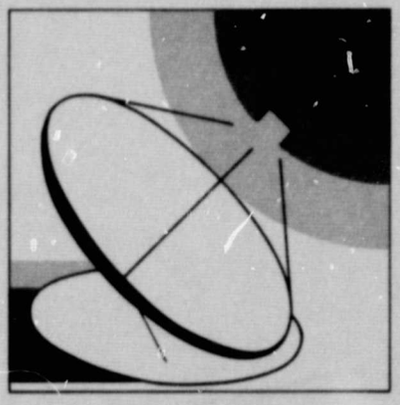
5105-28, Rev. A
Solar Thermal Power Systems
Parabolic Dish Project
Research and Advanced Development

DOE/JPL-1060-37
Distribution Category UC-62b

Status of JPL's Experience with Thin 7809 Glass for Solar Energy Applications

REPORT No. 1

F. L. Bouquet



October 1, 1980

Prepared for
Solar Energy Research Institute
Through an agreement with
National Aeronautics and Space Administration
by
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

(JPL PUBLICATION 80-96)

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FOREWORD

This report was prepared by the Applied Mechanics Technology Section, Jet Propulsion Laboratory, California Institute of Technology.

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For additional information or discussion concerning JPL's experience with Corning Code 7809 glass and its use in solar applications, please contact the following office:

Solar Thermal Power Systems
Parabolic Dish Project
Jet Propulsion Laboratory
4800 Oak Grove Drive
Pasadena, CA 91109

Telephone: (213) 577-9367
FTS 792-9367

ABSTRACT

Through an agreement with DOE, the Solar Energy Research Institute, Golden, Colorado, has supplied JPL with a shipment of advanced, high-transmittance glass for solar thermal power applications. This document, Status Report No. 1, records the results of both mirror and glass inspection. Surface and bulk defects are identified as well as the number broken or chipped during shipment and handling. Of the panels received, the thicker 1.5-mm (0.060-in.) glass exhibited a smaller breakage rate than the thin 1.0-mm (0.040-in.) panels.

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SECTION I

INTRODUCTION

This report of JPL's initial experience in receiving and handling high-transmittance glass for solar energy applications was prepared at the request of the Solar Energy Research Institute (SERI) (Refs. 1 and 2). The glass, Corning Code 7809, is one of a number of promising compositions being made available to industry by SERI. In this case, the glass is planned for use in advanced parabolic dish designs for the Solar Thermal Power Systems Parabolic Dish Project.

Arrangements for a no-cost loan from SERI to JPL were undertaken in FY 79, and most of the glass was silvered by Falconer Glass Industries, Inc., early in FY 80.

SECTION II

RESULTS OF GLASS/MIRROR INSPECTION

The shipment of Corning Code 7809 glass arrived in three cases that were immediately opened and inspected on March 28, 1980. The contents of the cases (identified as A, B, and C) were cataloged and the thicknesses measured. Table 1 indicates the requested quantities and types of glass/mirror lites; Table 2 lists the received quantities and types.

A summary of broken and available lites is presented in Table 3. It was found that 37 of the 253 lites (14.6%) were broken in shipment and handling. Five lites were broken during unpacking, handling, cutting, and repacking by JPL. Of the total pieces broken, 10.7% were the extremely fragile 1.0-mm (0.040-in.) thicknesses and 5.9% were the more sturdy 1.5-mm (0.060-in.) thicknesses.

Liquid-phase water has been implicated as being corrosive to second-surface silvered mirrors. It is noted that some of the mirrors and the separating papers were wet upon opening (crates A and B), and one mirror of the third case (crate C) exhibited water marks.

Table 1. Glass/Mirrors Requested*

Type and Thickness	Subtotal	Total
Glass		
1.0 mm (0.040 in.)	10	30
1.5 mm (0.060 in.)	20	
Mirrors		
1.0 mm (0.040 in.)	65	245
1.5 mm (0.060 in.)	180	

*Nominal Size: 0.9 m x 0.9 m (36 in. x 36 in.)

Table 2. Glass/Mirrors Received*

Type and Thickness	Case A	Case B	Case C	Subtotal	Total
Glass					
1.0 mm (0.040 in.)	0	22	0	22	34
1.5 mm (0.060 in.)	0	12	0	12	
Mirrors					
1.0 mm (0.040 in.)	45	0	0	45	219
1.5 mm (0.060 in.)	4	0	170	174	

*Nominal Size: 0.9 m x 0.9 m (36 in. x 36 in.)

Table 3. Glass/Mirror Status Summary (April 15, 1980)

Type and Thickness	Number Received	Broken Lites No.	Broken Lites %	Presently Available Lites No.	Presently Available Lites %
Glass					
1.0 mm (0.040 in.)	22	18*	82	4	18
1.5 mm (0.060 in.)	12	1	8	11	92
Mirror					
1.0 mm (0.040 in.)	45	8	18	37	82
1.5 mm (0.060 in.)	174	15	9	159	91

*Approximately 10 of the 18 lites had broken corners; one had a chipped edge. The remainder were broken across the glass' central regions.

SECTION III

MEASUREMENTS

Upon receipt, the length, width, and thickness of each lite was measured and tabulated. Considerable variations were observed in most dimensions (Table 4). A 10.16-cm x 10.16-cm (4-in. x 4-in.) sample of each of the two types of mirrors was measured. These preliminary results, shown in Figures 1 and 2, assume a one mil thick paint coating. These samples were arbitrarily selected and should not be interpreted as characteristic of the entire shipment. The measurements shown are for two opposite sides of each sample measured across the draw. The variation with the draw was not as noticeable when judged by eye.

Table 4. Glass/Mirror Dimensions

Type of Material	Thickness mm (in.)	Width m (in.)			Length m (in.)		
		Min	Avg	Max	Min	Avg	Max
Glass	1.0 (0.040)	0.51 (20.0)	0.65 (25.9)	0.73 (28.8)	1.30 (51.0)	1.30 (51.0)	1.30 (51.0)
	1.5 (0.060)	0.51 (20.0)	0.66 (25.9)	0.71 (28.0)	1.30 (51.0)	1.30 (51.0)	1.30 (51.0)
Mirror	1.0 (0.040)	0.743 (29.3)	0.91 (35.9)	0.92 (36.3)	1.07 (42.5)	1.09 (43.0)	1.09 (43.0)
	1.5 (0.060)	0.91 (36.0)	0.91 (36.0)	0.91 (36.0)	1.09 (43.0)	1.09 (43.0)	1.09 (43.0)

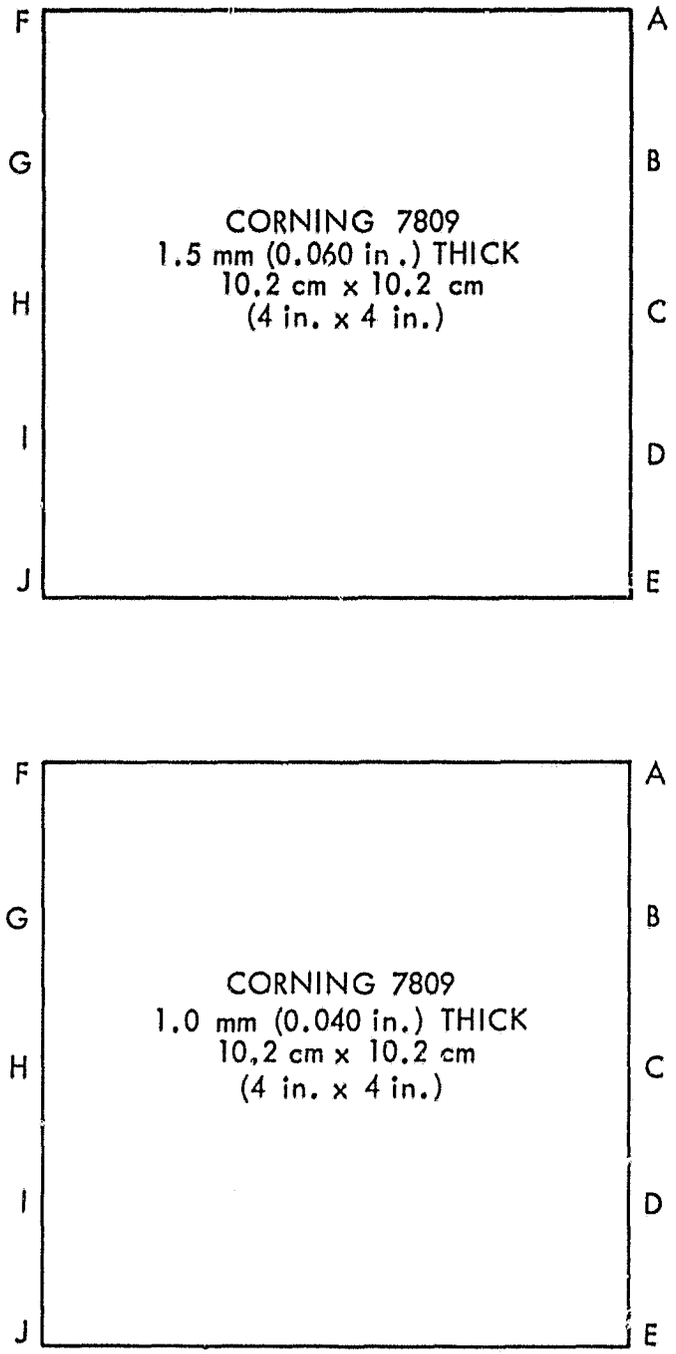

Figure 1. Layout of Sample Measurement Locations

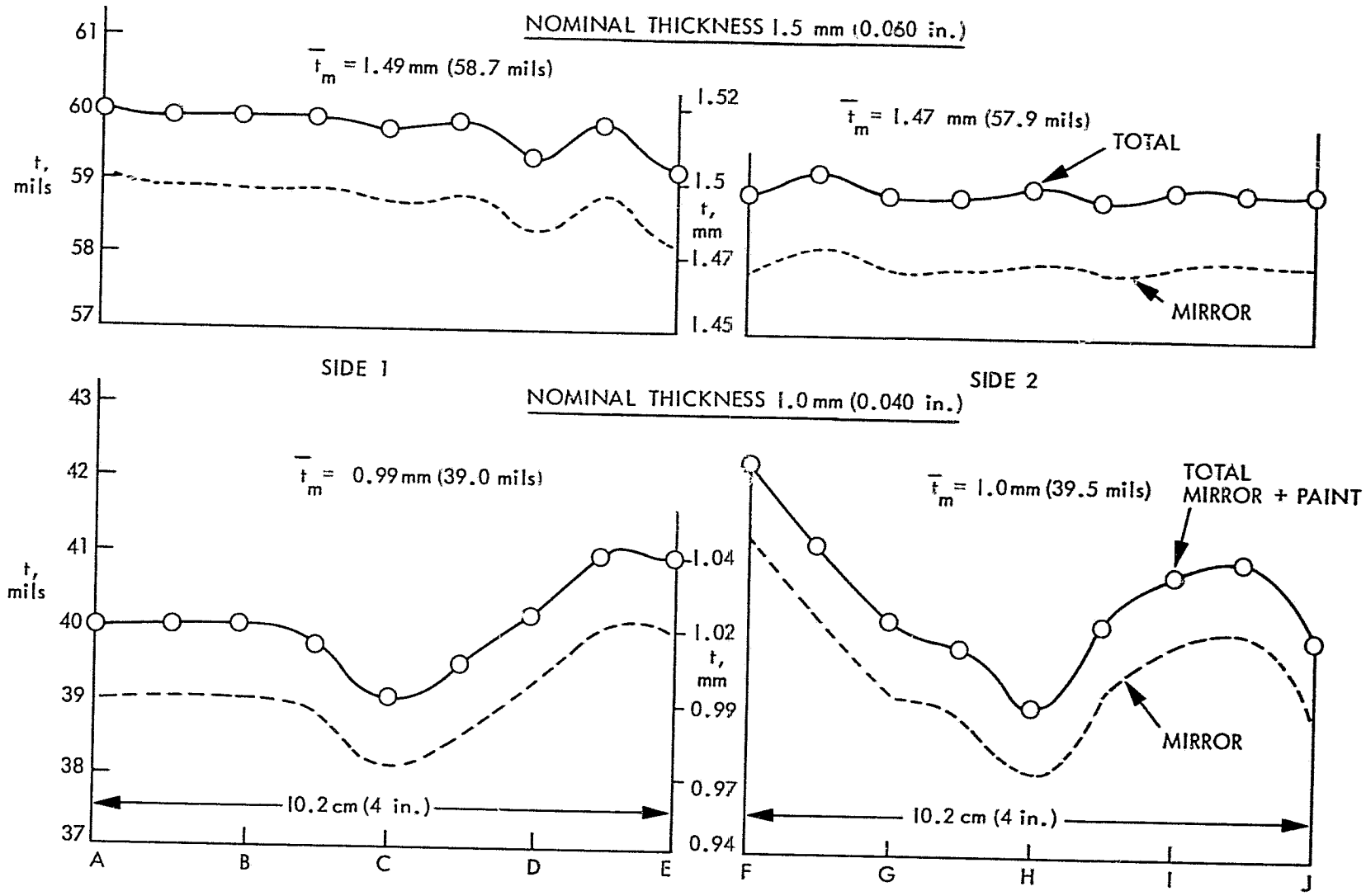

Figure 2. Results of Thickness Measurements (Across Draw Direction)

SECTION IV

SURFACE AND BULK DEFECTS

As the glass was unpacked, it was checked for surface waviness. The 1.0-mm (0.040-in.) thick glass and mirrors exhibited the greatest surface waviness. Surface striations along one edge of the glass were observed as well as local (~2- to 4-cm) waviness. (See Table 5.)

Various types of defects were observed in addition to surface waviness. These include bubbles in the bulk glass, breaks, cracks or chipped edges, and some minor spots where the silver metallization was degraded. The number and frequency (in percent) of the observed defects are shown in Table 5.

Table 5. Summary of Surface and Bulk Defects

Type and Thickness	Waves	%	Breaks, Cracks, or Chips	%	Bubbles	%	Reflectance Spots	%
Glass:								
1.0 mm (0.040 in.)	21	95	15	68	0	0	0	0
1.5 mm (0.060 in.)	12	100	5	42	1	8	0	0
Mirror:								
1.0 mm (0.040 in.)	45	100	11	24	20	44	1	2
1.5 mm (0.060 in.)	0	0	16	9	69	40	2	1

SECTION V

MIRROR DEPLOYMENT

Outdoor deployment efforts using the Code 7809 mirrors are currently underway at JPL. Mirror gores for technology demonstration and environmental testing are being fabricated. Typical gores of mirrors bonded to cellular glass are shown in Figures 3 through 5. The waviness of the mirrors is evident by the reflection of the parallel lines of the building. The two larger gores are 1.5-mm (0.060-in.) thick and approximately 0.61-m (2-ft) square. These particular mirrors have been fastened to blocks of cellular glass substrate for adhesive tests.

Additional environmental testing of mirror samples includes the following:

(1) Deployment of 4.8-cm x 4.8-cm (1.9-in. x 1.9-in.) samples at JPL on exposure racks at 45° facing south. (See Figure 6.)

(2) Deployment of the same size samples at Goldstone Test Site, Barstow, California.

(3) Deployment of 10.16-cm x 10.16-cm (4-in. x 4-in.) mirror samples at JPL.

The purpose of outdoor testing is to determine the effects of soiling and reflective surface degradation.

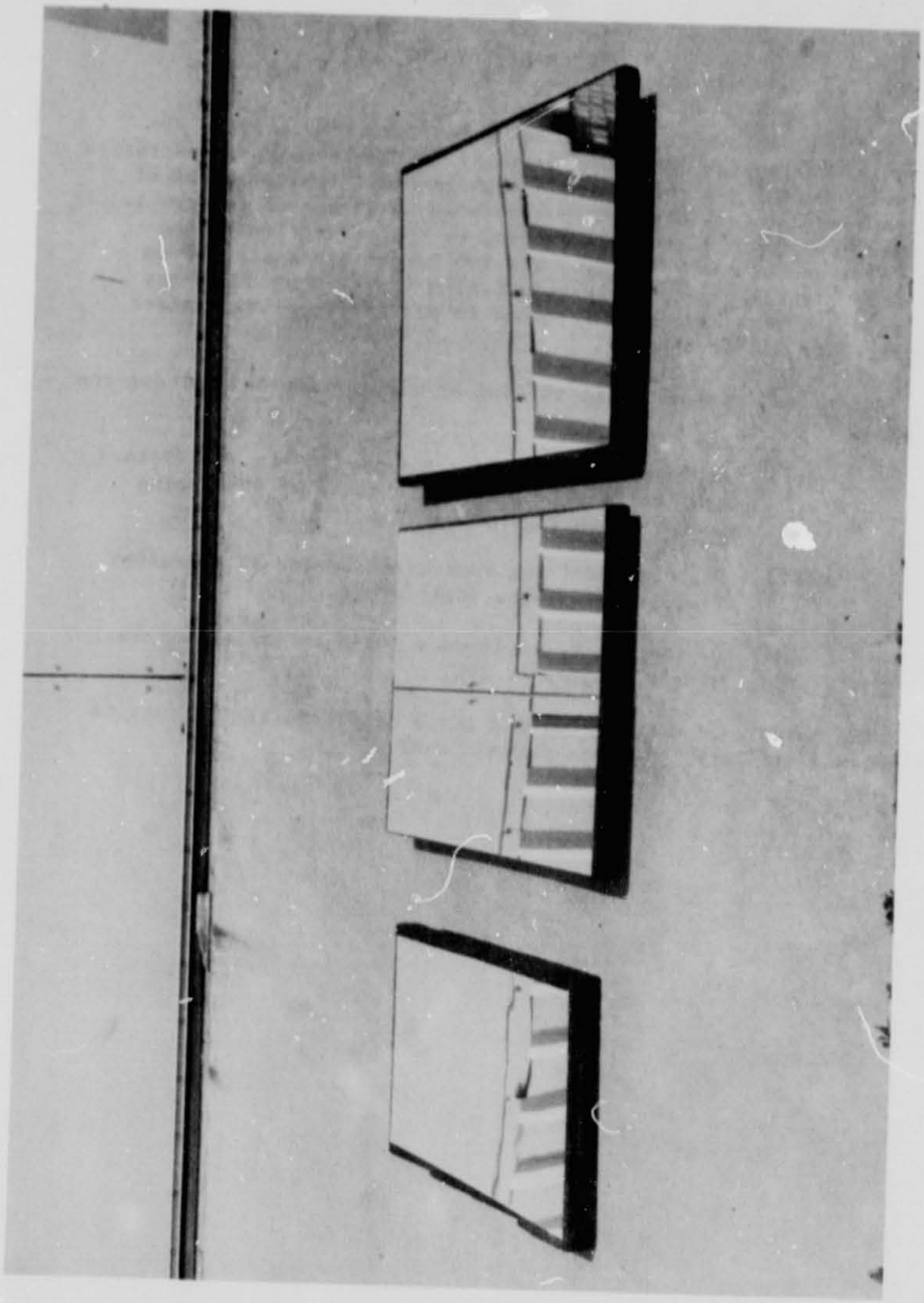

Figure 3. Mirrors Bonded to Cellular Glass

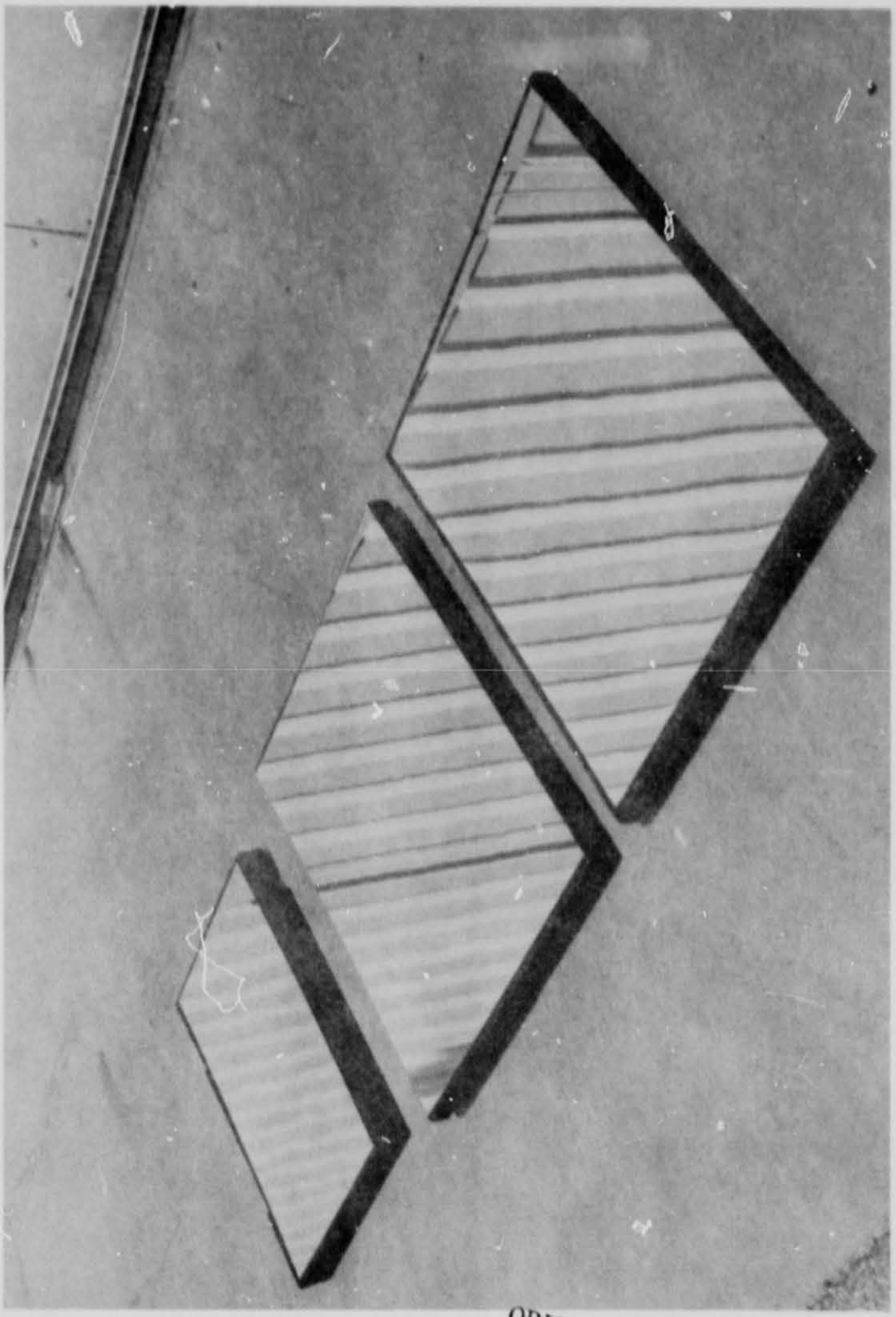

Figure 4. Reflection of Vertical Door Lines on Curved Mirrors

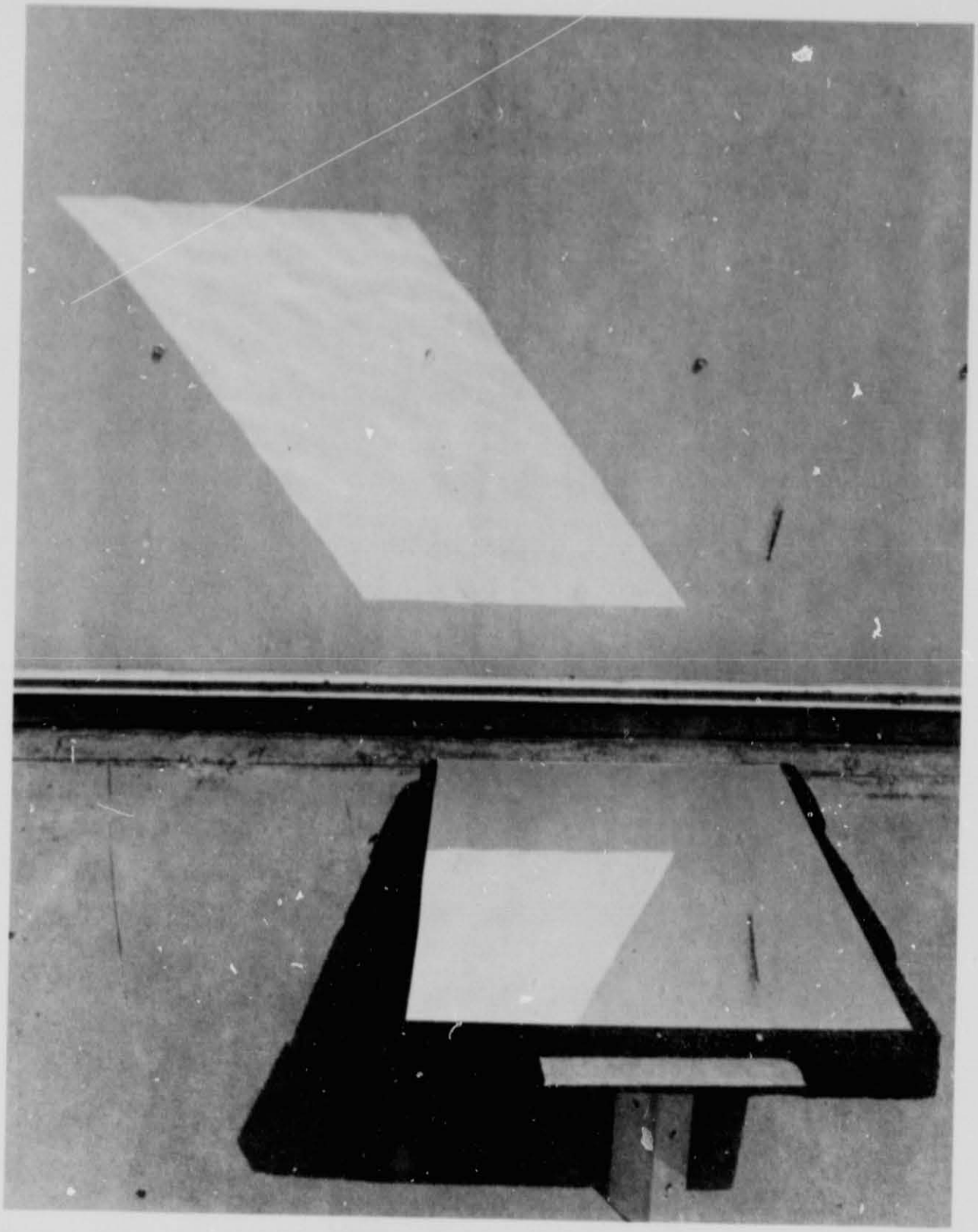

Figure 5. Reflection of Mirror Pattern on Wall
(10:00 a.m., May 5, 1980, Pasadena, California)

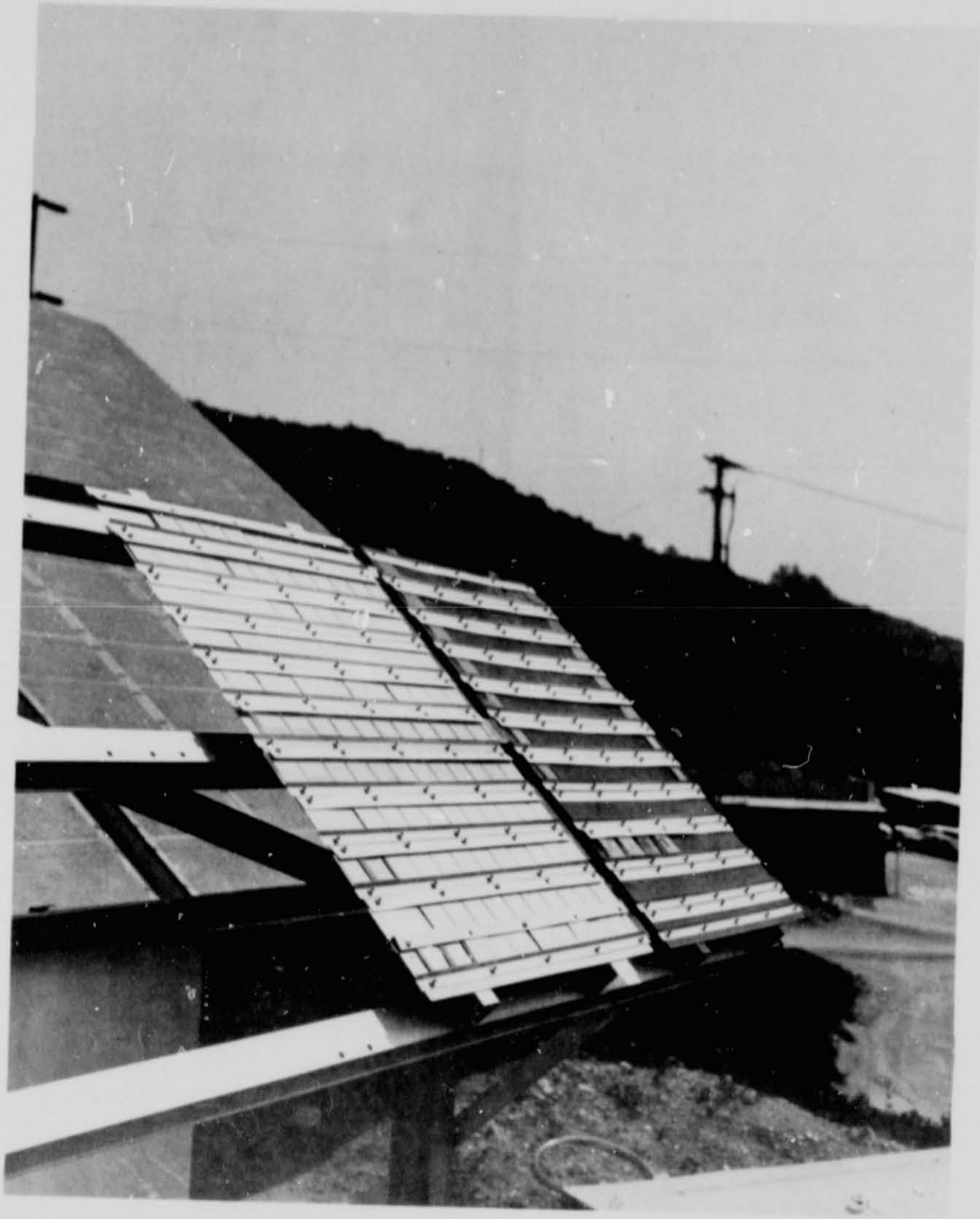

Figure 6. Outdoor Exposure Rack

SECTION VI

RECORDS

JPL has initiated a special record system for the Code 7809 glass. It consists of the following:

(1) Each incoming glass or mirror section is assigned an alphanumeric code.

(2) An inspection form is completed by the individual performing the evaluation. Cracks, blemishes, and other pertinent information are noted.

(3) The records of the Code 7809 glass/mirrors are filed in a special notebook and are available as needed.

SECTION VII

FUTURE PLANS

Present plans include increasing the deployment of both glass and mirror samples in the outdoor environment. Also, plans are being formulated for continued fabrication of the Corning Code 7809 mirrors into gores for outdoor and indoor testing. Further tests to characterize both the glass and mirrors are planned for this fiscal year.

REFERENCES

1. Letter from W. P. Painter to Rigo Medina entitled, "No Cost Agreement No. GD-9-8259-2," dated September 20, 1979.

2. Letter from R. Livingston to F. Bouquet, dated November 15, 1979.

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APPENDIX

Form used for Tabulation of Code 7809 Glass/Mirrors

SERI GLASS/MIRROR INSPECTION RECORD LEGEND:

Date	JPL Code No.	Lite		Characteristics			Condition			Remarks
		Glass	Mirror	T-mm (in.)	L-m (in.)	W-m (in.)	Breaks	Waves	Bubbles	