AD NUMBER

AD920984

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies only; test and evaluation; Apr 1974. Other requests shall be referred to Aeronautical Systems Division [YFCTD], Wright-Patterson Air Force Base, Ohio 45433.

AUTHORITY

ASD, USAF ltr, 11 Nov 1974.

ASD-TR-74-15
Final Report for Period 7 May 1973 - 31 August 1973

GUNFIRE TESTS OF F-15 NO. 1 FUEL TANK EXPLOSION SUPPRESSION FOAM CONFIGURATION

Douglas J. Clow, Capt, USAF
Floyd L. Cooper, Capt, USAF

April 1974

Distribution limited to U.S. government agencies only; This report contains information on test and evaluation of military hardware; April 1974; Other requests for this document must be refered to Aeronautical Systems Division (YFCTD)

AERONAUTICAL SYSTEMS DIVISION
AIR FORCE SYSTEMS COMMAND
WRIGHT-PATTERSON AIR FORCE BASE, OHIO 45344

AFLC-WPAFB-JUN 74 13

REPRODUCTION QUALITY NOTICE

This document is the best quality available. The copy furnished to DTIC contained pages that may have the following quality problems:

- Pages smaller or larger than normal.
- Pages with background color or light colored printing.
- Pages with small type or poor printing; and or
- Pages with continuous tone material or color photographs.

Due to various output media available these conditions may or may not cause poor legibility in the microfiche or hardcopy output you receive.

☐ If this block is checked, the copy furnished to DTIC contained pages with color printing, that when reproduced in Black and White, may change detail of the original copy.

NOTICE

When Government drawings, specifications, or other data are used for any purpose other than in connection with a definitely related Government procurement operation, the United States Government thereby incurs no responsibility nor any obligation whatsoever; and the fact that the government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data, is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufactuer, use, or sell any patented irvention that may in any way be related thereto.

Copies of this report should not be returned unless return is required by security considerations, contractual obligations, or notice on a specific document.

This technical report has been reviewed and is approved for publication.

Douglas J. Clow, Capt, USAF
F-15 Integration Engineer

Floyd L. Cooper, Capt, USAF
F-15 Survivability/Vulnerability Engineer

FOR THE COMMANDER

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER
ASD-TR-74-15

2. GOVT ACCESSION NO.

3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)
GUNFIRE TESTS OF F-15 NO. 1 FUEL TANK EXPLOSION SUPPRESSION FOAM CONFIGURATION

5. TYPE OF REPORT & PERIOD COVERED
Final Report
7 May 1973 - 31 Aug 1973

6. PERFORMING ORG. REPORT NUMBER

7. AUTHOR(s)
Douglas J. Clow, Capt, USAF
Floyd L. Cooper, Capt, USAF
Aeronautical Systems Division (YFE), Air Force Systems Command, WPAFB, Ohio 45433

8. CONTRACT OR GRANT NUMBER(s)

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Air Force Flight Dynamics Lab (PTS)
Air Force Systems Command
Wright-Patterson AFB, Ohio 45433

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
AFFDL
43630123

11. CONTROLLING OFFICE NAME AND ADDRESS
Aeronautical Systems Division (YFE)
Wright-Patterson Air Force Base, Ohio 45433

12. REPORT DATE
April 1974

13. NUMBER OF PAGES
24

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

15. SECURITY CLASS. (of this report)
Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)
Distribution Limited to U.S. Government Agencies Only; This report contains information on test and evaluation of military hardware; [illegible] 1974; Other requests for this document must be referred to Aeronautical Systems Division (YFCTD), Wright-Patterson Air Force Base, Ohio 45433

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)
Explosion Suppression Foam
F-15 Fuselage Fuel Tank
Gunfire Testing
Gross Voided Internal Foam
Fragment Impacts
Explosive Overpressure
Survivability/Vulnerability
Safety

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)
Gunfire testing was conducted to determine whether a 50% voiding foam configuration for the F-15 No. 1 fuselage fuel tank can suppress fuel vapor explosions to maximum peak overpressures of less than the structural strength limitation of the tank. The resulting peak overpressures stayed well within the 15 psig limit as established by the F-15 Fuel System Design Analysis Report, MDC 0372.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

FOREWORD

The writer's of this report wish to express their appreciation for the excellent support provided by the Air Force Flight Dynamics Lab in the accomplishment of the subject testing. The AFFDL found time within its busy schedule to fabricate and gunfire test articles in a time frame compatible with F-15 objectives. This testing was accomplished under AFFDL Project Number 43630.

SECTION I

IMPACT FLASH TESTS

1. INTRODUCTION

The purpose of this test was to determine whether 0.125 in. Al or 0.250 in. Al produced the largest exit side flash (worse case ignition source) from fragment impact. Both material gages represent actual thicknesses of aluminum that a fragment might penetrate before entering the fuel tank. The thickness selected would be used as the front and back panels on the follow-on foam configuration tests.

2. DESCRIPTION OF TEST ITEM

Two test panels, one 0.125 in. 2024-T3 and one 0.250 in. 2024-T3 aluminum were each backed with a slab of 22-23 ppi red reticulated foam. The foam was glued to the aluminum panels so as to leave a 10 in. x 10 in. unglued area to duplicate foam restraints within the test tank. See Figure 1.

3. TEST SETUP AND PROCEDURES

The test panels were mounted in the vertical position with the foam facing away from the gun. A 500 frame/sec camera was placed to view the foam from a side view. An opaque shield was placed around the panel to keep the camera from viewing the impact flash from the front side of the panel.

The projectiles fired were two simultaneous, sabot-launched, 130 gram fragments which impact the panel at 0° obliquity with 6-8 in. of separation between fragment impact points. Aim point was the center of the 10 in. x 10 in. unglued area. The fragment size and velocity were selected to simulate typical missile warhead fragments.

4. RESULTS

The flash from the 0.125 in. panel was very large compared with that from the 0.250 in. panel. The results are shown by the photographs of Figures 6 and 7. The flash from the 0.125 in. aluminum extended 2 1/2 - 3 ft. Fragment velocity for both shots was above 5000 fps.

5. CONCLUSION

The 0.125 in. panel was selected for use in the foam configuration tests.

SECTION II

FOAM CONFIGURATION GUNFIRE TESTS

1. INTRODUCTION

In an effort to better optimize the explosion suppression foam in the F-15's No. 1 fuselage fuel tanks, MCAIR has proposed a higher voiding configuration than that currently specified. The proposed MCAIR configuration allows for approximately 50.2% voiding.

The purpose of the foam is to provide protection against fuel vapor explosion overpressures caused by external threats. From the F-15 Fuel Subsystem Design Analysis Report, MDC A0372, Vol 2, it is determined that the structural strength limitation of the No. 1 tank, under low flight loading, is 15 psig overpressure. A successful foam configuration should ensure that the maximum peak overpressure resulting from fuel vapor explosions remain less than 15 psig.

The purpose of the test is to determine whether the 50% voiding foam configuration, proposed by MCAIR for the No. 1 fuselage fuel tank, can suppress fuel vapor explosions to maximum peak overpressures less than 15 psig.

2. DESCRIPTION OF TEST ITEM

The basic tank was made by clamping together the two AFFDL tank wall simulator (TWS) tanks. Front and rear panels were 0.125 in. 2024-T7 aluminum clamped to the ends of the basic tanks. For the .50 cal API shot an additional 0.125 in. plate was secured to the impact point to form a total skin thickness of 0.250 in. to completely strip the incendiary jacket. Rigid styrofoam was placed along the four corners where the tank walls joined to cover protruding bolts and provide a smooth surface to butt against the foam. A representative bladder was secured to the rear panel. Thermocouples and pressure transducer ports were located under the foam next to the tank wall. Bomb sample ports and fill lines were installed on top at each end and a drain/vacuum line on the bottom of the tank. The tank configuration is shown by Figures 2, 3 and 4. Characteristics of the proposed F-15 No. 1 tank and of the test fixture are summarized in Table 1.

3. TEST SETUP

Parts of the test setup consisted of the test tank, gun, charging system and instrumentation. For the fragment shots, the gun was positioned and loaded so the two fragments would enter the voids to the left and right of the aim point. Impact obliquity was 7° from the perpendicular. For the .50 cal API the aim point was the center void at 0° obliquity. All shots were in the horizontal plane. The propane charging system contained a compressed propane bottle, compressed air bottle, mixing bottle, vacuum pump, necessary piping and pressure/vacuum gauges. Instrumentation consists of thermocouples pressure transducers and recorder. The test setup is shown by the photograph of Figure 8. The test was setup to achieve a worse case situation as follows

a. Two thicknesses of aluminum were available for fabricating the front and rear panels. The previous impact flash tests showed that 0.125 in. Al created a larger exit side flash than 0.250 Al and therefore was used for constructing the panels.

b. Bladder material was not used on the backside of the entrance panel to avoid possible flash suppression.

c. Void sizes in the test tank were on the average larger than in the actual tank.

d. The aim point was selected so that fragment shots would penetrate adjacent voids creating dual explosions.

e. For the fragment shots an impact obliquity of 7° was used so that the fragments would cut across as many voids as possible.

4. PROCEDURE

The test tank was filled with JP-5 to wet the foam and then drained. A vacuum of 27 inches Hg was drawn on the test tank and mixing bottle. The mixing bottle was pressurized with the proper amounts of propane and air to achieve a 5% mixture. The test tank was then charged from the mixing bottle to a slight overpressure and bomb samples taken from both ends of the tank. Gunfire commenced when both bomb samples were over 70 psig. Pressures, temperatures and projectiles velocity were recorded.

5. DISCUSSION OF TEST RESULTS

The pressure and temperature traces recorded during the tests are plotted on Figure 5. The peak pressures and temperatures are given in Table 2.

Shot 1

Inspection of the foam after shot 1 showed evidence of burning in 79 of the 90 voids. Complete burnthrough occurred only in the 1 3/8" foam next to the rear panel where the fragments exited the tank. P5 was hit by a fragment and therefore showed no trace. Pressure rises remained within the established criteria. Photographs of shot 1 are shown by Figures 9 through 16.

Shot 2

Examination of data showed no pressure or temperature rises. Inspection of the foam showed no evidence of burning. Bomb samples were acceptable from both ends of the tank. The fragments remained close together and traveled through the same voids. Charring occurred where the hot fragments cut through the foam. The propane-air mixture may not have been close enough to stociometric to permit ignition by the impact flash. Previous gunfire testing with fragments by AFAPL tend to substantiate the belief that ignition of fuel vapor by fragment impact flash is extremely sensitive to obtaining the proper stociometric mixture. This test failed to function properly. Figure 17 is a photograph of the first solid and voided foam blocks.

Shot 3

The .50 cal API projectile caused burning in just the first center void. Only T1 showed a temperature rise which was 81°F. There were no pressure rises. Burning was completely constrained to this one void. Figure 18 is a photograph of the first tier voids.

6. CONCLUSION

The results from shots 1 and 3 show that the measured pressures did not exceed the design limits of the No. 1 fuel tank. Extrapolating the 48.53% voiding in the test tank to the proposed 50.2% in the actual tank leads to an analytical prediction that the peak pressure recorded (4.86 psig) would have gone to 5.1 psig in the 50.2% configuration. It is probable that higher pressures occurred at other tank wall locations, but these pressures would not be expected to exceed the 15 psig criteria. Even though the statistical base is very low, the results of this testing gives confidence that the proposed voiding concept is acceptable for the No. 1 fuel tank.

TABLE 1

FUEL TANK CONFIGURATIONS

CHARACTERISTIC	PROPOSED F-15 NO. 1	TEST FIXTURE
Volume (Gal)	442.86 gal	417.44 gal
Foam Vol (Gal/%)	221.43/50	214.86/51.47
Void Vol (Gal/%)	221.43/50	202.58/48.53
Type of Foam	Red Polyurethane	Red Polyurethane
Foam Configuration	Egg Crate Void Sizes ≤ 10"X10"X5"	Egg Crate - Nominal 10"X10"X5" void size
Combustion Vapor	JP-4	Propane
Fuel to Wet Foam	JP-4	JP-5
Thickness of Al Tank Liner Impacted by Threat (inches)	.016 - .133	.125
Threat Type/Avg Frag Mass/ Impact Vel (- /grains/fps)	Omitted to Avoid Classifying Report	.50 cal API & Two Sabot Steel Fragments/130/ 5000
Location of Fuel Tanks Bladder	Against Entry and Exit Fuel Tank Liners	Only Against Exit Fuel Tank Liners
Minimum Foam Thickness Between Voids (inches)	2	2
Initial Internal Tank Pressure	Pressure at Altitude + .5 psi Worst Case (s.l.) = 15.2 psia 10,000 ft = 10.1 psia	14.3 psia

TABLE 2

TEST RESULTS

	Threat	Projectile Velocity	Bomb Samples	Peak Pressure Rises	Temperature Rises
SHOT 1	2-130 grain fragments	3920 fps	86.4 psig *64 psig	P_3-4.86 psig P_1-1.65 psig	T_1-555°F T_2-223°F T_3- 85°F T_4- 14°F T_5- 24°F
SHOT 2	2-130 grain fragments	Not Recorded	85.3 psig 76.5 psig	None Recorded	None Recorded
SHOT 3	1-.50 Cal API	Not Recorded	87.2 psig 88.0 psig	None Recorded	T_1- 81°F

* Many attempts were made to achieve a sample above 70 psig. Time limitations necessitated shooting with the indicated bomb sample

FIGURE 1

IMPACT FLASH TEST PANEL

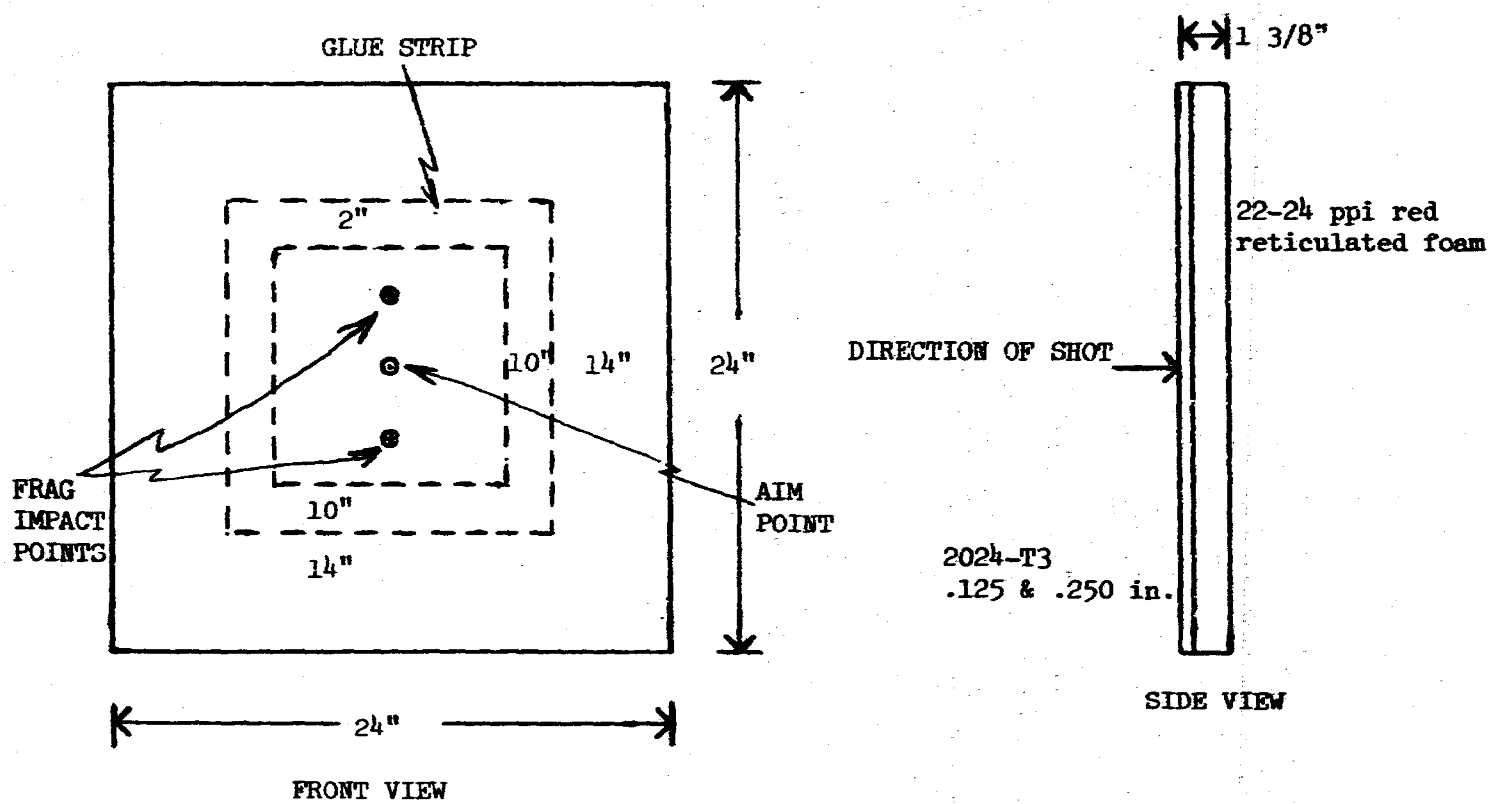


FIGURE 2

TEST TANK CONFIGURATION - FRONT VIEW

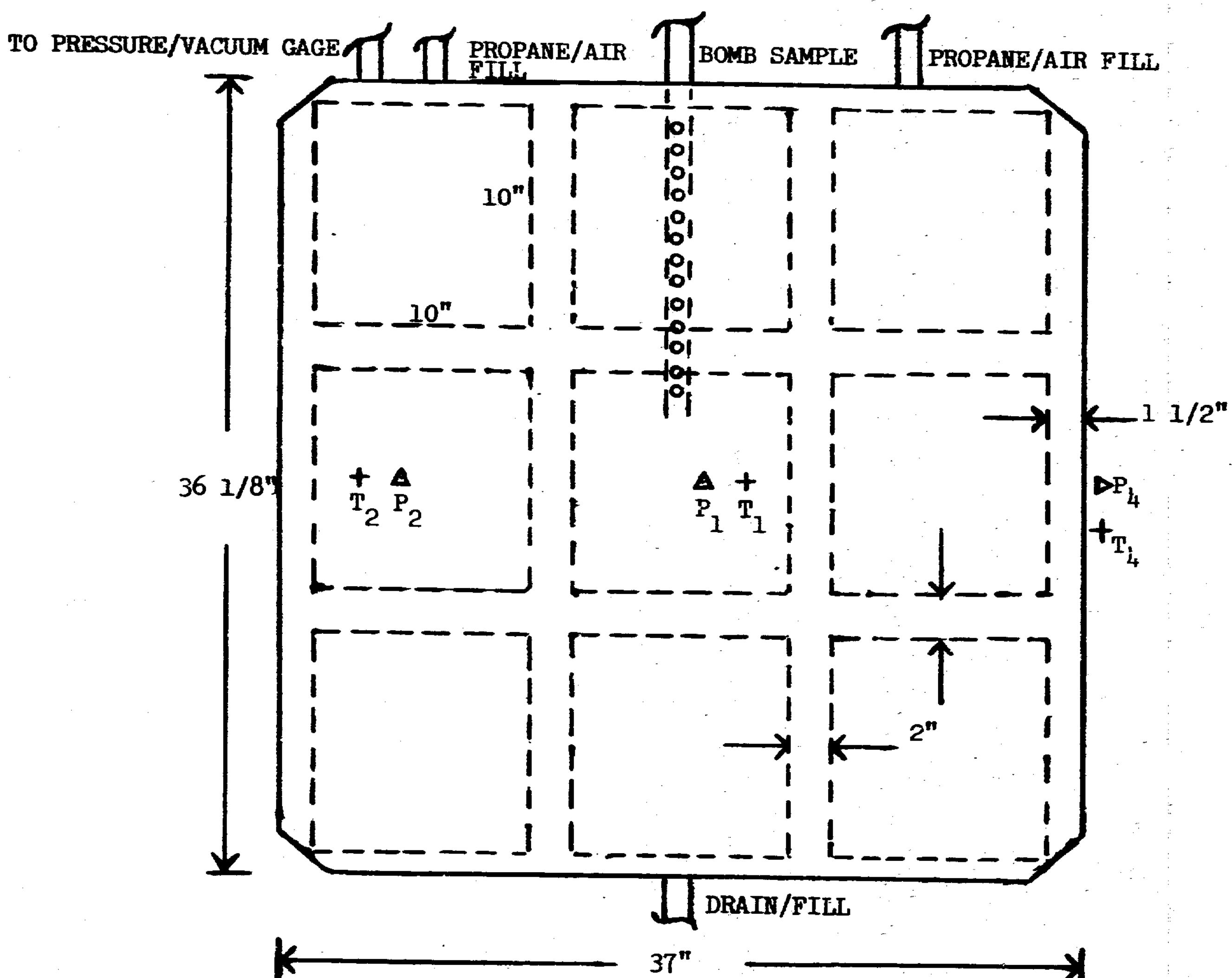


FIGURE 3

TEST TANK CONFIGURATION - SIDE VIEW

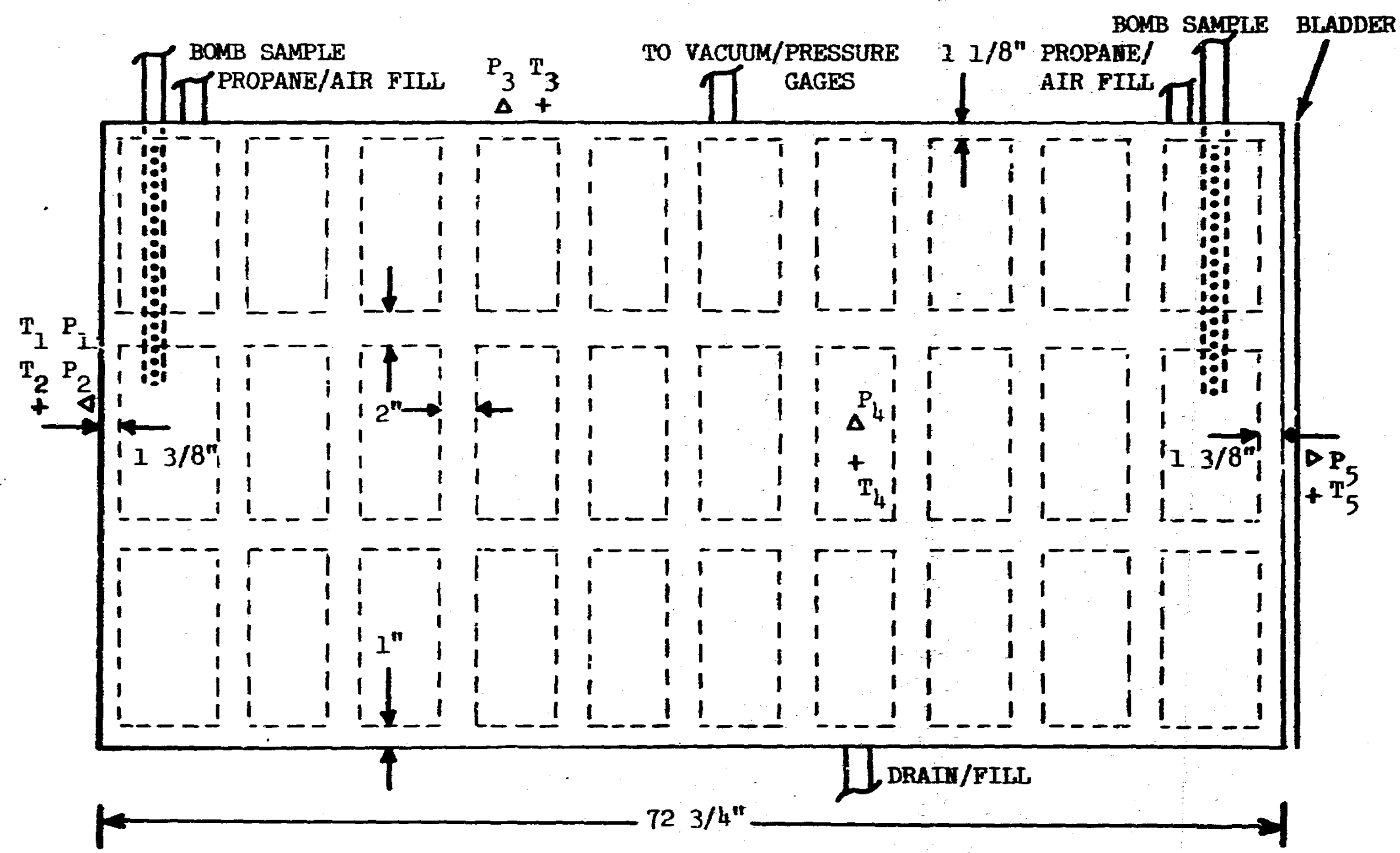


FIGURE 4

TEST TANK CONFIGURATION - TOP VIEW

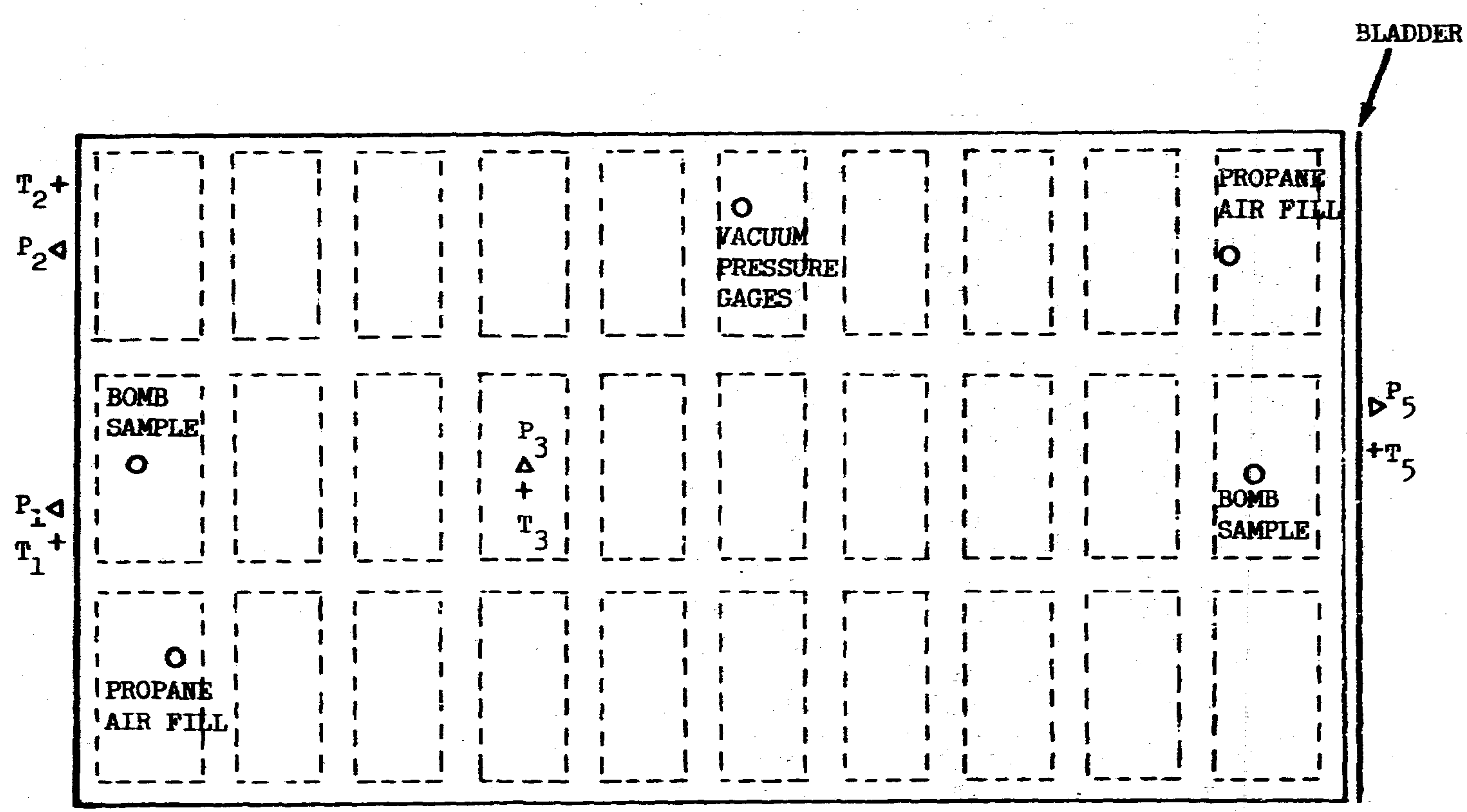


FIGURE 5 - PRESSURE/TEMPERATURE vs TIME

Figure 6
Flash from 0.125 in. panel
Page 12

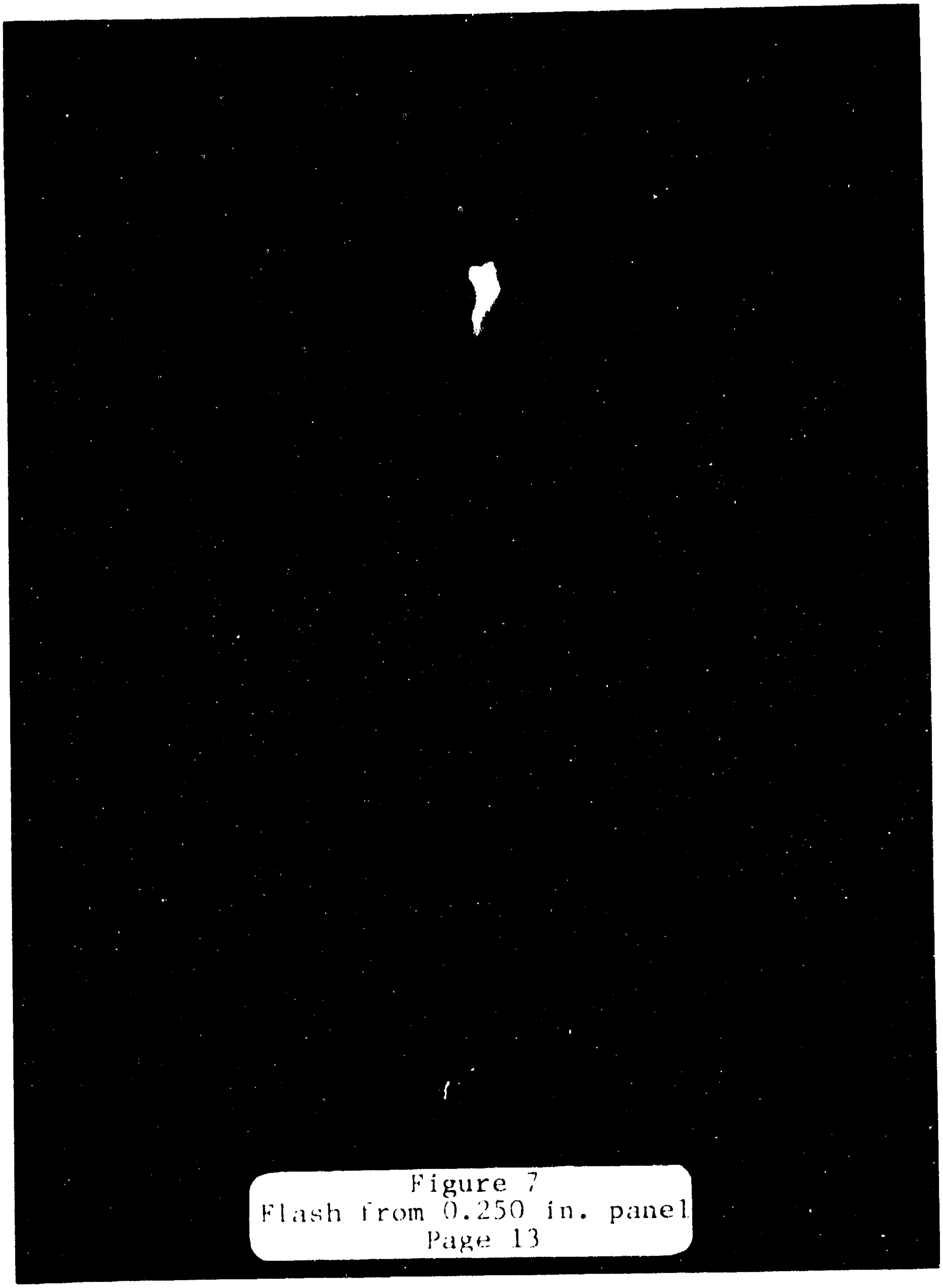


Figure 7
Flash from 0.250 in. panel
Page 13

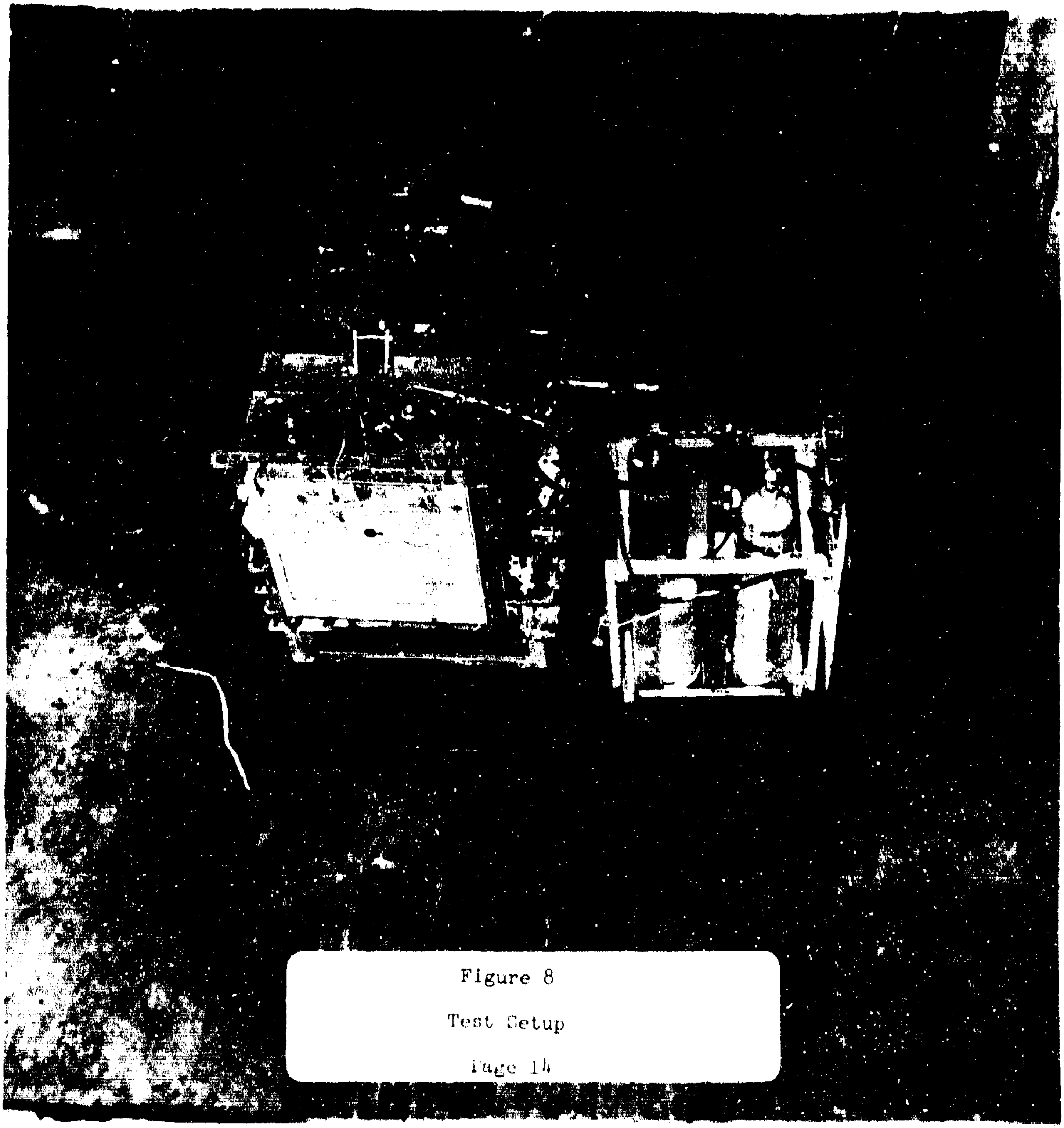


Figure 8

Test Setup

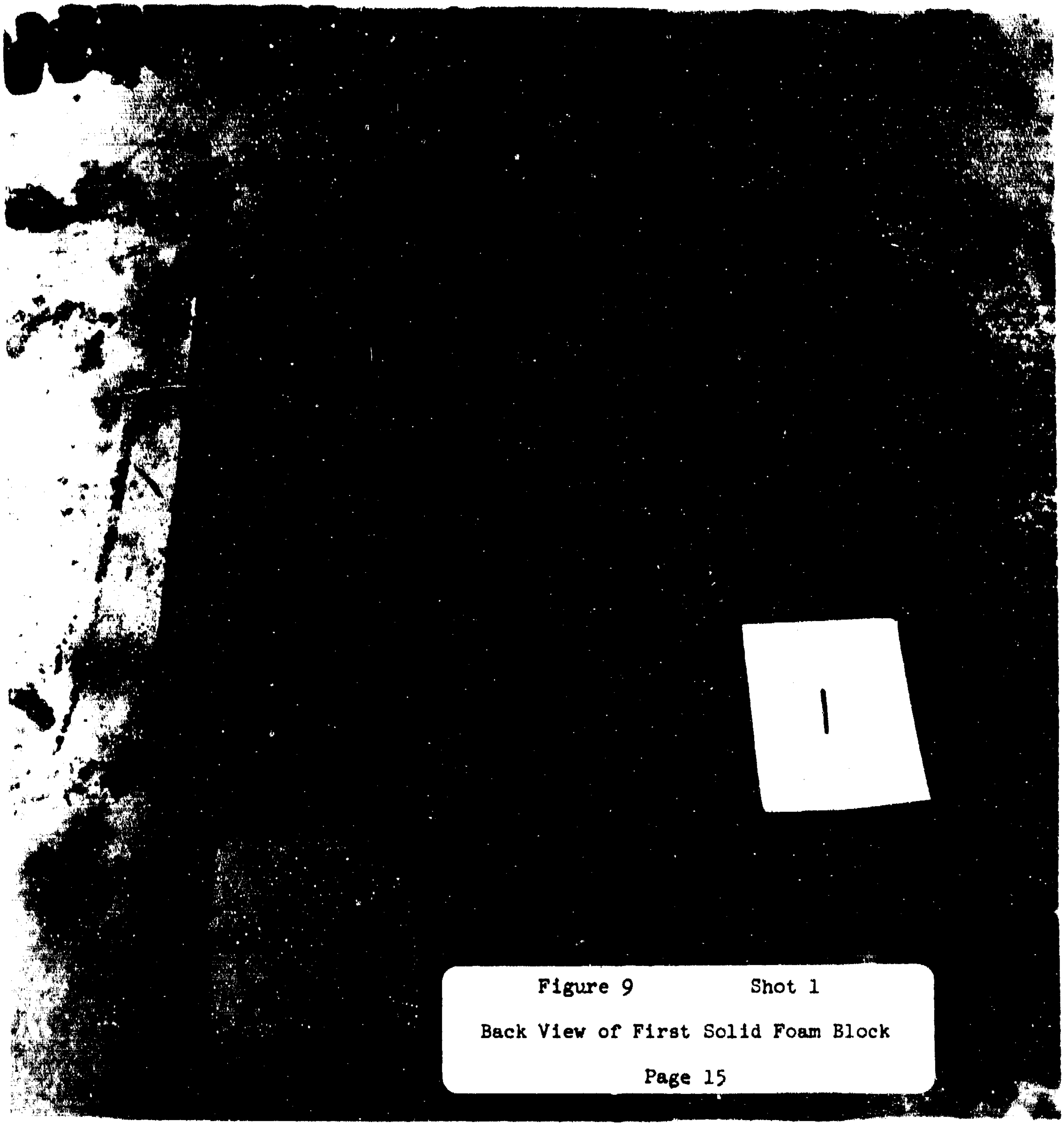
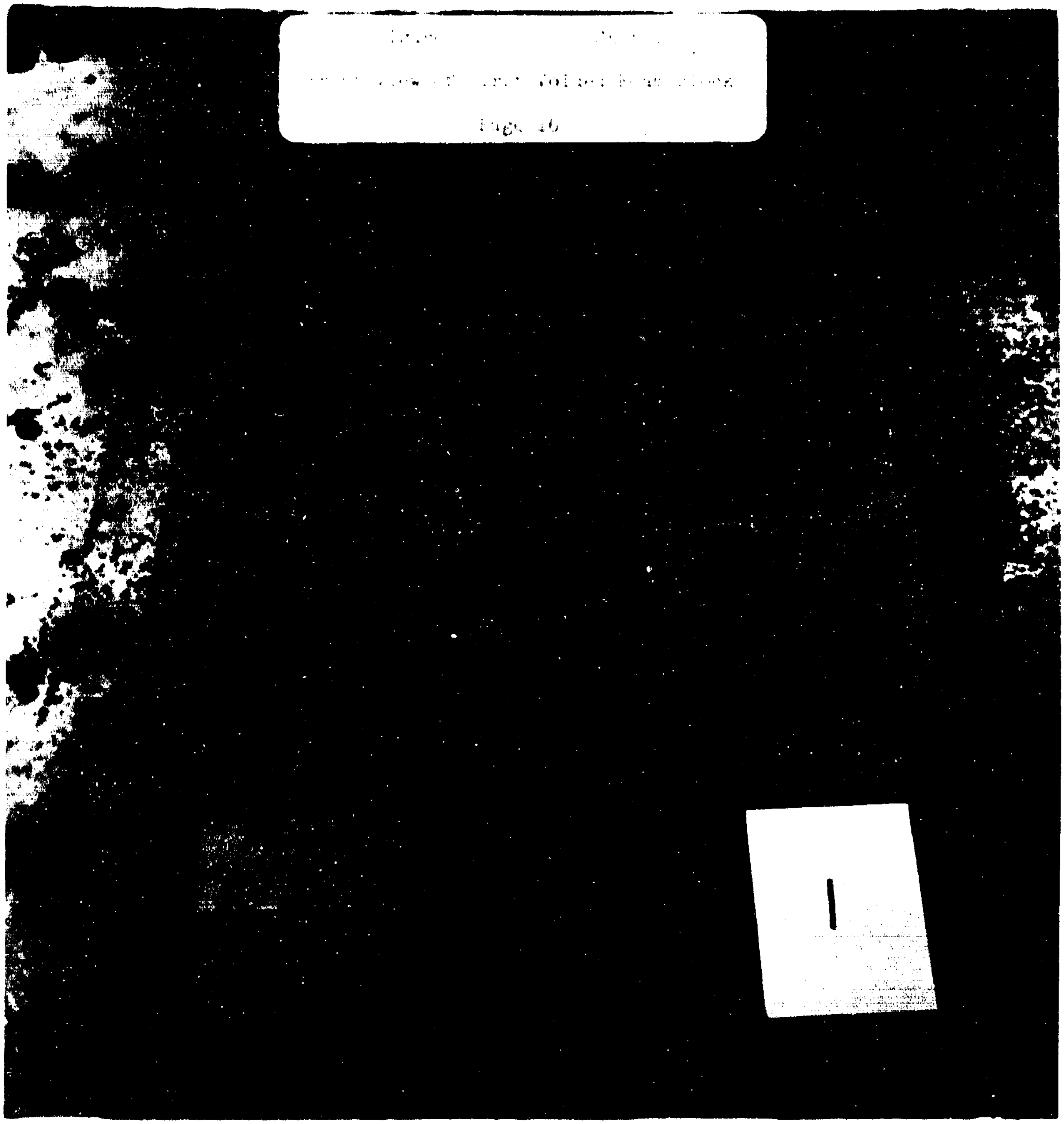
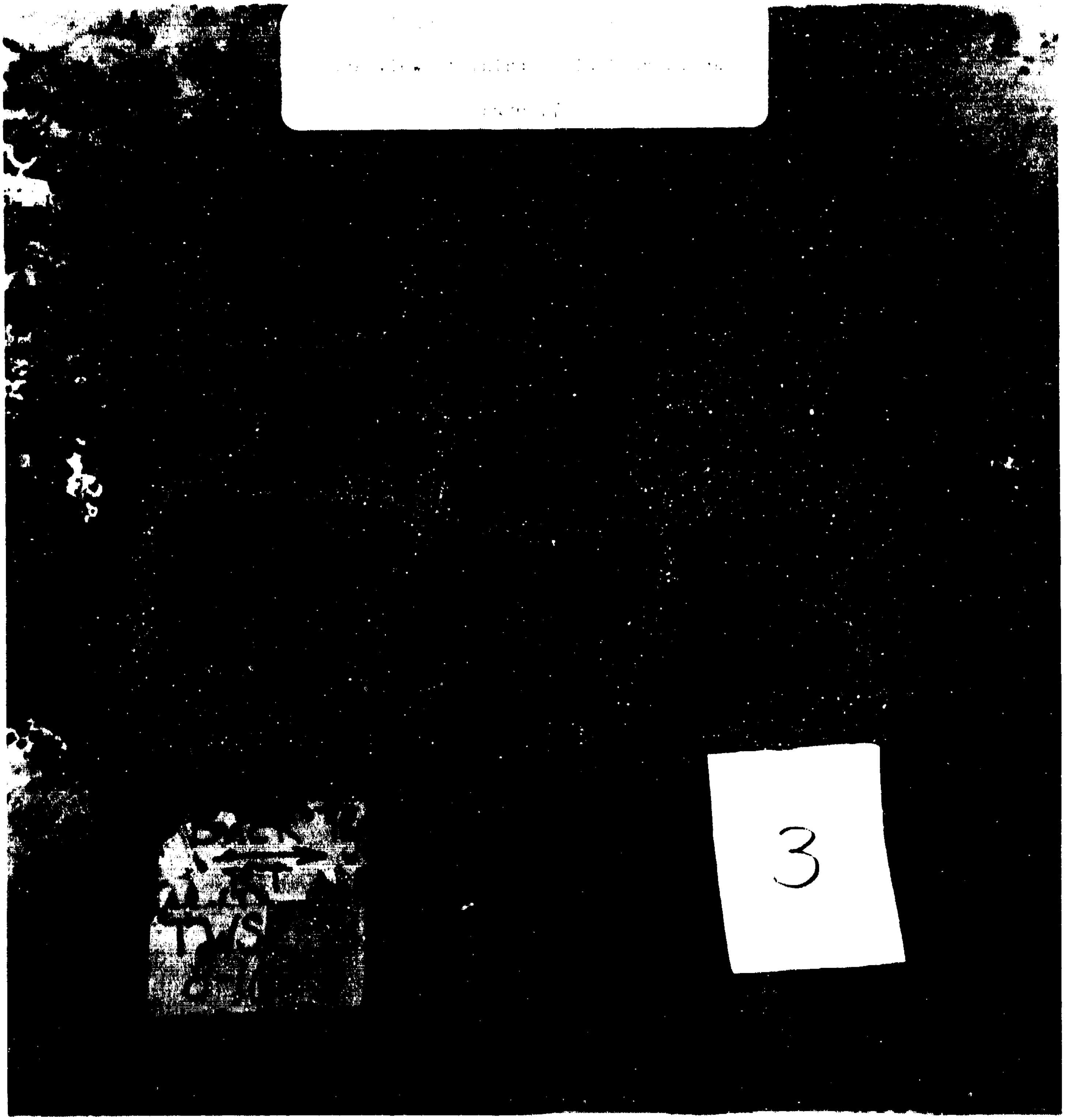


Figure 9 Shot 1

Back View of First Solid Foam Block

Page 15


Page 16


3

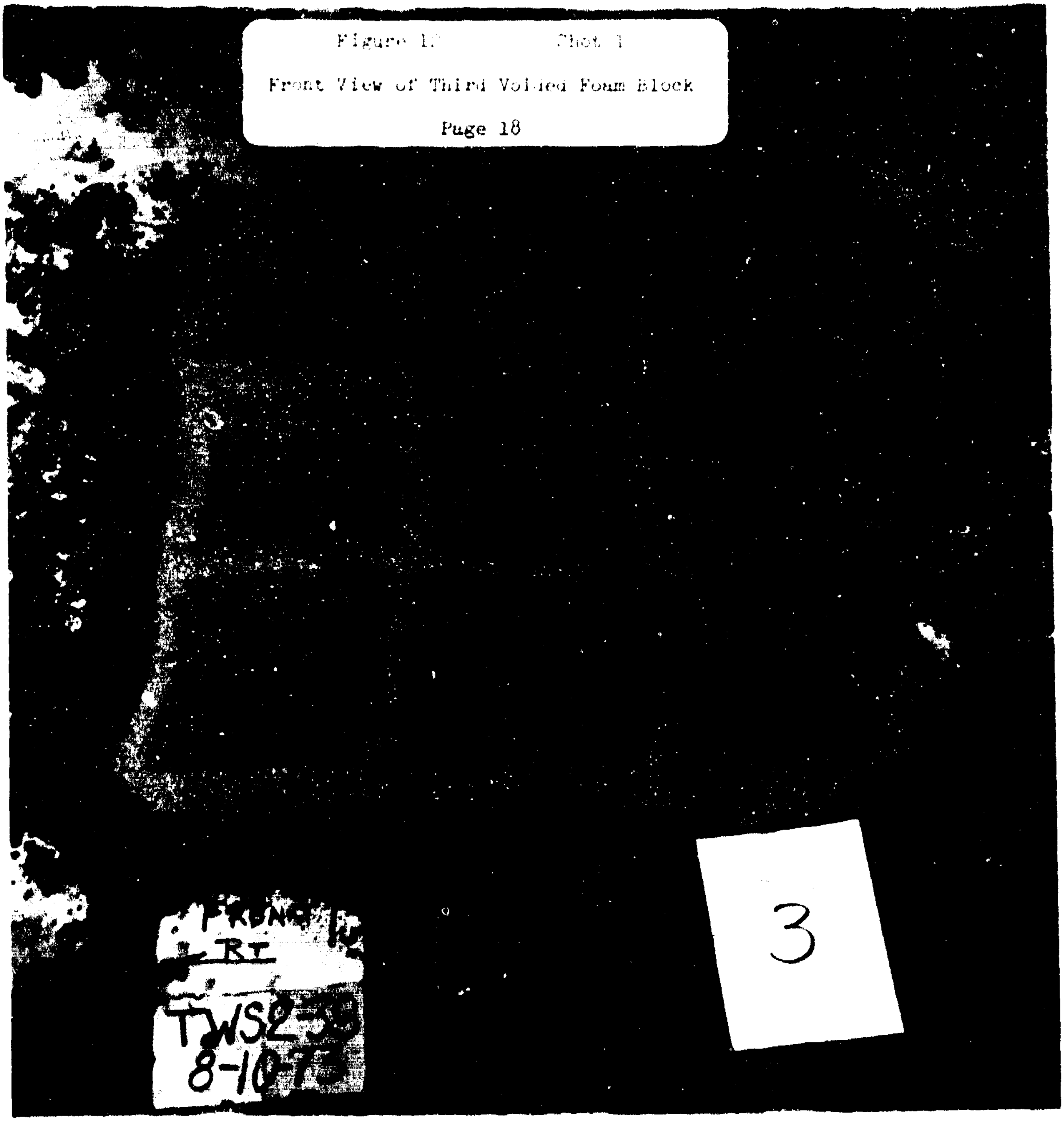


Figure 1[illegible] Shot 1

Front View of Third Voided Foam Block

Page 18

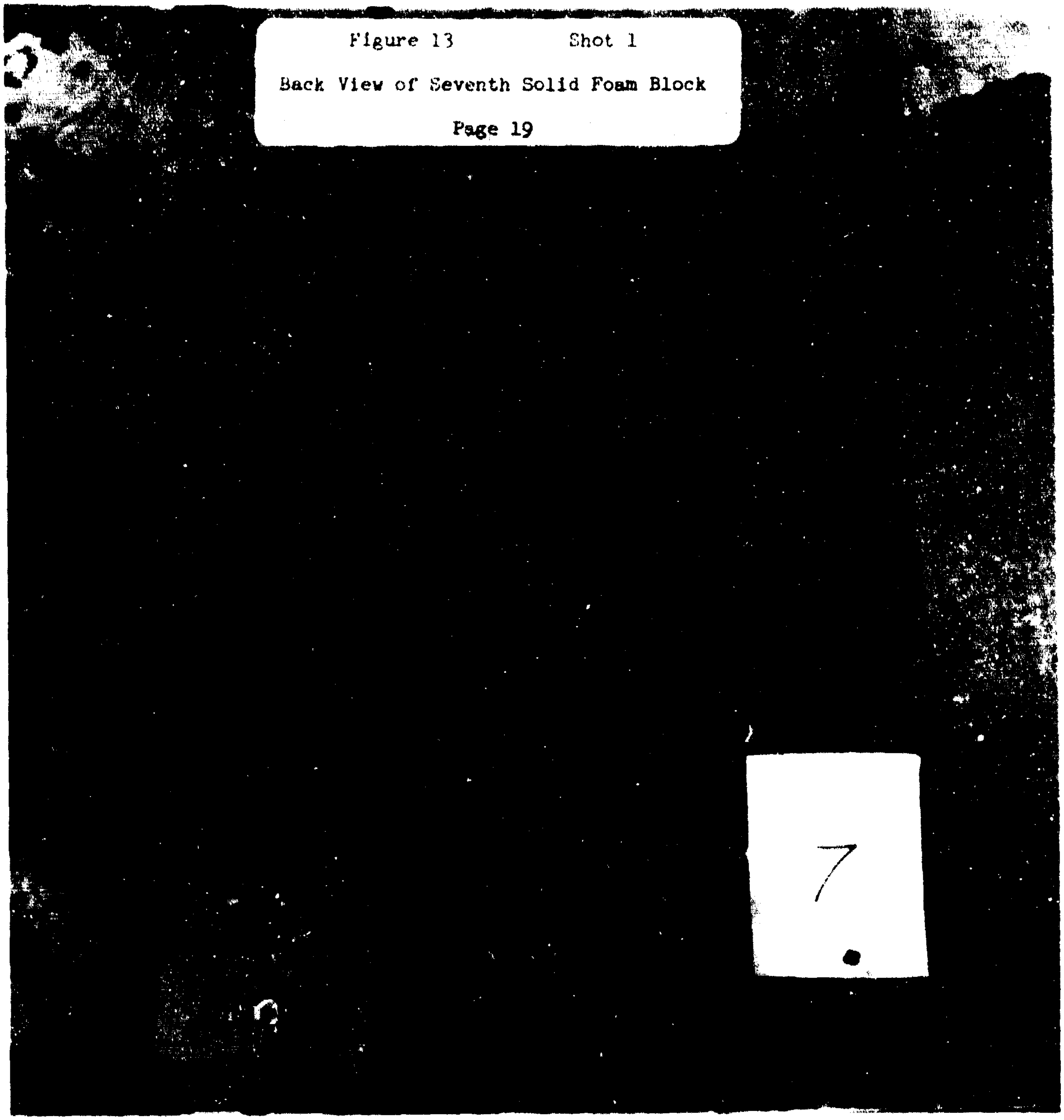


Figure 13 Shot 1

Back View of Seventh Solid Foam Block

Page 19

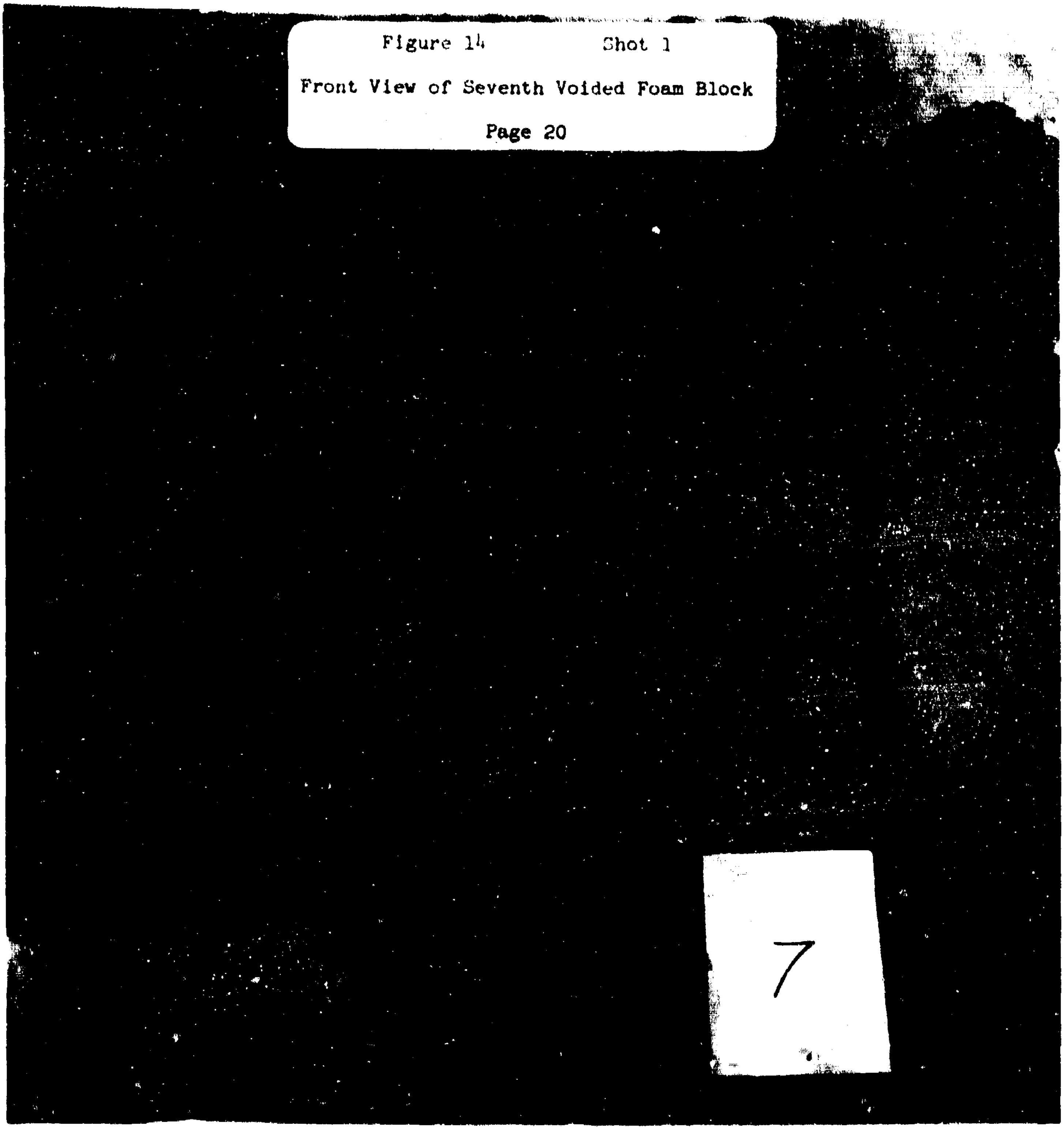


Figure 14 Shot 1

Front View of Seventh Voided Foam Block

Page 20

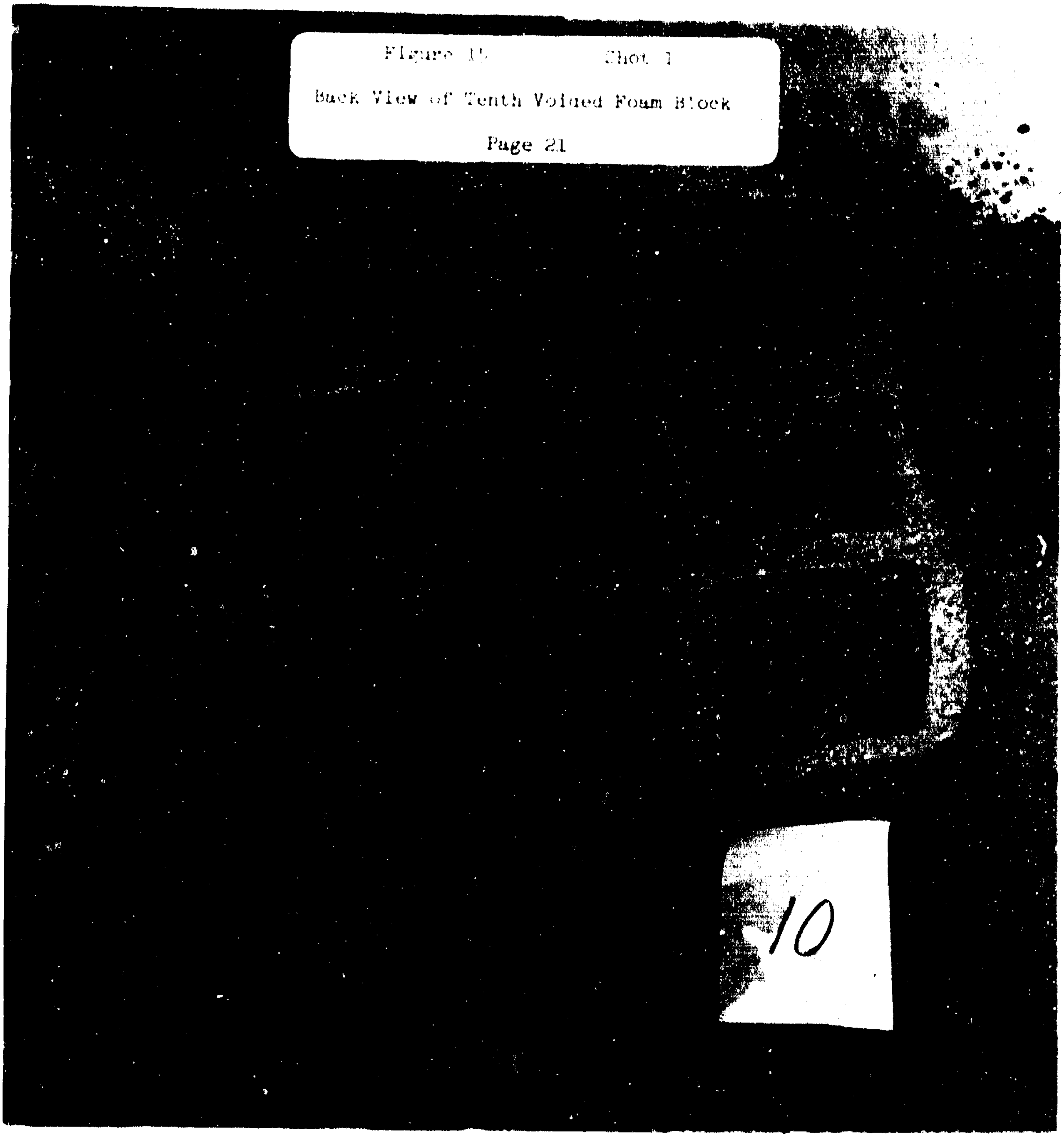


Figure 15 Shot 1

Back View of Tenth Voided Foam Block

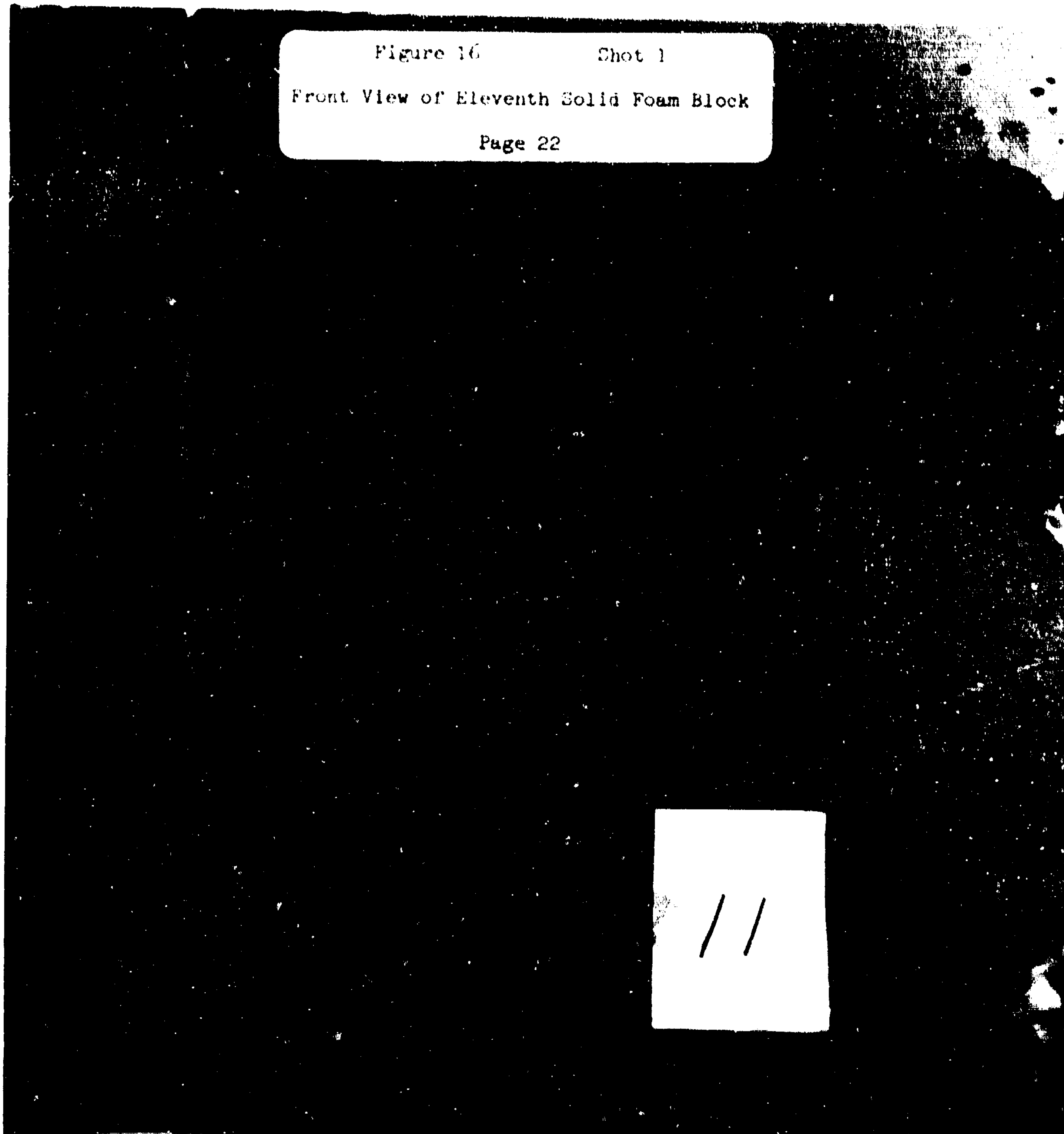


Figure 16 Shot 1

Front View of Eleventh Solid Foam Block

Page 22

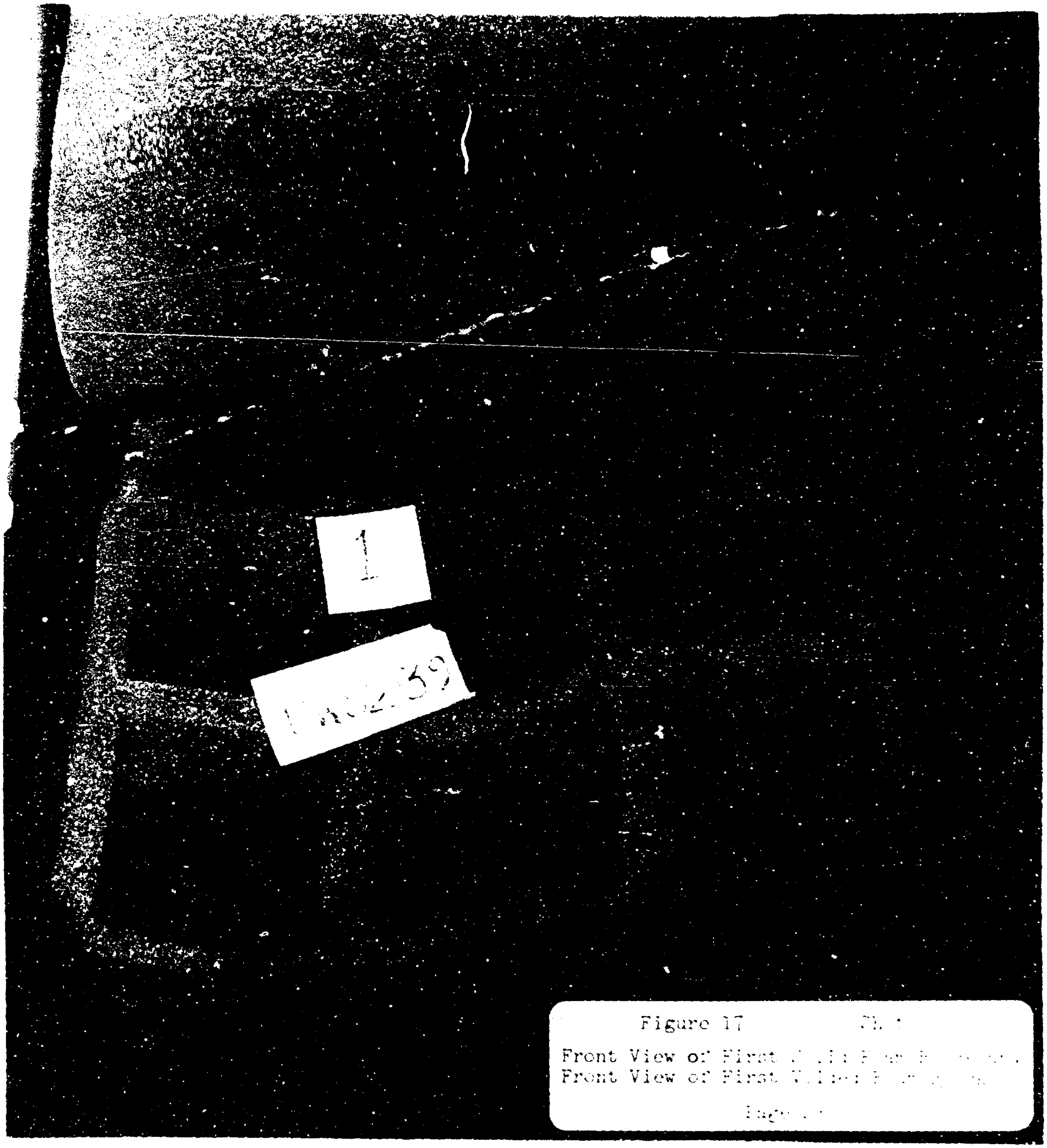


Figure 17 [illegible]

Front View of First [illegible]
Front View of First [illegible]

Page [illegible]

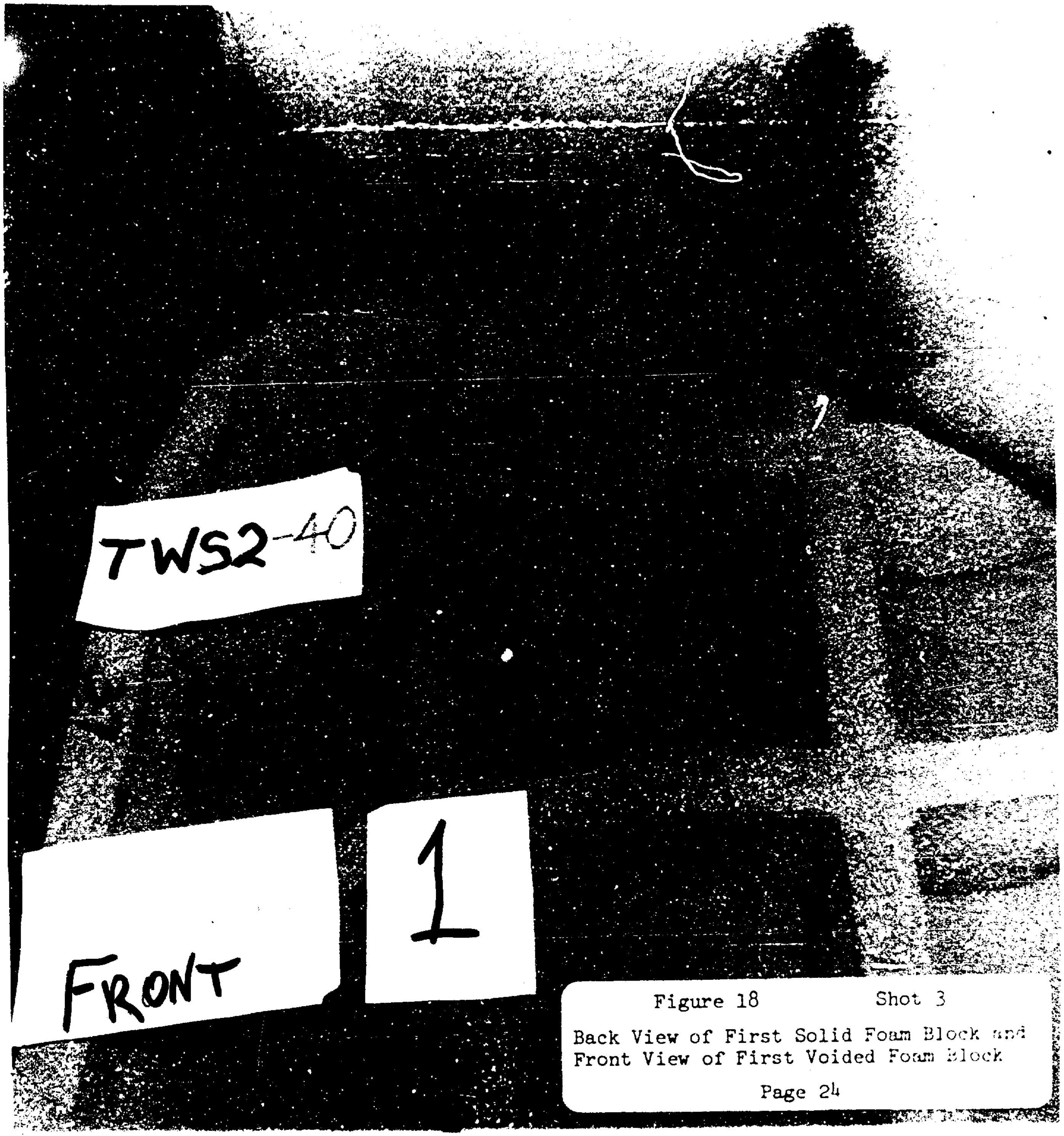


Figure 18 Shot 3

Back View of First Solid Foam Block and Front View of First Voided Foam Block