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RS 7331/411

RADIANT HEAT TEST OF MAR ANTENNA WINDOW ELEMENTS (U)

Organization 7300 Environmental Test Report

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Introduction

The object of this test was to determine the structural integrity of the MAR windows when subjected to an environment simulating multiple nuclear thermal pulses. Also of interest was the acquisition of temperature and strain data at selected points on the elements to support future analysis.

The Alumina (Al_2O_3) and Beryllia (BeO) windows were four inches in diameter, with various thicknesses, as shown in Table I. Two teflon windows were also tested. Various types of hexagonal face plates were used as shown in Table I.

Three different heat flux vs time profiles were used to simulate different thermal nuclear pulse environments.

This test was requested by Bell Telephone Laboratories on October 28, 1965. G. Bruington. 7331, was the Test Coordinator. The test item was received November 30, 1965, and the test was completed February 16, 1966.

Summary

Twelve Alumina, eight Beryllia and two Teflon windows, supplied and instrumented by Bell Telephone Laboratories, were exposed to various heat flux vs time profiles simulating multiple thermal nuclear pulses. The Alumina and Beryllia windows were four inches in diameter with various thicknesses. The Teflon samples were 6" in diameter.

A special small metal building with a filtered ventilating system was fabricated in which to conduct these tests, because of the potential hazard involved with testing Beryllia and Teflon.

A graphite heater array consisting of three 3/8" graphite resistors was used, along with a shutter mechanism and a movable platform, to obtain the desired heat flux vs time profiles.

Procedure and Results

Twenty-two radar antenna windows for the Nike-X MAR sites, consisting of twelve Alumina, eight Beryllia and two Teflon, were exposed to various heat flux vs time profiles as shown in Table I. This table is a summary of test runs between February 15 and February 21, 1966. Three different heat flux vs time profiles, referred to as pulses A, B and C, were used, and are illustrated in Figures 1-3, respectively. The actual heat flux versus time profiles illustrated are average values, since the heat pulse did vary from test to test.

To obtain pulse A, a shutter mechanism that would remain open for 8/10 second was used, which produced a square wave instead of the slight slope of the requested curve shown in Figure 1. Although the actual shape of the obtained pulse was not correct, the total integrated flux was within specified limits, thus producing the desired results.

Because of the warm-up time of the graphite resistors and the peak 403 BTU/FT^2-sec. incident heat flux of pulse A, it was difficult to protect the water-cooled gold-plated shutter. Silicone Dioxide cloth was used in an attempt to protect the shutter, but in some instances, did not prove satisfactory, as shown in Figure 4. However, enough protection was afforded to the shutter to enable some test windows to be exposed to pulse A.

To obtain pulses B and C, a movable platform, as shown in Figures 5 and 6, was used. Referring to Figures 2 and 3, the desired pulse and the actual pulse produced, may be noted.

When the shutter was raised at the proper time, a small step input was obtained initially because the table was approximately 14 inches away from the graphite heaters. The raising of the shutter actuated a microswitch which caused the platform to move forward at a given rate automatically. The forward speed of the platform could be adjusted by means of a motor and gear box arrangement, thus producing the two and three second rise time desired for pulses B and C, respectively. It should be noted that although pulse B has a higher peak flux level than pulse C, pulse C is considered the more severe of the two, because it has a greater total integrated flux.

Figure 7 illustrates, incorrectly, the position of the two calorimeters used for the calibration of the three graphite heater array. Figure 7 shows one calorimeter in the center of the test item holder and one calorimeter below the center position. Initially, this was the position of the calorimeter. Because of problems developing early in the calibration tests, i.e., the shutter did not cover up the lower calorimeter, the test fixture was turned upside down so that during the rest of the calibration and test runs, the lower calorimeter was on top.

The two calorimeters were used so that the difference in readings between the center and top calorimeters could be noted and the heat flux at the center of the test windows could be calculated during each test run. The top calorimeter indicated an average of 48 BTU/FT^2-sec. incident, less than the center calorimeter. Consequently, the incident heat flux experienced by the test specimen was on the average 48 BTU/FT^2-sec. greater than the recorded flux level.

Figure 7 also illustrates the outdoor metal building which was constructed because of the potential health hazard involved in testing Beryllia and Teflon windows. The building was equipped with four Cambridge Absolute Filters, Model No. 1F1000, and an exhaust fan which produced sufficient air velocity across the samples to pull any smitted small particles of Beryllia into the filter system. Environmental Health, Organization 3311, monitored the inside of the building and the exhaust of the fan as well as taking swipe samples on the specimens and test item holder for any possible contamination. Contamination thus far has been below minimum requirements. The potential hazard from running the teflon windows was from the various Fluorine gases emitted when the teflon window decomposed. These gases were exhausted to the atmosphere, thus eliminating the hazard.

Temperature and strain gage instrumentation was used on various windows throughout this series of tests. The data recorded was reduced by BTL and not available for inclusion in this report. Reference should be made to T-90321 for temperature and strain gage information on Alumina windows previously tested.

Figure 8 shows the three graphite resistor heater arrays that were used to obtain the desired heat flux vs time profiles. Note the two manifolds that were used to blow nitrogen gas between the test sample and heat source to eliminate severe arcing caused by ionized gases.

Figures 9-11 show some windows that were tested on December 1-3, 1965. The window holder design was faulty, thus causing the windows to pop out as soon as the window was exposed to its respective heat flux. This series of tests was terminated so that the window holder could be redesigned.

Figures 12 and 13 show various windows after their exposure to the desired heat flux vs time profile.

In Table I, the "BTU/FT^2-sec. Incident (Top)" column gives the average peak flux level read by a Hy-Cal, water-cooled, asymptotic calorimeter, Model No. C-1301-B-500-072, Serial No. 14116, 500 BTU/FT^2-sec. range located just above the test window.

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Temperature readings in the "Graphite Temp. at Shutter Open" column were taken with an automatic optical pyrometer, viewing the carbon resistor at an angle of approximately 10° from the plane of the resistor. The readings taken from this angle may not be the same as readings from a normal to the resistor. These readings were taken for the purpose of obtaining an approximation of graphite temperatures and not for correlation with measured flux rates.

Figure 14 shows the LSRN Teflon window before its exposure to three "C" pulses.

Figure 15 shows the LSRN Teflon window after its exposure to three "C" pulses.

Figure 16 shows the LSRO Teflon window after its exposure to two "C" pulses.

A summary of test results is given in Table I.

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TABLE I

SUMMARY OF THERMAL RADIATION TESTS

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Sample #	Test No.	Pulse	Average Pulse (MV)	BTU Inc./ FT^2-sec. (Top)	Thickness (in.)	Hex. Design	Graphite Temp. at Shutter Open (°FX 100)	Sample Temp. Max. (°F)	Visual Inspection	Dye Check
KA25-1	1-215	3C	4.0	225	.281	SG	46	880	N	N
KA35-1	1-216	3C	3.8	214	.378	SG	44	710	N	N
EA3AH	2-216	3C	3.5	197	.378	A	--	450	N	N
EA3AHS	3-216	3C	3.8	214	.378	AS	45	470	N	N
[redacted]2AH	4-216	3C	3.7	208	.281	A	45	480	N	[redacted]
KB35-2	1-217	2B	---	---	.378	SG	45	600	N	[redacted]
[redacted]45-1	2-217	1A	6.2	350	.422	SG	47	495	N	[redacted]
[redacted]		2B	5.0	281			44.5	760		
KB35-2	3-217	3B	4.9	278	.378	AS	44	740	N	[redacted]
[redacted]2AHS	1-218	3B	5.0	281	.200	AS	46.5	720	N	[redacted]
[redacted]2AH	2-218	3B	5.0	281	.200	A	44	745	N	[redacted]
KB45-2	3-218	3B	5.4	304	.422	AS	46	710	N	[redacted]
[redacted]3AH	4-218	1B	5.6	316	.378	A	48	390	N	[redacted]
KA25-2	5-218	3B	5.5	310	.281	AS	45	1000	N	C
KB35-3	6-218	3B	5.5	310	.378	SG	47	810	N	N
EA25AH	1-219	3B	5.7	325	.250	A	47	---	C	B
KA35-2	2-219	3B	5.3	302	.378	AS	46	850	C	C
EA25AH	3-219	3B	5.4	304	.250	A	--	---	C	C
KA25-3	4-219	3B	5.5	310	.281	SG	--	---	C	C
KA35-3	5-219	3C	3.4	191	.378	SG	--	---	N	N
LSRN (Teflon)	1-221	3C	3.9	215	.312	--	44	---	-	-
EA25AH	2-221	3C	4.5	254	.250	A	--	640	-	-
LSRO (Teflon)	3-221	2C	---	---	.312	-	--	---	-	-

SYMBOL KEY:

Sample #: 2nd letter A = Alumina, 2nd letter B = Beryllia
Test No.: 1-215 = 1st test run, February 15, 1966
Pulse: 3C = 3 pulses of pulse C
Hex. Design: SG = Steel, Gold-plated, A = Aluminum, AS = Schooped Aluminum

Visual Inspection and Dye Check: N = Negative, C = Cracked, B = Broken

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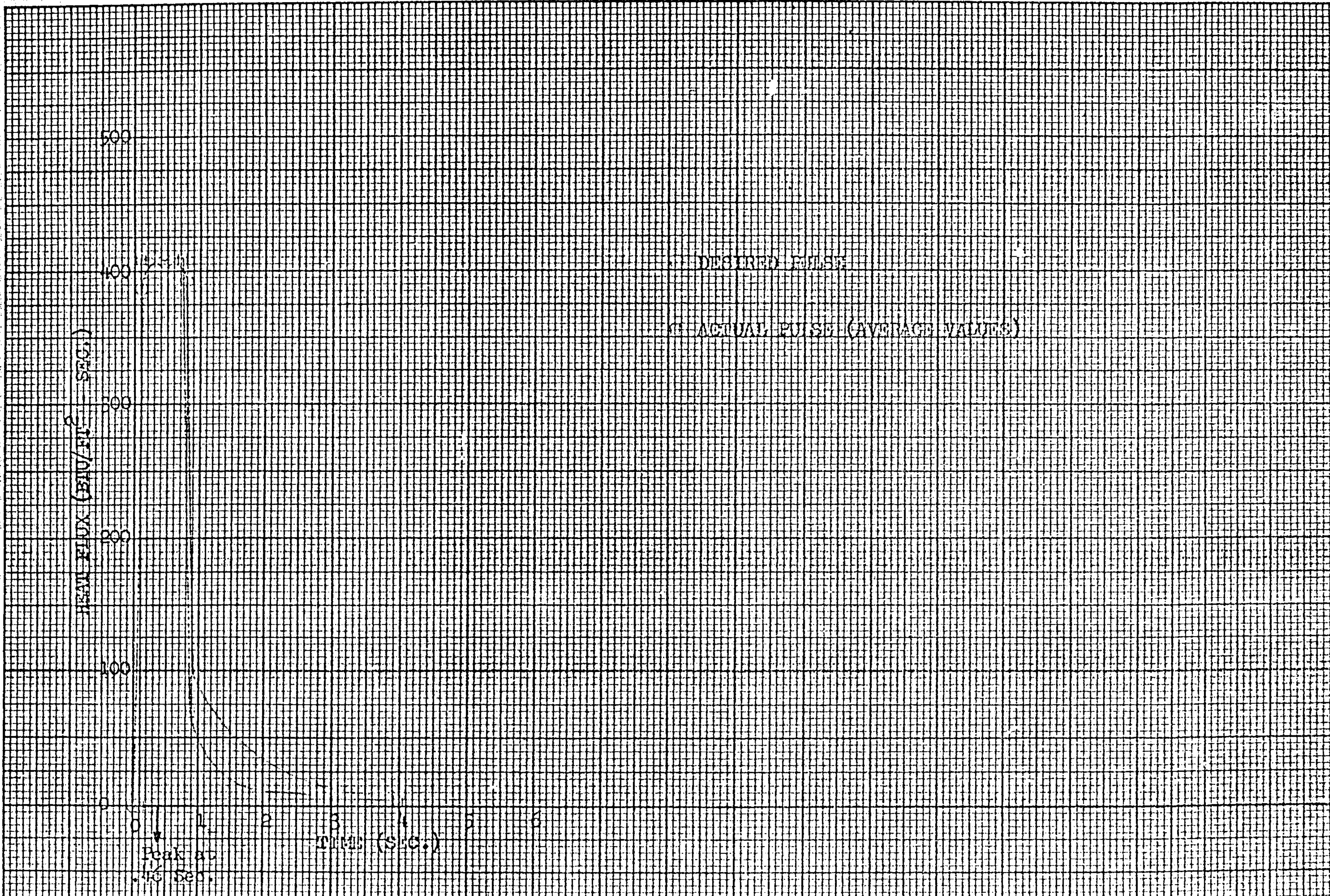

FIGURE 1. HEAT FLUX vs TIME PROFILE, PULSE A, DESIRED PULSE AND ACTUAL PULSE.

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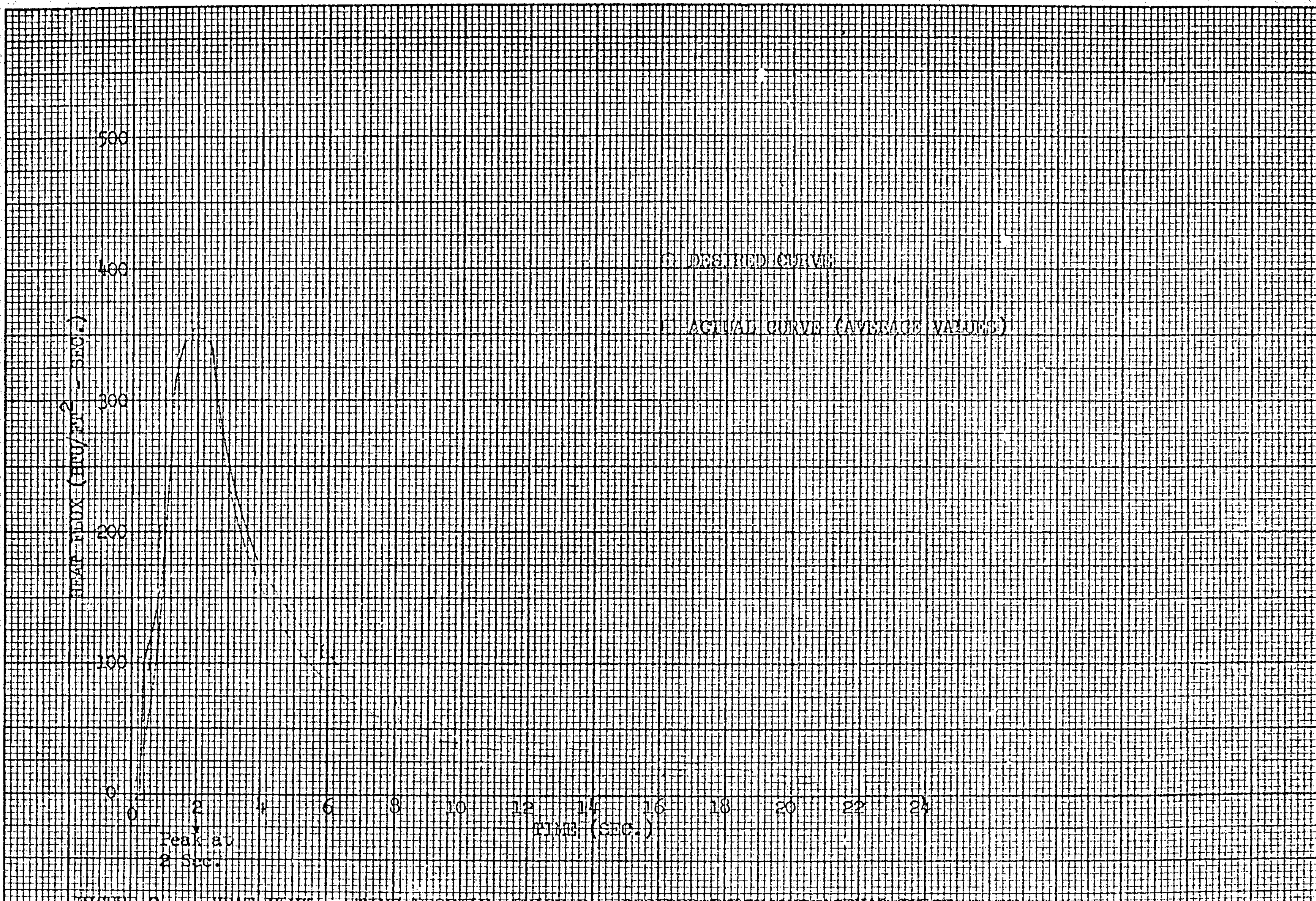

FIGURE 2. HEAT FLUX vs TIME PROFILE, PULSE B. DESIRED PULSE AND ACTUAL PULSE.

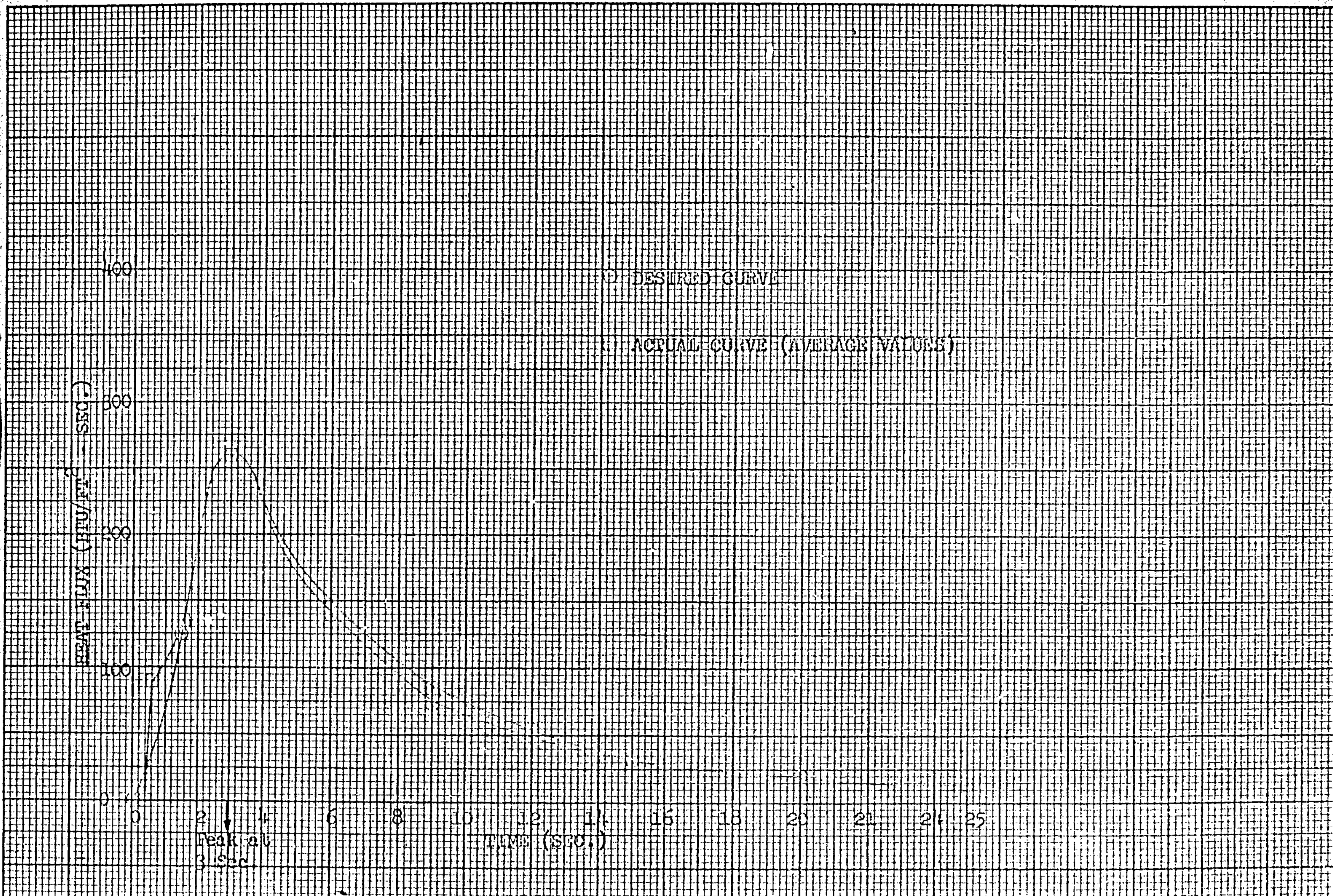

FIGURE 3. HEAT FLUX vs TIME PROFILE, PULSE C. DESIRED PULSE AND ACTUAL PULSE.

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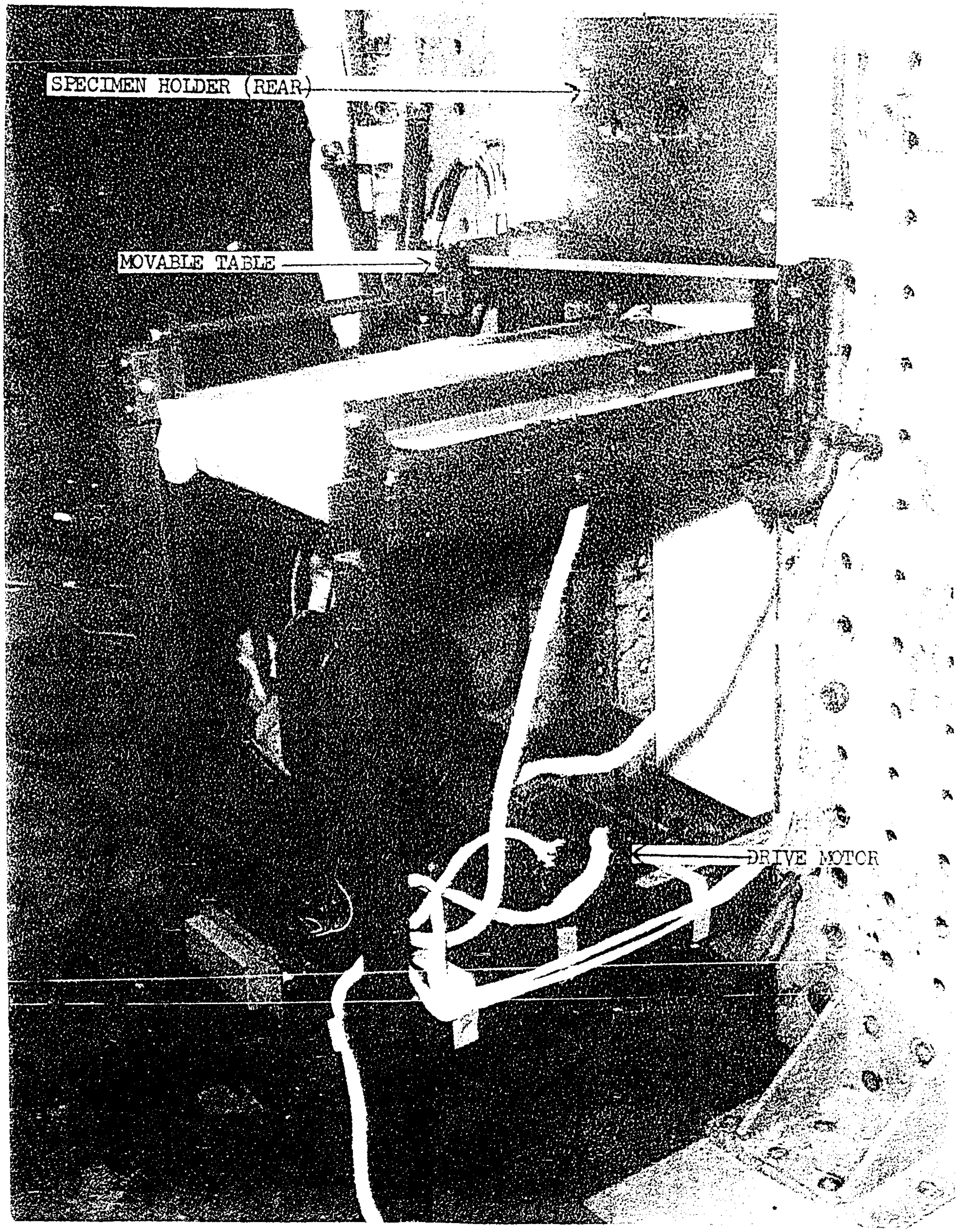

FIGURE 5. THE RIGHT SIDE OF THE MOVABLE TABLE USED TO PRODUCE THE LEADING EDGE OF THE DESIRED HEAT PULSE.

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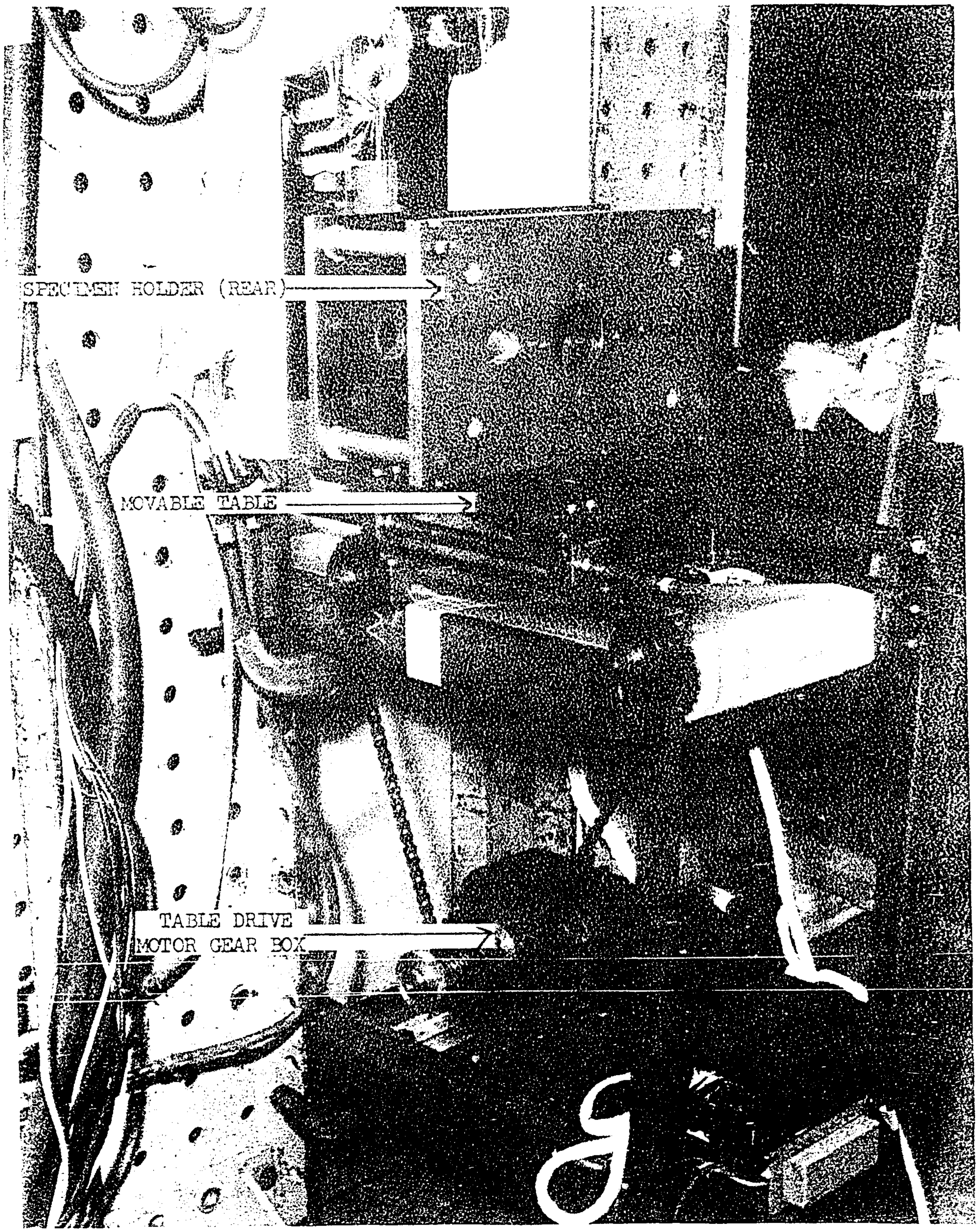

FIGURE 6. THE LEFT SIDE OF THE MOVABLE TABLE USED TO PRODUCE THE LEADING EDGE OF THE DESIRED HEAT PULSE.

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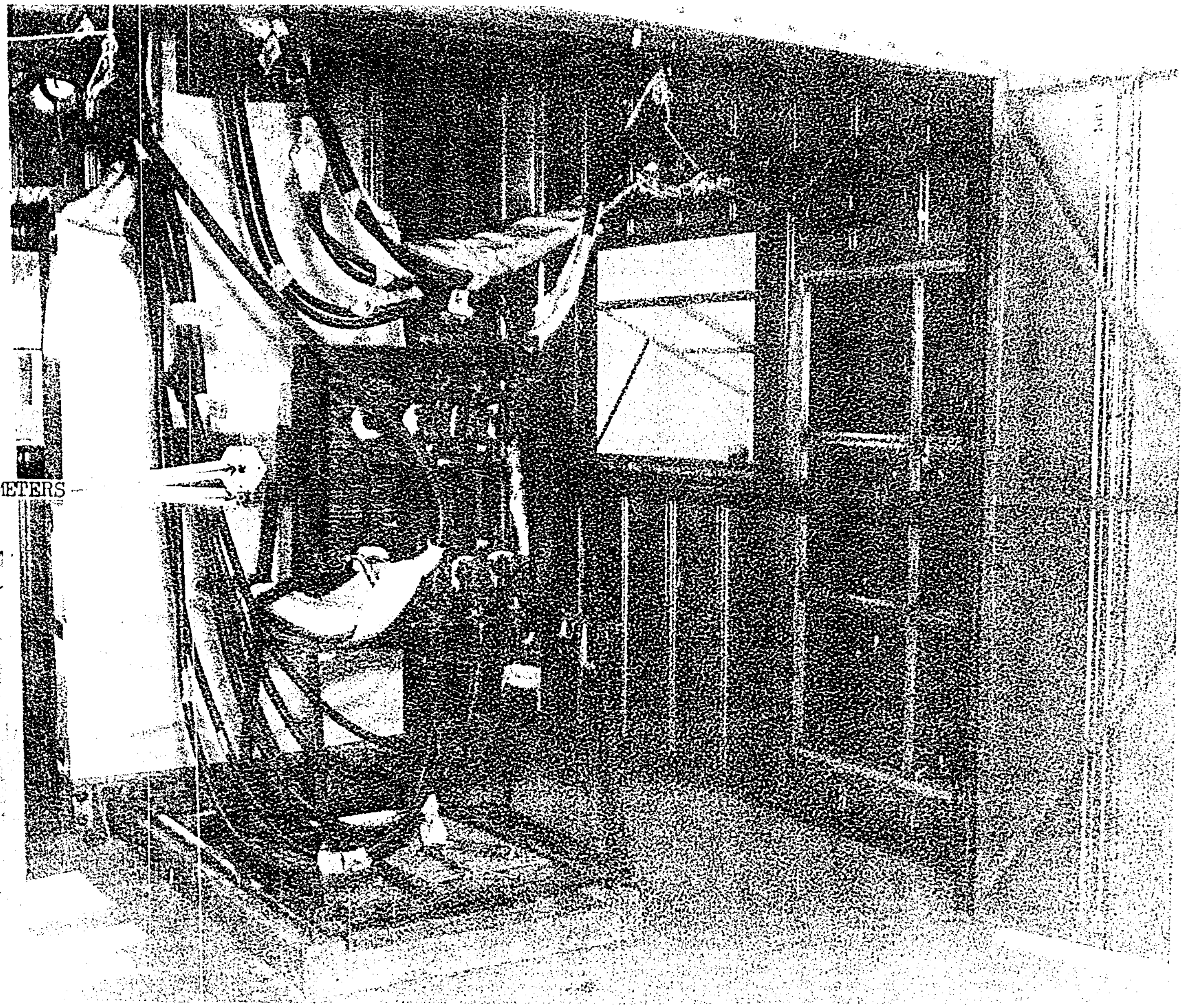

FIGURE 7. THE BUTLER BUILDING TEST SETUP. NOTE THE TWO CALORIMETERS USED FOR THE CALIBRATION IN THE TEST ITEM HOLDER

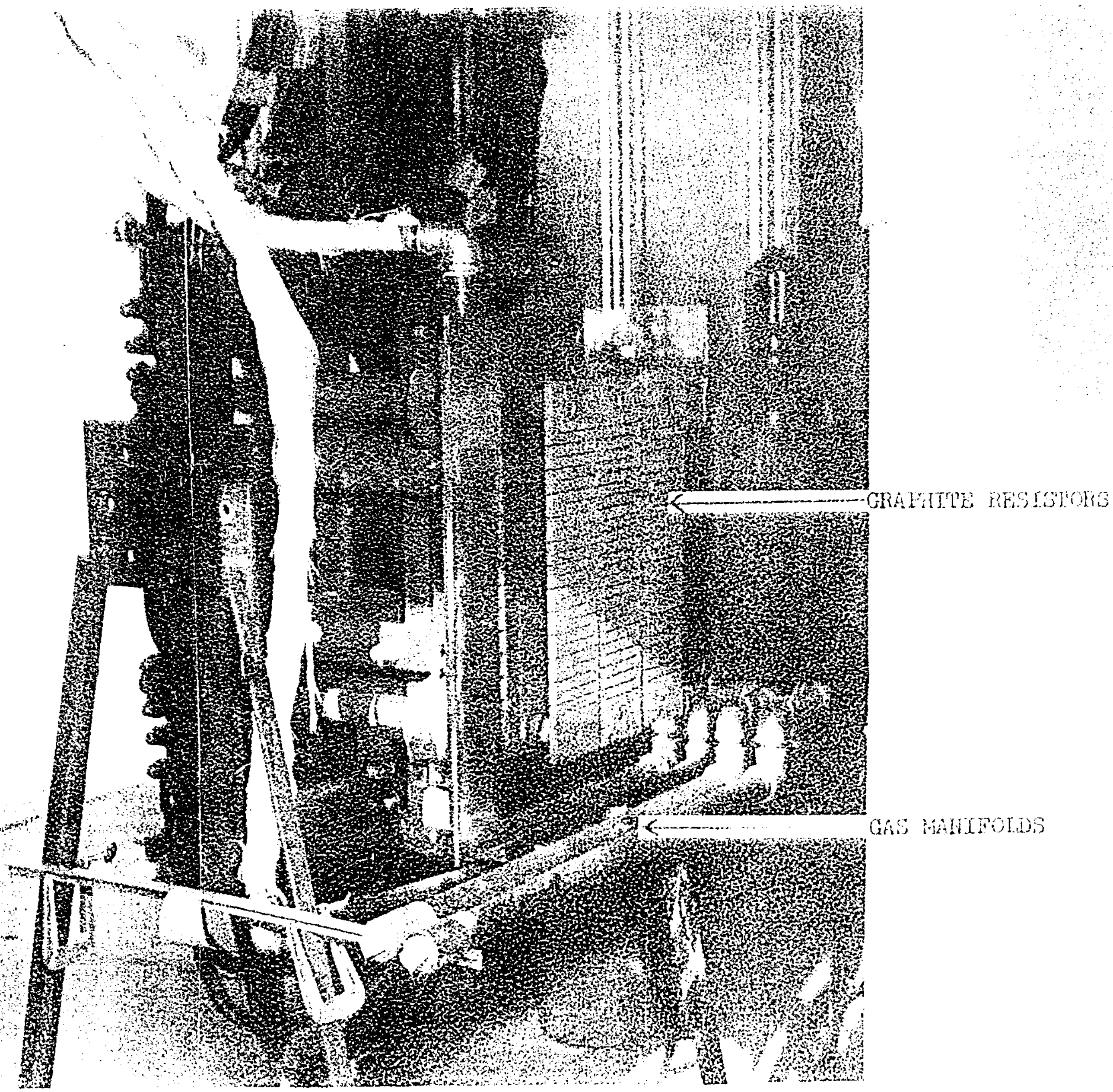

FIGURE 3. THE VERTICAL THREE CARBON HEATER ARRAY WITH TWO NITROGEN GAS MANIFOLDS.

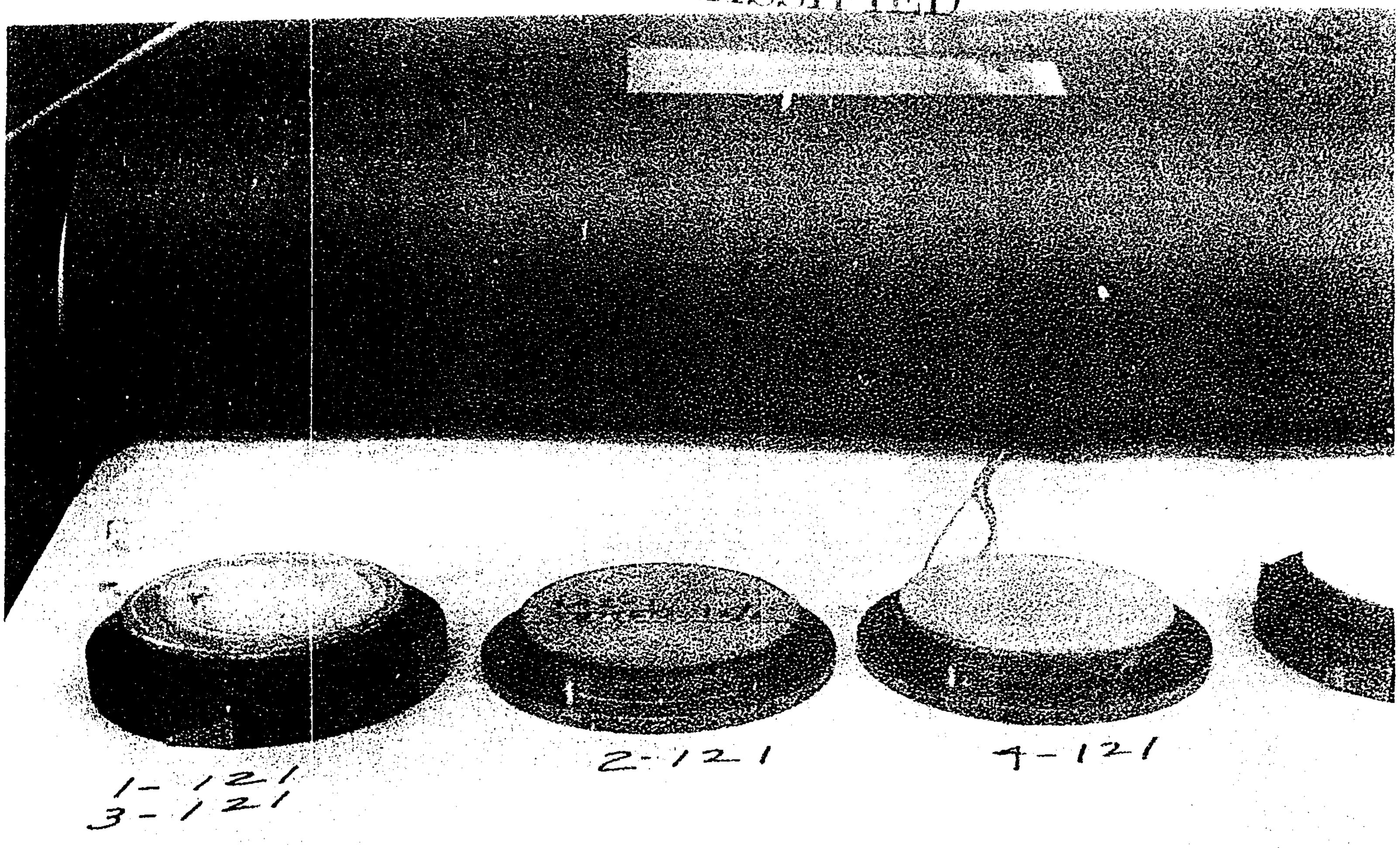

FIGURE 10. ALUMINA TEST WINDOWS AFTER EXPOSURE TO THEIR RESPECTIVE HEAT PULSES. NOTE HOW SOME OF THE WINDOWS HAVE POPPED OUT OF THE WINDOW HOLDER.

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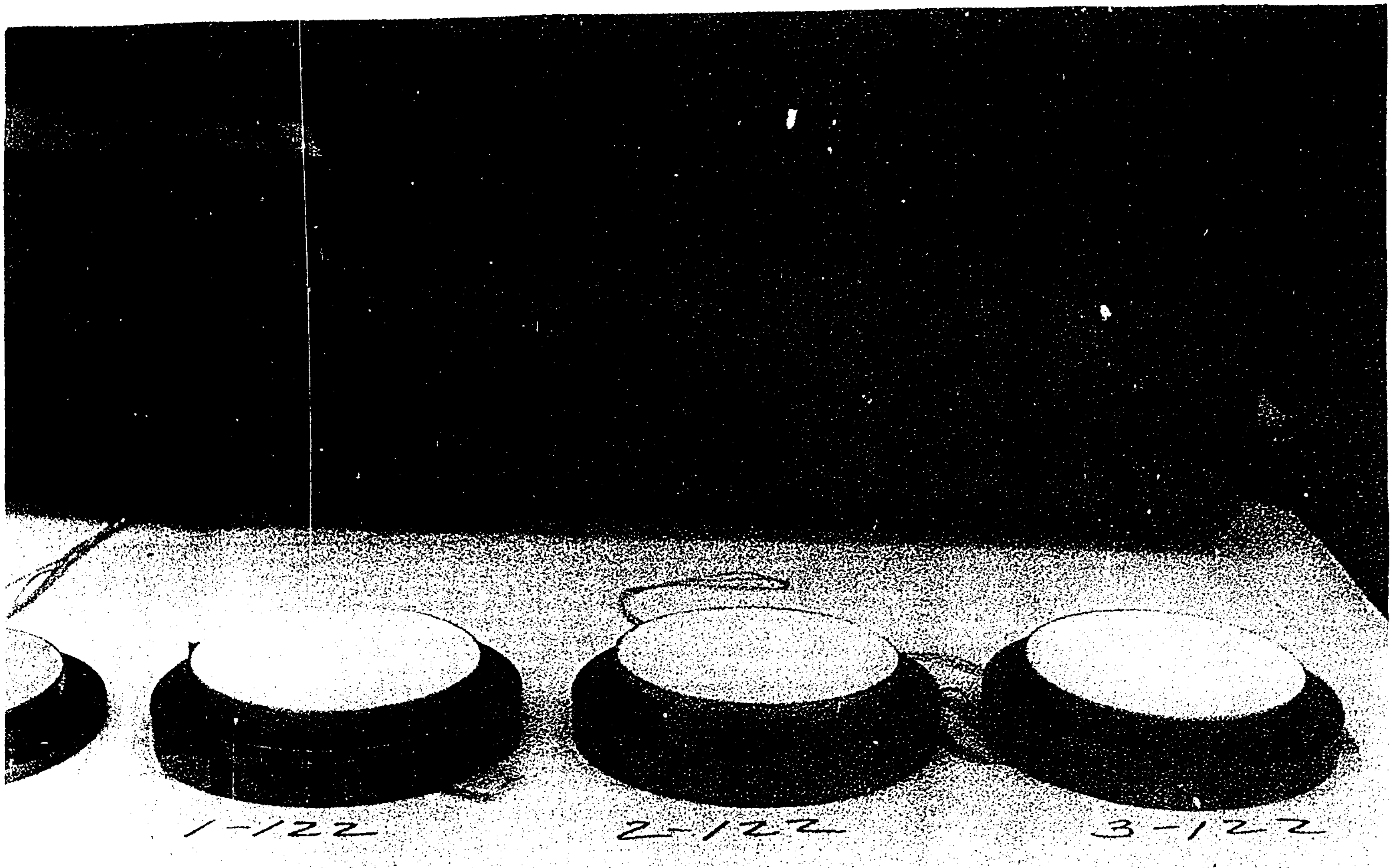

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FIGURE 11. BERYLLIA TEST WINDOWS AFTER EXPOSURE TO THEIR RESPECTIVE HEAT PULSES. NOTE HOW SOME OF THE WINDOWS HAVE POPPED OUT OF THE WINDOW HOLDER.

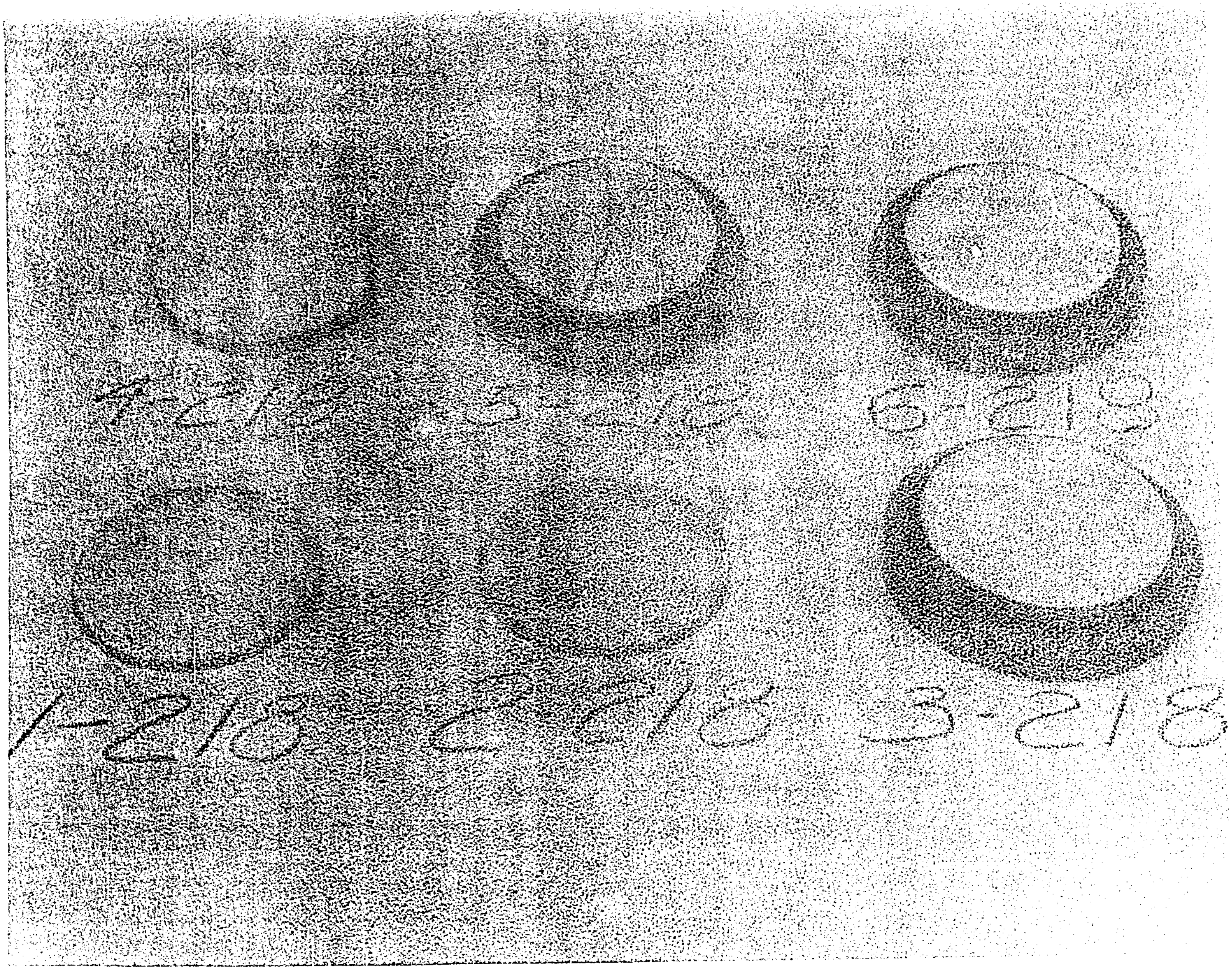

FIGURE 12. FIVE BERYLLIA WINDOWS AND ONE ALUMINA ([illegible]) WINDOW AFTER EXPOSURE TO [illegible] HEAT FLUX vs TIME PROFILES.

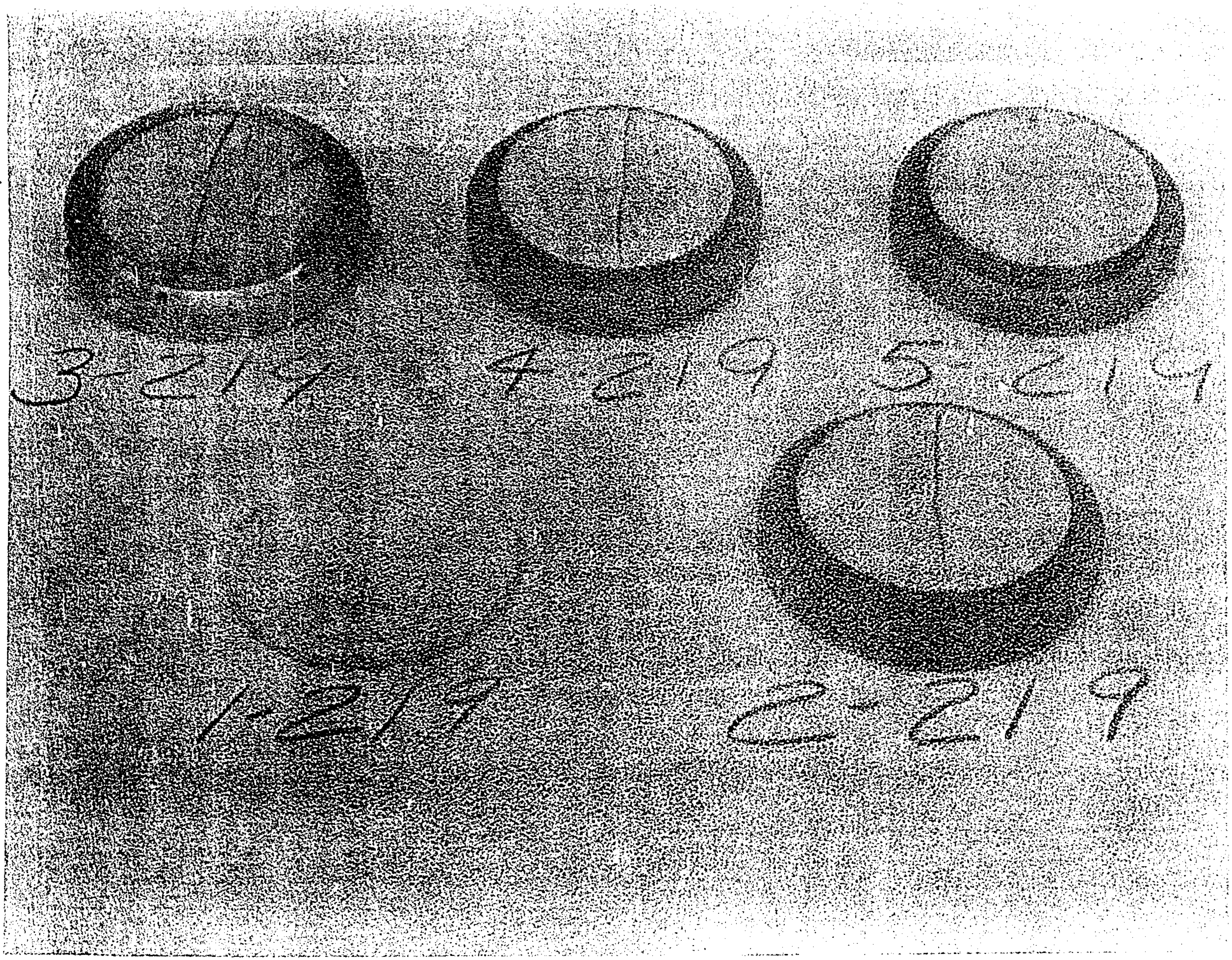

FIGURE 13. ALUMINA WINDOWS AFTER EXPOSURE TO THEIR RESPECTIVE HEAT FLUX vs TIME PROFILES.

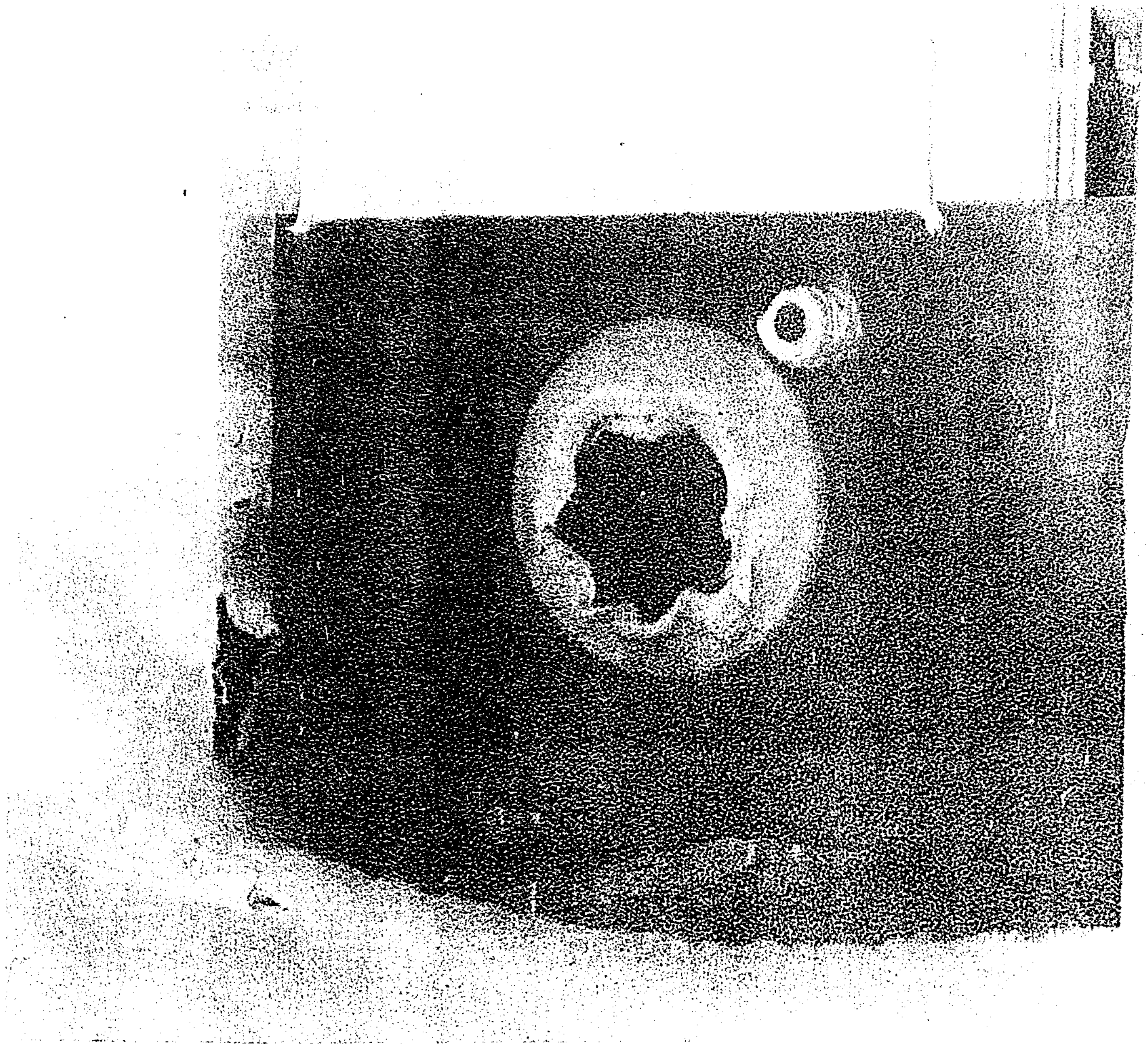

FIGURE 15. THE LSRH TEFLON WINDOW AFTER 3 "C" PULSES.

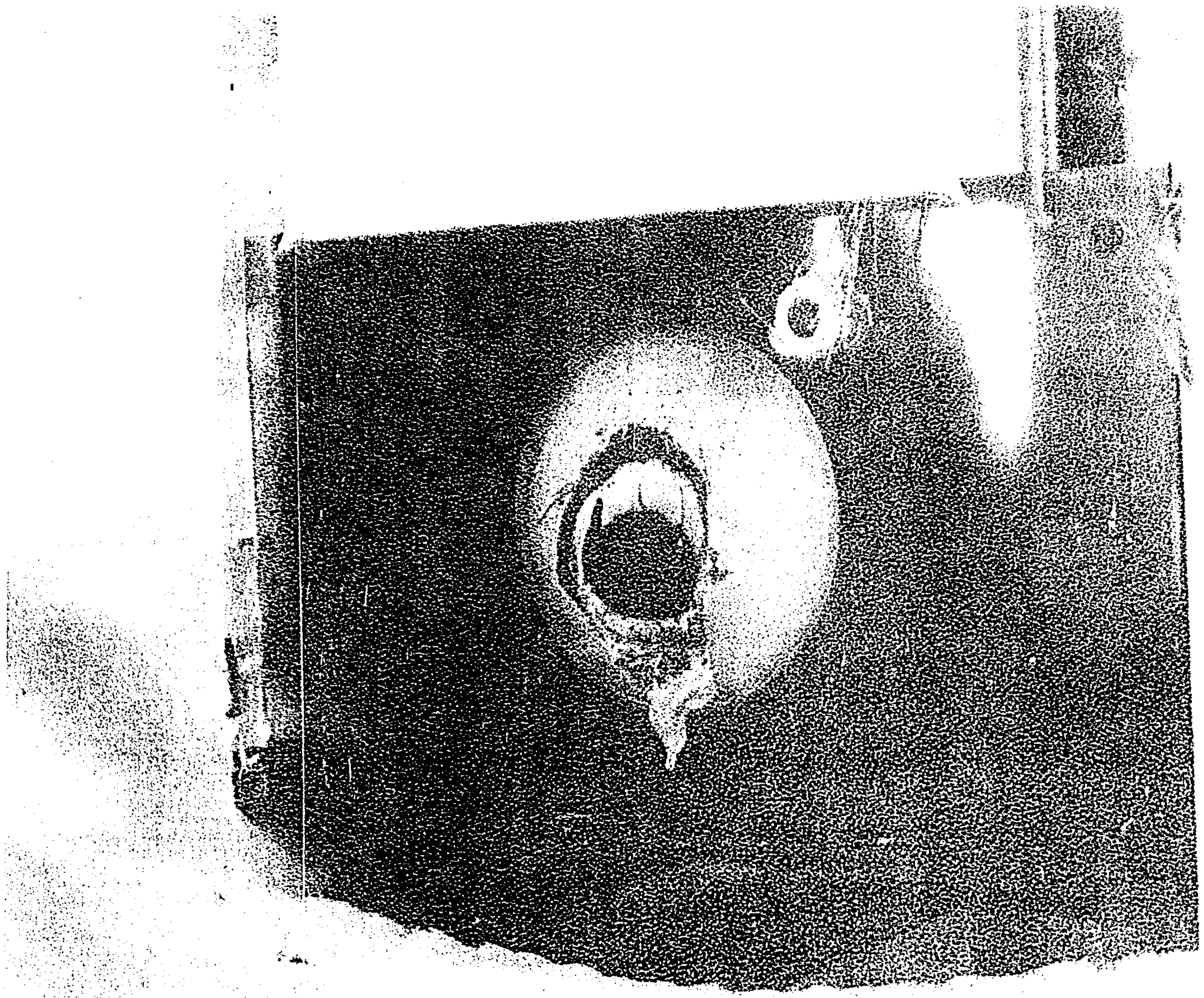

FIGURE 16. THE LSRO TEFLON WINDOW AFTER TWO "C" PULSES.