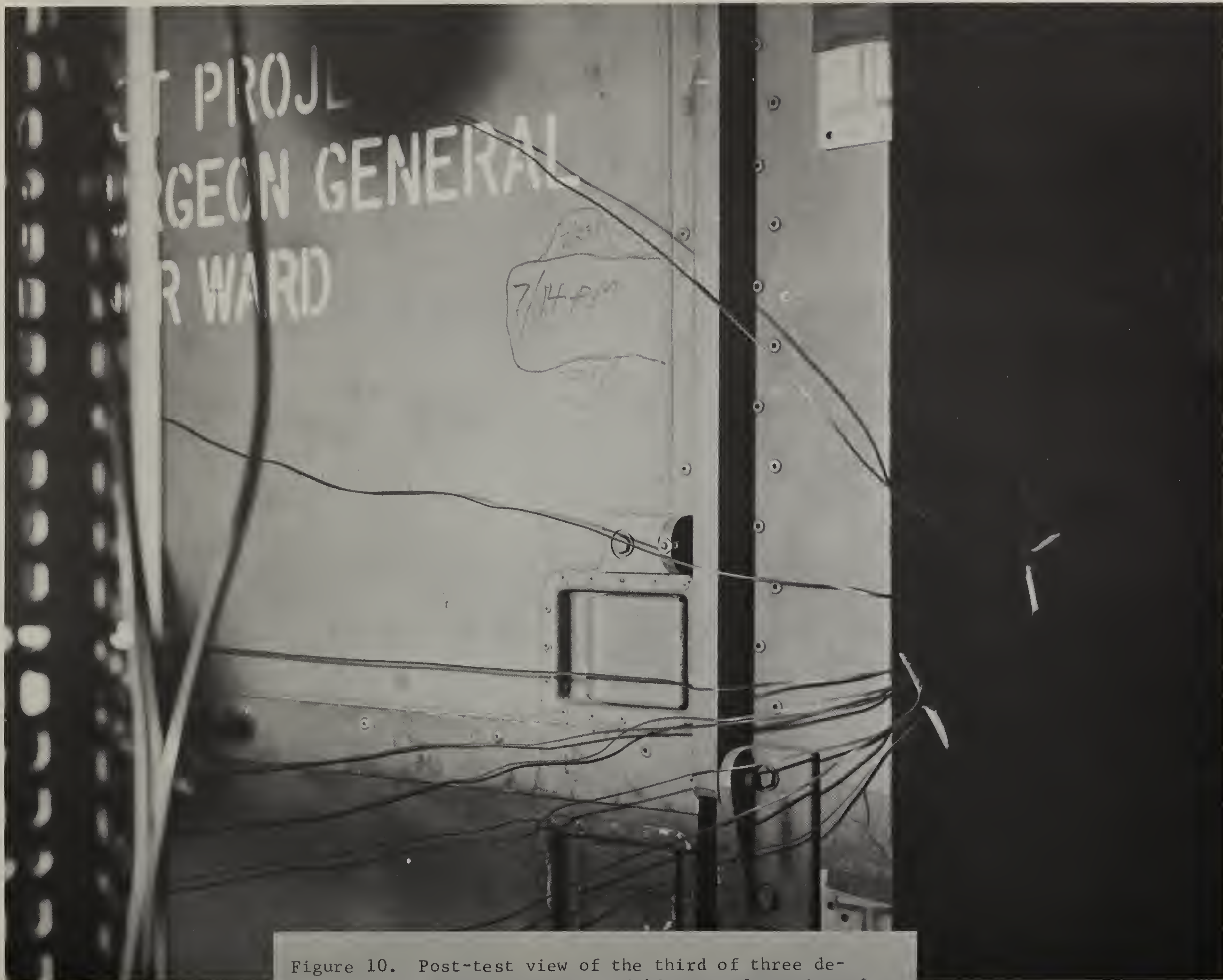

Figure 10. Post-test view of the third of three delaminated areas on folding roof section of Ward A. (See figure 4).

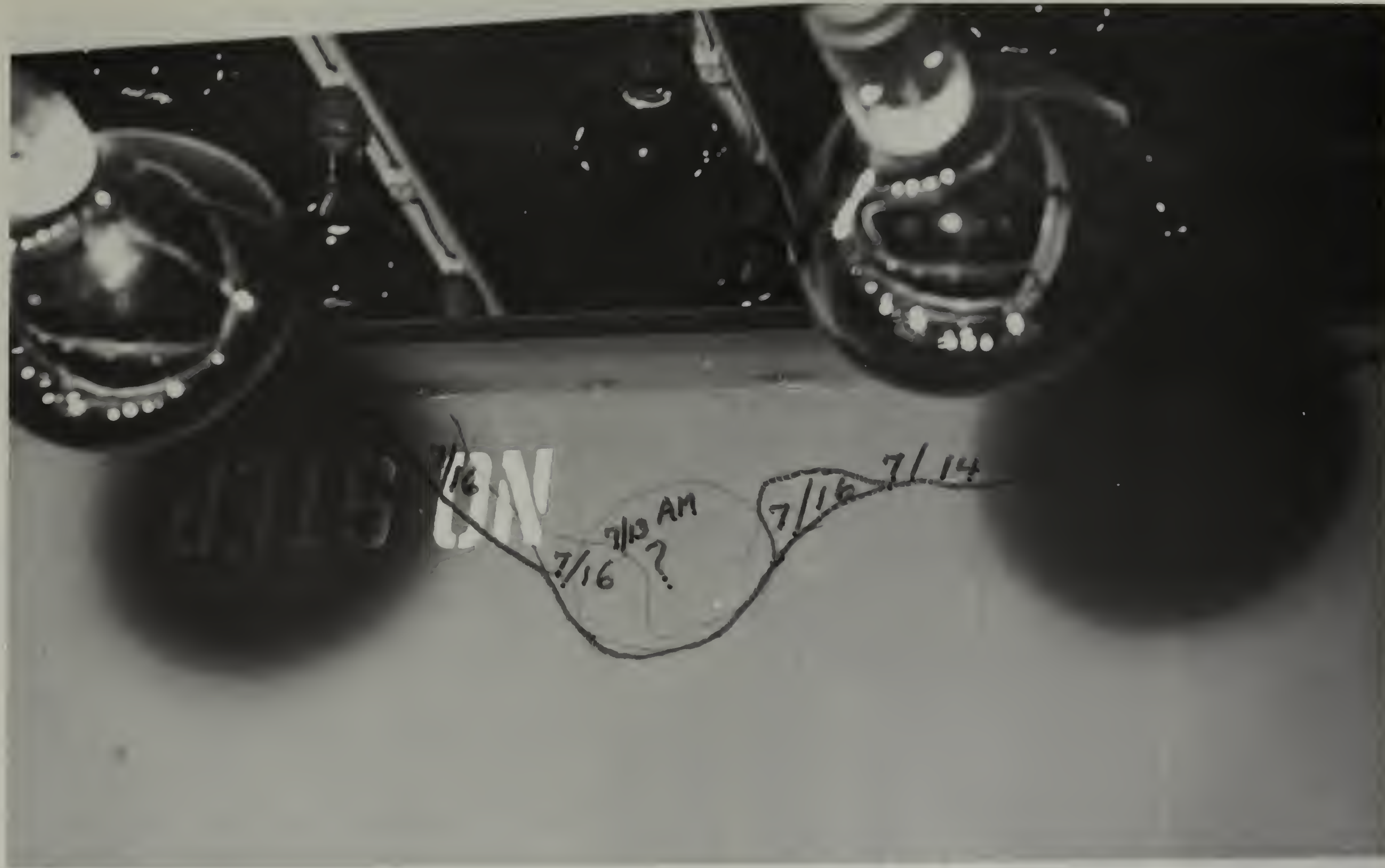

Figure 11. Post-test view of one of two delaminated areas on the folding roof section of Ward B. See figure 5 for location.

Figure 12. Post-test view of the second of two delaminated areas on the folding roof section of Ward B. See figure 5 for location.

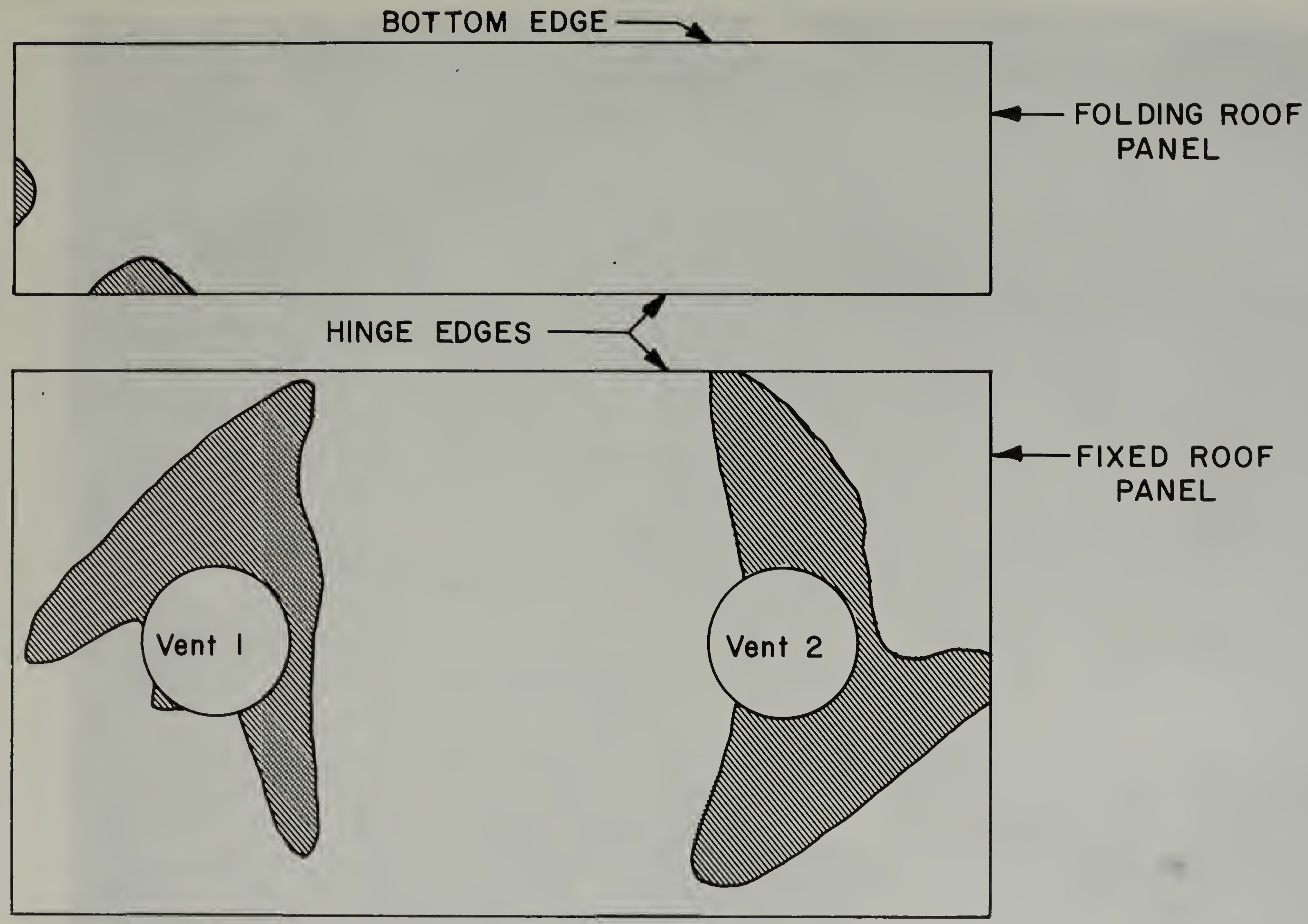

Figure 13. Drawing of delaminated areas of Ward B. Cross-hatching indicates delaminated areas.

Figure 14. View of delaminated area around Vent 2, Ward B. See figure 13 for location.

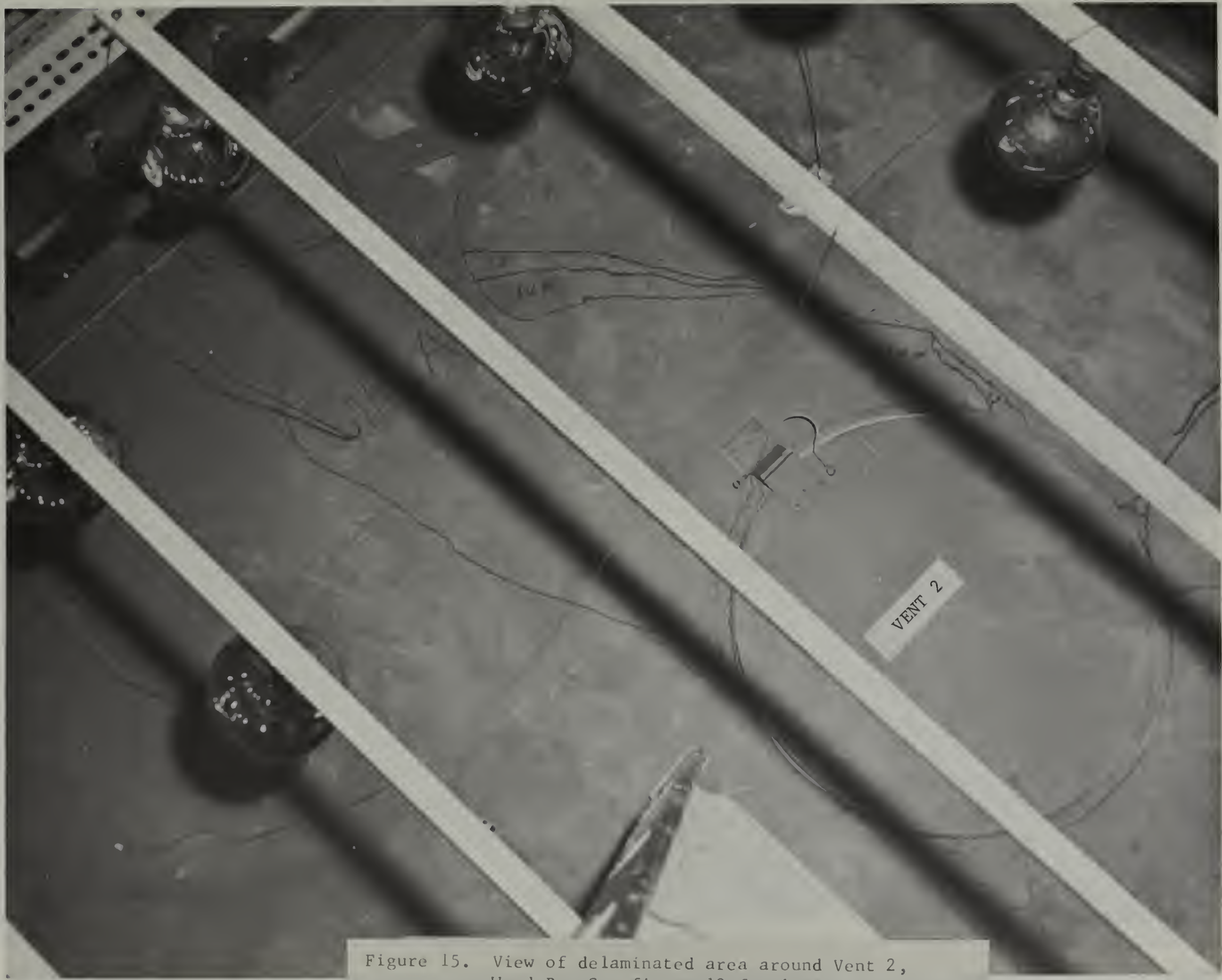

Figure 15. View of delaminated area around Vent 2, Ward B. See figure 13 for location.

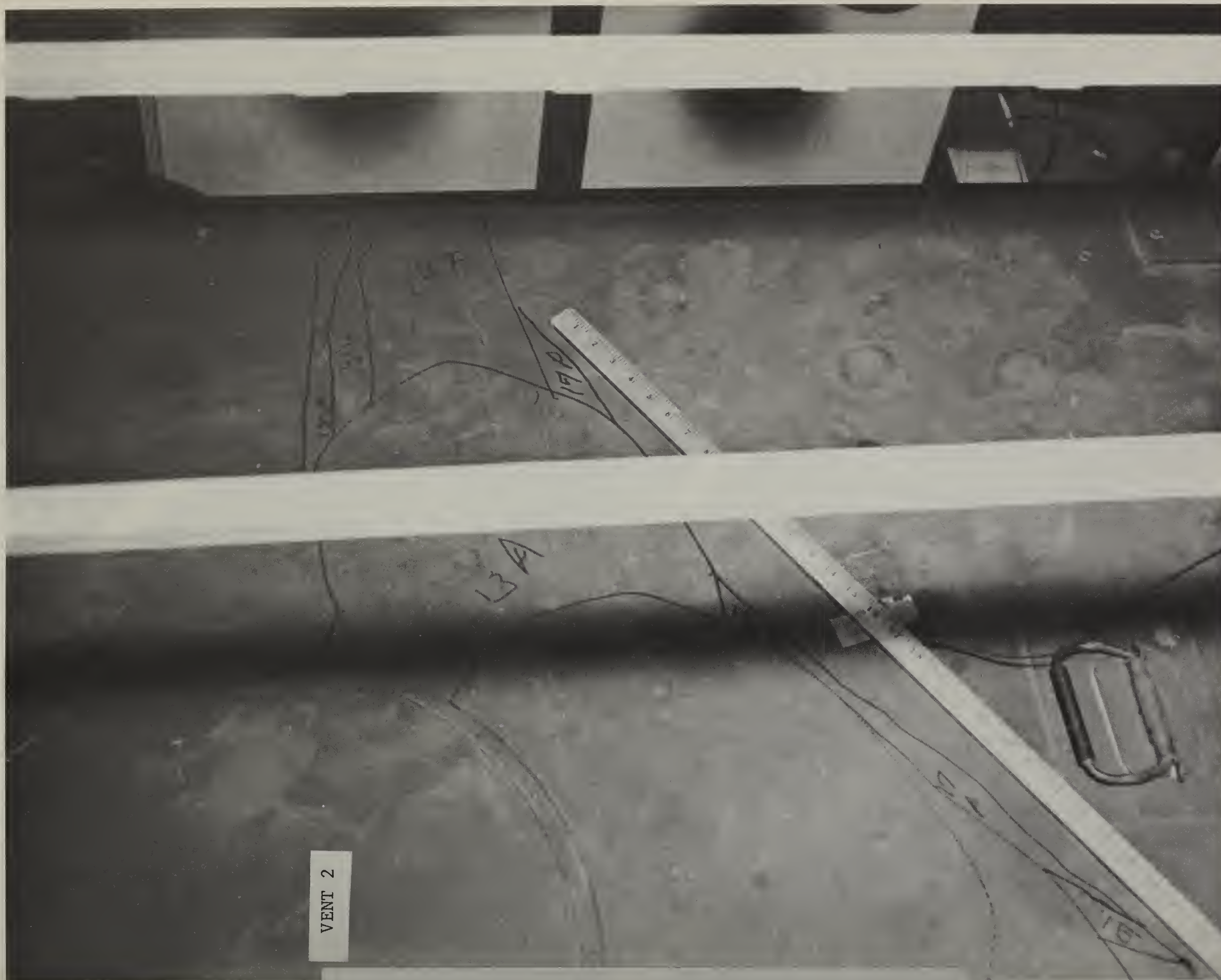

Figure 16. View of delaminated area around Vent 2, Ward B. See figure 13 for location.

Figure 17. View of Ward A showing the auxiliary cooling coil used to help maintain the interior temperature of 75 °F.

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