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# **Effectiveness of Water Spray Mitigation Systems for Accidental Releases of Hydrogen Fluoride**

**Volume VI  
Appendix H  
Selected Still Photographs**

*Prepared by:*

**The Industry Cooperative HF  
Mitigation / Assessment Program**

**Water Spray Subcommittee**

**June, 1989**

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VOLUME VI

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## **DISCLAIMER**

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PREFACE

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This report is one of several work products generated by the Industry Cooperative HF Mitigation/Assessment Program. This ad hoc industry program began in late 1987 to study and test techniques for mitigating accidental releases of hydrogen fluoride (HF) and alkylation unit acid (AUA) and to better estimate ambient impacts from such releases.

The hazards of HF have long been recognized. Standard operating practices focused on minimizing the possibility of a release and mitigating the effects if a release should occur. These practices are continually monitored and improved to maximize safety protection based on the available technical data. This recent program targeted further improvements based on new technical data.

Twenty companies from the chemical and petroleum industries sponsored and funded this program. These include:

Allied-Signal	Elf Aquitaine	Shell Internationale
Amoco	Exxon	Sun/Suncor
Ashland	Kerr-McGee	Tenneco
BP	Marathon	Texaco
Chevron	Mobil	Unocal
Conoco/Dupont	Phillips	3M
Dow	Saras	

K. W. Schatz, Mobil Research and Development Corporation (MRDC) and R. P. Koopman, Lawrence Livermore National Laboratories (LLNL) prepared this document as part of the work for the Water Spray Subcommittee.

The cooperation of the members of the following groups is gratefully acknowledged:

1. Allied-Signal for providing anhydrous hydrogen fluoride, analytical equipment and personnel.
2. Chevron for providing personnel.
3. Colorado State University, for consulting on scale-up, flow chamber design and flow chamber testing.
4. Conoco/DuPont, for providing personnel, safety training and data modeling.
5. Dow Chemical for providing personnel.
6. Exxon R&E for providing personnel.

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7. Industry cooperative HF Mitigation/Assessment program sponsors for funding the program.
8. Insitec for conducting the aerosol measurements.
9. Lawrence Livermore National Laboratories for providing personnel and services.
10. Mobil Central Research Laboratories for providing laboratory space and consulting on experiments.
11. Mobil Refineries, Paulsboro, NJ, and Joliet, IL, for providing alkylation unit acid.
12. Mobil R&D Corp., for providing personnel and services.
13. Phillips for providing personnel.
14. United Engineers & Constructors, Stearns Roger Division, Denver, for engineering, procurement and construction of the flow chamber.
15. U. S. Department of Energy and contractors EG&G and ReeCo for providing the test site and services.

The results of this study are being published with the intent of making them available to any interested party. The deliverables of the program consist of a report with several appendices, a supplementary report (with a planned release date of third quarter 1989), a volume of still pictures, video tapes and magnetic data tapes. These can be obtained through the U.S. Department of Commerce, National Technical Information Services (NTIS), Springfield, Virginia 22161. Anyone may use these results, subject to the rights of others, to contribute to the further maximization of safety protection. However, neither the sponsors for this work, nor their contractors, accept any legal liability or responsibility whatsoever for the consequences of its use or misuse.

## Appendix H

The appendix contains selected still pictures of the Hawk test series, conducted during August and September 1988 at DOE's test site at Mercury/Nevada. The following Table H-1 is a summary of the pictures shown in this appendix. The Photo No. is using the same nomenclature as the originals produced by Lawrence Livermore National Laboratory: the camera was either a Pentax (P) or a Nikon (N), the frame (F) number is listed after the camera identification.

Table H-1  
Selected Still Pictures  
Hawk Test Series

Fig. No.	Test No.	Photo I.D.	Description
H-1	-	-	Flow chamber, and electric panels
H-2	-	-	Flow chamber, inside view
H-3	-	-	Utilities: water tank, AUA tank, nitrogen trailer, generator, steam boiler
H-4	-	-	Acid skid with operating cylinder and conditioning tank
H-5	1	P, F4	Test in progress, downflow 1st header
H-6	2	P, F18A	Test in progress, downflow 1st header
H-7	3	P, F11	Test in progress, downflow 1st header
H-8	4	P, F17	Test in progress, downflow 1st header
H-9	5	P, F15	Test in progress, strong bottom jet along right wall
H-10	6	P, F25A	Test in progress, with steam upflow 1st header
H-11	7	P, F5	Start of test, steam upflow and water downflow
H-12	7	P, F10	Test in progress
H-13	8	N, F18	Test in progress, downflow 2nd header
H-14	9	P, F15	Test in progress, steam upflow and water downflow
H-15	10	P, F4	Upflow water spray, 1st header
H-16	10	P, F11	Upflow water spray, test in progress
H-17	11	P, F3A	Dual curtain water sprays, 1st and 2nd header
H-18	11	P, F9A	Test in progress
H-19	12	P, F16	Test in progress, downflow 1st header
H-20	13	P, F0A	Downflow water spray, 1st header

Table H-1 (continued)

Fig. No.	Test No.	Photo I.D.	Description
H-21	13	P, F7A	Test in progress
H-22	14	P, F18	Test in progress, downflow 1st header
H-23	15	P, F1	Water spray, downflow 1st header, aerosol and IFS probes
H-24	15	P, F9	Test in progress
H-25	16	P, F21	Test in progress, downflow 1st header
H-26	17	N, F9	Test in progress, strong bottom jet
H-27	18	N, F20	4 nozzle water spray, 1st header
H-28	18	P, F13	Test in progress
H-29	19	P, F25	Single nozzle downflow, 2nd header
H-30	19	P, F32	Test in progress
H-31	20	N, F6	Test in progress, downflow 1st header
H-32	21	P, F13	Upflow water spray, 1st header
H-33	21	P, F16	Test in progress
H-34	22	N, F8	Test in progress, upflow 1st header
H-35	23	N, F5	Test in progress, some fuming from liquid drop-out
H-36	24	P, F12	Monitor, wide angle setting
H-37	24	P, F19	Test in progress
H-38	25	N, F29	Test in progress, monitor wide angle setting
H-39	26	P, F7	Test in progress, narrow angle setting
H-40	27	N, F5	Monitor, narrow angle w/splash plate, from about 50 ± ft.
H-41	27	N, F8	Test in progress
H-42	28	N, F13	Steam through monitor, downflow 1st header 16 ft. up, w/ splash plate
H-43	28	N, F17	Test in progress
H-44	29	P, F2	Monitor, wide angle setting
H-45	29	P, F7	Test in progress
H-46	30	N, F1	Monitor w/o splash plate, narrow angle, from 50 ± ft.
H-47	30	N, F9	Test in progress
H-48	31	P, F20	Test in progress, downflow 1st header
H-49	32	P, F31	Test in progress, downflow 1st header
H-50	33	P, F8	Test in progress, downflow 1st header
H-51	34	P, F5	Test in progress, downflow 1st header
H-52	35	N, F20	Test in progress, downflow 1st header
H-53	36	N, F32	Test in progress, upflow 1st header

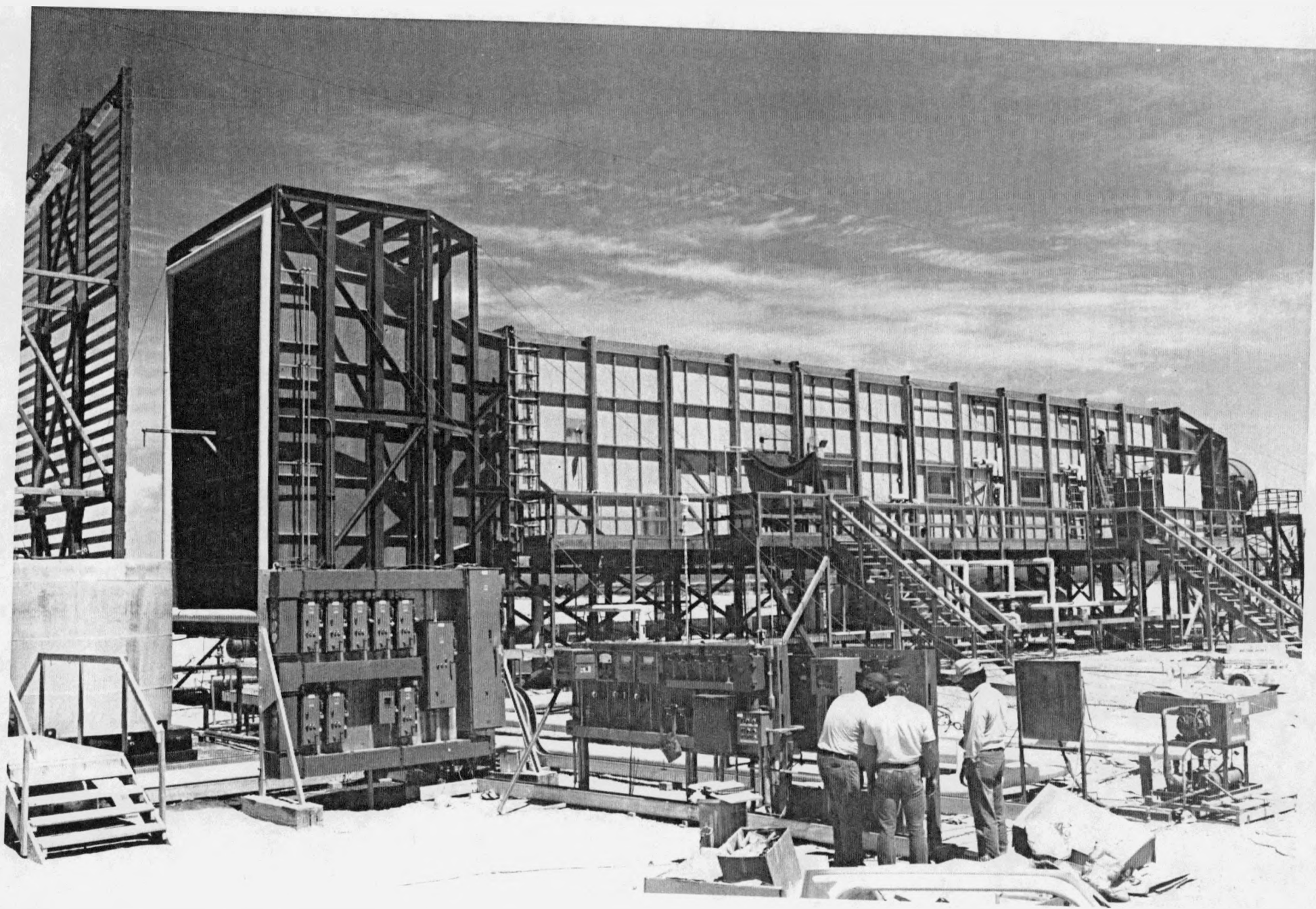
Table H-1 (continued)

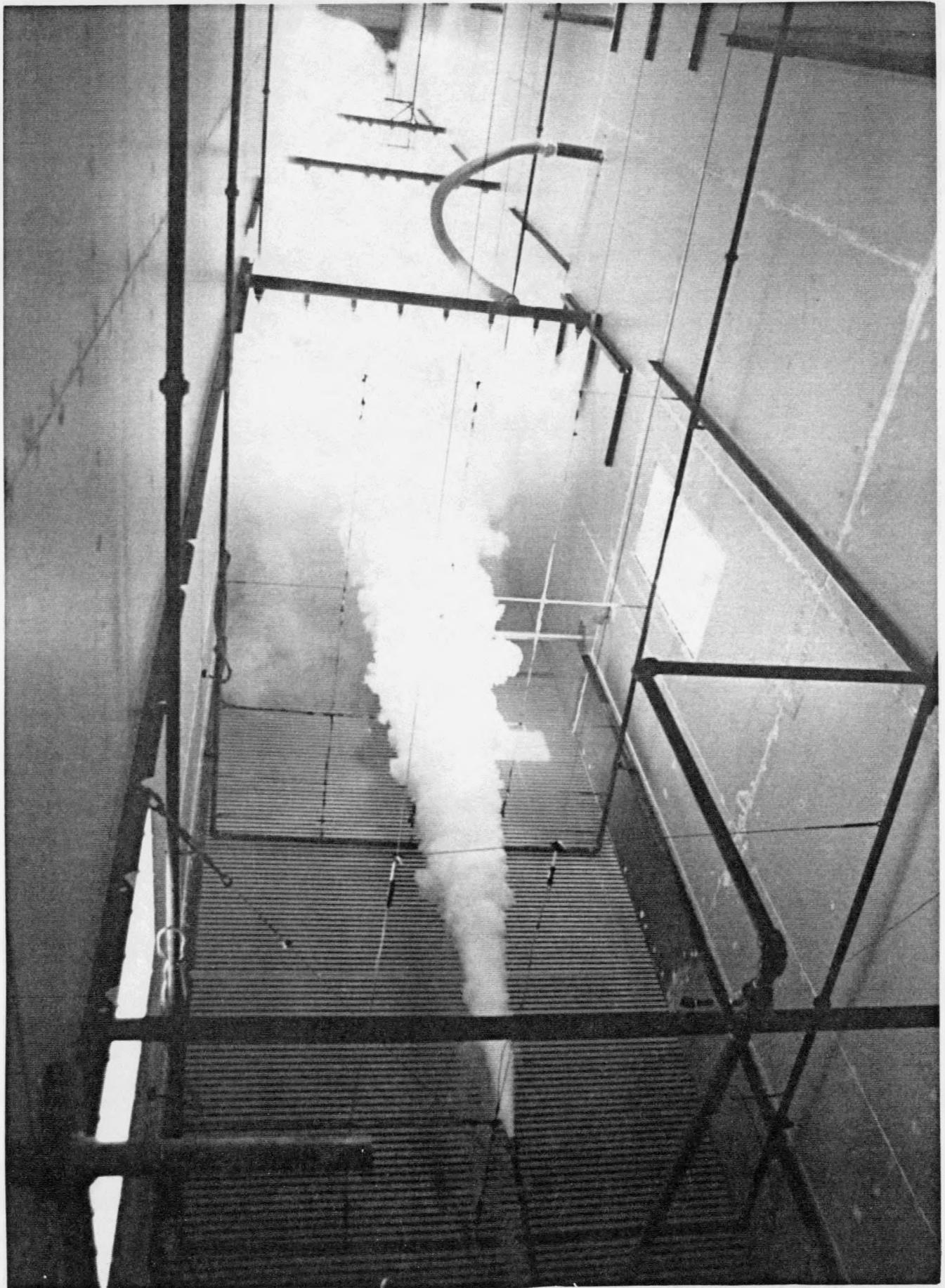
Fig. No.	Test No.	Photo No.	Description
H-54	37	N, F8	Test in progress, upflow 1st header
H-55	38	N, F8	Test in progress, upflow 1st header
H-56	39	N, F18	Test in progress, downflow 1st header
H-57	40	P, F9	Test in progress, downflow 2nd header 16 ft. up
H-58	42	P, F33	Test in progress, downflow 2nd header 16 ft. up
H-59	43	P, F8A	Test in progress, downflow 1st header
H-60	44	P, F18	Test in progress, acid nozzle elevation 8 ft. bypassing
H-61	45	N, F32	Test in progress, with stagnation plate
H-62	46	N, F5	Pool test in progress, downflow 1st header
H-63	47	N, F33	Pool test in progress, downflow 1st header
H-64	48	N, F5	Pool test in progress, downflow 1st header
H-65	49	P, F3	Aerosol test w/o water spray, start of jet, aerosol probe
H-66	49	P, F6	Aerosol test in progress, w/o spray
H-67	50	P, F17	Test in progress, downflow 1st header
H-68	51	P, F30	Aerosol test w/o water spray, in progress, HF pressure $120 \pm$ psig
H-69	52	P, F9A	Aerosol test with water spray, 1st header, HF pressure $120 \pm$ psig
H-70	53	P, F20A	Aerosol test w/o water spray, HF pressure $60 \pm$ psig
H-71	54	P, F5	Aerosol test w/o water spray, AUA at $150 \pm$ psig
H-72	55	P, F20	Aerosol test with water spray, 1st header, AUA
H-73	57	P, F4A	Aerosol test with water spray, 1st header, AUA
H-74	58	P, F17A	Test in progress, downflow 1st header
H-75	59	N, F32	Test in progress, strong bottom jet
H-76	60	P, F6	Test in progress, downflow 1st header, 16 ft. up
H-77	61	P, F18	Test in progress, upflow 1st header
H-78	62	P, F6A	Test in progress, co-current flow, single nozzle, 1st header
H-79	63	N, F4A	Test in progress, downflow 1st header, strong bottom jet



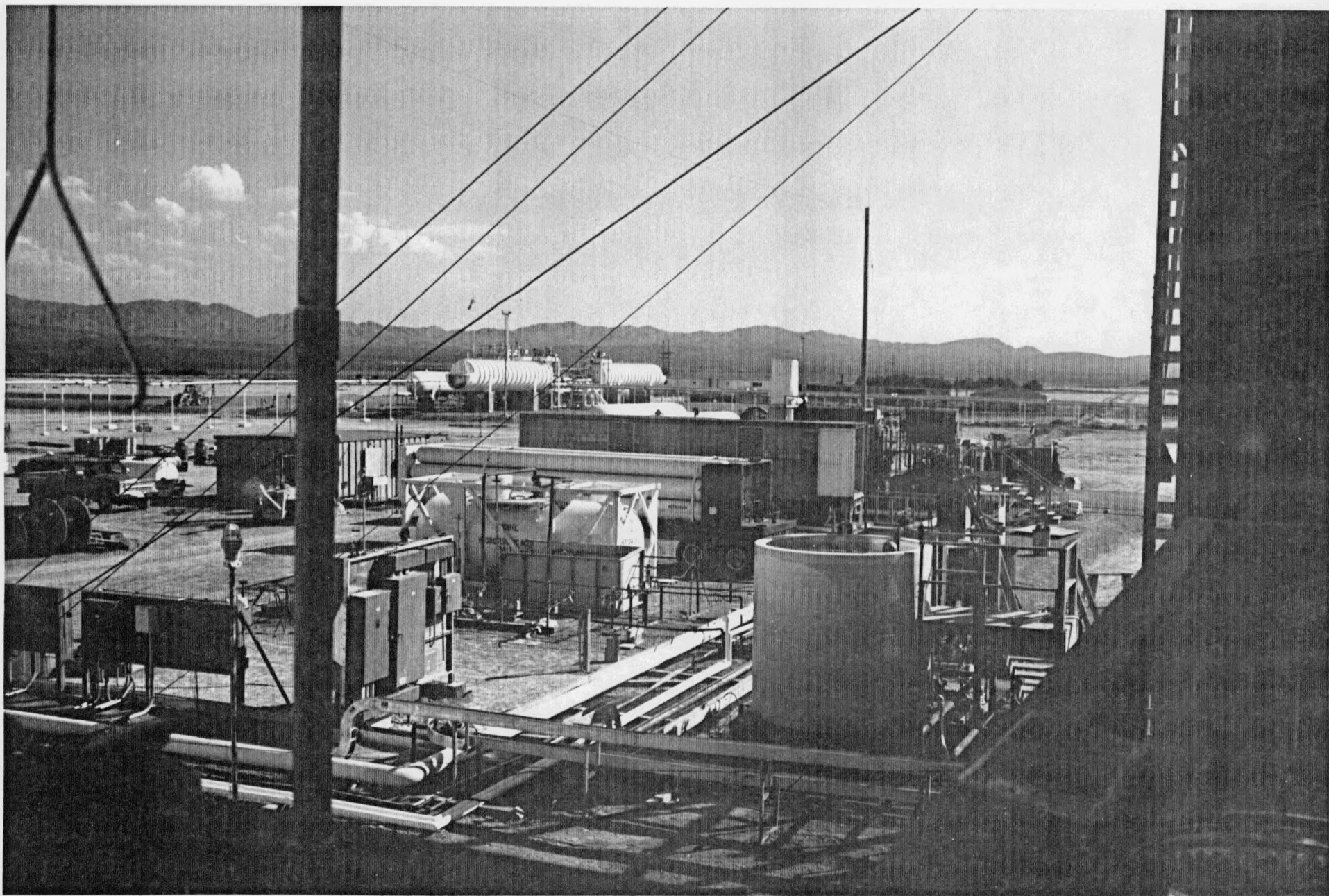
Table H-1 (continued)

Fig. No.	Test No.	Photo I.D.	Description
H-80	64	N, F19A	Test in progress, downflow 1st header, strong bottom jet
H-81	65	P, F9	Test in progress, downflow 1st header
H-82	66	P, F17	Test in progress, downflow 1st header
H-83	67	P, F33	Test in progress, downflow 1st header
H-84	68	P, F6	Test in progress, downflow 1st header
H-85	69	N, F18	Test in progress, downflow 1st header
H-86	70	N, F6	Test in progress, downflow 1st header, cold HF
H-87	71	P, F18	Test in progress, downflow 1st header, cold HF
H-88	72	P, F25	Water spray, upflow 1st header
H-89	72	P, F33	Test in progress, upflow 1st header
H-90	73	P, F8	Test in progress, upflow 1st header
H-91	74	P, F5	Test in progress, upflow 1st header
H-92	75	P, F25	Test in progress, upflow 1st header
H-93	76	P, F1	Water spray up-and downflow 2nd header
H-94	76	P, F8	Test in progress
H-95	77	P, F13	Water spray 2 nozzles, downflow 1st header
H-96	77	P, F15	Test in progress, strong bottom jet
H-97	78	P, F30	Test in progress, strong bottom jet
H-98	79	P, F8A	Test in progress, strong bottom jet, bypassing
H-99	80	P, F13A	Monitor, wide angle setting
H-100	80	P, F18A	Test in progress
H-101	81	P, F25A	Monitor, narrow angle setting, from 12 ft., w/splash plate
H-102	81	P, F30A	Test in progress, no fumes at fan exit
H-103	82	P, F6	Test in progress, baffle from ceiling to header
H-104	83	P, F5	Test in progress, wind speed increased to 6 m/s
H-105	84	P, F18	Test in progress, downflow 1st header
H-106	85	P, F25	Monitor, narrow angle setting, from 12 ft., w/splash plate
H-107	85	P, F30	Test in progress, no fumes at fan exit









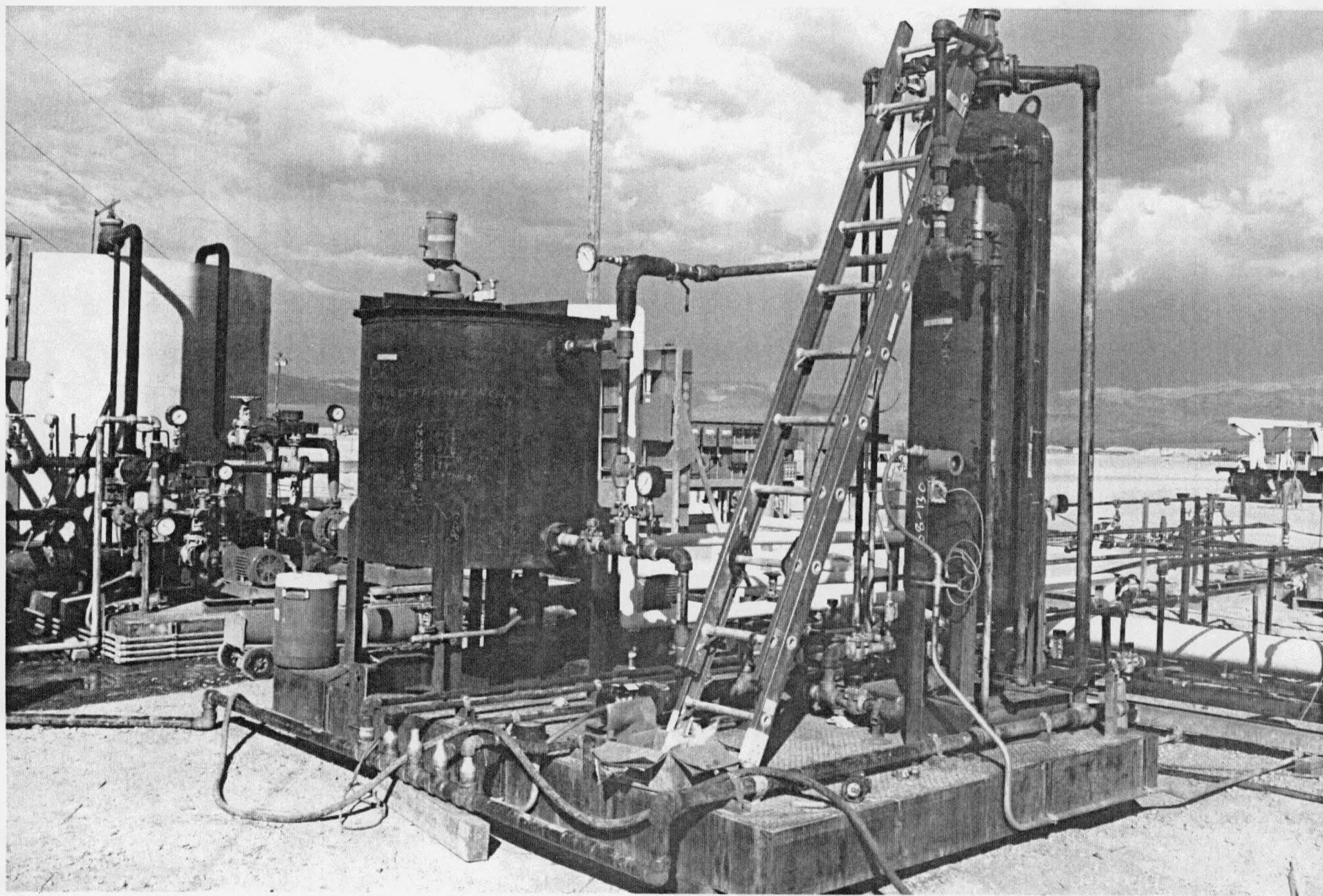




Figure H-5  
Test 1

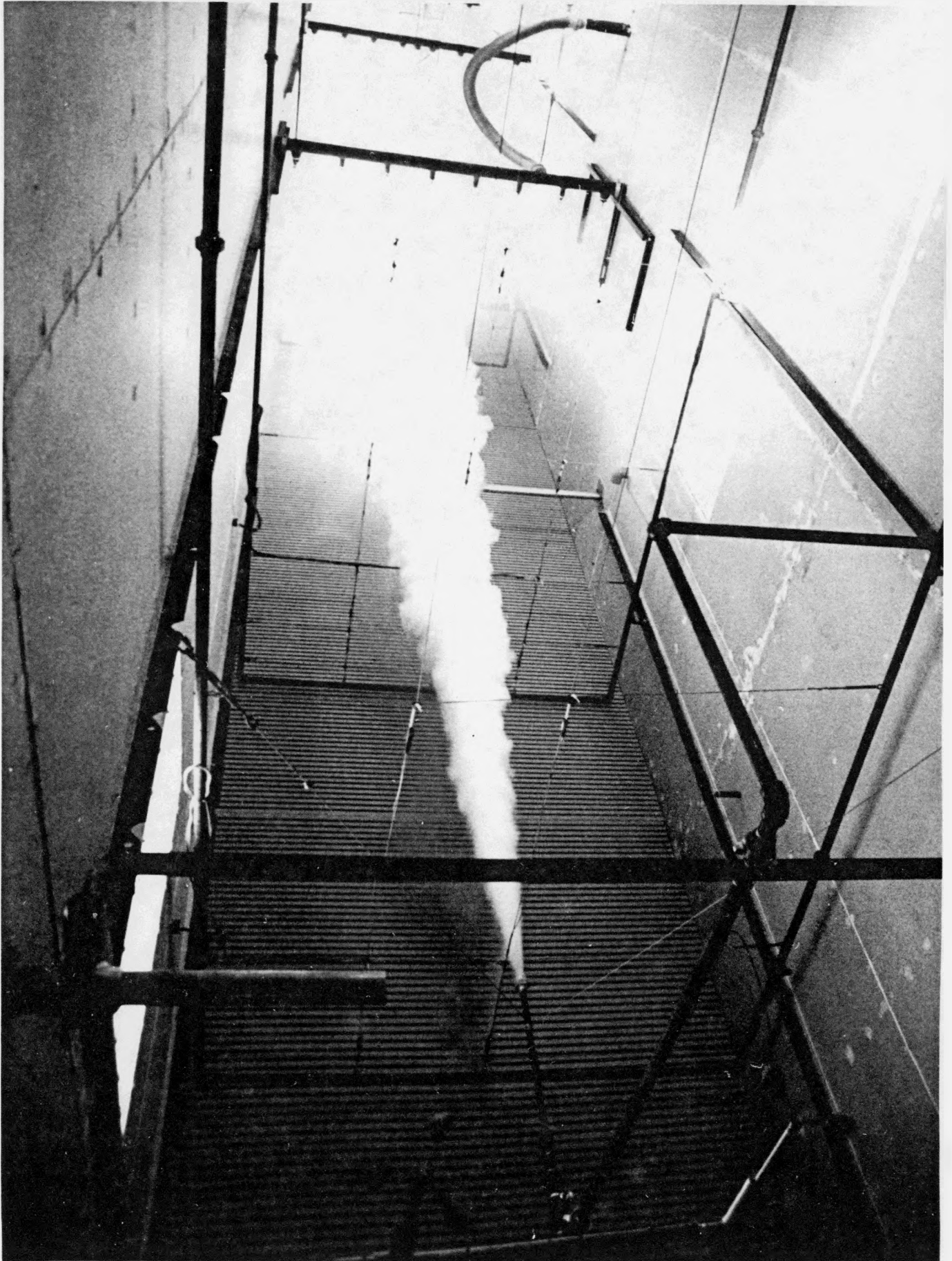


Figure H-6  
Test 2





Figure H-7  
Test 3

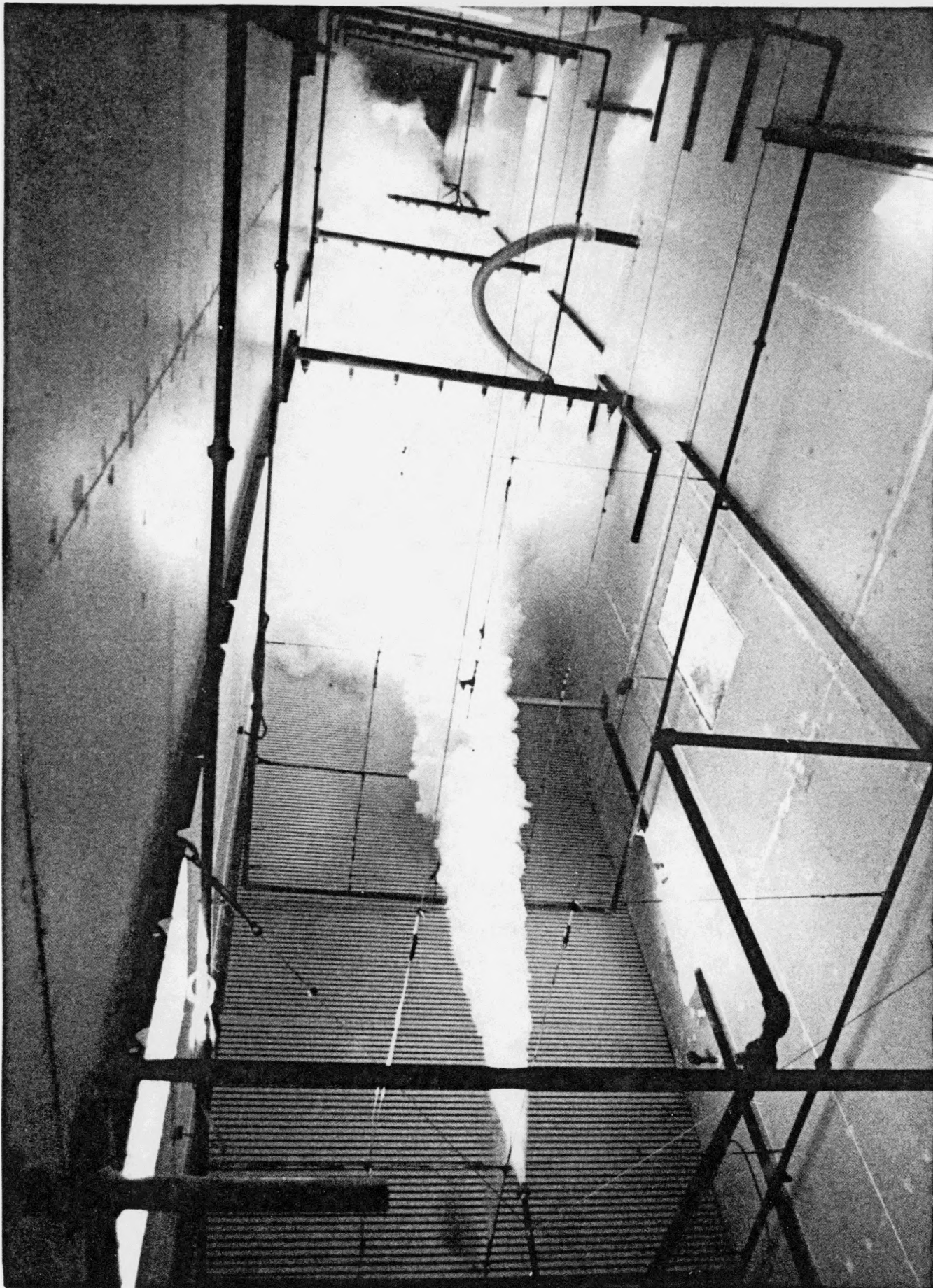


Figure H-8  
Test 4

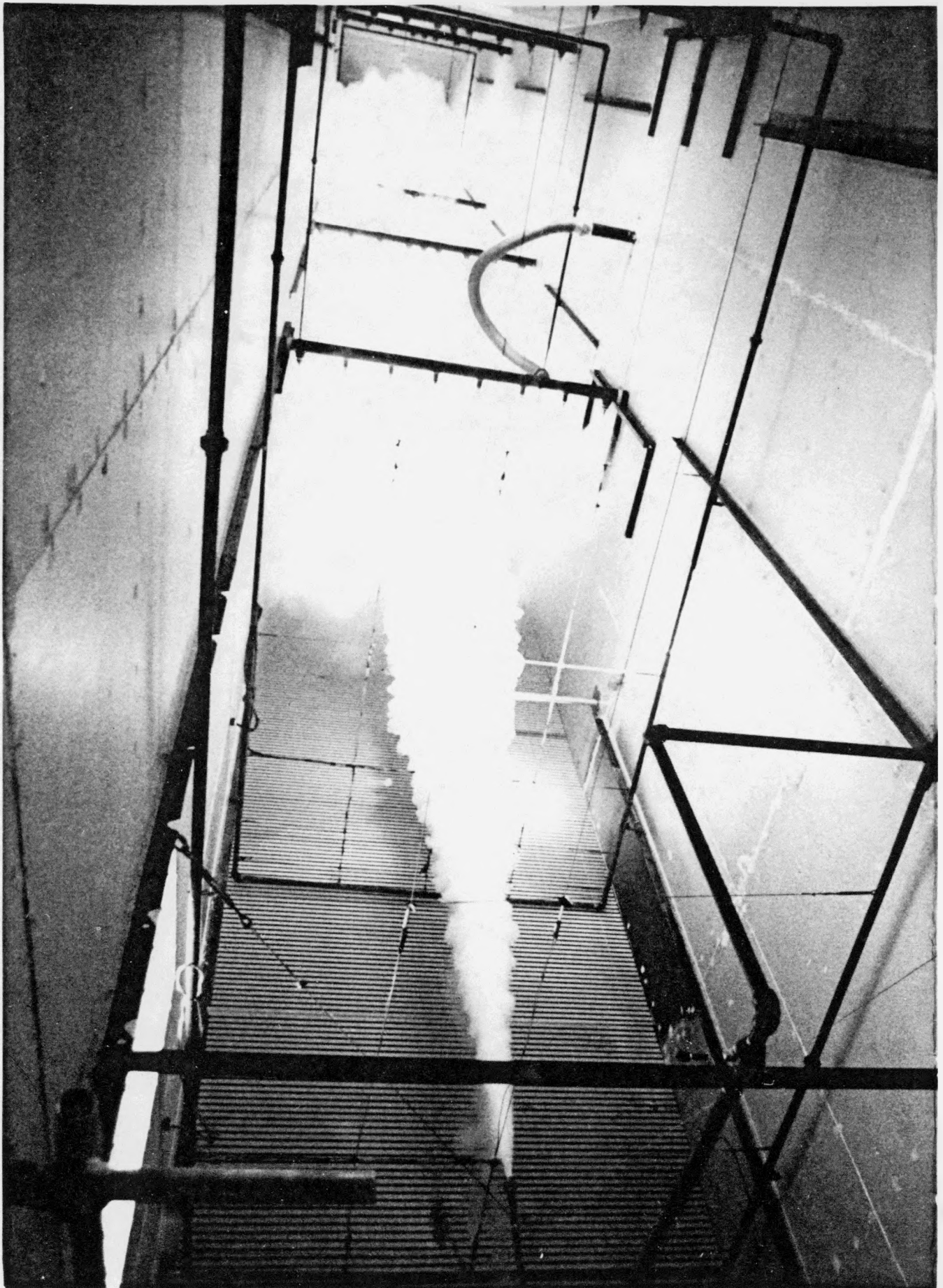




Figure H-9  
Test 5

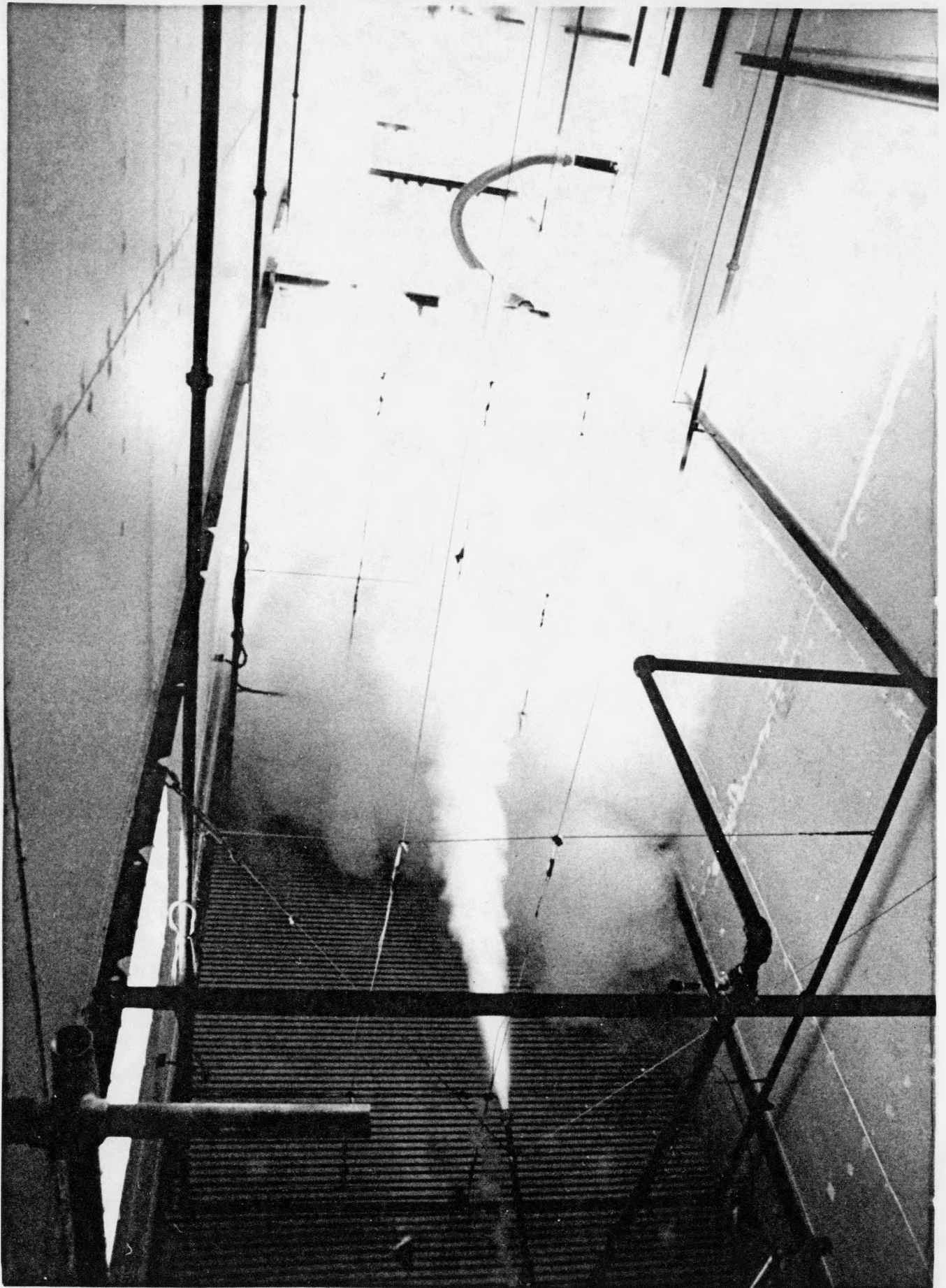
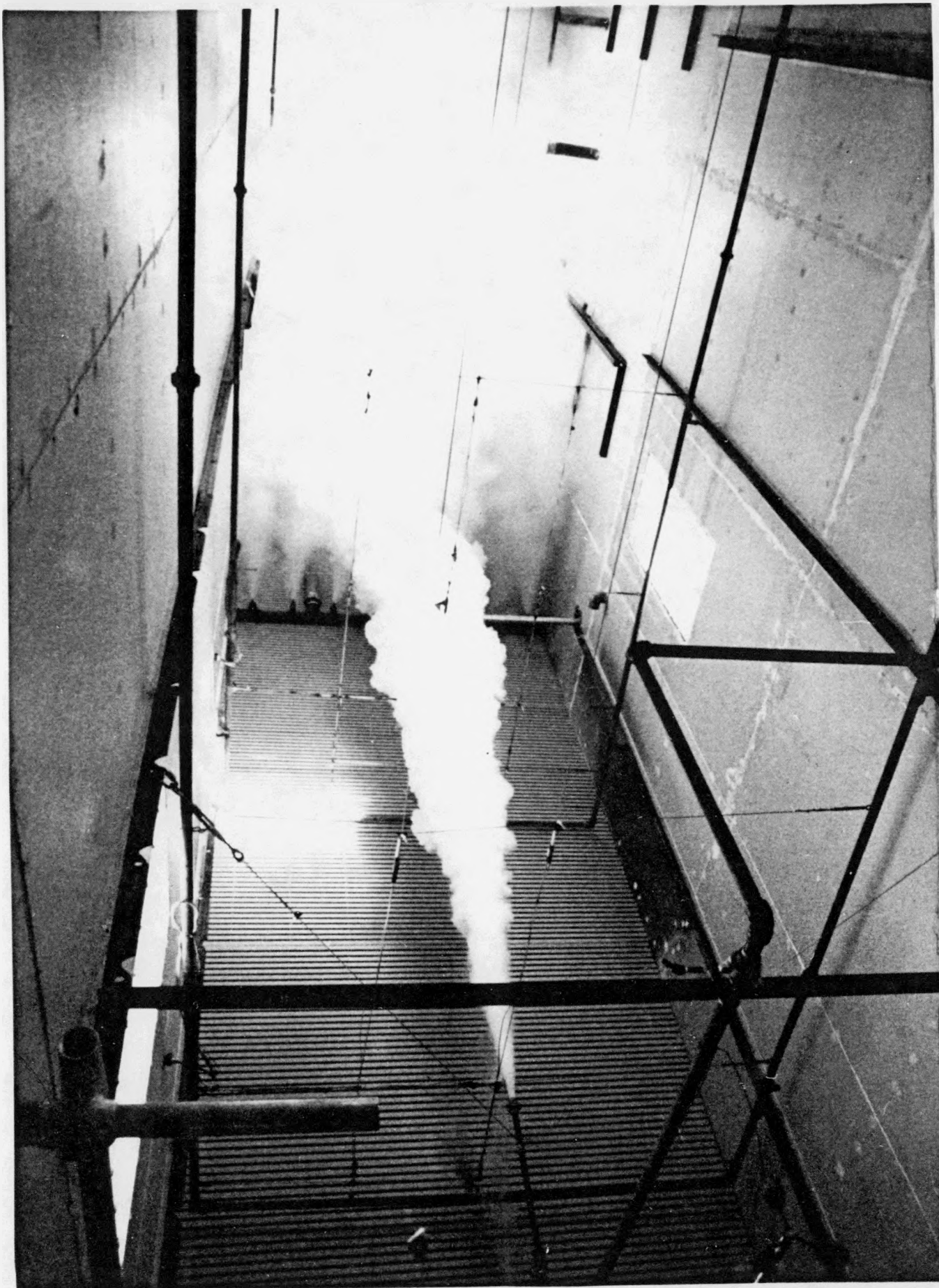




Figure H-10  
Test 6



-H14-

Figure H-11  
Test 7



Figure H-12  
Test 7

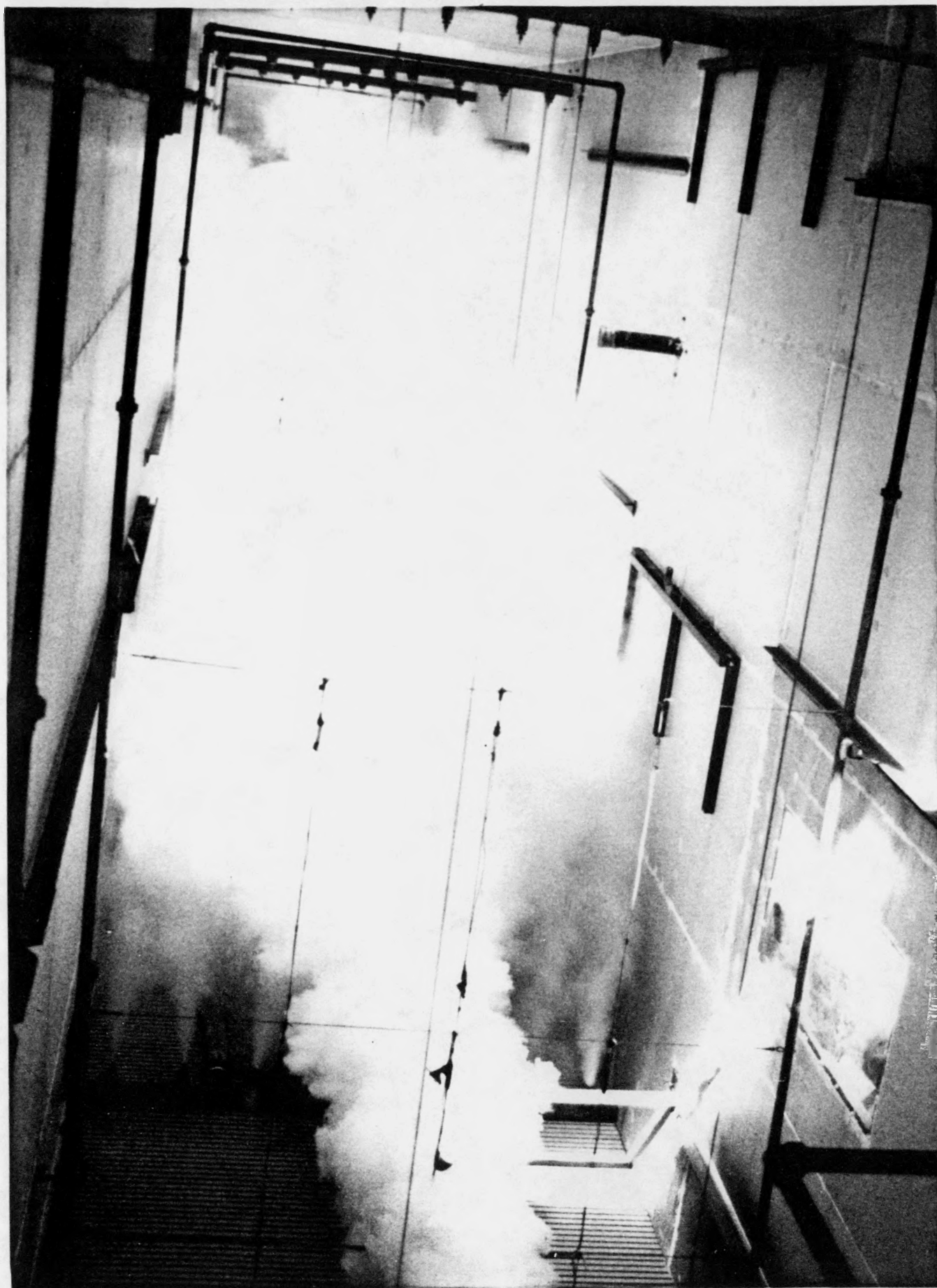




Figure H-13  
Test 8



Figure H-14  
Test 9



-H18-



Figure H-15  
Test 10

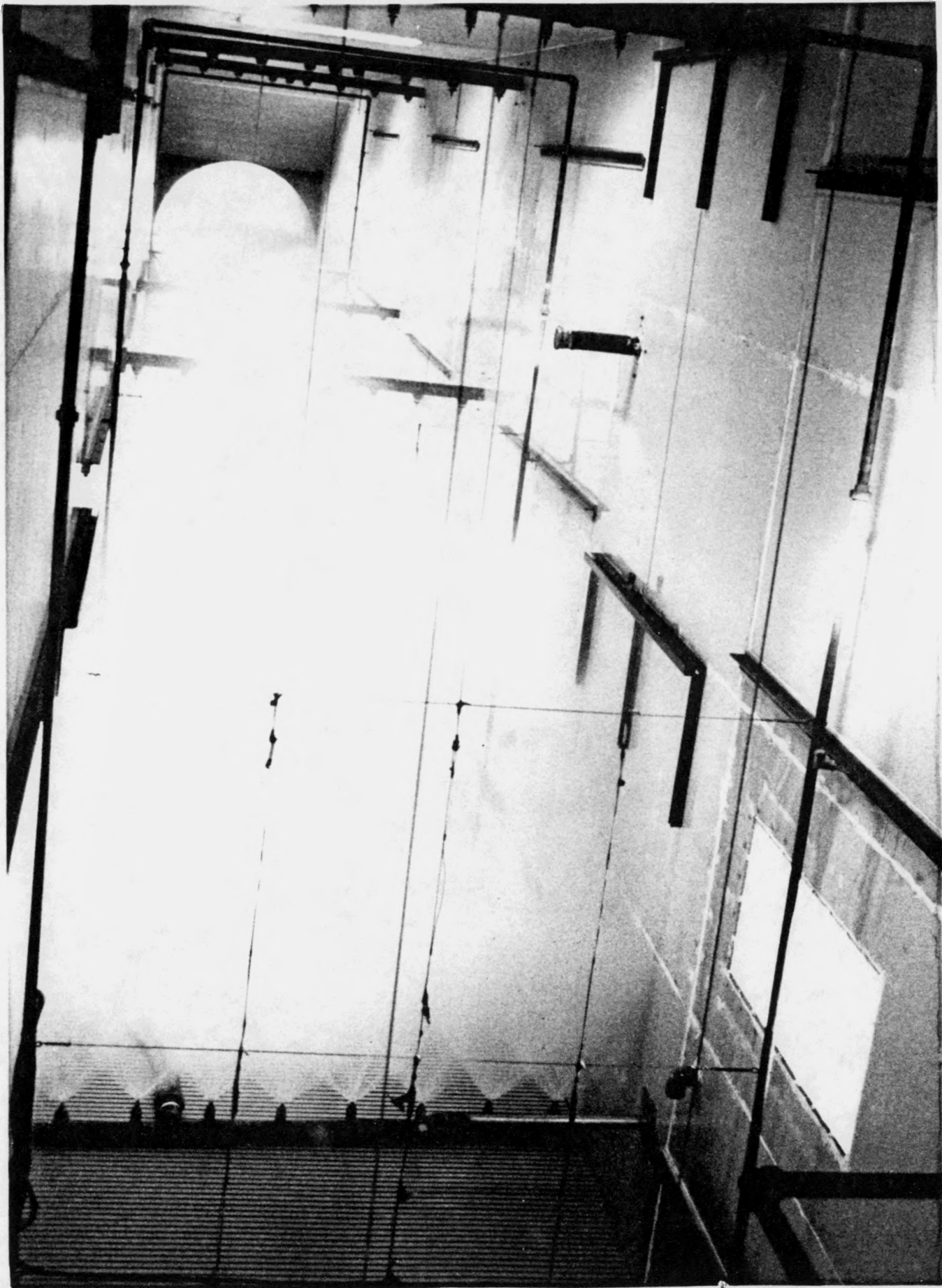


Figure H-16  
Test 10



-H20-

Figure H-17  
Test 11



-H21-



Figure H-18  
Test 11

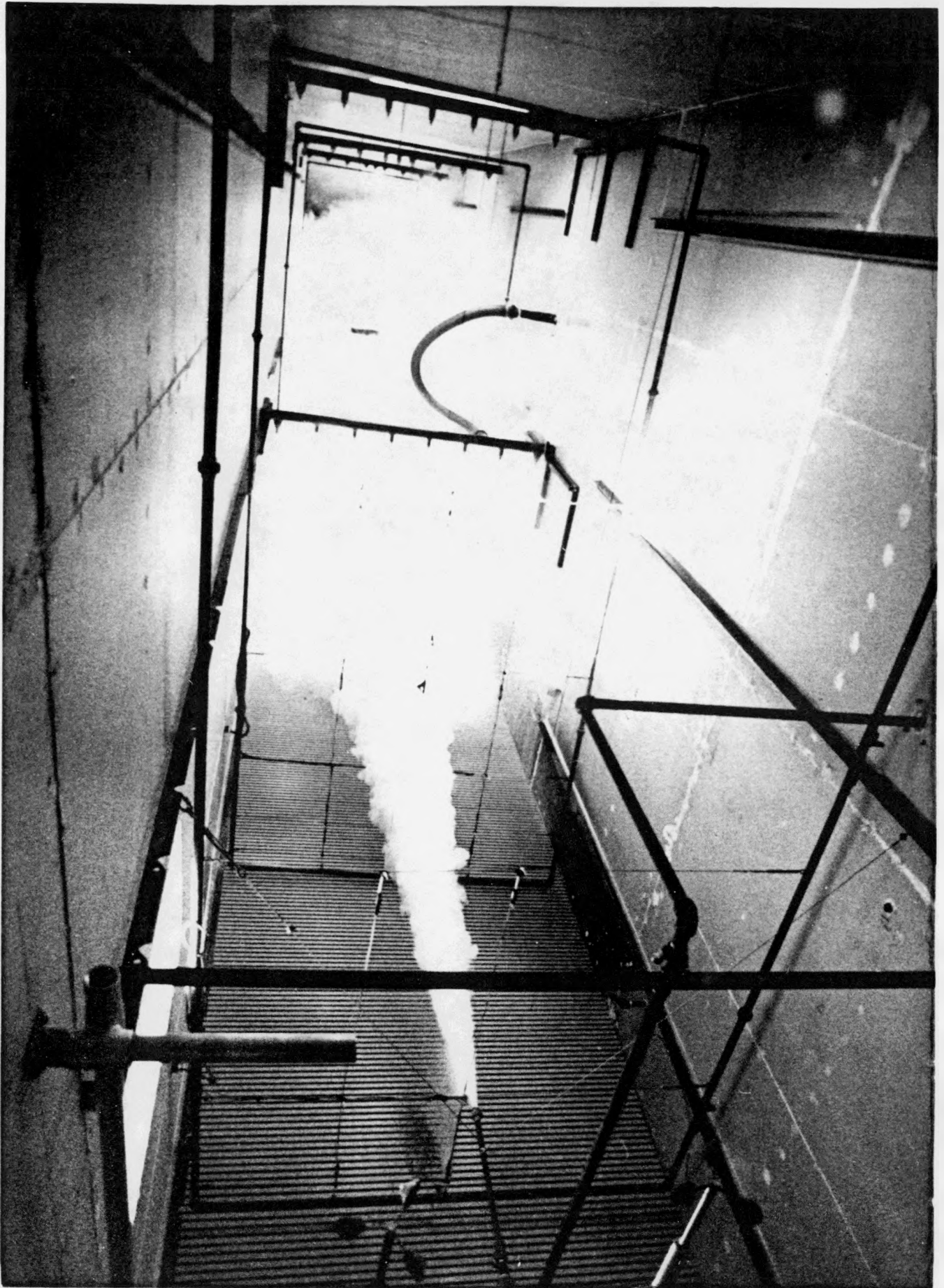


Figure H-19  
Test 12



-H23-



Figure H-20  
Test 13



Figure H-21  
Test 13



-H25-



Figure H-22  
Test 14





Figure H-23  
Test 15

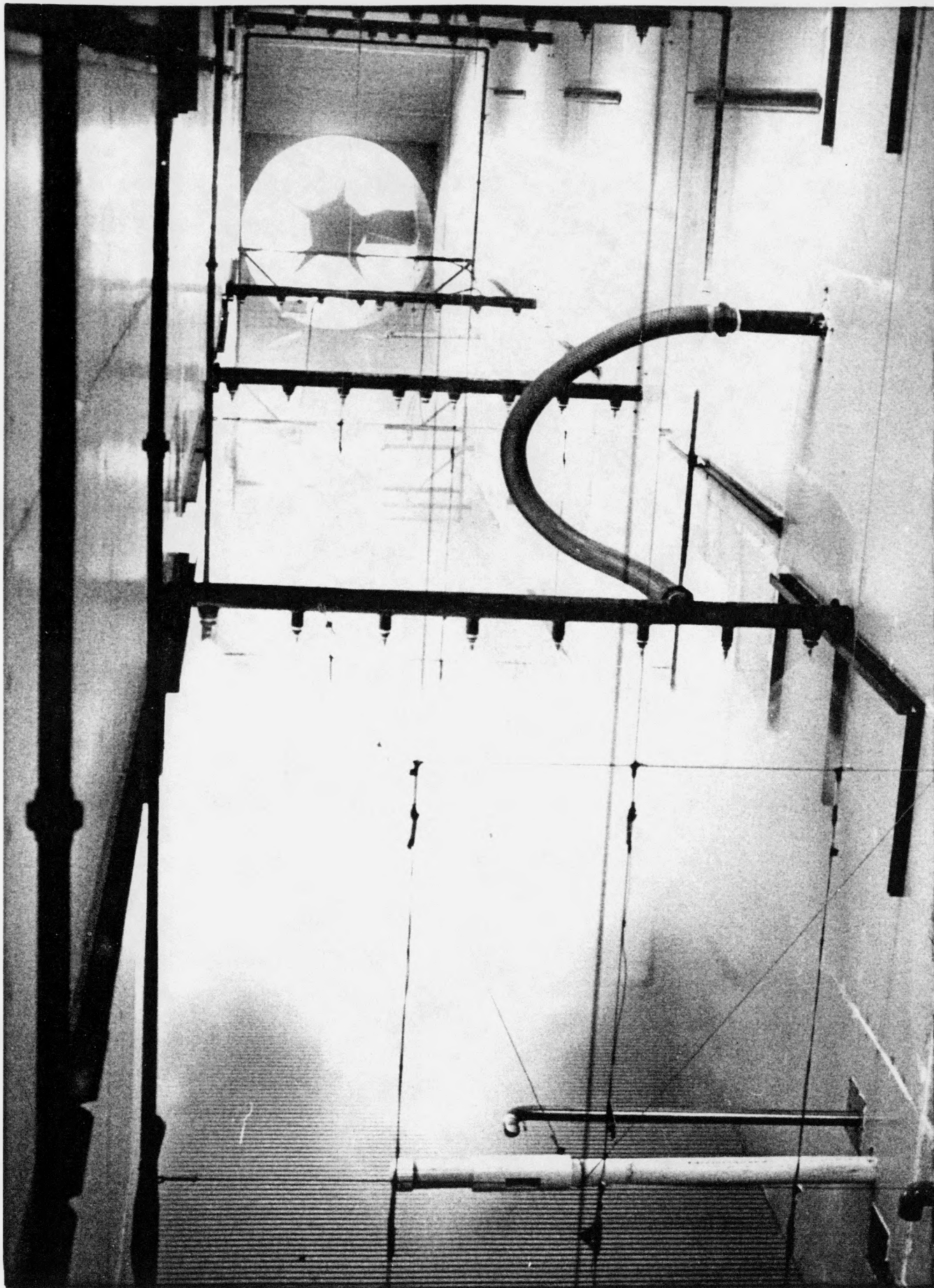


Figure H-24  
Test 15





Figure H-25  
Test 16

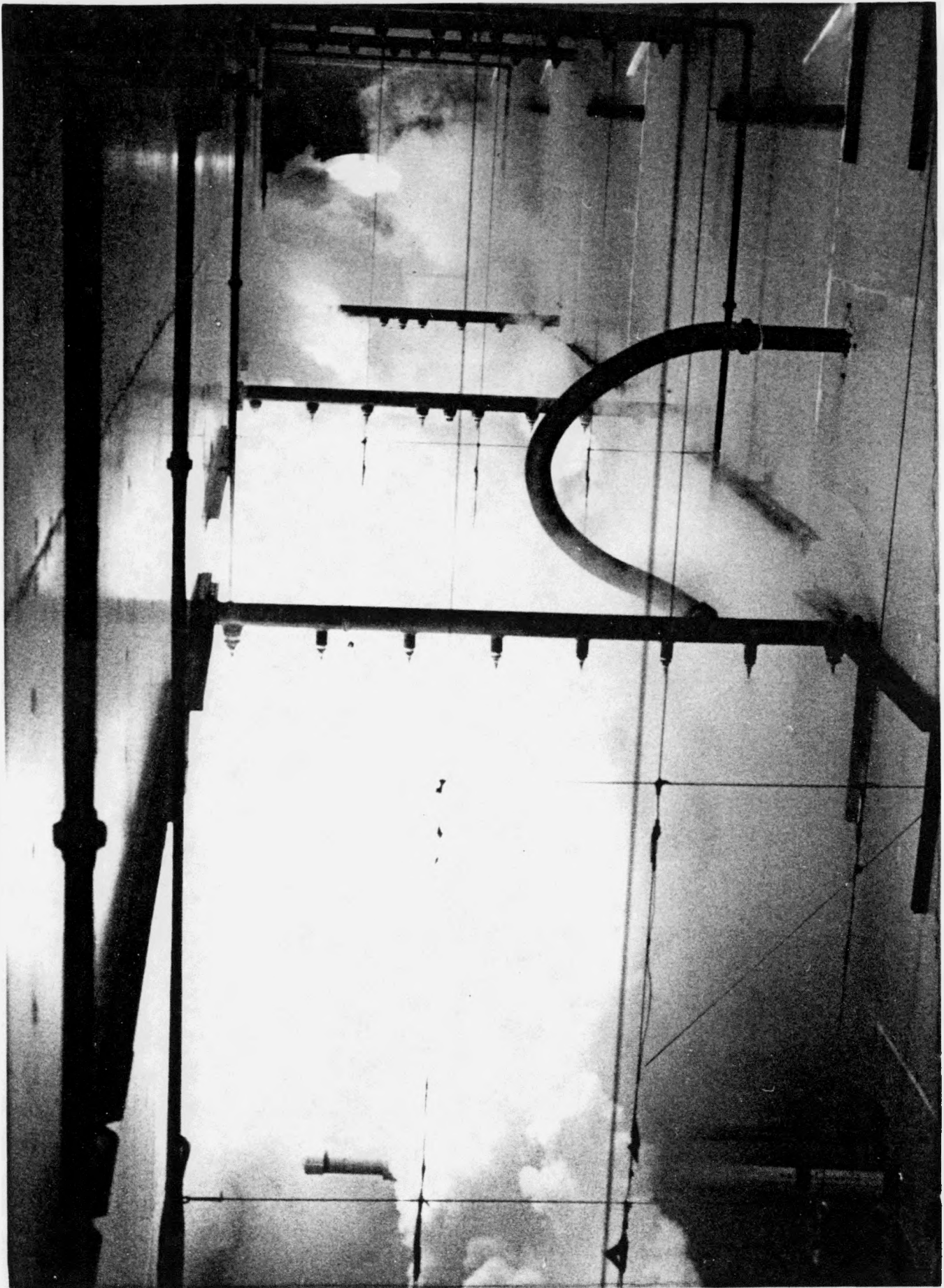


Figure H-26  
Test 17

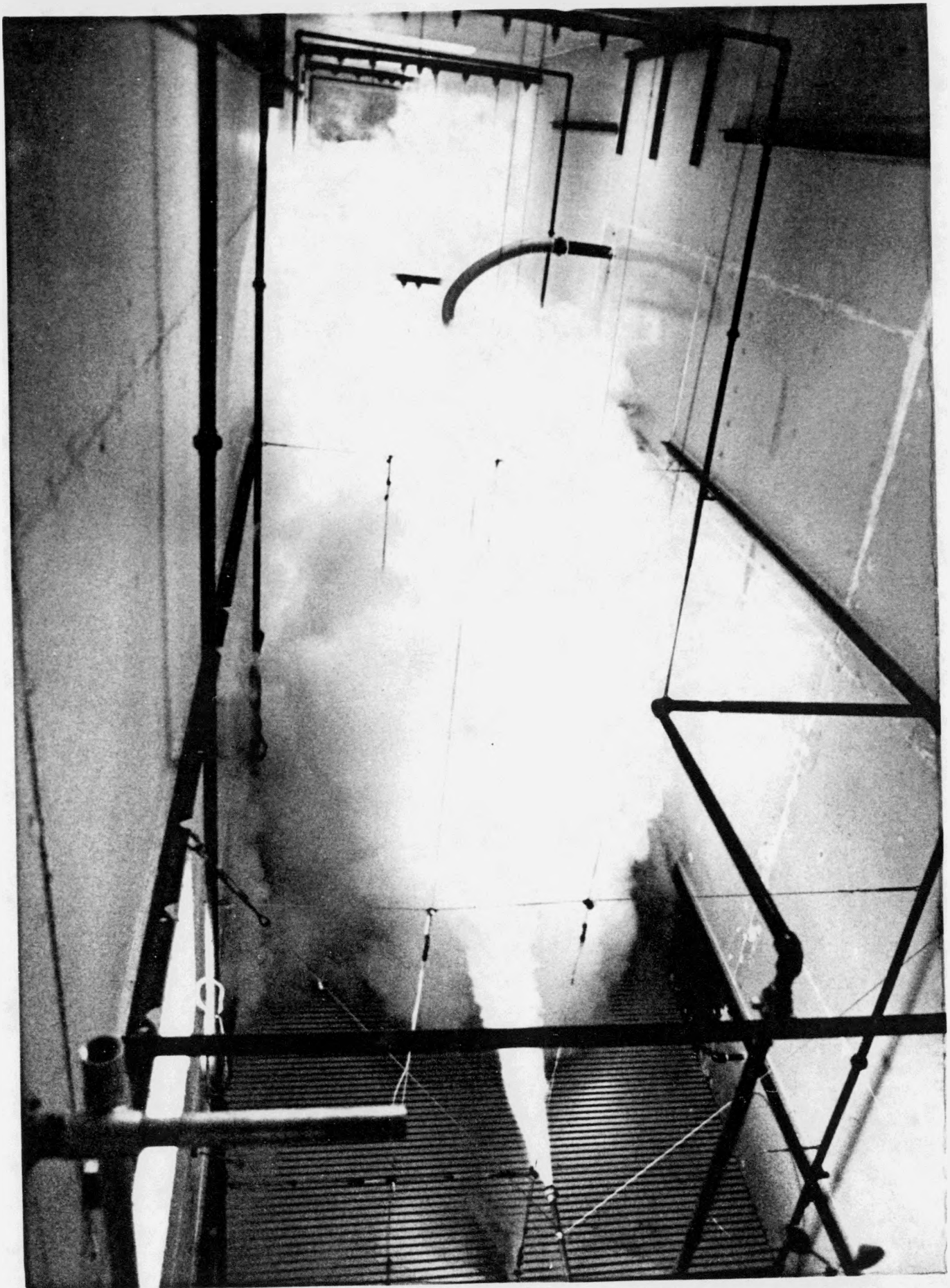




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Test 18

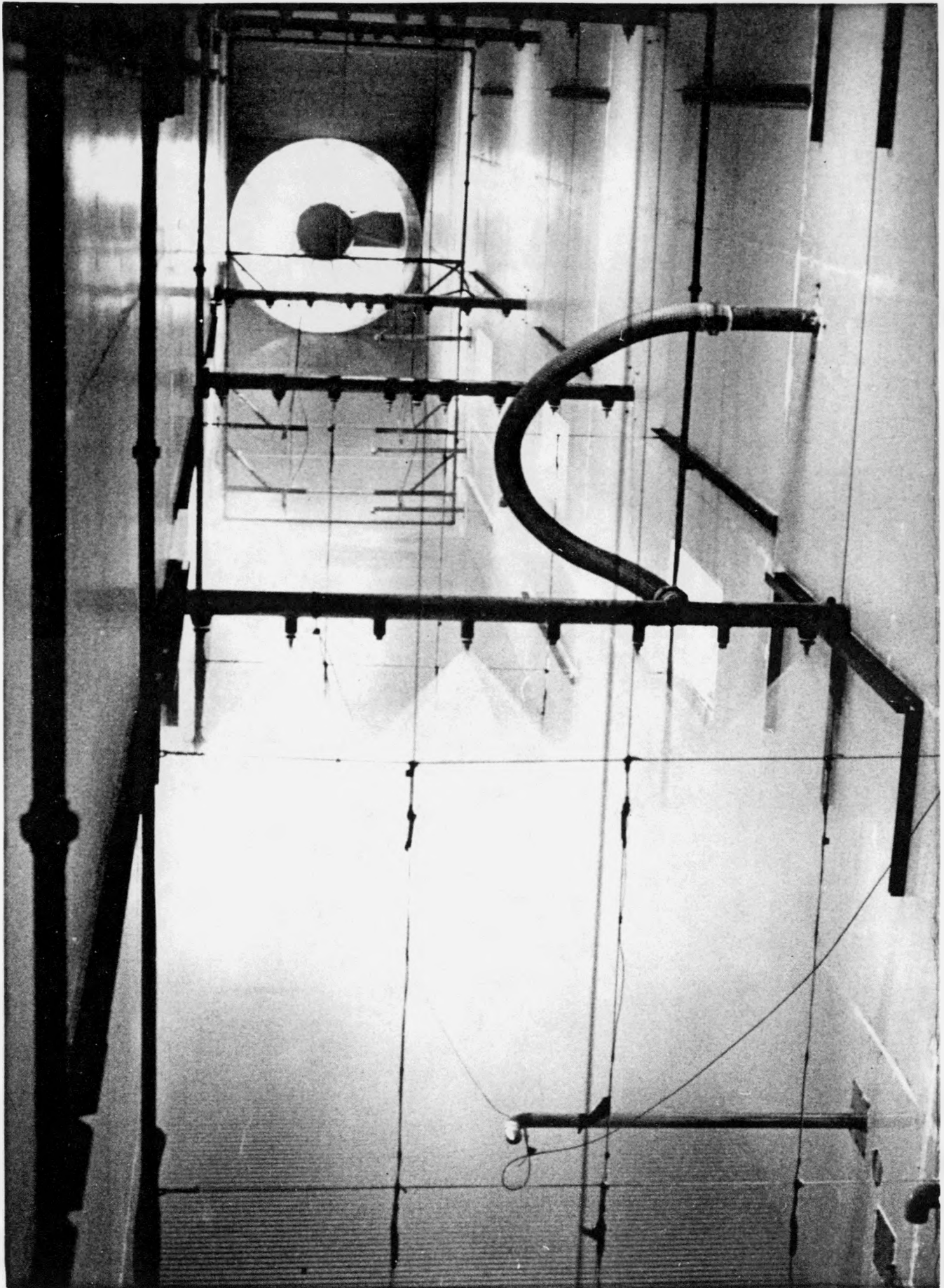
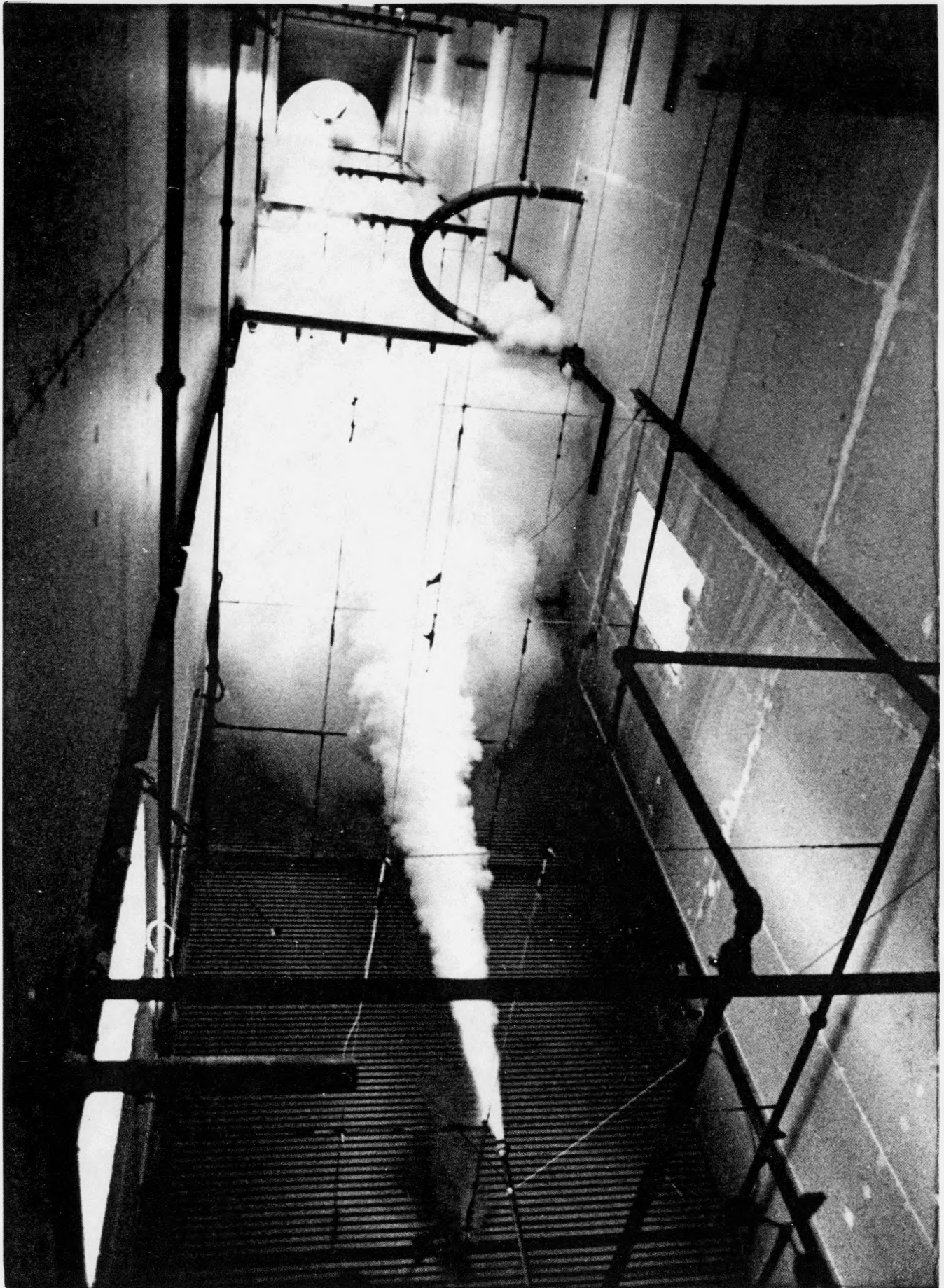


Figure H-28  
Test 18



-H32-



Figure H-29  
Test 19



Figure H-30  
Test 19

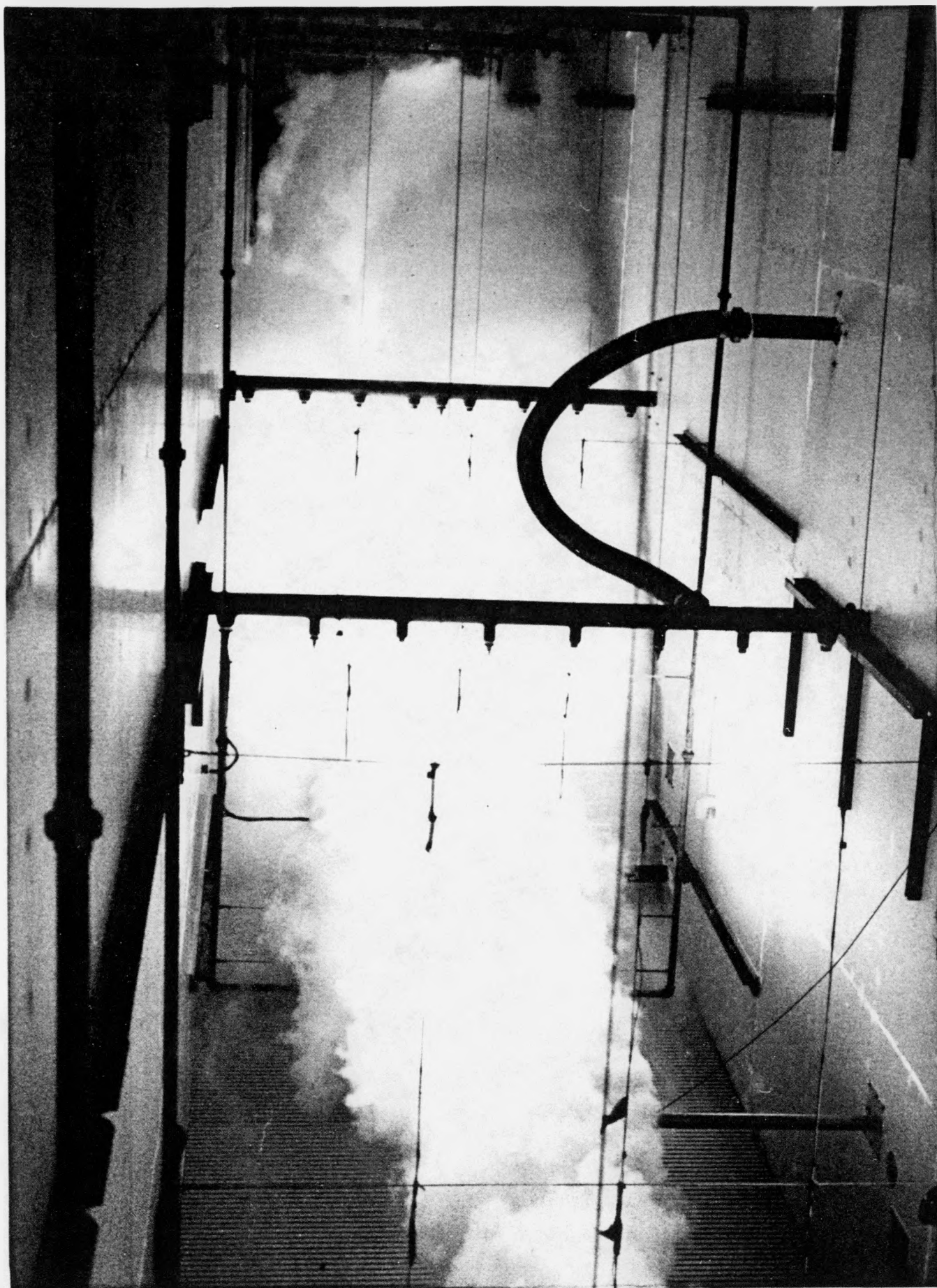




Figure H-31  
Test 20



Figure H-32  
Test 21



Figure H-33  
Test 21



-H37-



Figure H-34  
Test 22





Figure H-35  
Test 23



Figure H-36  
Test 24



Figure H-37  
Test 24

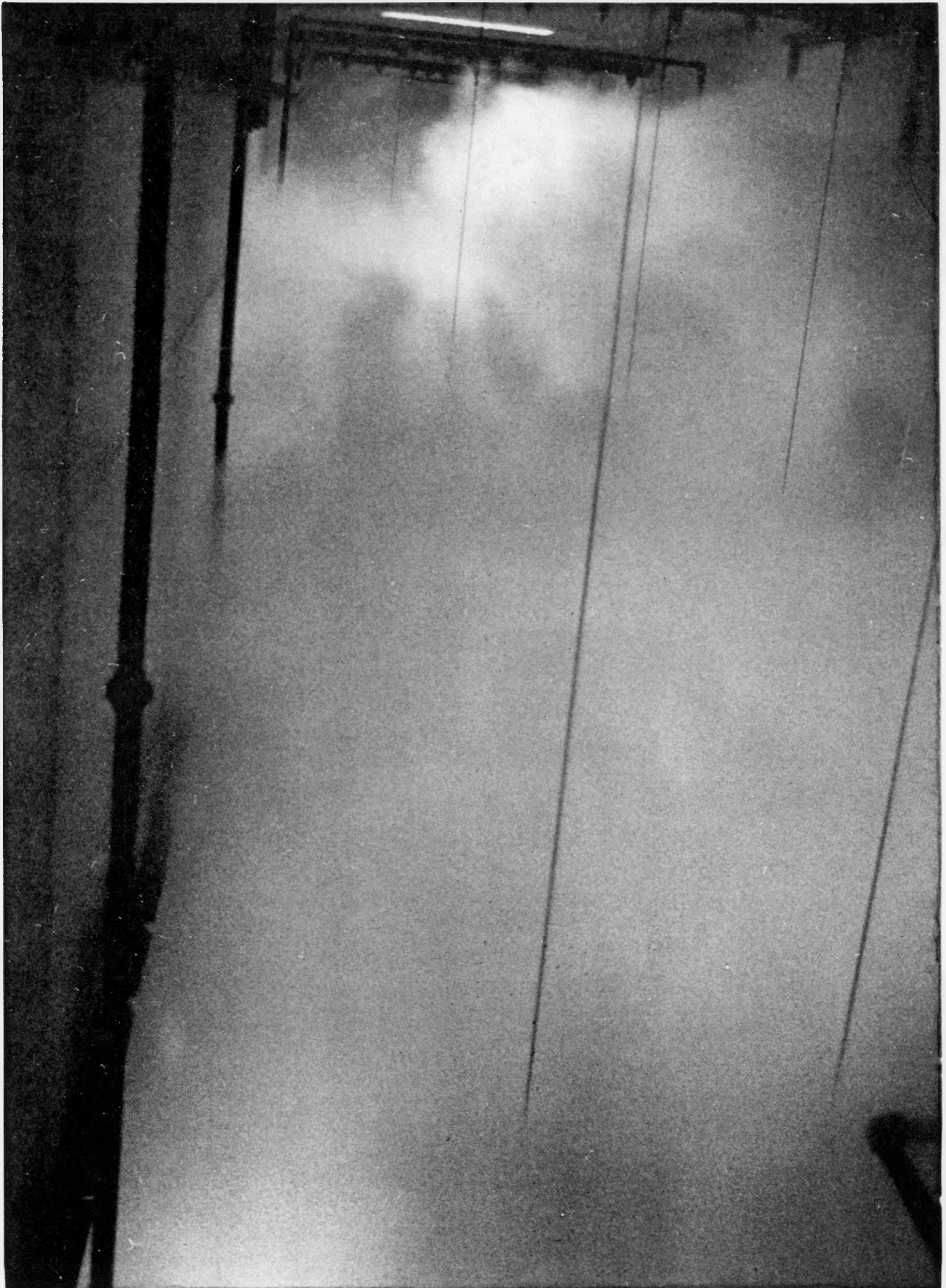




Figure H-38  
Test 25



Figure H-39  
Test 26



-H43-



Figure H-40  
Test 27



-H44-



Figure H-41  
Test 27

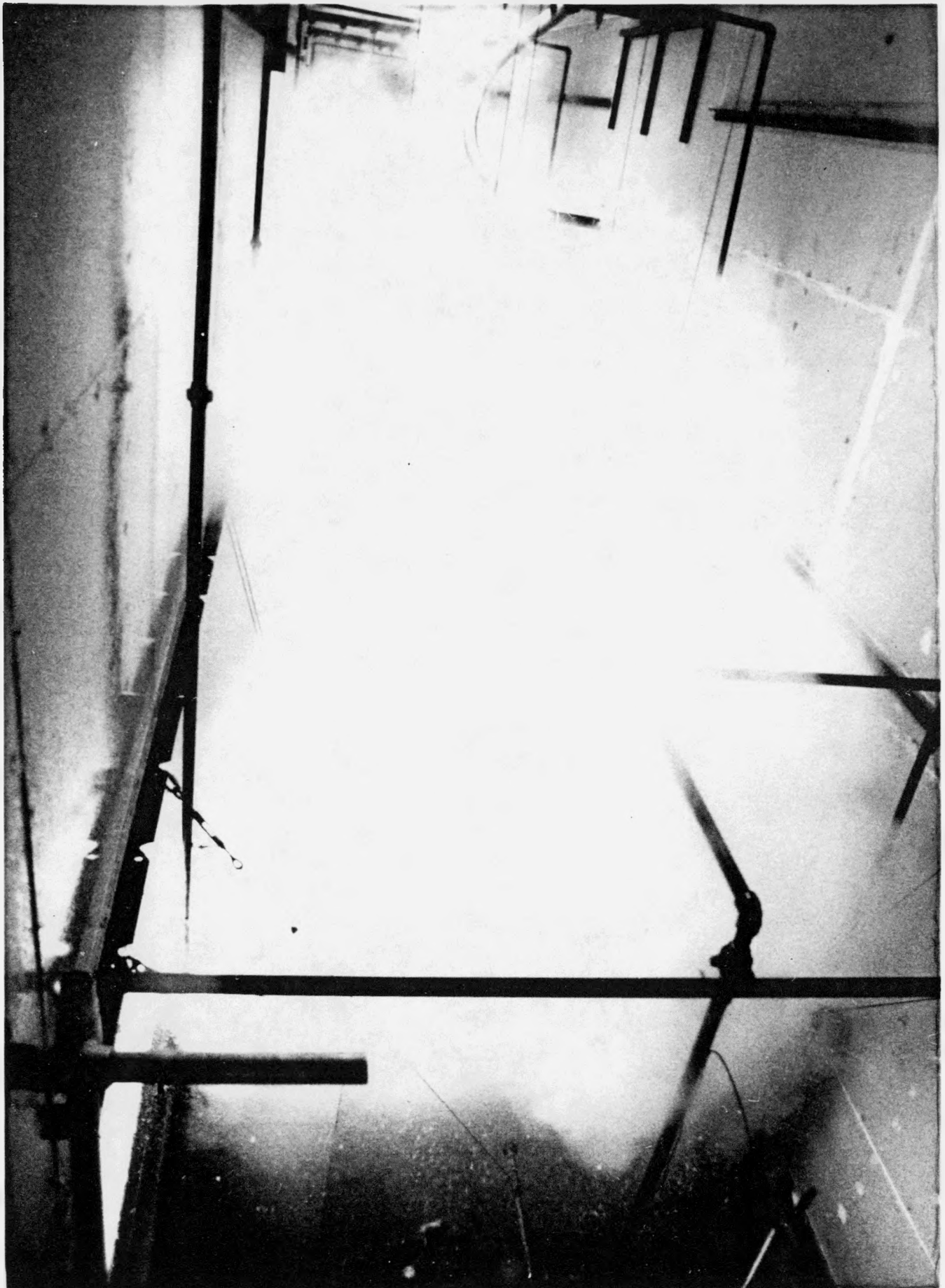


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Test 28

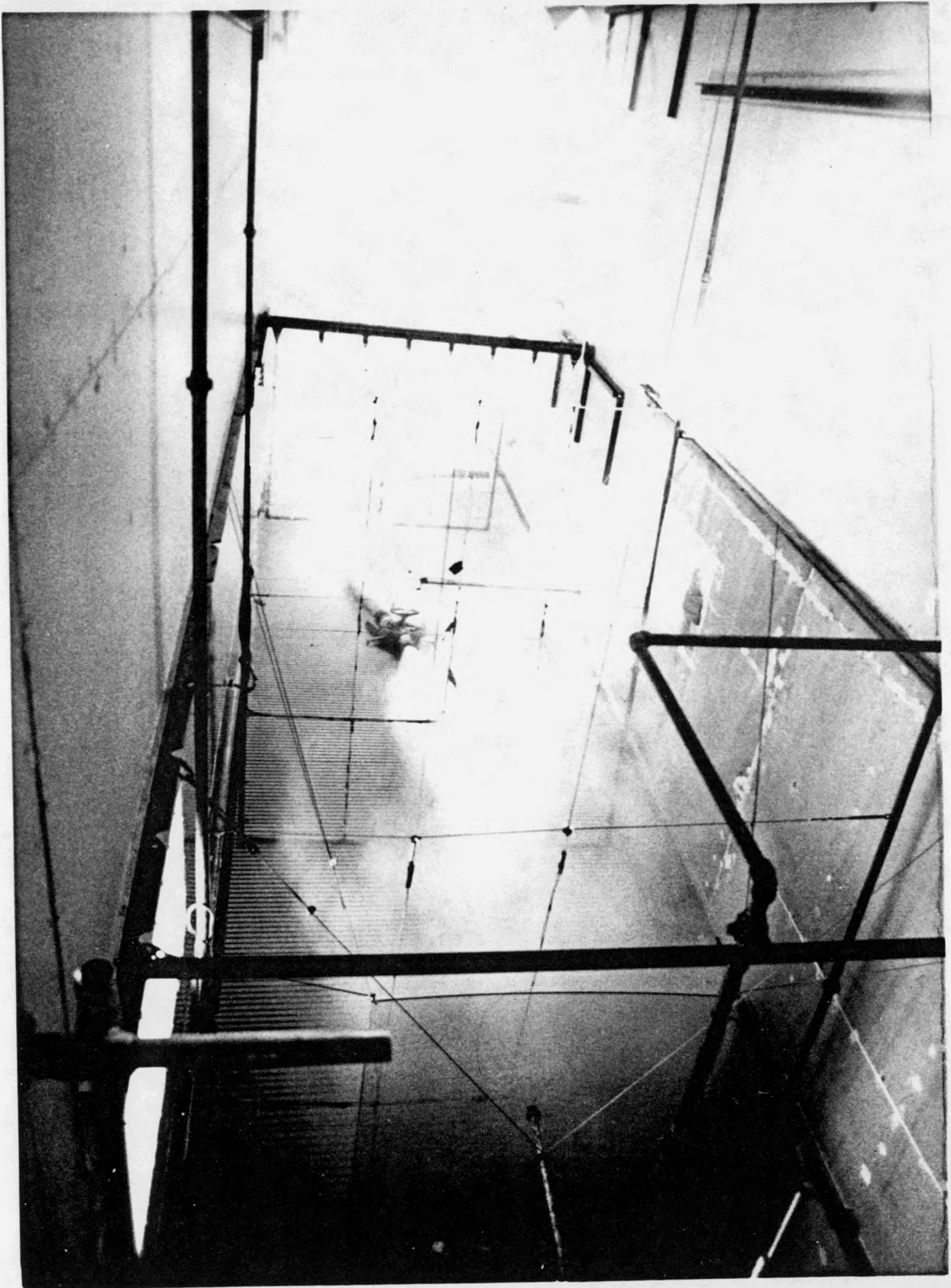
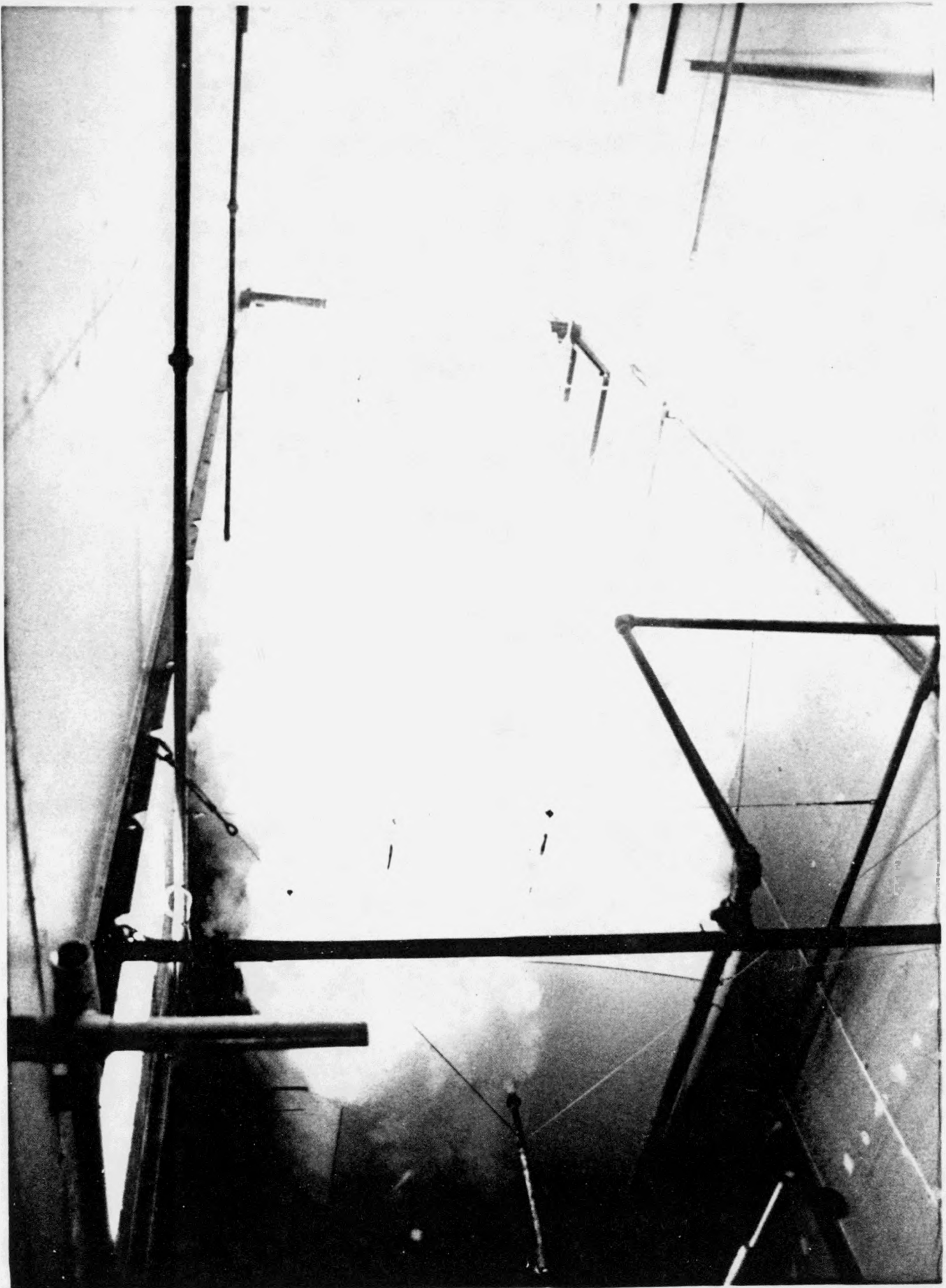


Figure H-43  
Test 28



-H47-



Figure H-44  
Test 29

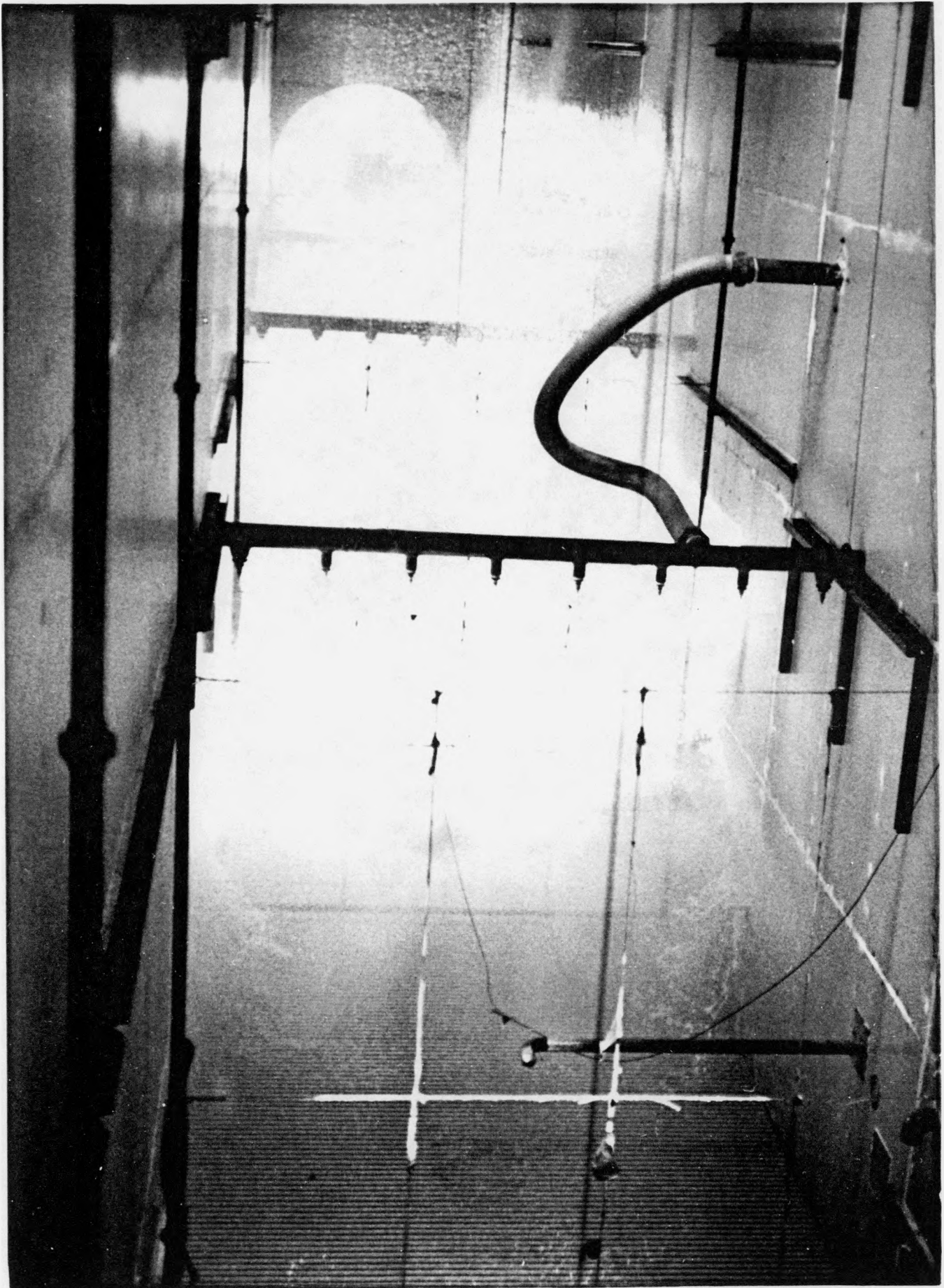
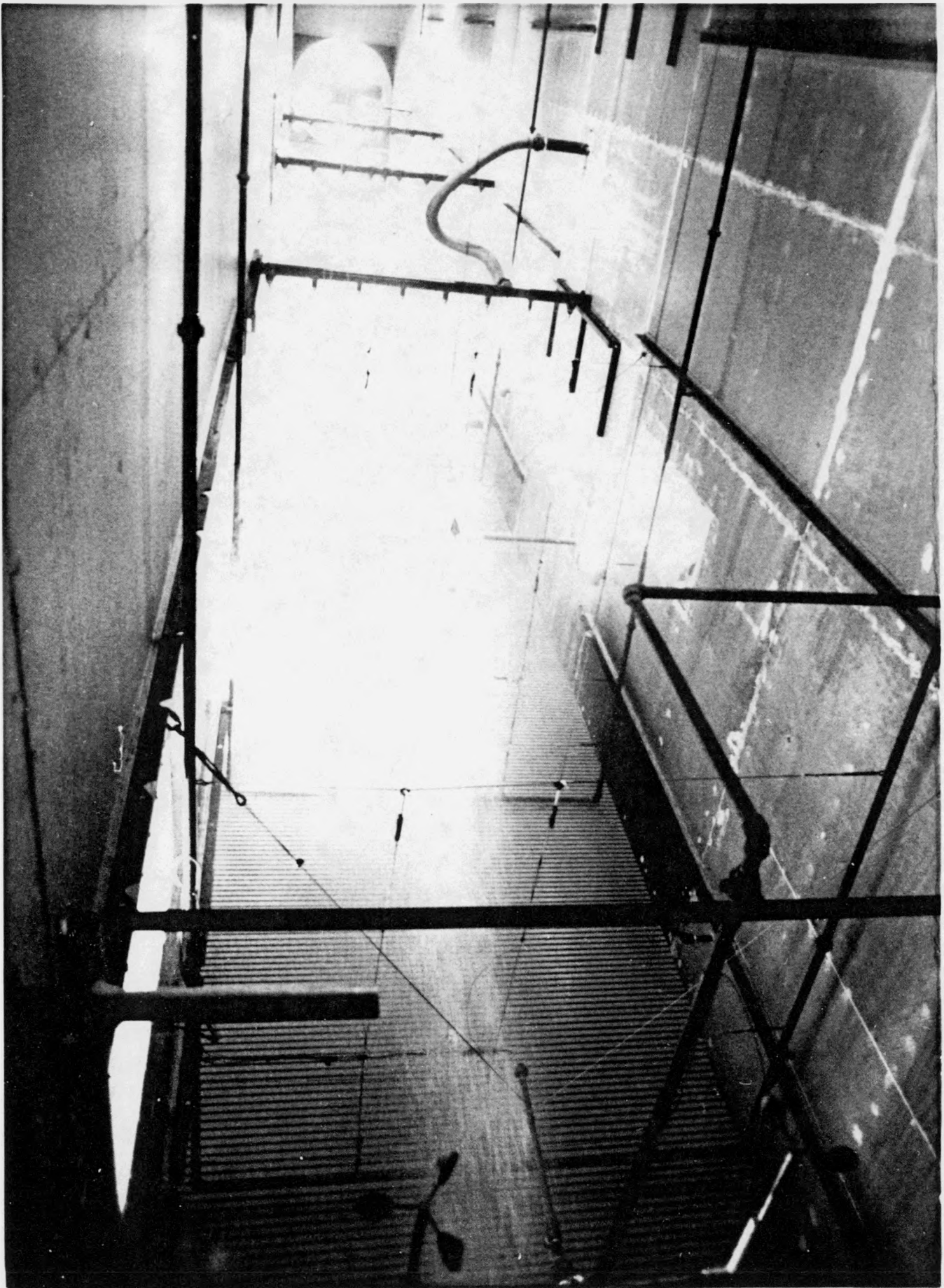


Figure H-45  
Test 29





Figure H-46  
Test 30



-H50-



Figure H-47  
Test 30

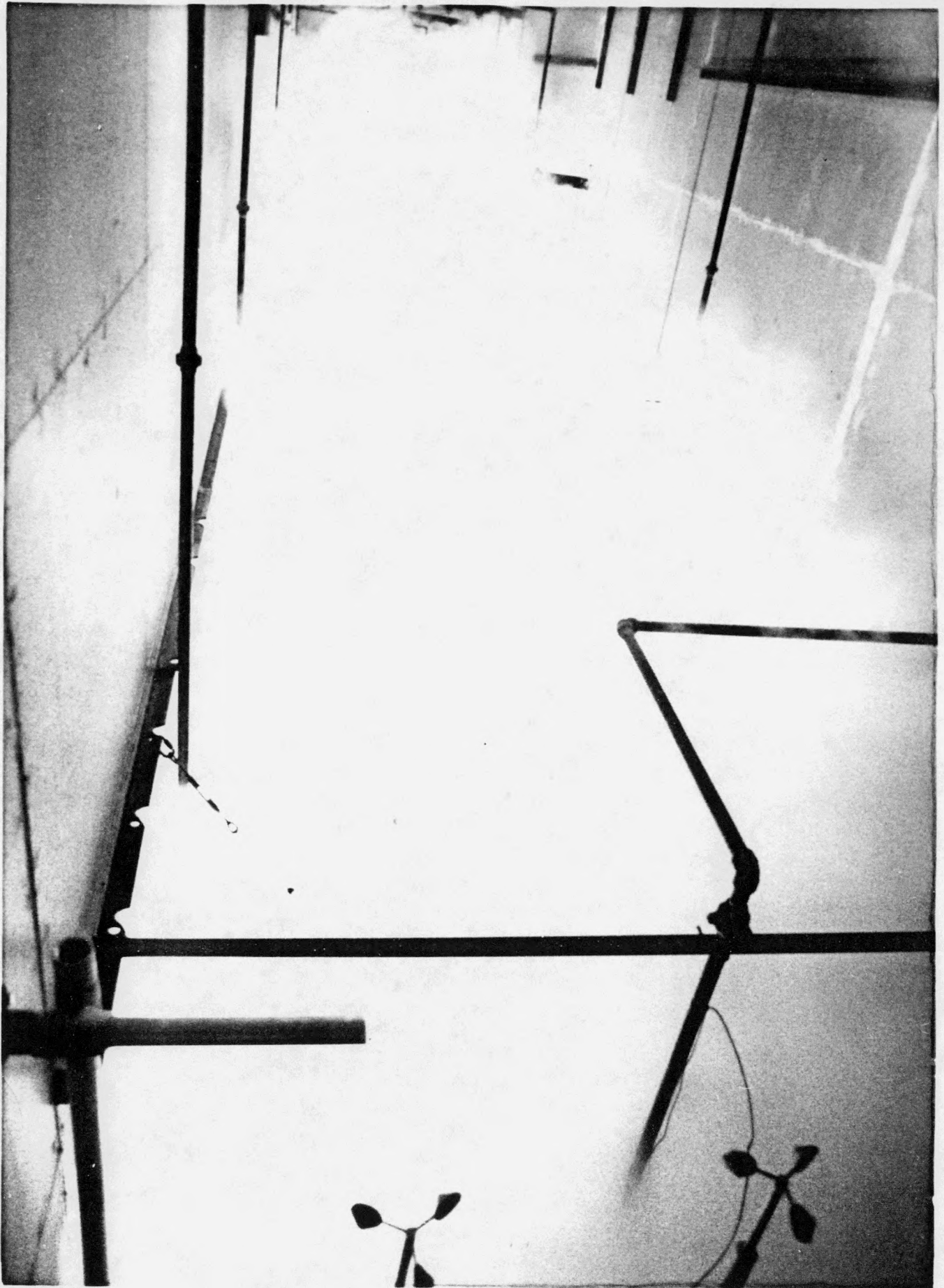
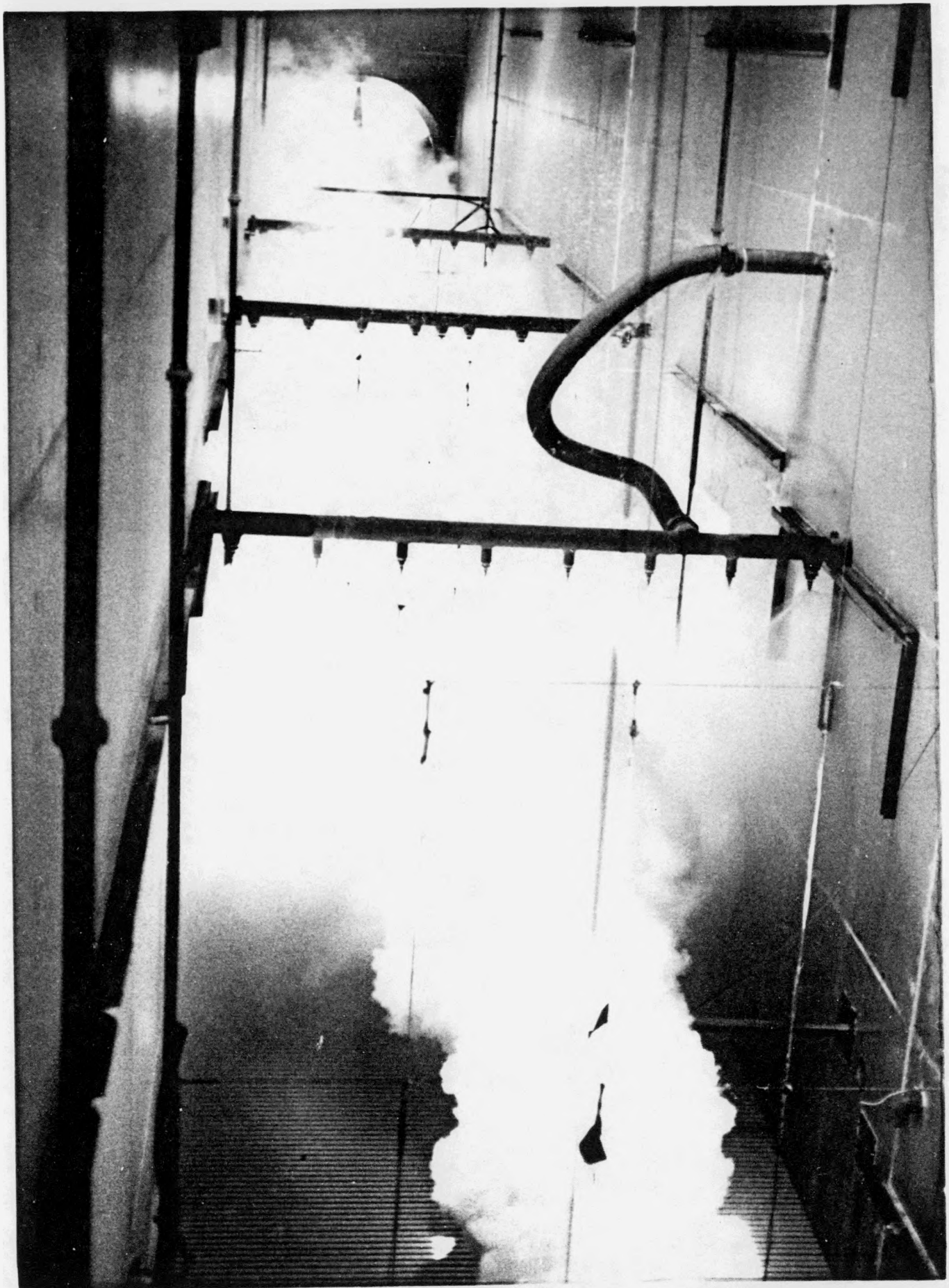


Figure H-48  
Test 31



-H52-

Figure H-49  
Test 32





Figure H-50  
Test 33



Figure H-51  
Test 34



-H55-



Figure H-52  
Test 35

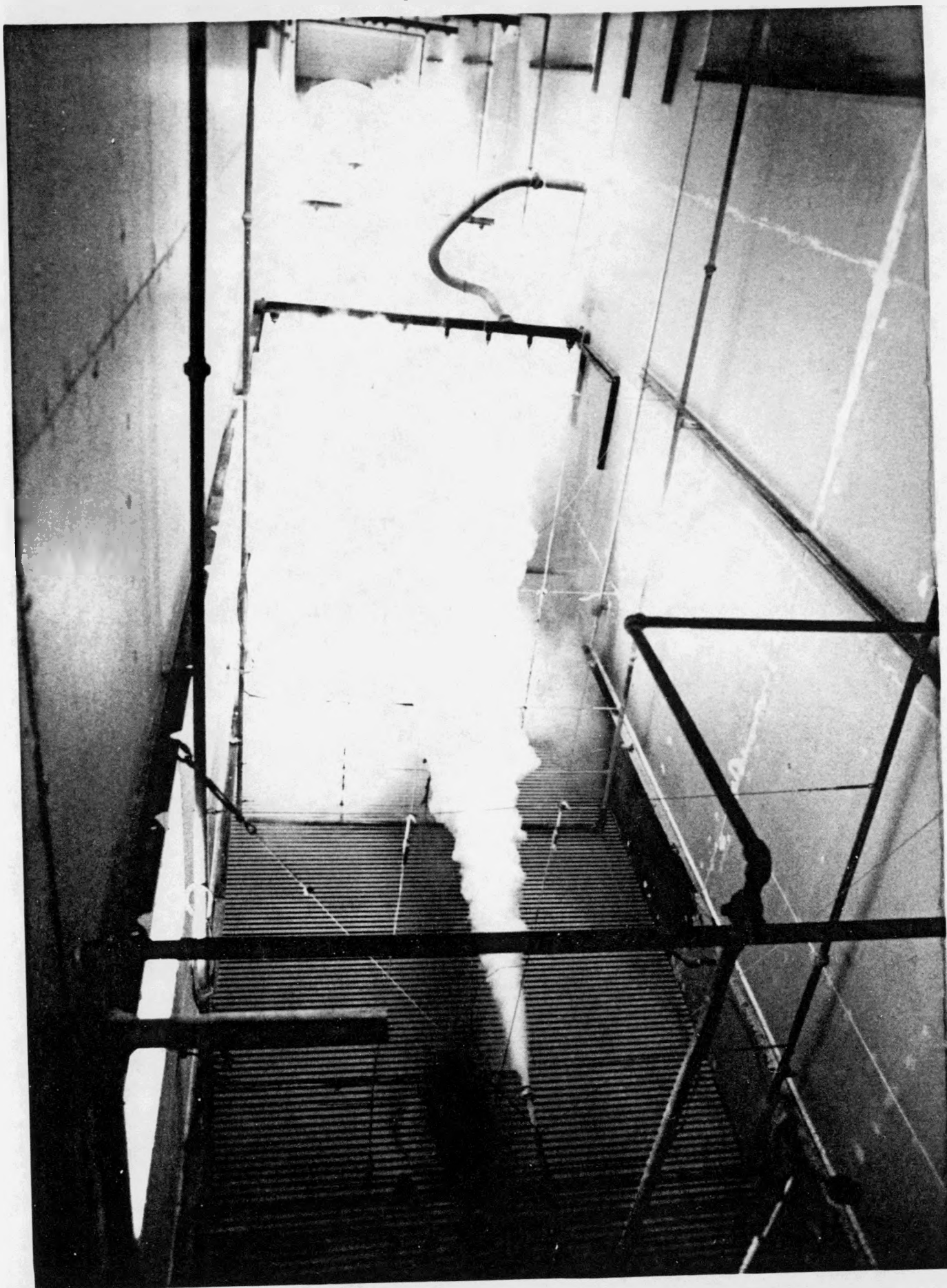




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Test 36

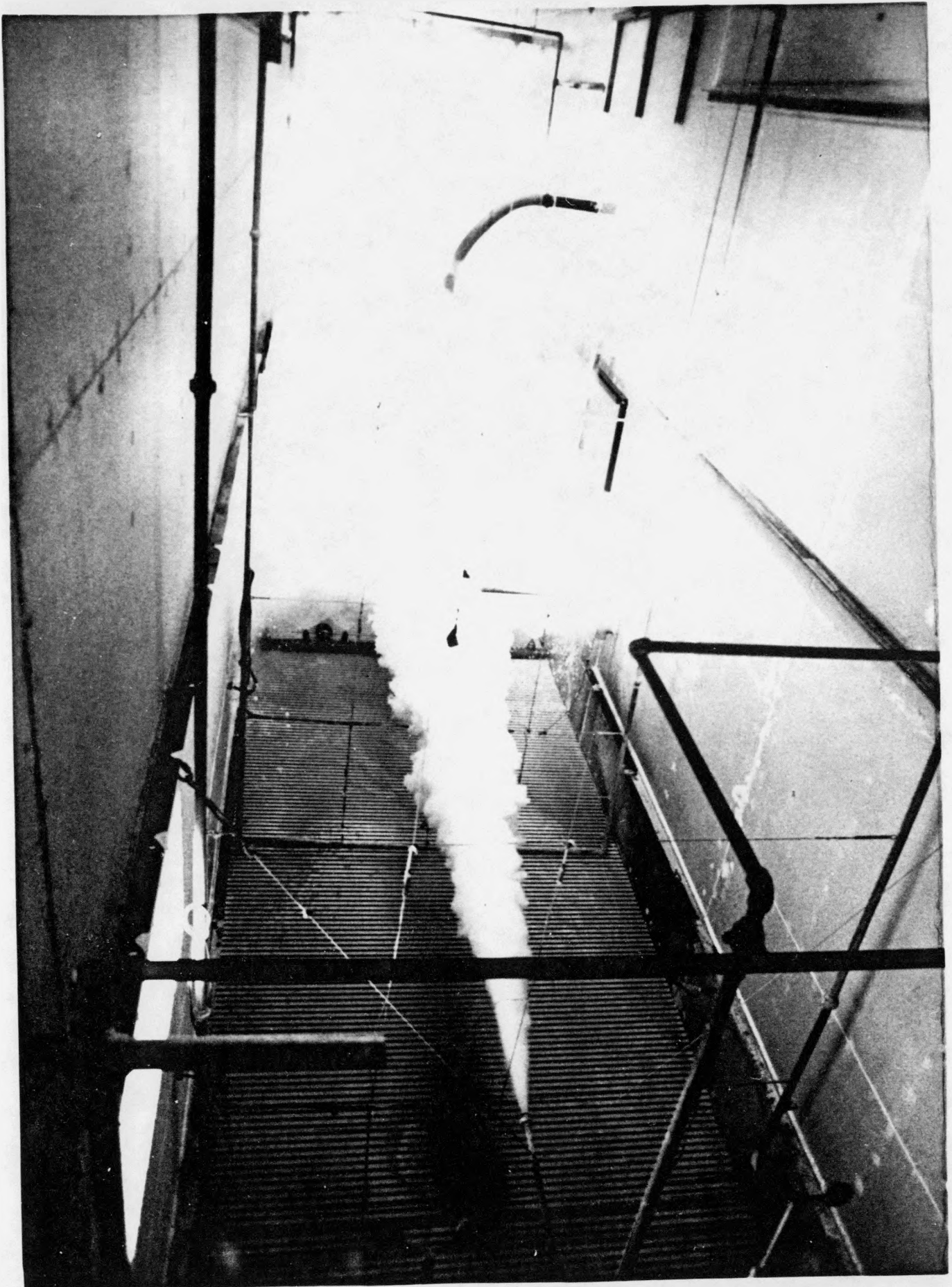


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Test 37

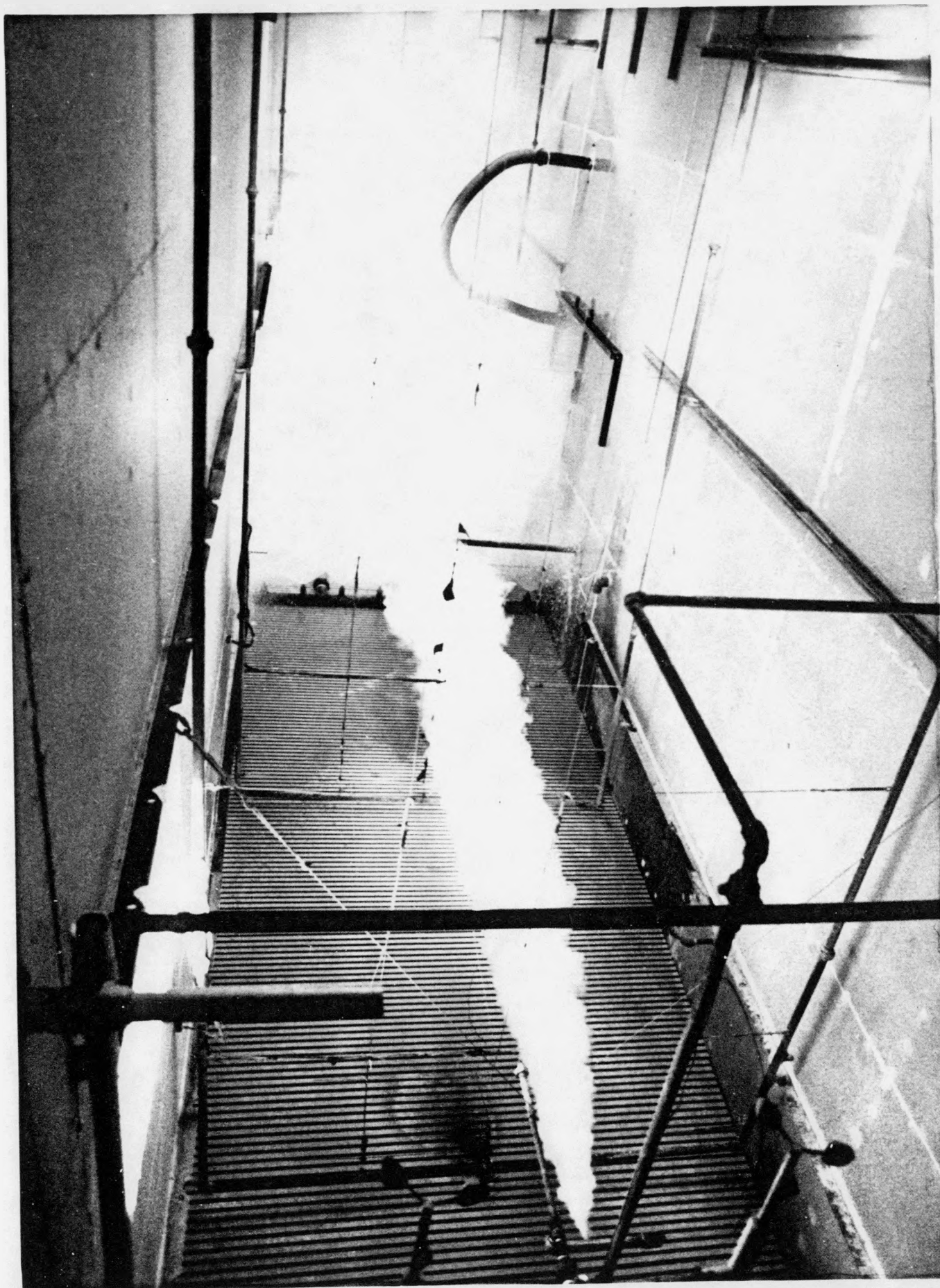




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Test 38

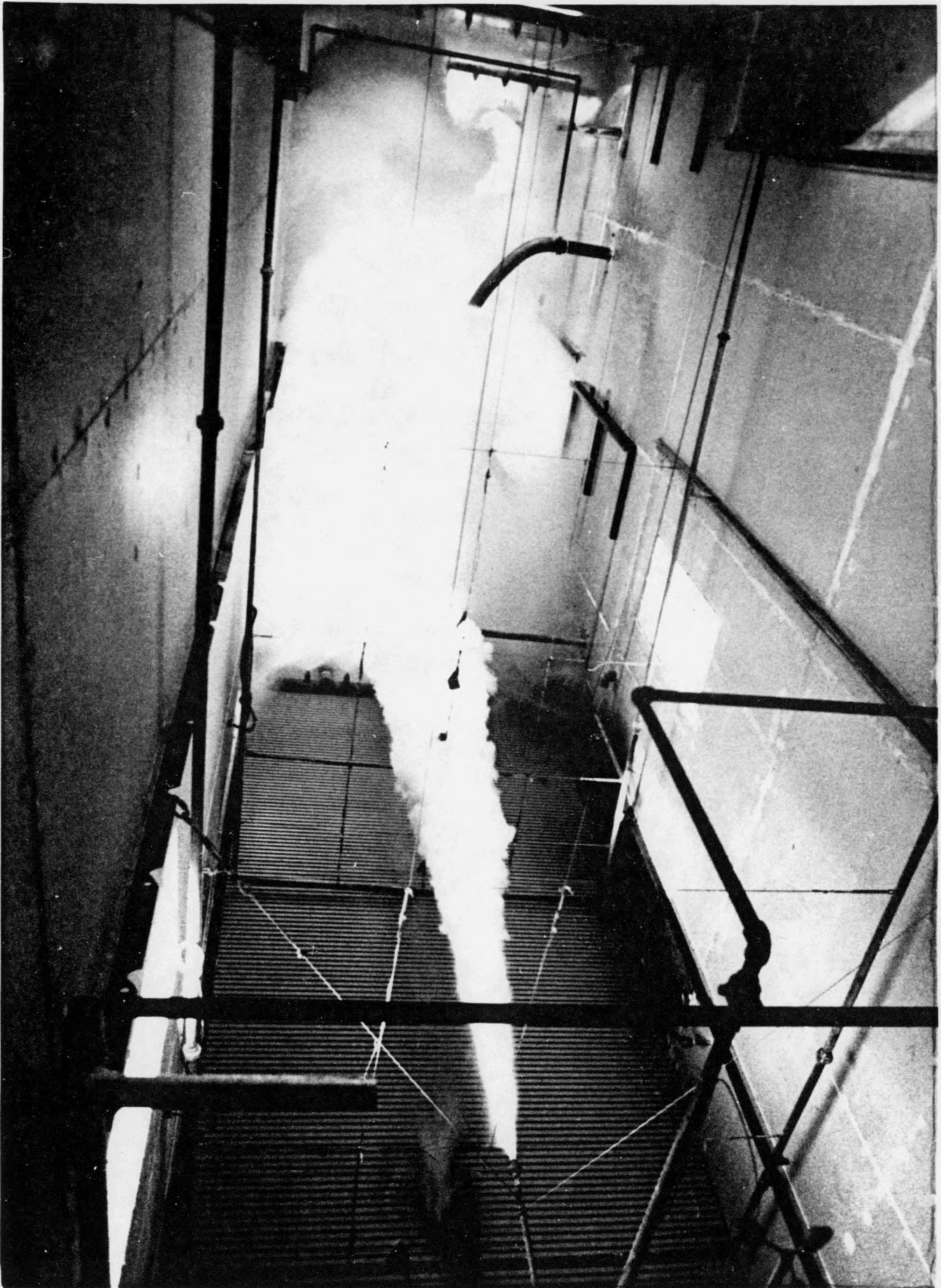
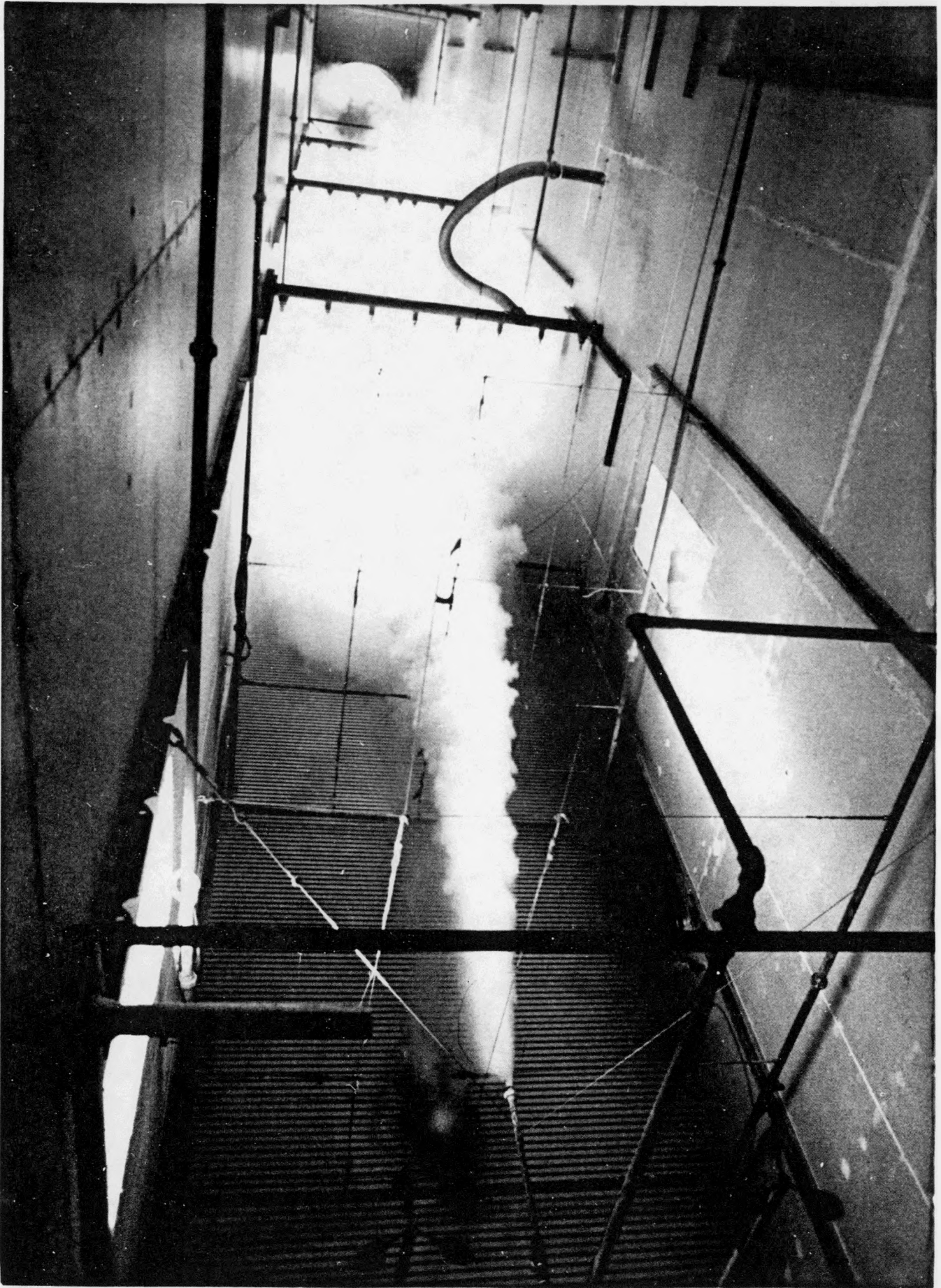




Figure H-56  
Test 39



-H60-

Figure H-57  
Test 40



-H61-



Figure H-58  
Test 42



-H62-



Figure H-59  
Test 43



Figure H-60  
Test 44

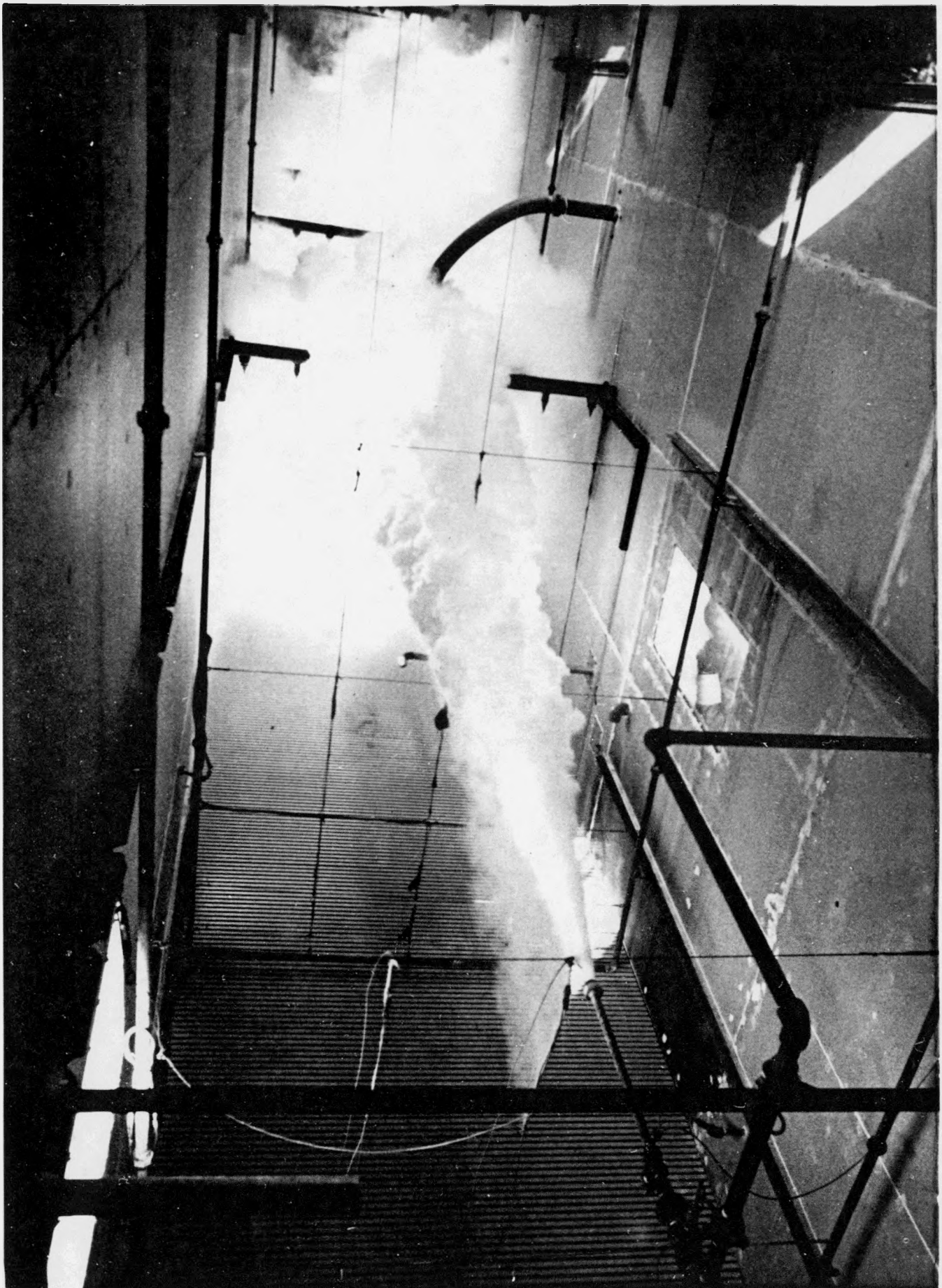




Figure H-61  
Test 45



-H65-

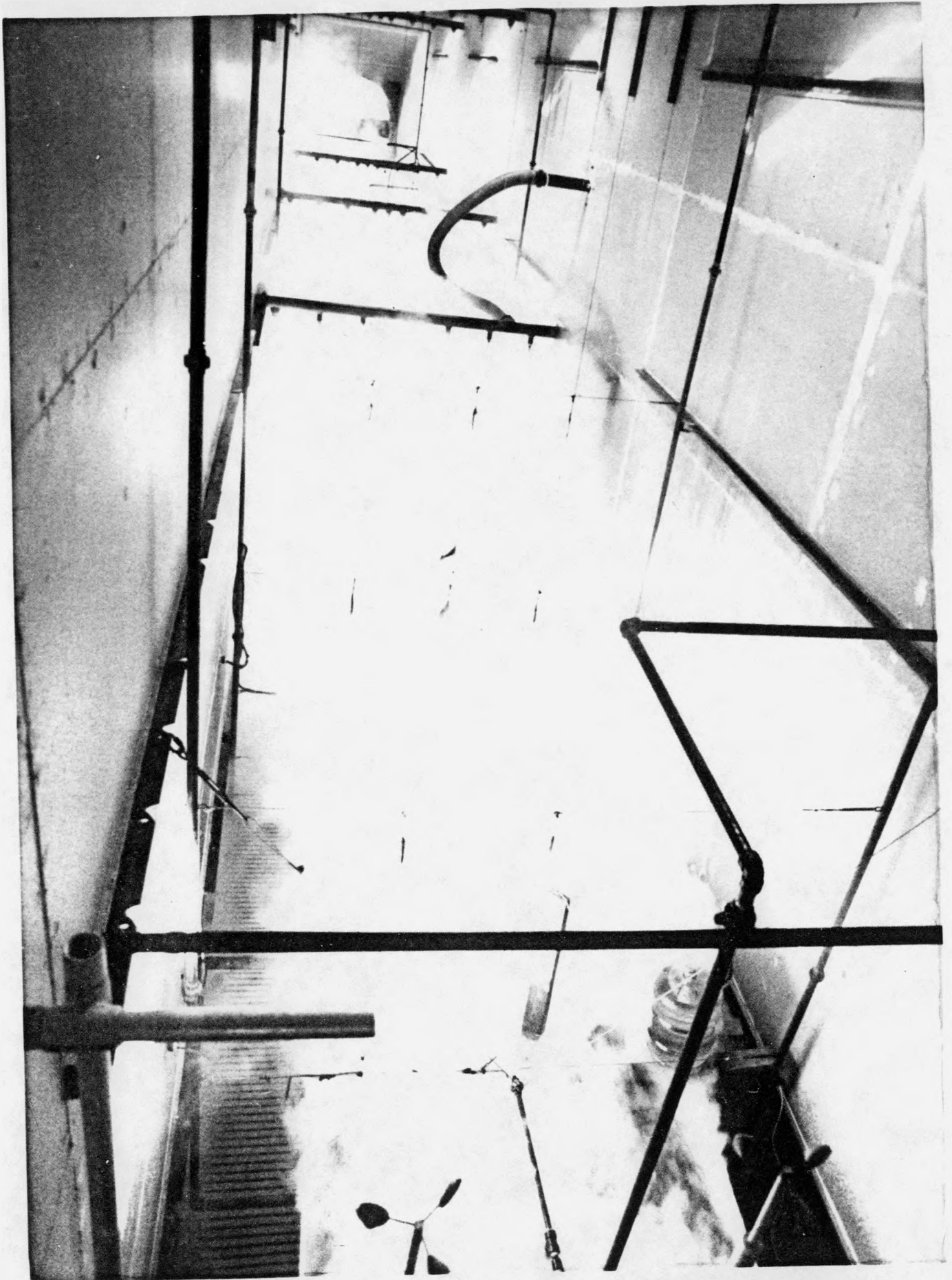


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Test 46



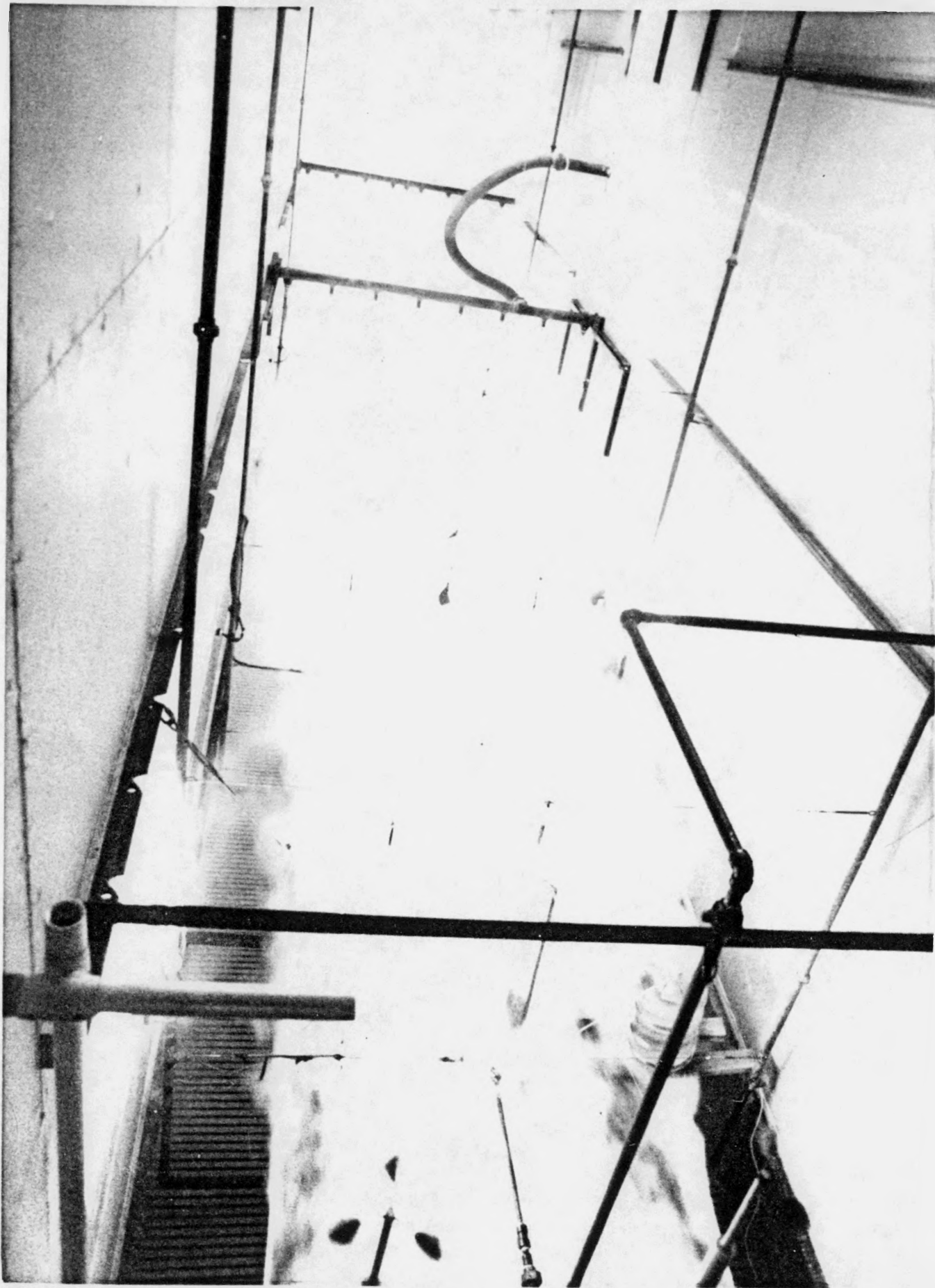
-H66-

Figure H-63  
Test 47



-H67-

Figure H-64  
Test 48



-H68-



Figure H-65  
Test 49



-H69-

Figure H-66  
Test 49



-H70-

Figure H-67  
Test 50



-H71-



Figure H-68  
Test 51



Figure H-69  
Test 52





Figure H-70  
Test 53





Figure H-71  
Test 54



-H75-

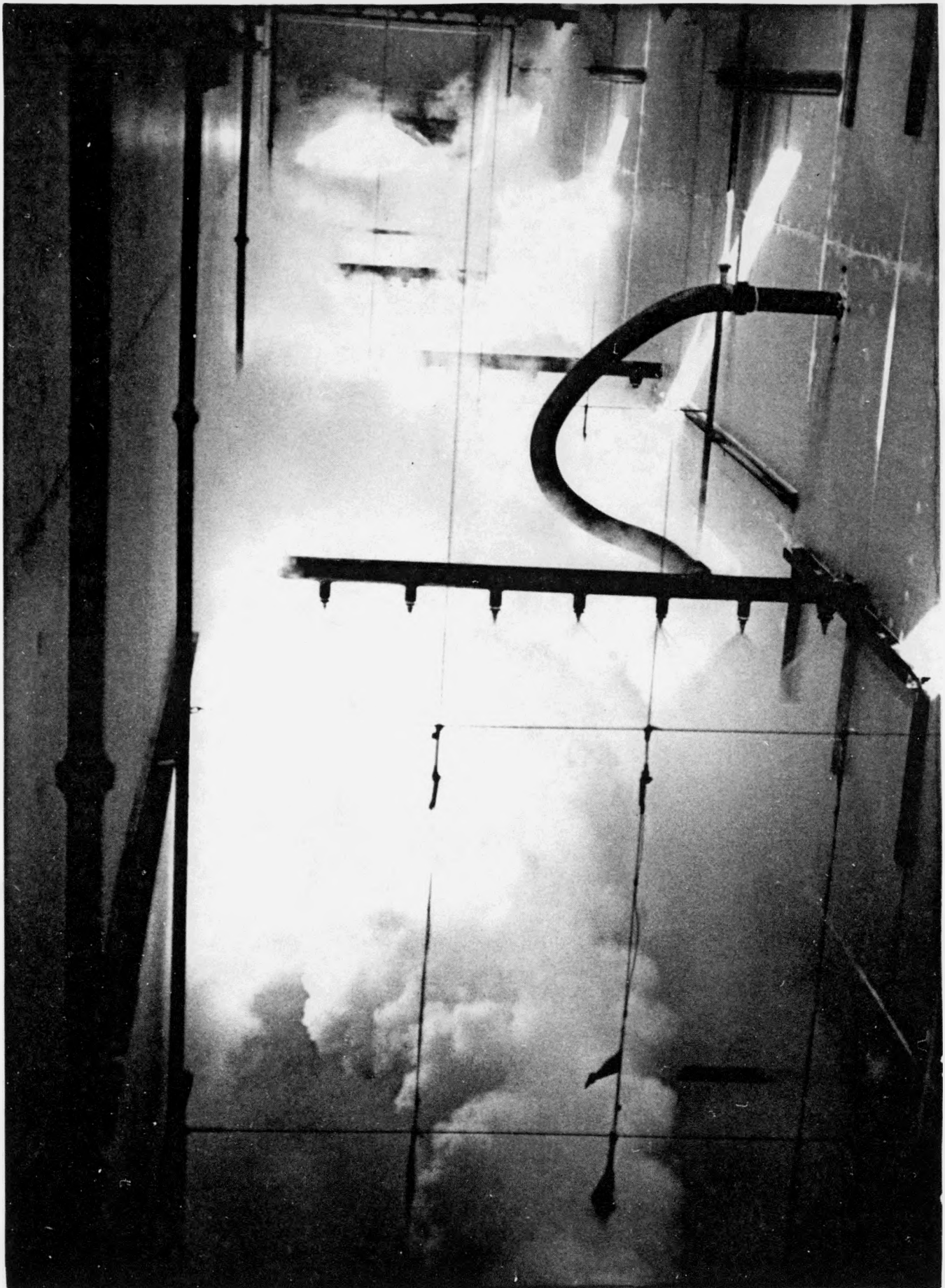
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Test 55



-H76-



Figure H-73  
Test 57



-H77-



Figure H-74  
Test 58

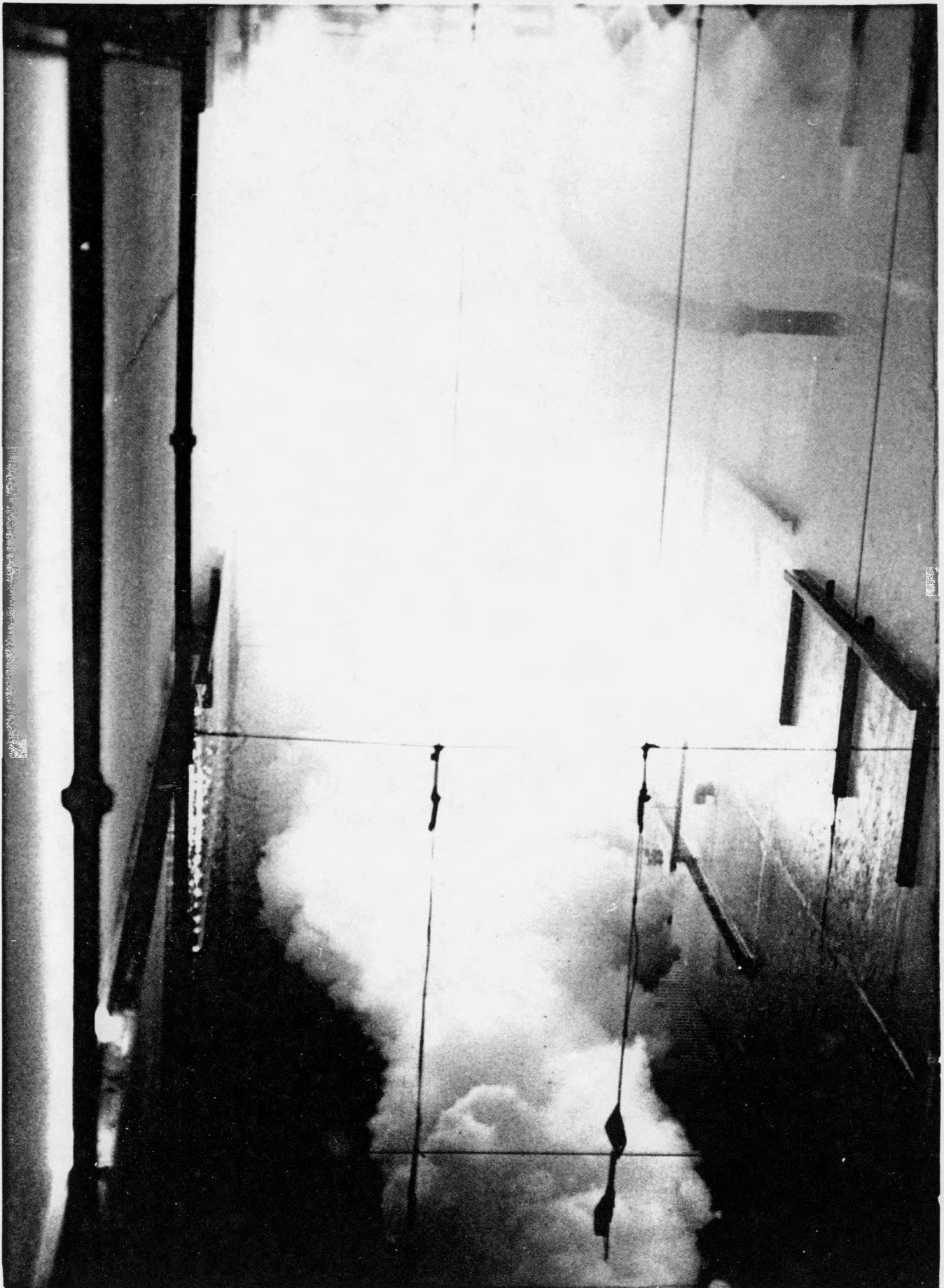


Figure H-75  
Test 59





Figure H-76  
Test 60



-H80-



Figure H-77  
Test 61



Figure H-78  
Test 62

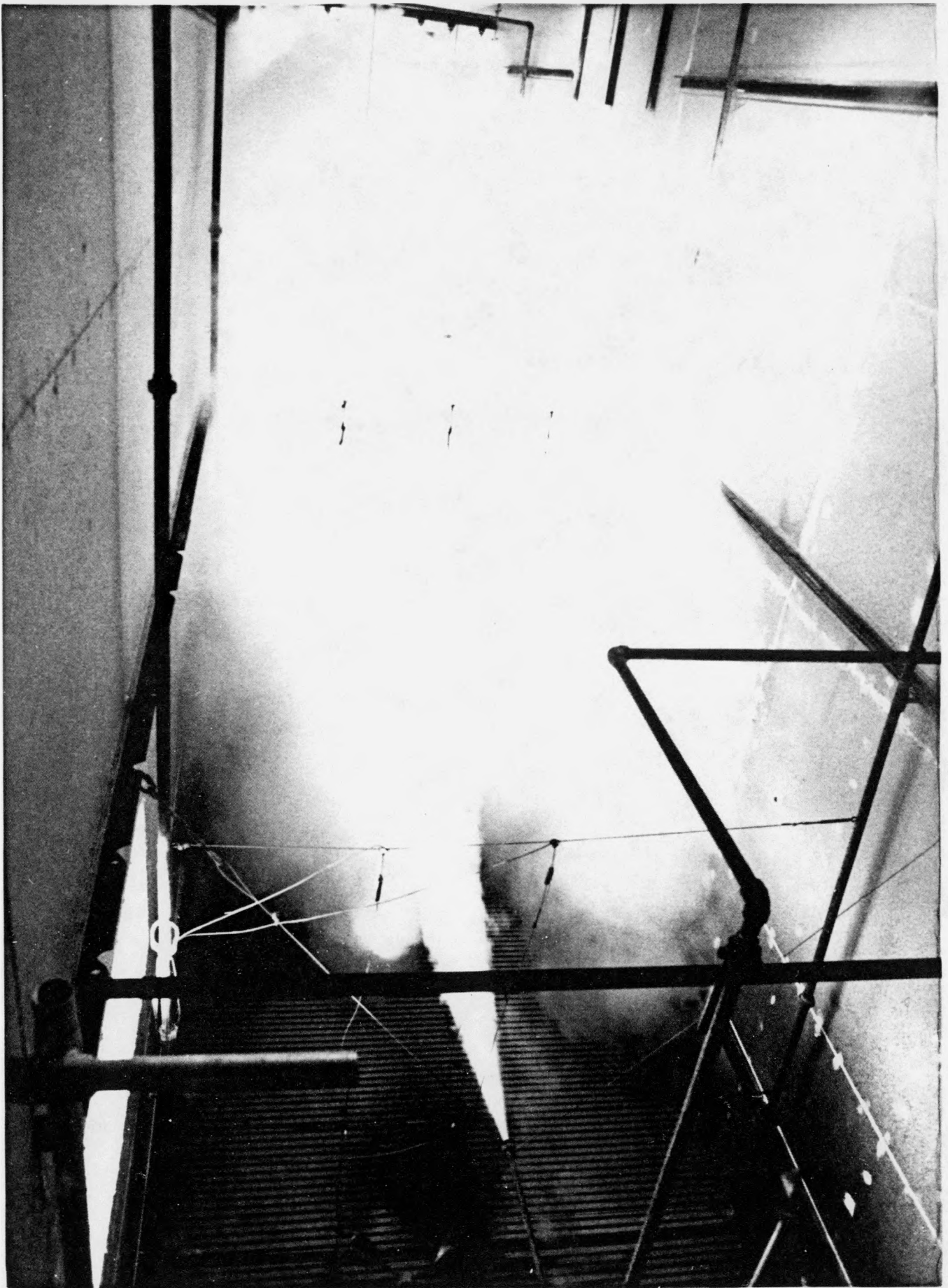


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Test 63





Figure H-80  
Test 64



-H84-

Figure H-81  
Test 65

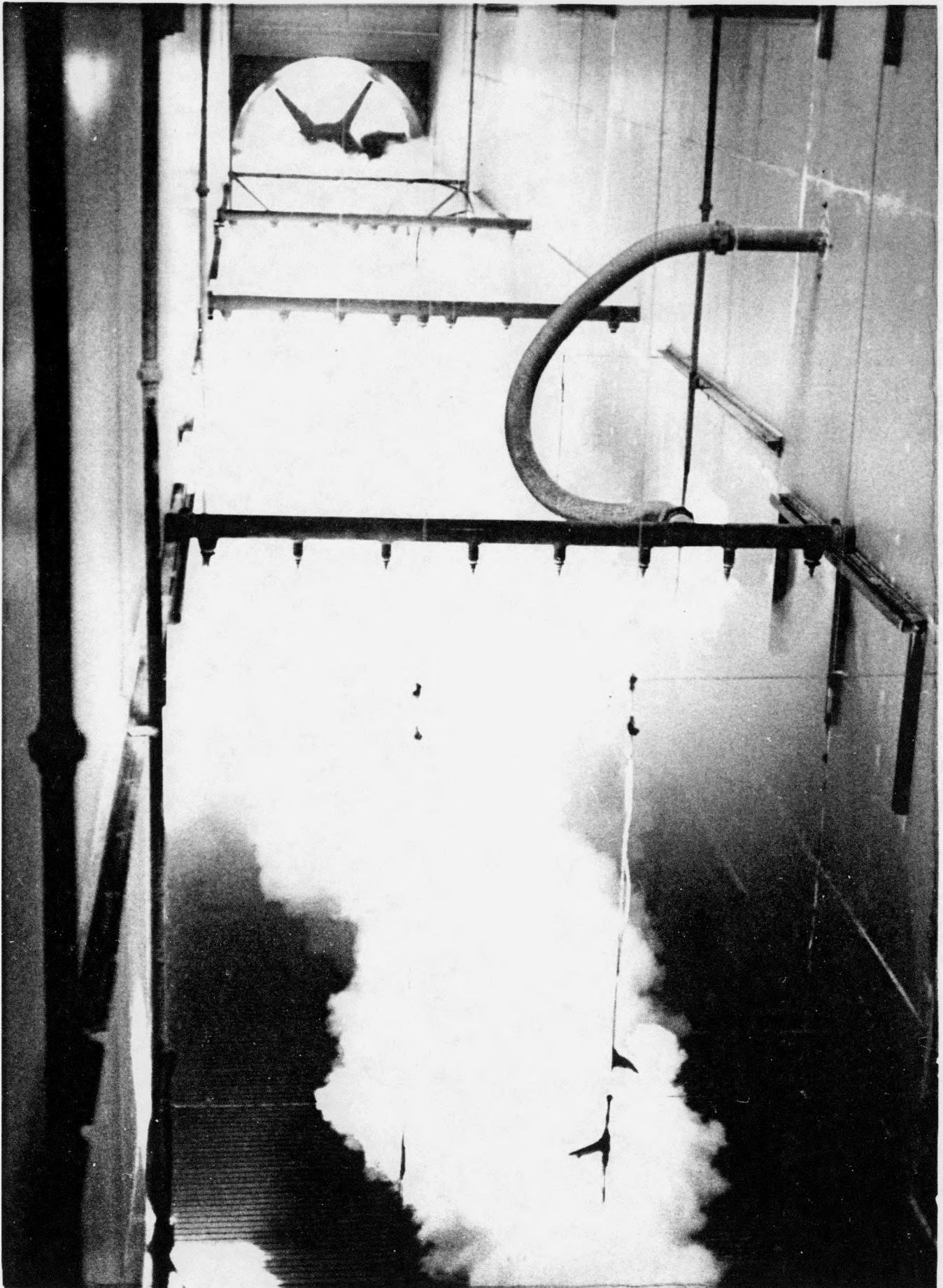


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Test 66

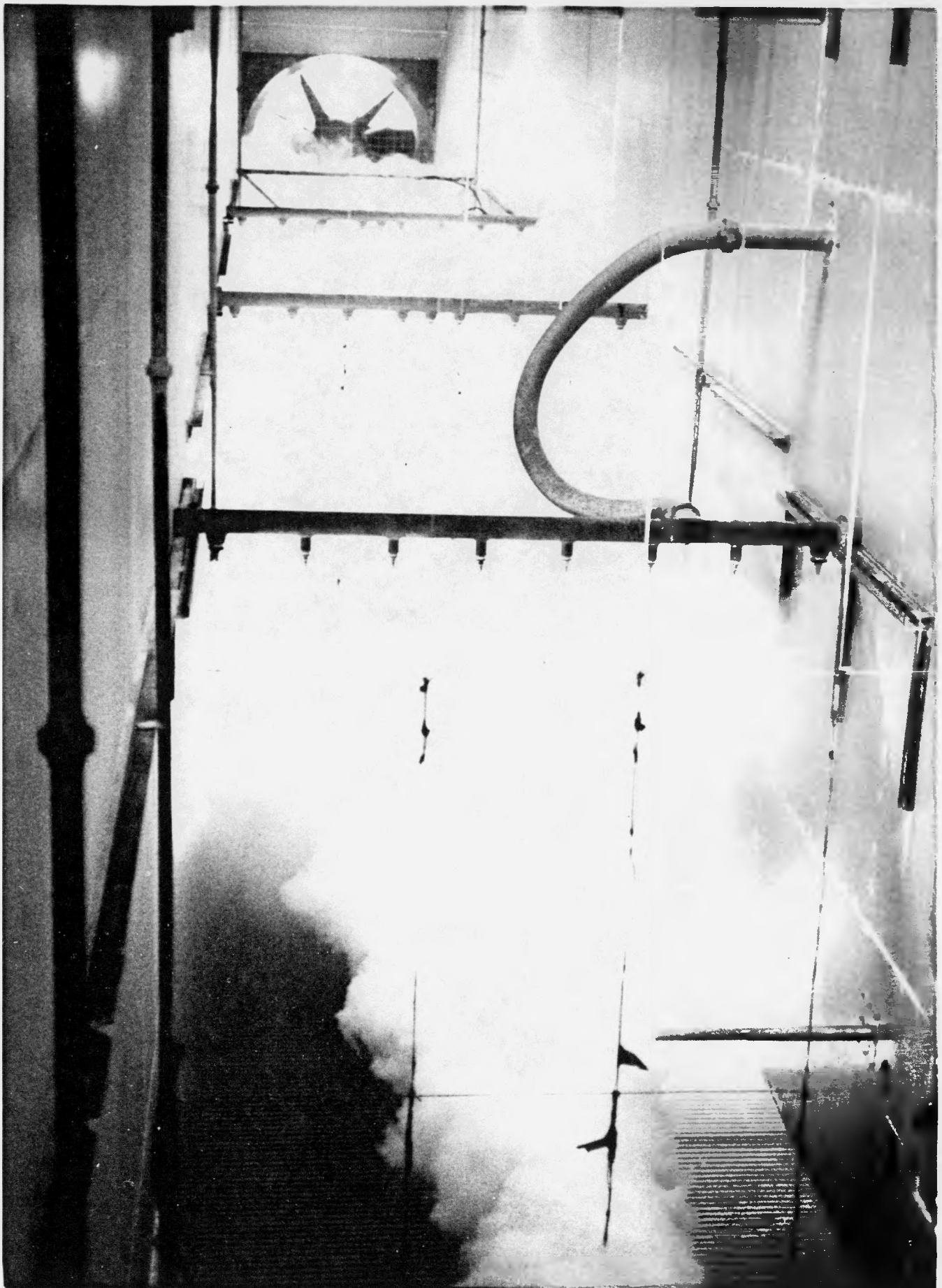




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Test 67

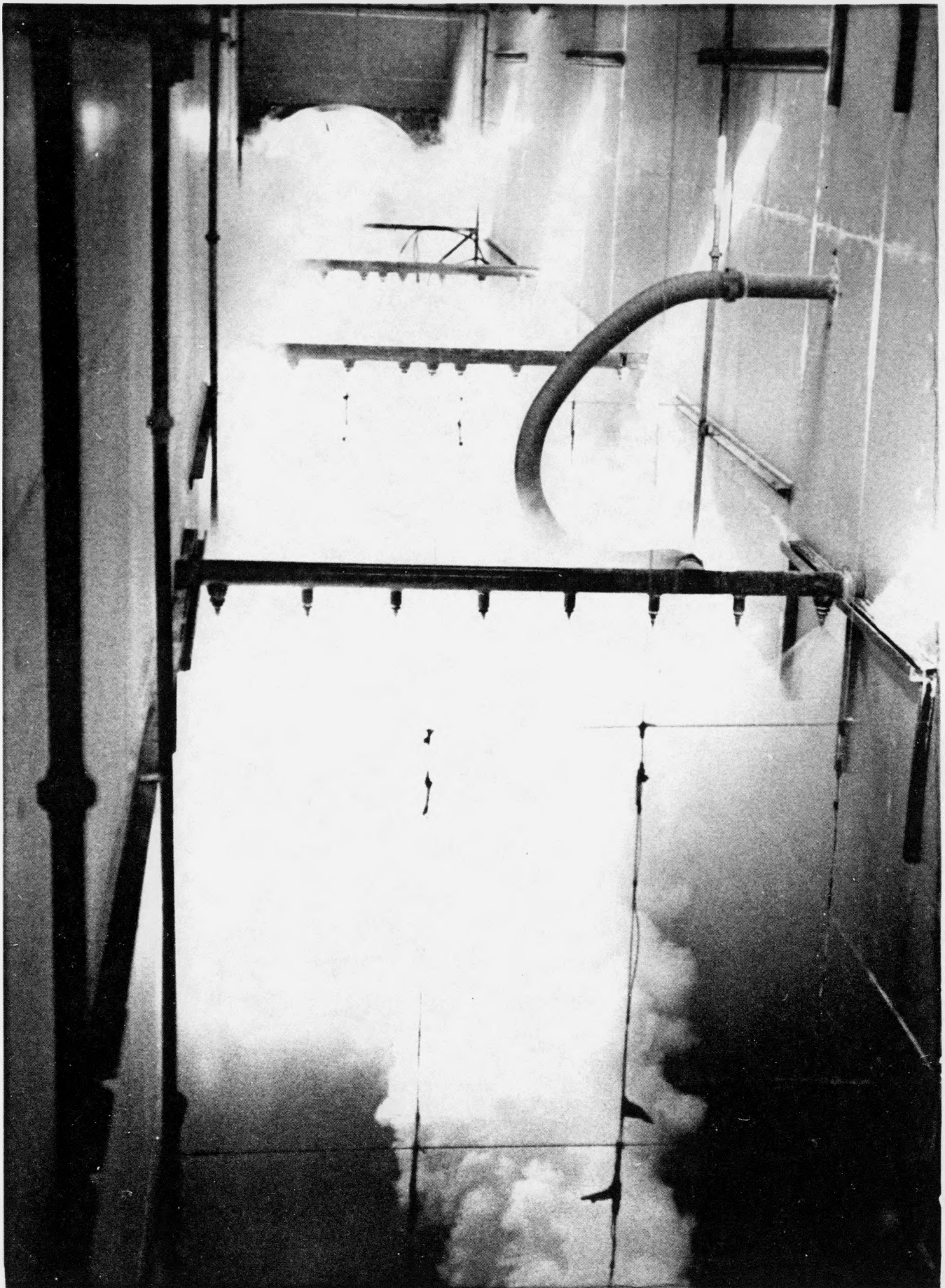


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Test 68

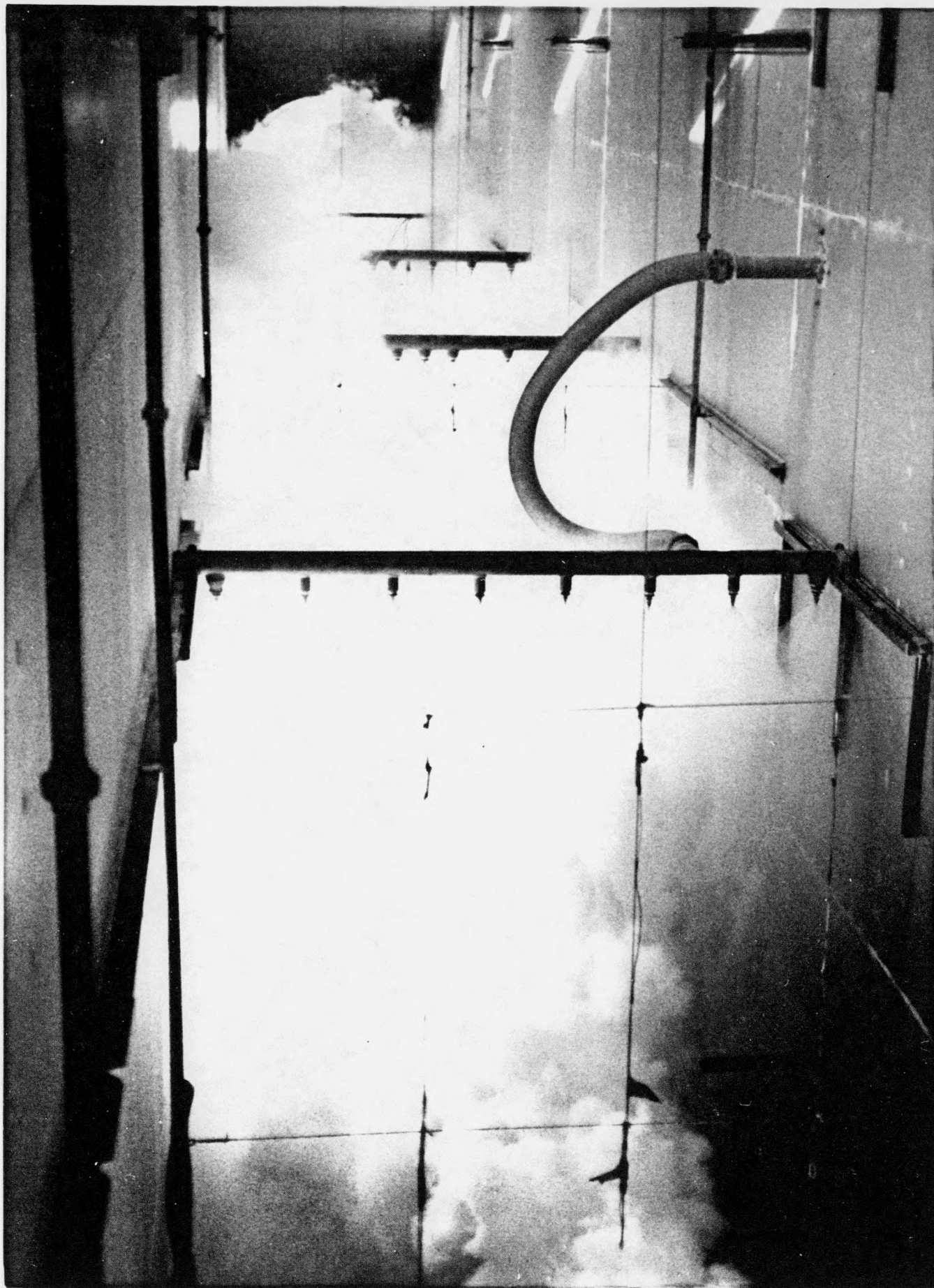
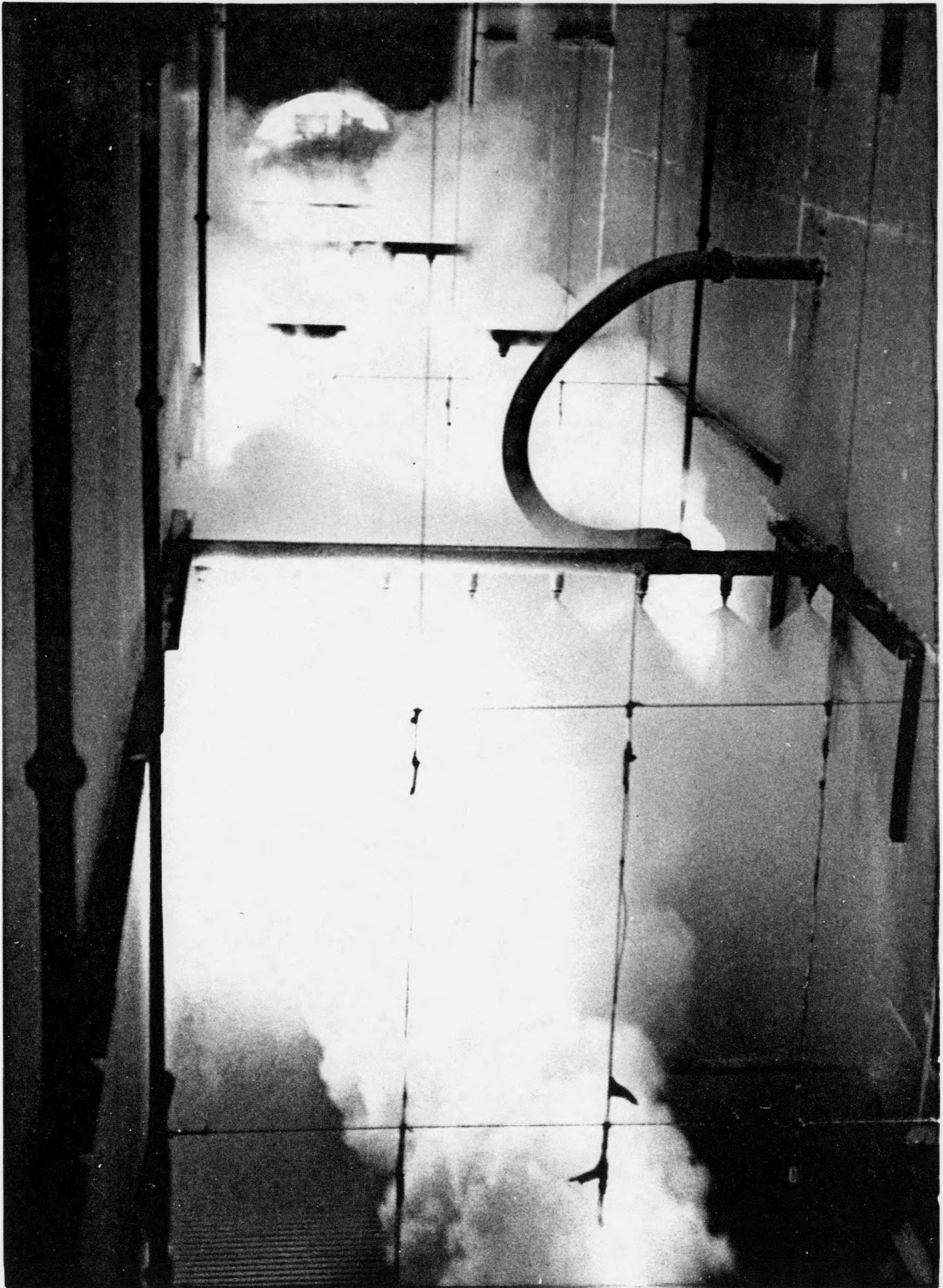




Figure H-85  
Test 69



-H89-



Figure H-86  
Test 70



Figure H-87  
Test 71



-H91-

Figure H-88  
Test 72





Figure H-89  
Test 72



-H93-

Figure H-90  
Test 73



Figure H-91  
Test 74



-H95-



Figure H-92  
Test 75

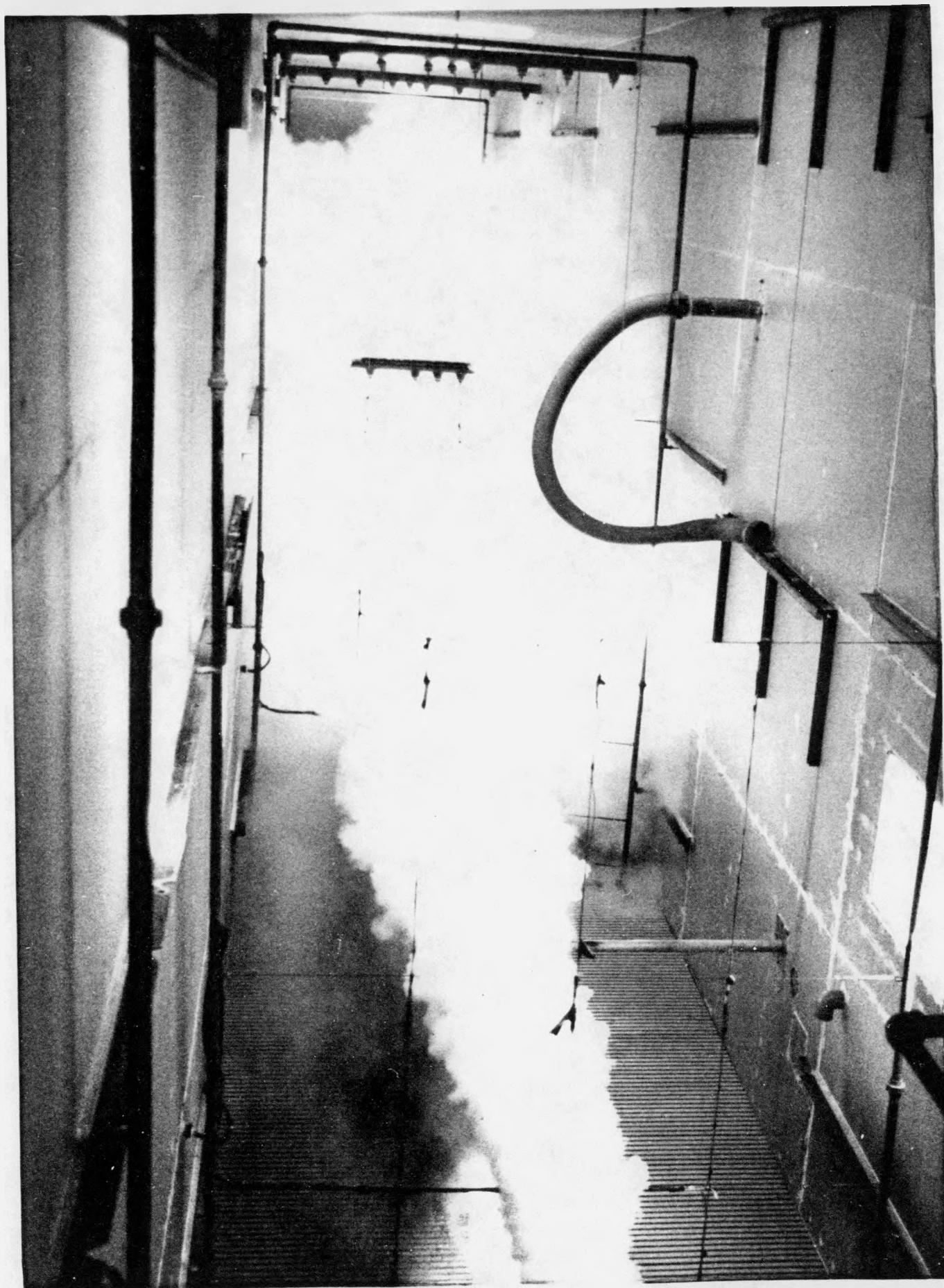


-H96-

Figure H-93  
Test 76



Figure H-94  
Test 76



-H98-



Figure H-95  
Test 77



Figure H-96  
Test 77



-H100-

Figure H-97  
Test 78





Figure H-98  
Test 79



Figure H-99  
Test 80





Figure H-100  
Test 80



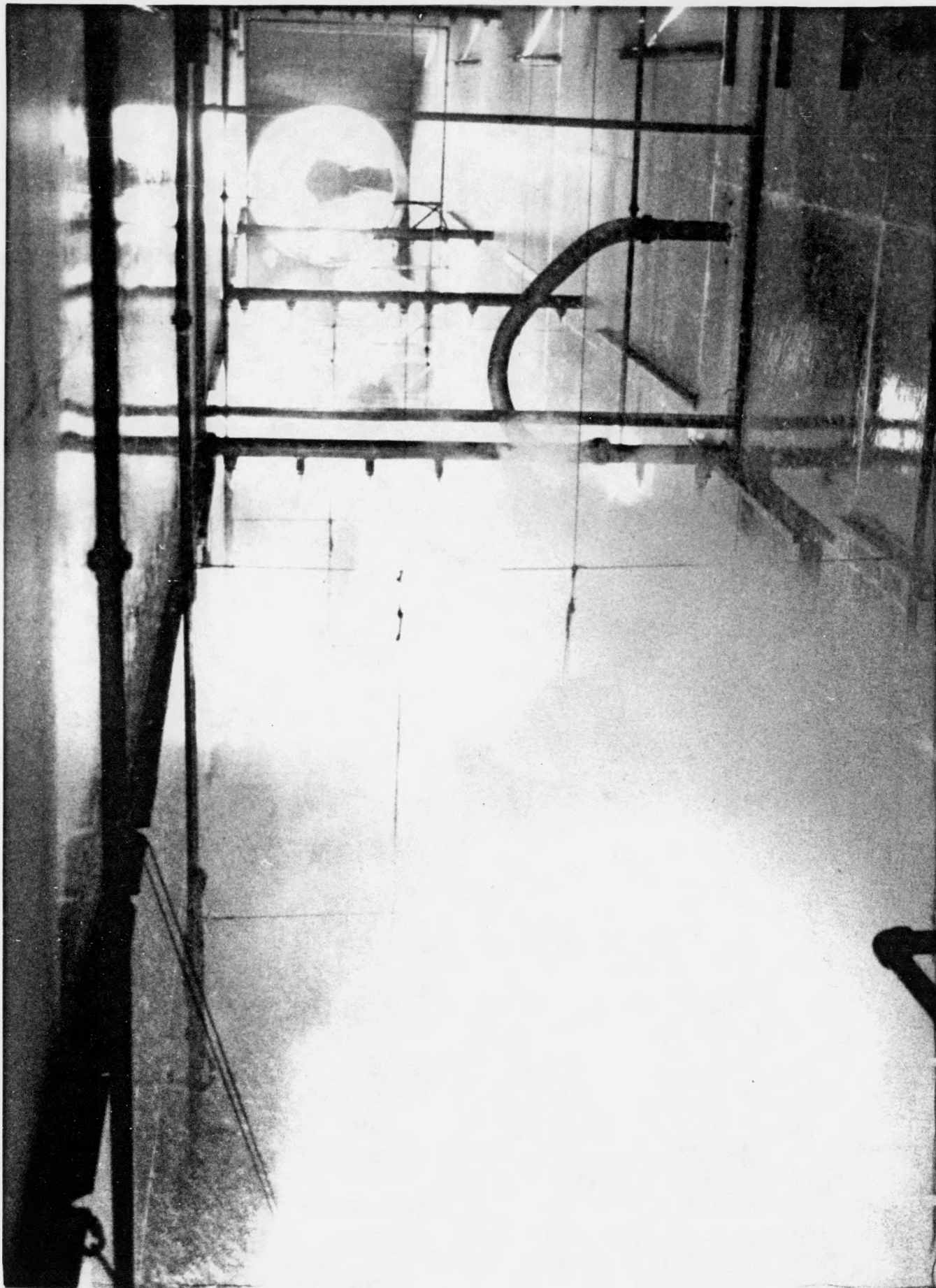


Figure H-101  
Test 81



-H105-

Figure H-102  
Test 81



-H106-



Figure H-103  
Test 82



-H107-



Figure H-104  
Test 83



-H108-

Figure H-105  
Test 84



-H109-



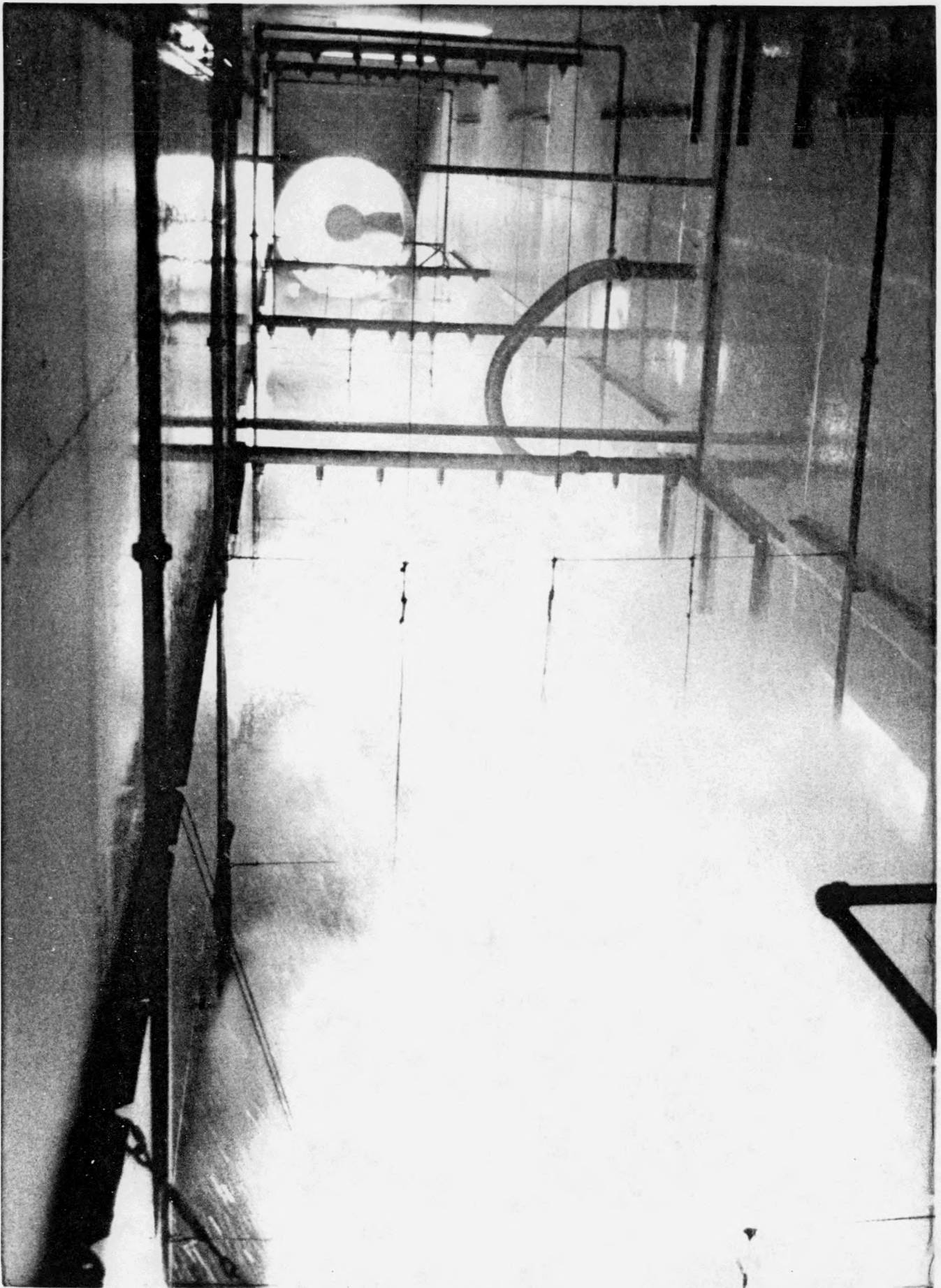
Figure H-106  
Test 85



-H110-



Figure H-107  
Test 85



-H111-