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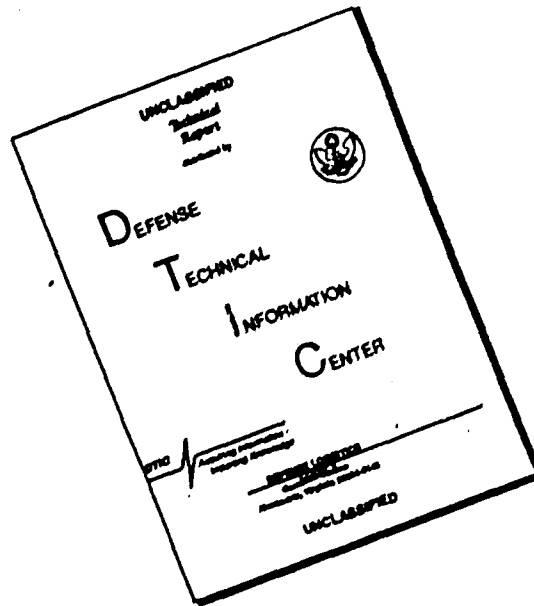


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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 728

DEFORMABLE PROJECTILES (SQUEEZEBORE)

20th Partial Report

RECOVERY FIRING OF 5"/375 DEFORMABLE
PROJECTILES WITH FORWARD SKIRTS

FINAL Report

Copy No. 19

Task

Assignment NP6-13-Re3b-215-2

Classification CONFIDENTIAL

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NPG REPORT NO. 728

Recovery Firing of 5"/37.5 Deformable
Projectiles with Forward Skirts

PART A

SYNOPSIS

1. Ten (10) 5"/37.5 deformable projectile bodies and forward skirts were manufactured. These bodies and forward skirts were assembled with rear flanges and dummy nose plugs, and fired for recovery from the 5"/54 gun with and without the muzzle squeeze attachment, to determine projectile performance.
2. The design of forward skirt tested did not perform satisfactorily. The skirt functioned properly in the gun, but as the projectile left the muzzle the skirt expanded, at times to its original diameter, due to gas pressure.

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NPG REPORT NO. 728

Recovery Firing of 5"/3775 Deformable
Projectiles with Forward Skirts

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Recovery Firing of 5"/375 Deformable
Projectiles with Forward Skirts

PART B

INTRODUCTION

1. AUTHORITY:

This test was authorized by references (a) and (b).

2. REFERENCES:

- a. BUORD ltr Re3b-PTL:mf Ser 6150 of 20 Feb 1950.
- b. TelCon P. T. Lanham (Re3b BUORD) and R. B. Butler (NAVPROV) on 20 Jul 1950.
- c. BUORD Sk. 147681 Forward Skirt and Body Details for 5"/375 Deformable Projectile.
- d. BUORD Sk. 238752 Assembly and Details (Rear Flange Pc 6A ACME thread) of 5"/375 Deformable Test Slug.
- e. BUORD Sk. 147423 Details and Assembly 5"/375 Deformable Projectile Type Ex 24.

3. BACKGROUND:

The Bureau of Ordnance requested, in reference (a), manufacture and recovery firing of ten (10) 5"/375 deformable projectiles with forward skirts in place of the three forward studs. In reference (b) permission was granted to fire two rounds with four (4) equally spaced vent holes in the forward skirt.

4. OBJECT OF TEST:

The object of this test was to determine the serviceability of deformable projectiles with a particular design of forward skirt.

5. PERIOD OF TEST:

- | | |
|--|-------------|
| a. Date of Letter Authorizing Project | 20 Feb 1950 |
| b. Date Program Activities | 1 Jun 1950 |
| c. Date Last Test Conducted Prior to This Report | 10 Aug 1950 |

Recovery Firing of 5"/3775 Deformable
Projectiles with Forward Skirts

PART C

DETAILS OF TEST

6. DESCRIPTION OF ITEM UNDER TEST:

The projectile bodies and forward skirts were manufactured in accordance with Figure 26, Appendix (B). The rear flange was in accordance with reference (d), and the nose plug was manufactured in accordance with Figure 28, Appendix (B). The vent holes in the forward skirt were in accordance with Figure 25, Appendix (B). A view of the assembled projectile is shown in Figure 1, Appendix (B).

The forward skirts were made of mild steel (AISI 1020 normalized).

The physical properties called for in reference (e) for the projectile body could not be met with the steel on hand. Appendix (E) describes the steel, method of heat treatment, chemical analysis, and physical properties, of the material used in manufacture of the bodies.

7. PROCEDURE:

Ten (10) projectiles were prepared for recovery firing at service charge. Three (3) were fired in the 5"/3775 Gun Type A Mod 0 without the muzzle squeeze attachment and seven (7) were fired in the same gun with the vented squeezer. The three projectiles fired without squeezer were fired empty, and the seven fired with squeezer were loaded with Epsom salt. Projectiles of similar design when fired at high velocity into the recovery bin had been breaking up. It was believed that if the projectiles were salt-loaded they would withstand the impact better.

Measurements were taken of the diameter at various points of the body, rear flange and forward skirt, after firing, to show the diameter after passing through squeezer with a diameter of 37765. Each assembled part was stenciled with a Naval Proving Ground number to facilitate identification.

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NPG REPORT NO. 728

Recovery Firing of 5"/375 Deformable
Projectiles with Forward Skirts

Velocity, copper crusher gage pressures and spin rates (Appendix (D)) were taken. Star gauge data and transverse strain gauge readings on the muzzle squeeze attachment were taken and the results are given in Appendix (C) and in Figure 27, Appendix (B). Fourteen (14) rounds were fired through this squeezer prior to this test.

Microflash photographs were taken of the projectiles in flight 150 feet from the muzzle and are included in Appendix (B), (Figures 14 to 23 inclusive). Photographs of the recovered projectiles are also included in Appendix (B), (Figures 2 to 10 inclusive). The five recovered projectiles that were fired through the squeezer were sectioned along the center line and photographed (Appendix (B), Figures 11 to 13 inclusive) to show the conditions of the forward skirt and rear flange.

8. RESULTS AND DISCUSSION:

Complete before and after firing data are given in Table I, Appendix (A). The results of this test indicate that a forward skirt of this design is not satisfactory in that gas pressure causes expansion of the skirt as it leaves the muzzle. The projectiles with vent holes in the skirt did not show improved performance.

There was no evidence to indicate unsatisfactory performance of the projectile bodies, but in two cases the rear flange was observed to fail. One projectile (Appendix (B), Figure 3) fired without muzzle squeezer broke at the rear flange thread. This occurred after it had entered the recovery bin, since the microflash picture (Appendix (B), Figure 15) and the yaw cards did not show any sign of breakage. One projectile (Appendix (B), Figure 5) fired with muzzle squeezer broke into three pieces. Three round holes approximately 3-3/4 to 4-1/4 inches in diameter were in each yaw card, and the microflash picture caught a part of the rear flange (Appendix (B), Figure 17). This piece and the nose plug were recovered, but the body was not recovered and the cause of the failure was not determined.

The device of salt-loading the projectile bodies improved the recovery procedure by definitely reducing the tendency of the bodies to break up in the bin.

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NPG REPORT NO. 728

Recovery Firing of 5"/375 Deformable
Projectiles with Forward Skirts

PART D

CONCLUSIONS

9. It is concluded that design of forward skirt tested did not perform satisfactorily. The skirt functioned properly in the gun, but as the projectile left the muzzle the skirt expanded, at times to its original diameter, due to gas pressure.

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Captain, USN
Ordnance Officer
By direction

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NPG REPORT NO. 723

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Twentieth Partial Report

on

Deformable Projectiles (Squeezebore)

Final Report

on

Recovery Firing of 5"/3775 Deformable
Projectiles with Forward Skirts

Project No.: NPG-13-Re3b-215-2
Copy No.: 19
No. of Pages: 6

Date:

FEB 13 1951

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Recovery Firing of 5"/3875 Deformable Projectiles with Forward Skirts

NIG REPORT NO. 728

TABLE I (Continued)

Proj. No.	Condi- tion	Pdr. Chg. (Lbs.)	Pressure (t.s.i.)		Muzzle Velocity (ft/sec)	% Nominal Spin	Diameters after Firing				Weight Lbs.						
			Gage	Ave.			Rear Flange Aft.	Rear Flange Fwd.	Body Rear	Body Fwd.	Fwd. Skirt (a)	Body	Fwd. Flange	Rear Flange	Nose Plug	Total	
434 (c)	C	18.5	18.8	18.4	3883							15.52	2.31	7.15	3.24	1.65	29.87
			18.5														
			17.8														
435	C	18.5	19.4	19.4	3899	106.5	Damaged	3.777	3.750	3.745	3.760	15.54	2.30	7.19	3.23	1.66	29.92
			19.5														
			19.2														
436	B	18.5	19.1	19.4	3890	109.0	3.800	3.782	3.752	3.743	3.750	15.55	2.30	7.13	3.24	1.65	29.87
			19.3														
			19.7														
437	B	18.5	19.1	19.5	3883	103.3	Damaged	3.779	3.751	3.743	3.800	15.55	2.29	7.21	3.25	1.63	29.93
			19.4														
			20.1														

A.

Fired in 5"/3875 Gun Type A Mod. O, without muzzle squeeze attachment. Gun had 83.3 MSR prior to test.

B.

Fired in 5"/3875 Gun Type A Mod. O, with muzzle squeeze attachment. Squeeze had 14 rounds fired through it prior to test.

C.

Forward Skirt had 4-3/8" dia. vent holes and fired in gun with squeezer.

(a)

Diameter taken at datum dia. (Before firing 3.659)

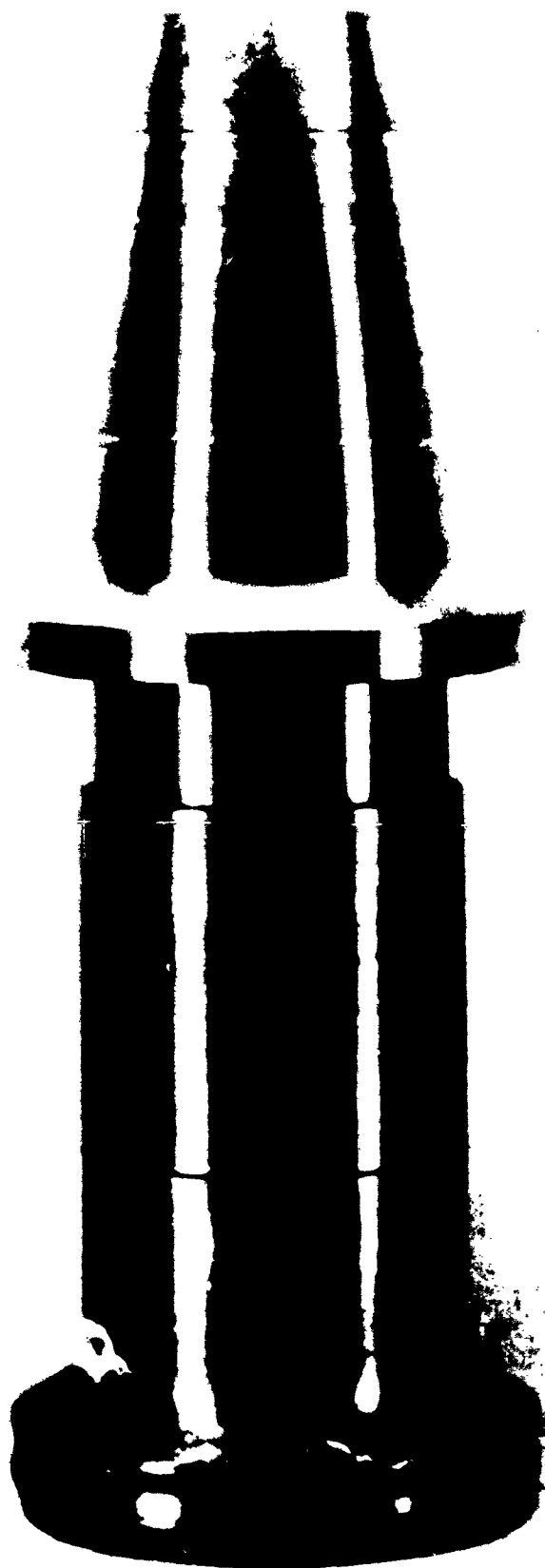
(b)

Projectile No. 431 broke in three pieces in gun or soon after it left muzzle, made three holes in yaw cards.

(c)

Projectile No. 434 had good flight, no yaw; but went completely through recovery bin and was not recovered.

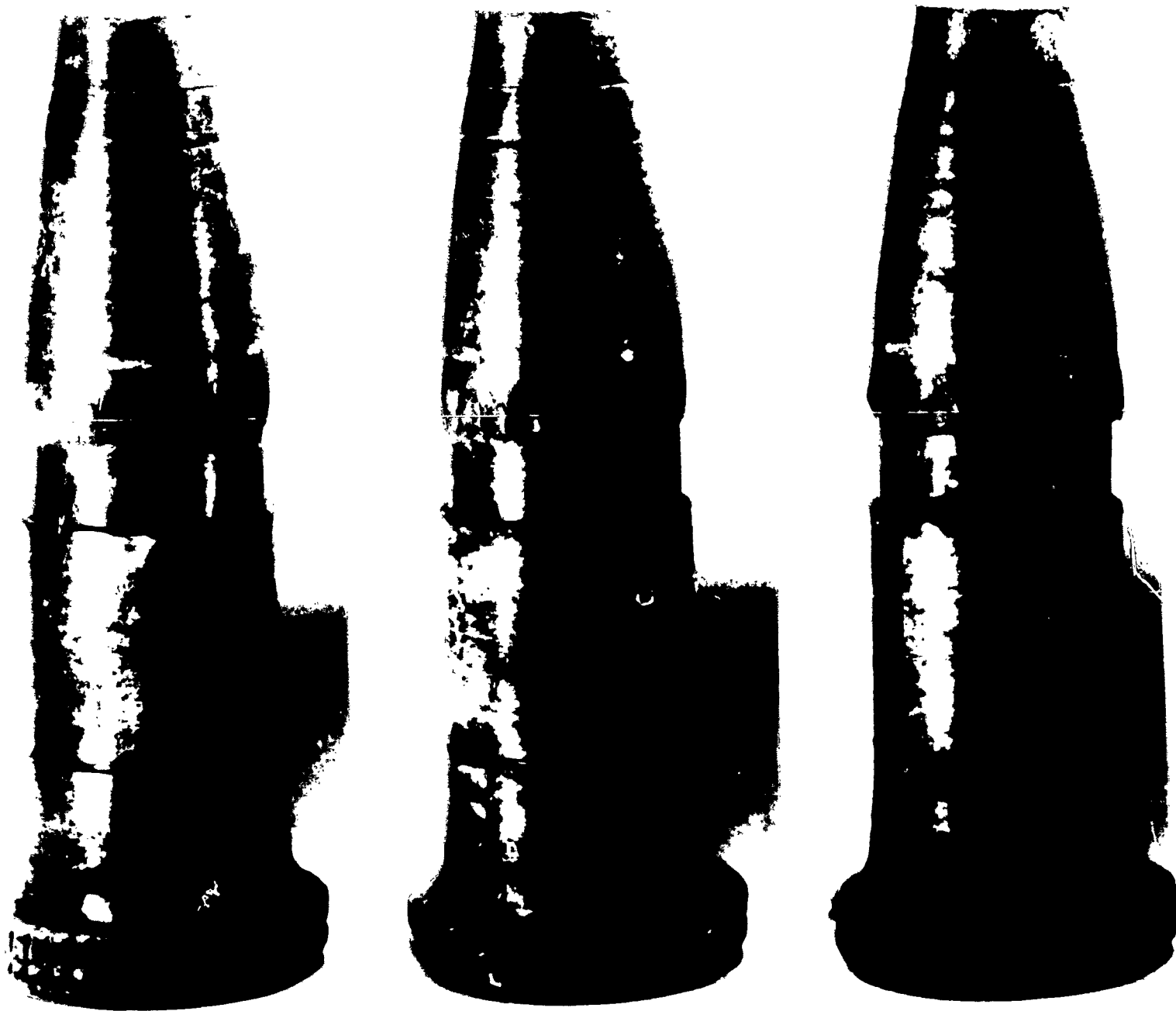
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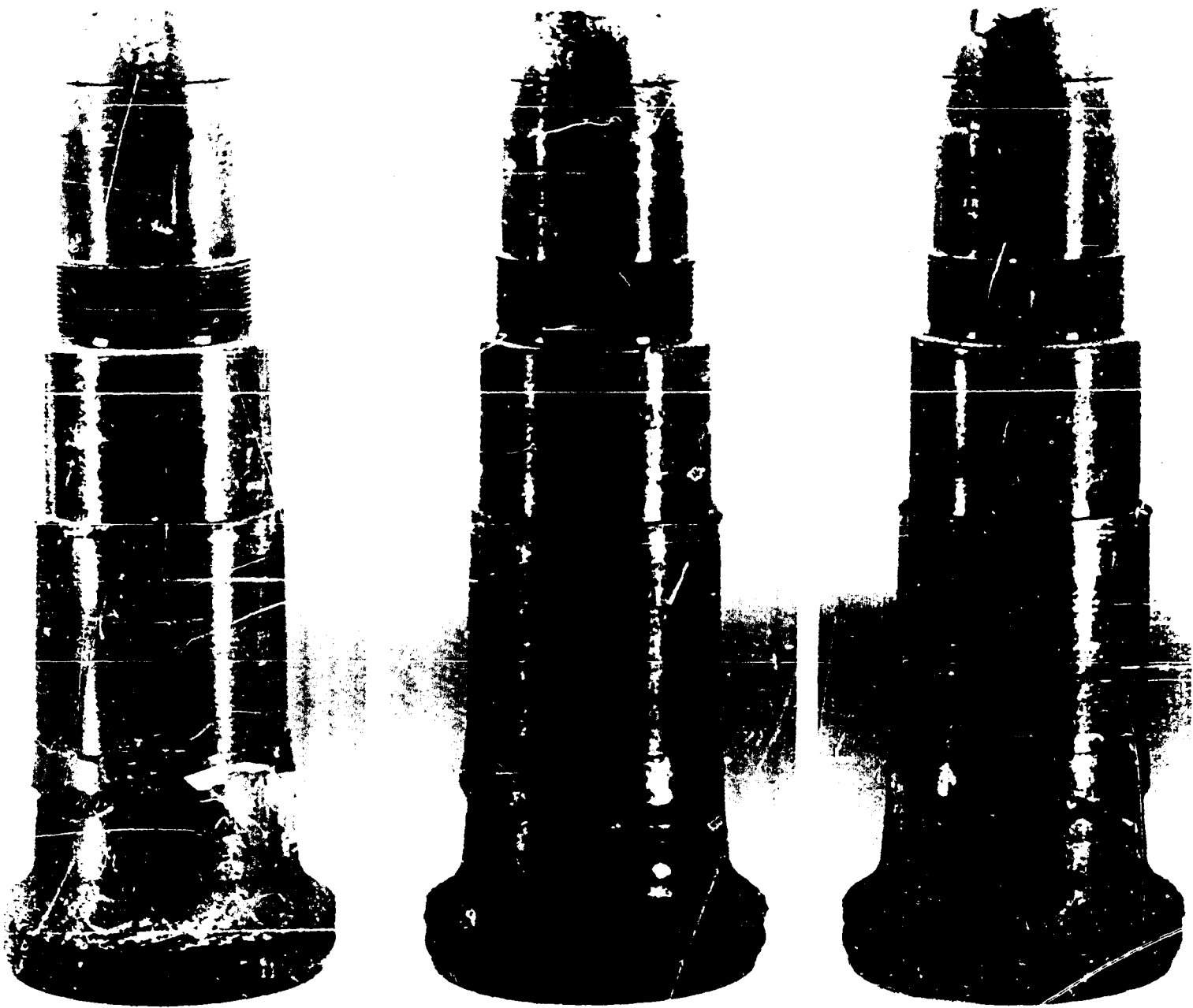
NP9 42198 - 5"/37mm Deformable Projectile, with Forward Skirt, before firing.
18 May 1950

Figure 1

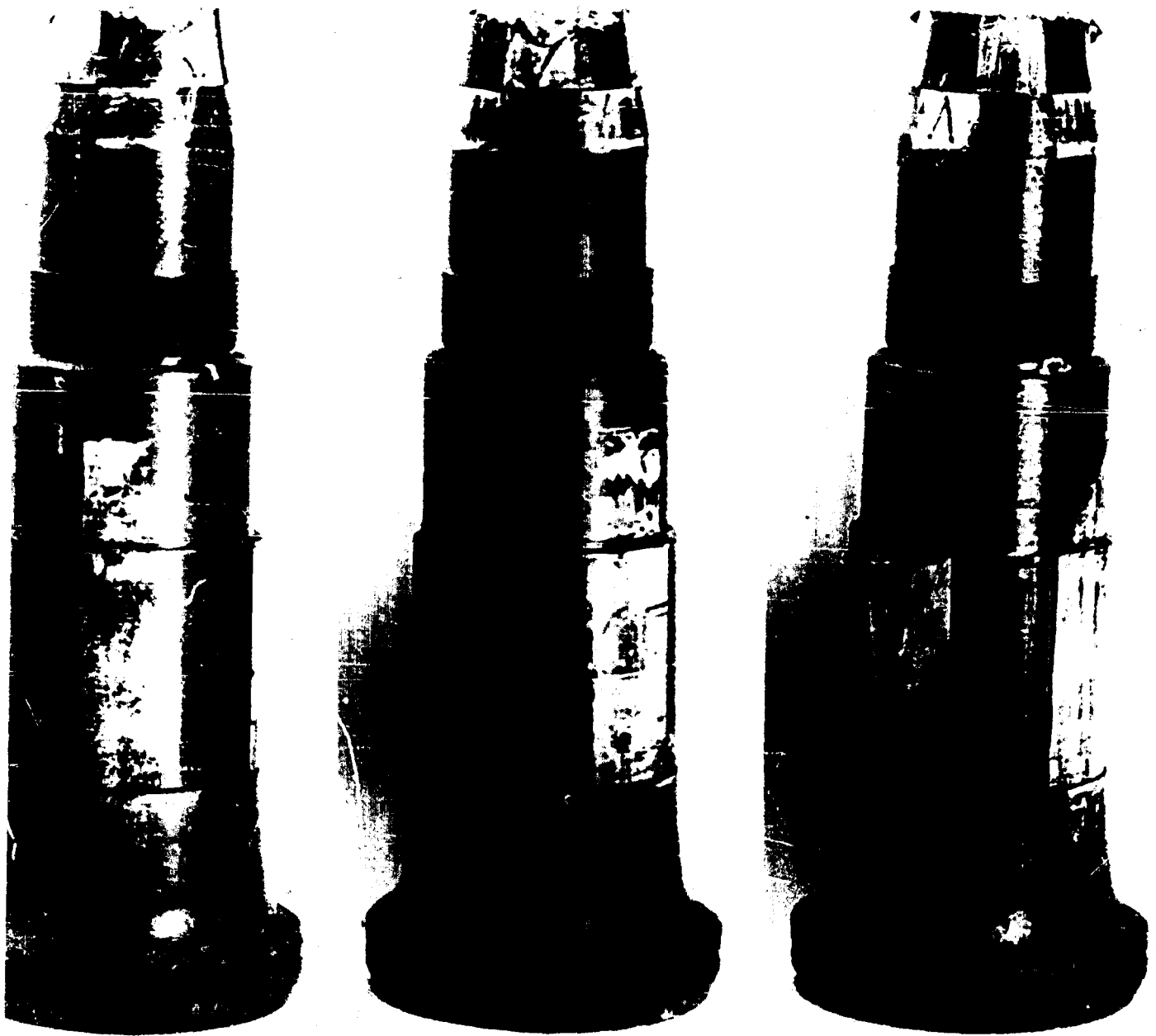
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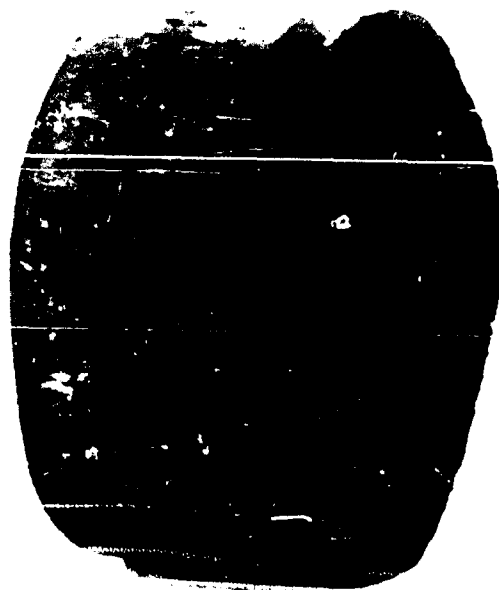
NP9 42199 - Three views (120° apart) of recovered 5"/375
Deformable Projectile No. 428. Fired without muzzle squizzer.
1 June 1950 Figure 2 CONFIDENTIAL



NP9 42200 - Three views (120° apart) of recovered 5"/3"75
Deformable Projectile No. 429. Fired without muzzle squezer.
1 June 1950 Figure 3 CONFIDENTIAL



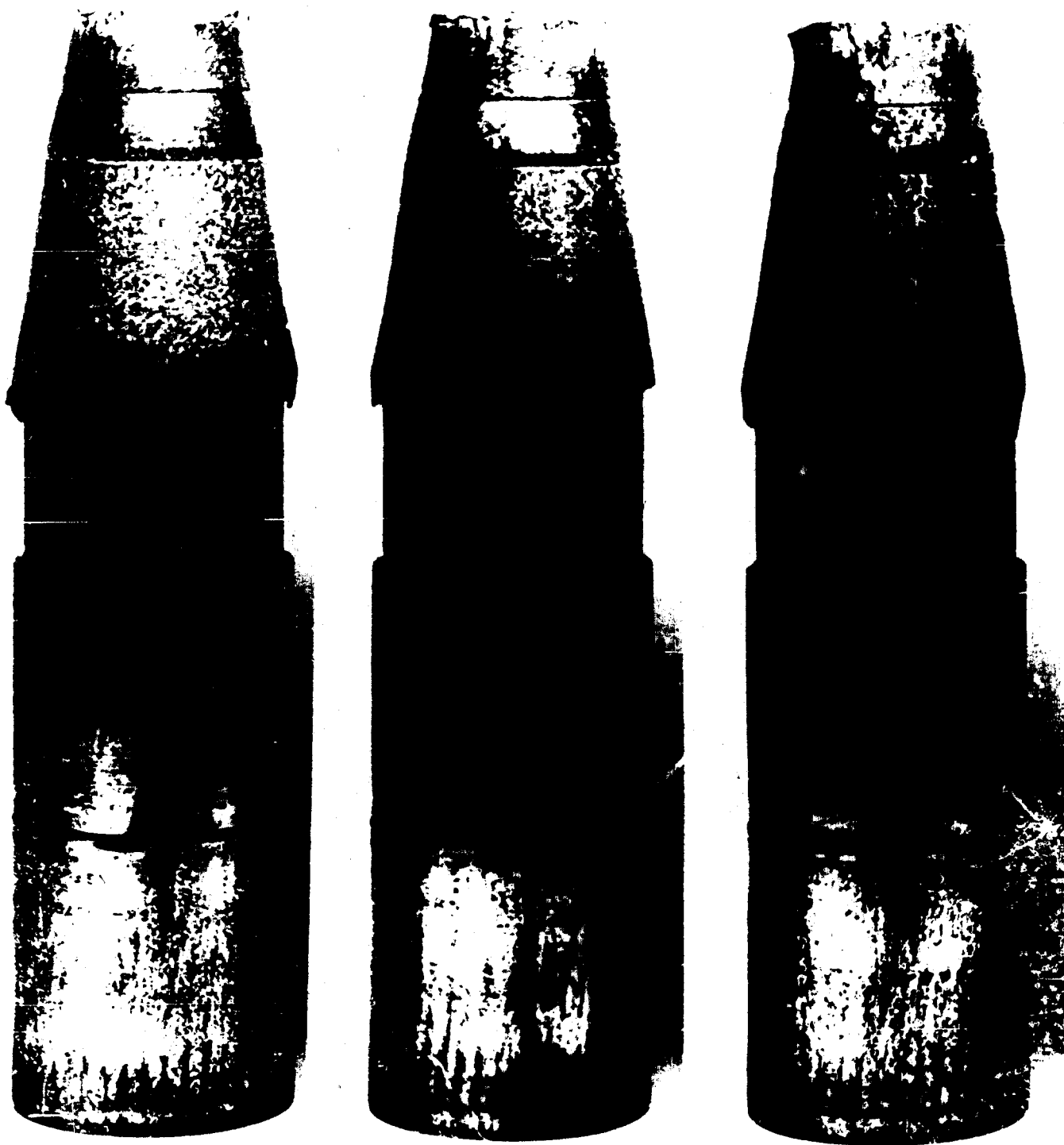
NP9 42201 - Three views (120° apart) of recovered 5"/3"75
Deformable Projectile No. 430. Fired without muzzle squeezer.
1 June 1950 Figure 4 CONFIDENTIAL



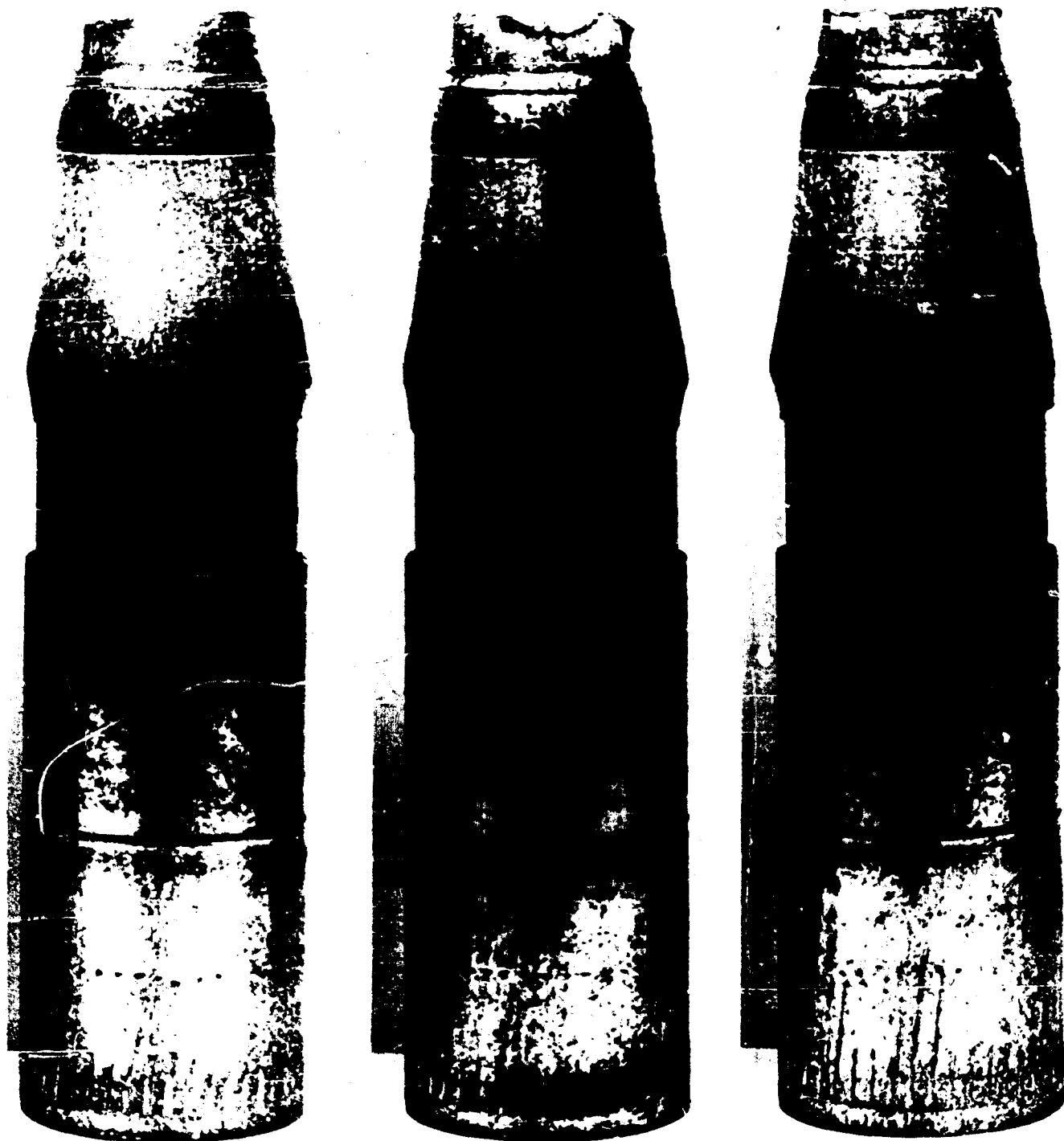
WFO-42202 - View showing part of recovered rear flange from
5"/3"75 Deformable Projectile No. 431. Fired with modified
squeezer.
22 June 1950

Figure

CONFIDENTIAL



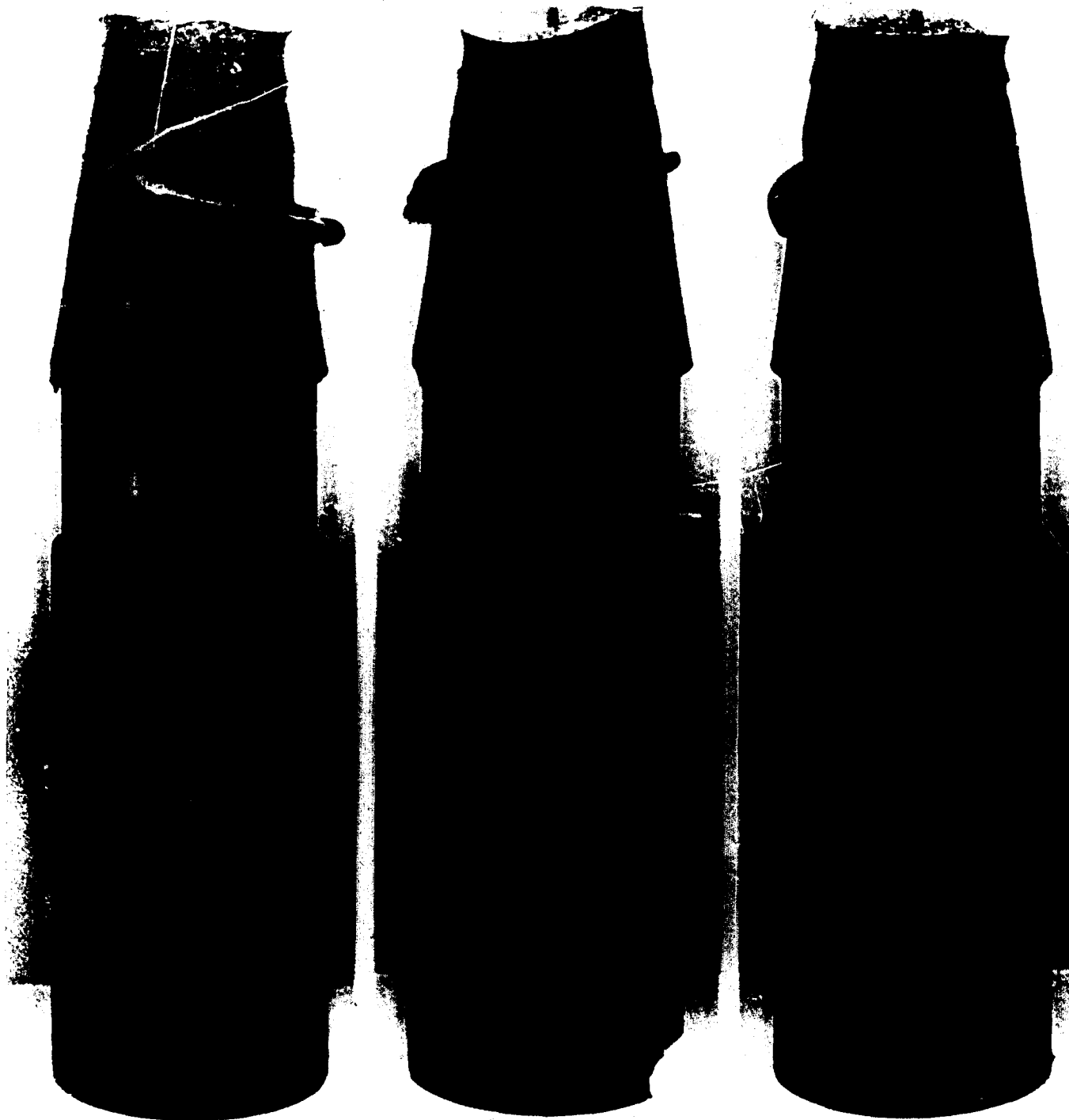
NP9 42926 - Three views (120° apart) of recovered 5"/37.5
Deformable Projectile No. 432. Fired with modified squeezer.
22 June 1950 Figure 6 CONFIDENTIAL



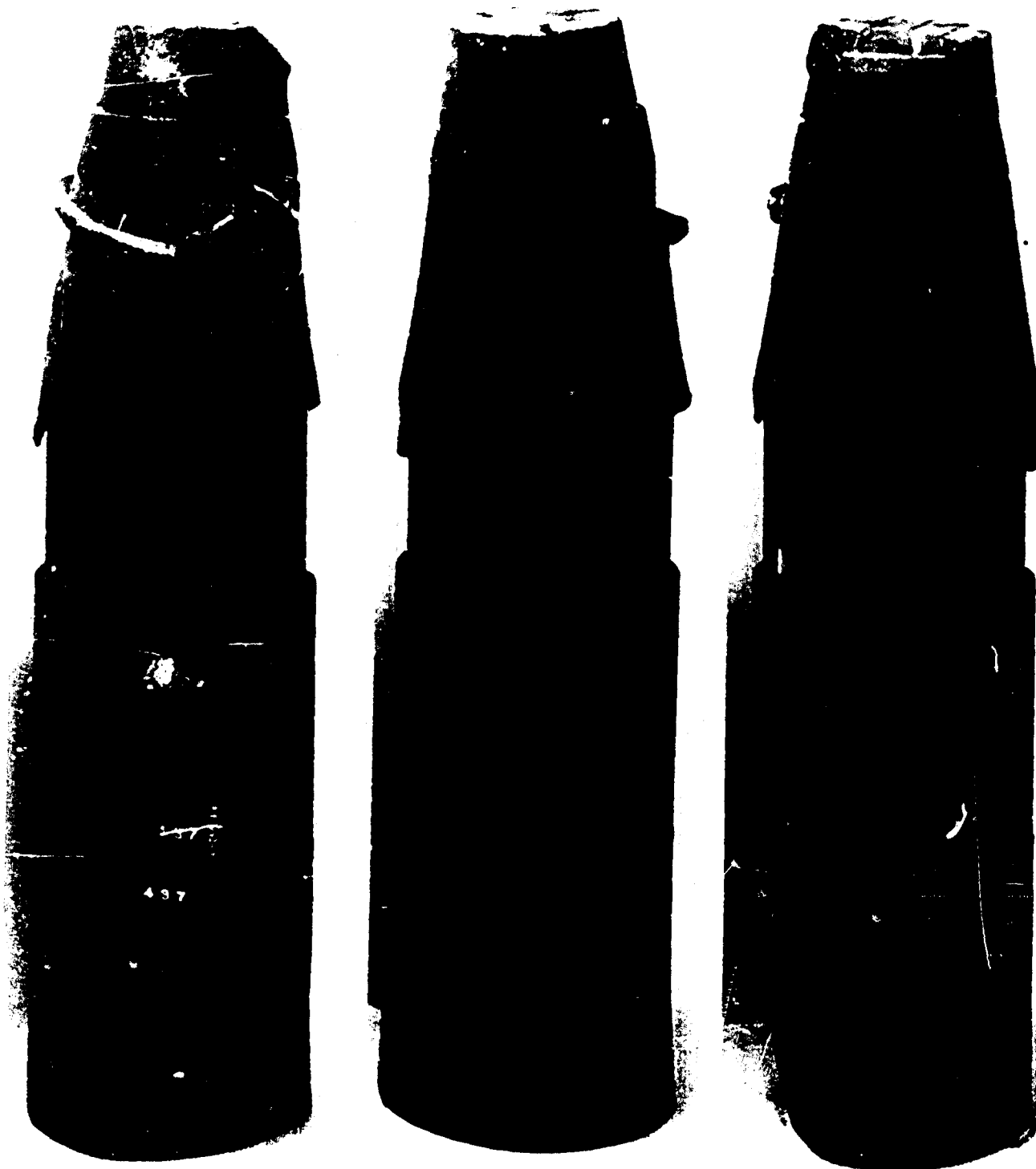
N19 42827 - Three views (120° apart) of recovered 57mm M75
deformable Projectile No. 433. Fired with modified squeezer.
22 June 1950 Figure 7 CONFIDENTIAL



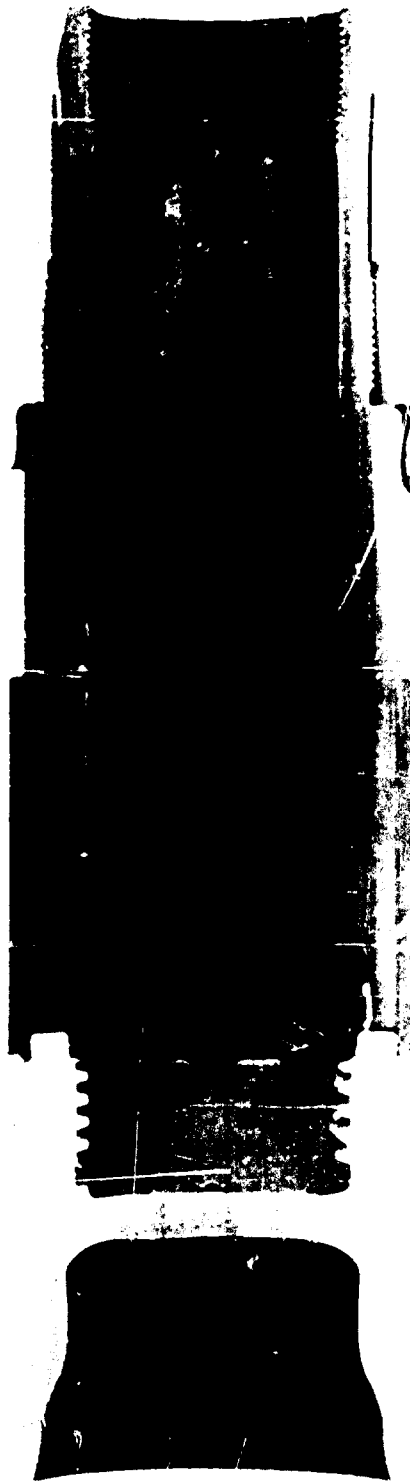
NP9 42828 - Three views (120° apart) of recovered 5"/3"75
Deformable Projectile No. 435. Fired with modified squeezer.
11 August 1950 **Figure 8** **CONFIDENTIAL**



NPG 42829 - Three views (120° apart) of recovered 5"/375
Deformable Projectile No. 436. Fired with modified squeezer.
10 August 1950 Figure 9 CONFIDENTIAL



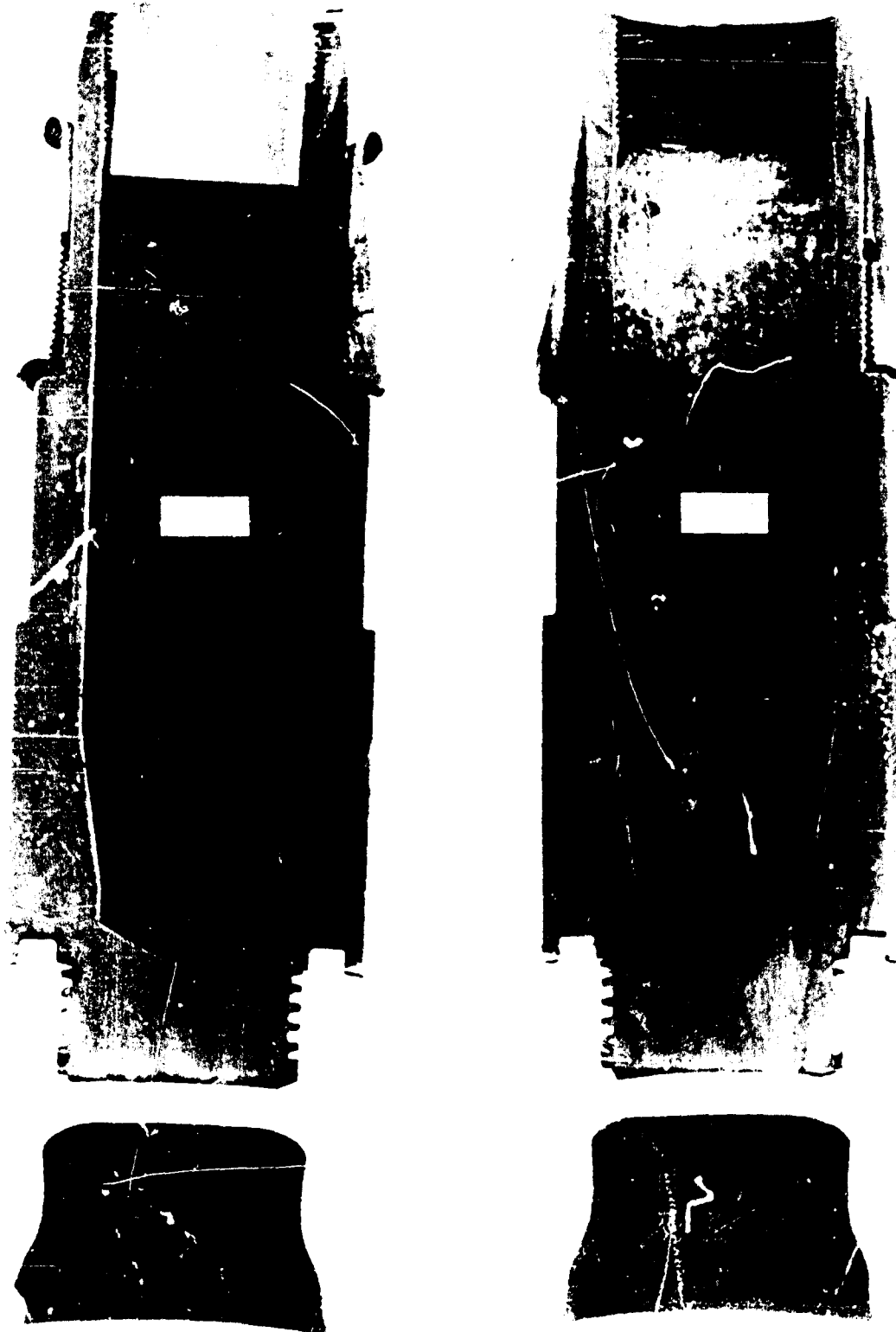
NP9 42830 - Three views (120° apart) of recovered 5"/375
Deformable Projectile No. 437. Fired with modified squeezer.
11 August 1950 Figure 10 CONFIDENTIAL



NP9 42831 - View showing section (center line) of recovered
5"/3775 Deformable Projectile No. 433.
22 June 1950

Figure 11

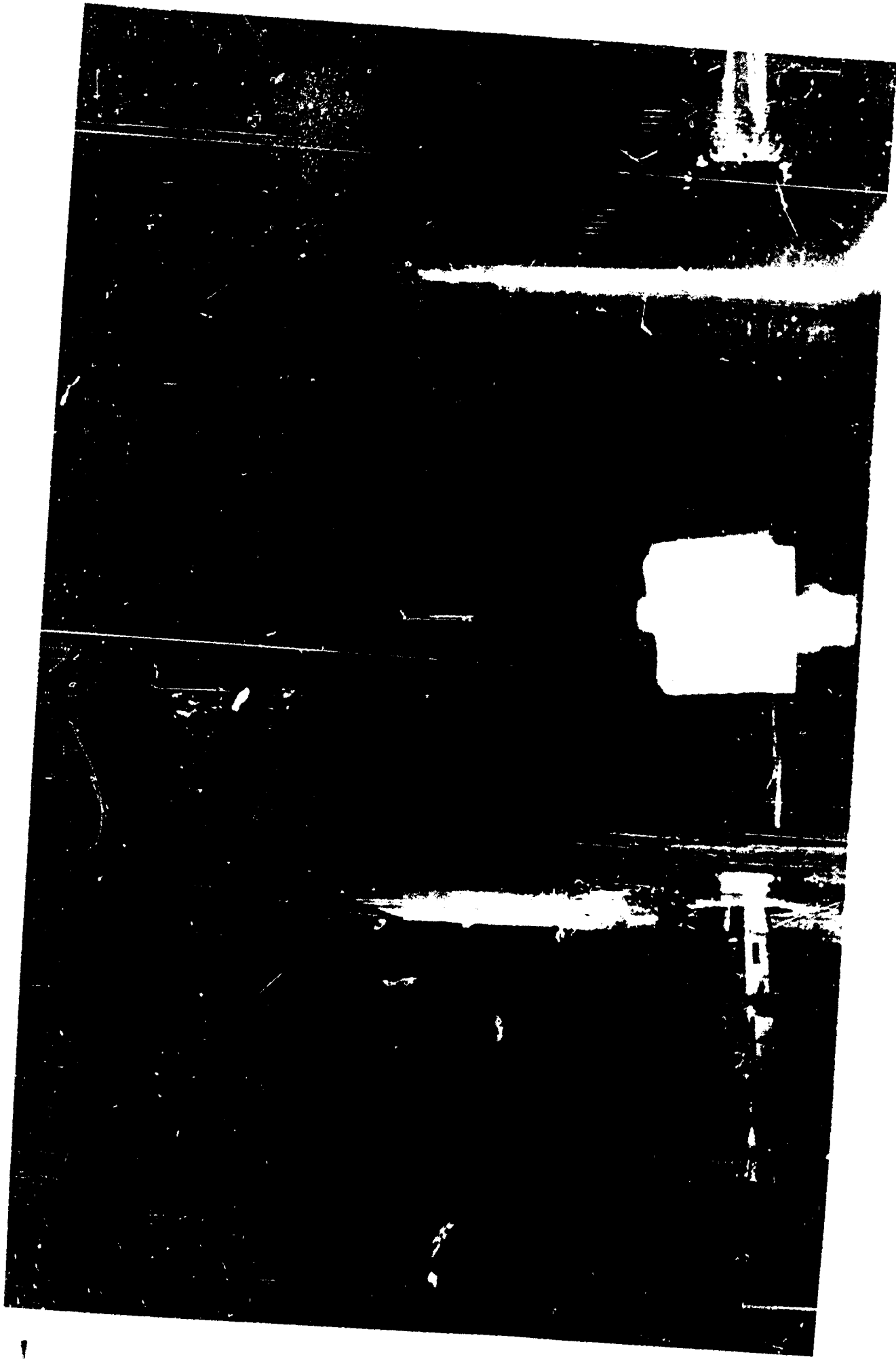
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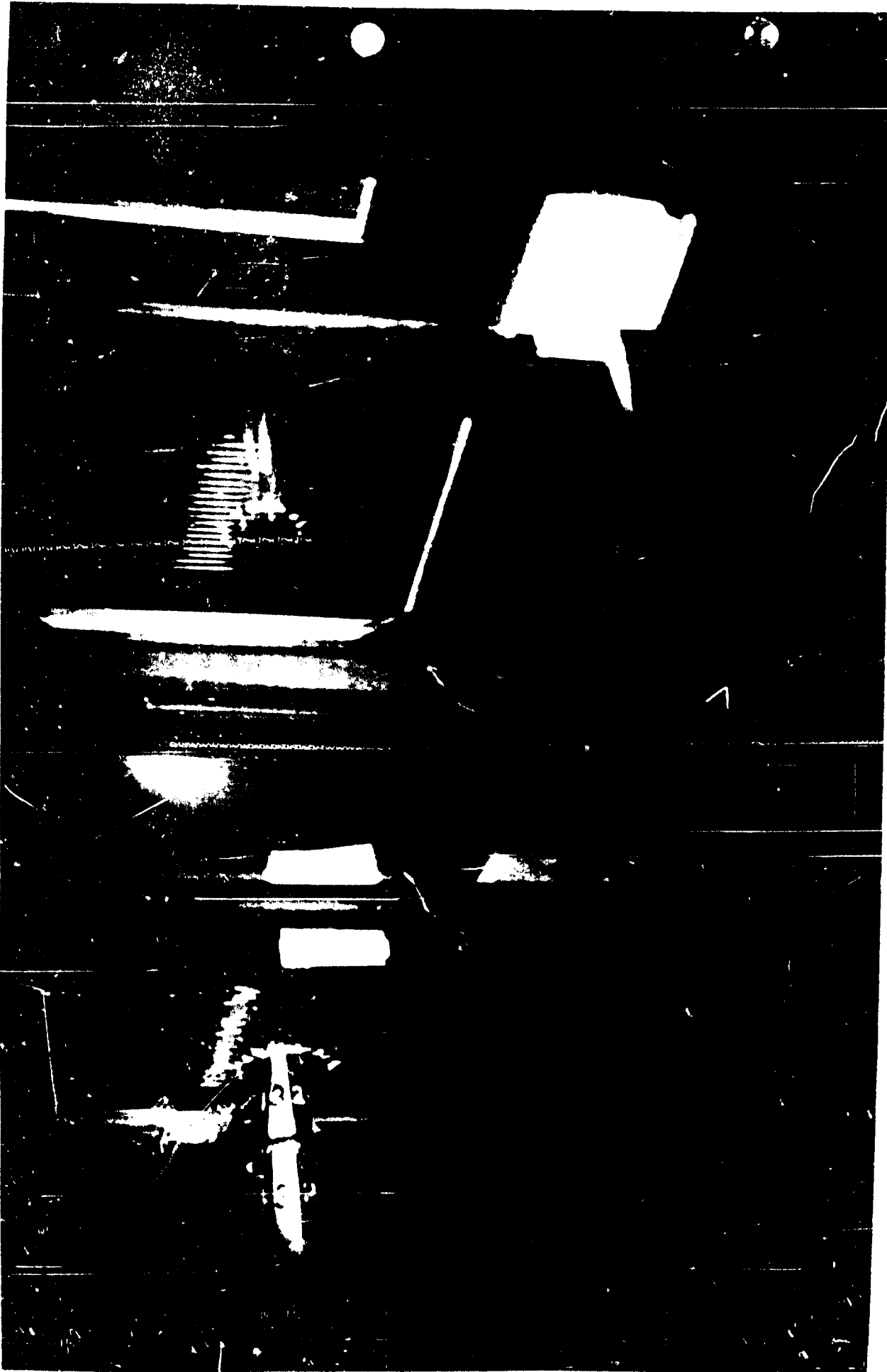
NP9 42832 - View showing section (center line) of recovered
57/3775 Deformable Projectiles Nos. 432 and 435.
11 August 1950 Figure 12 CONFIDENTIAL



NP9 42949 - View showing section (center line) of recovered
5"/37.75 Deformable Projectiles Nos. 436 and 437.
11 August 1950 Figure 13 CONFIDENTIAL.

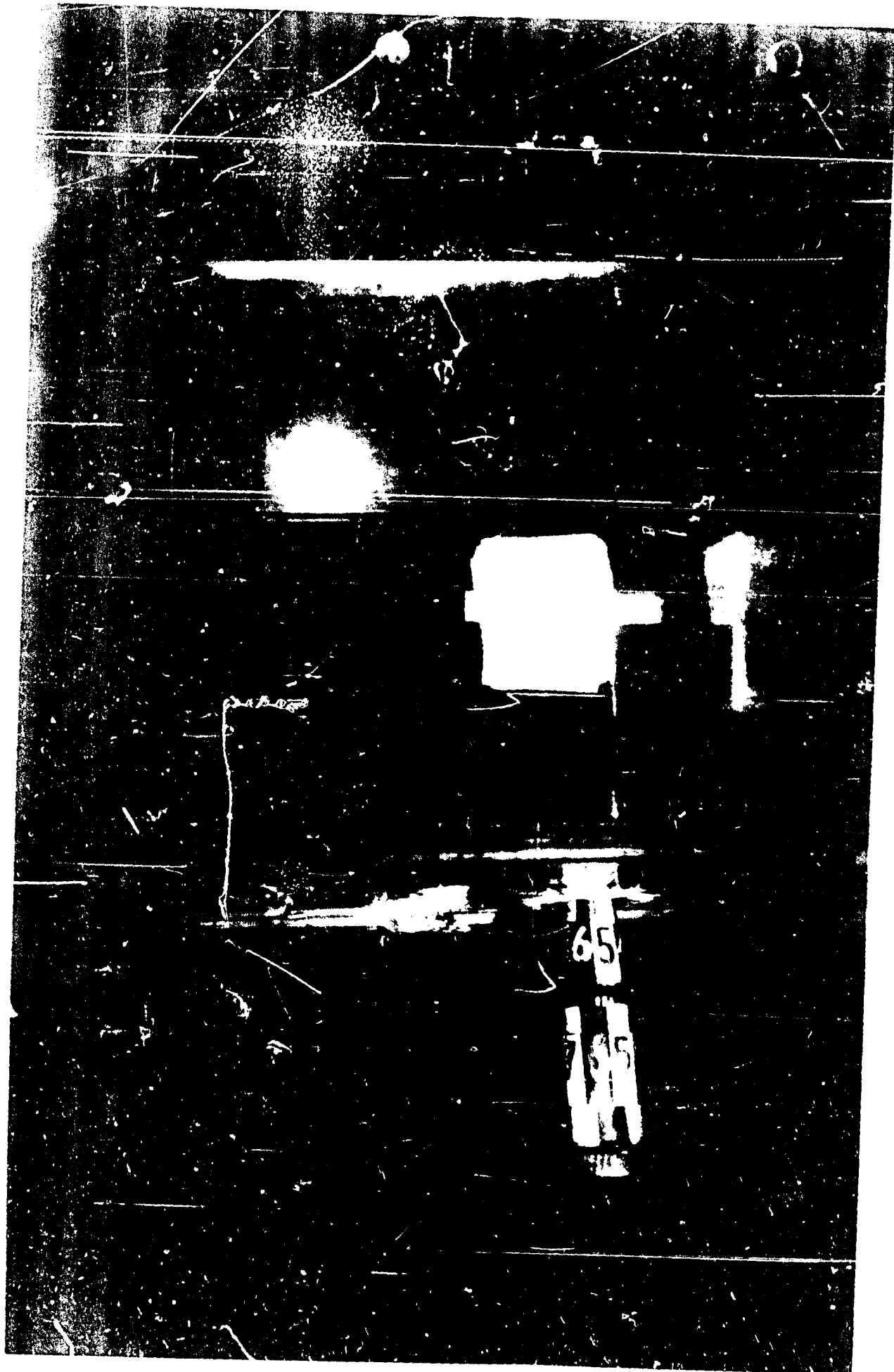


AD9-2050 - Photograph taken from a ship, showing a large, rectangular object (possibly a light source or a small structure) in the center of the frame. The image is heavily degraded with noise and artifacts. The text "AD9-2050" is visible in the top left corner. The text "AD9-2050" is visible in the top left corner. The text "AD9-2050" is visible in the top left corner.



42951 - Microflash picture of 3.75 Deformable Projectile No. 289
in flight. Fired without muzzle squeezer.
June 1950
Figure 15

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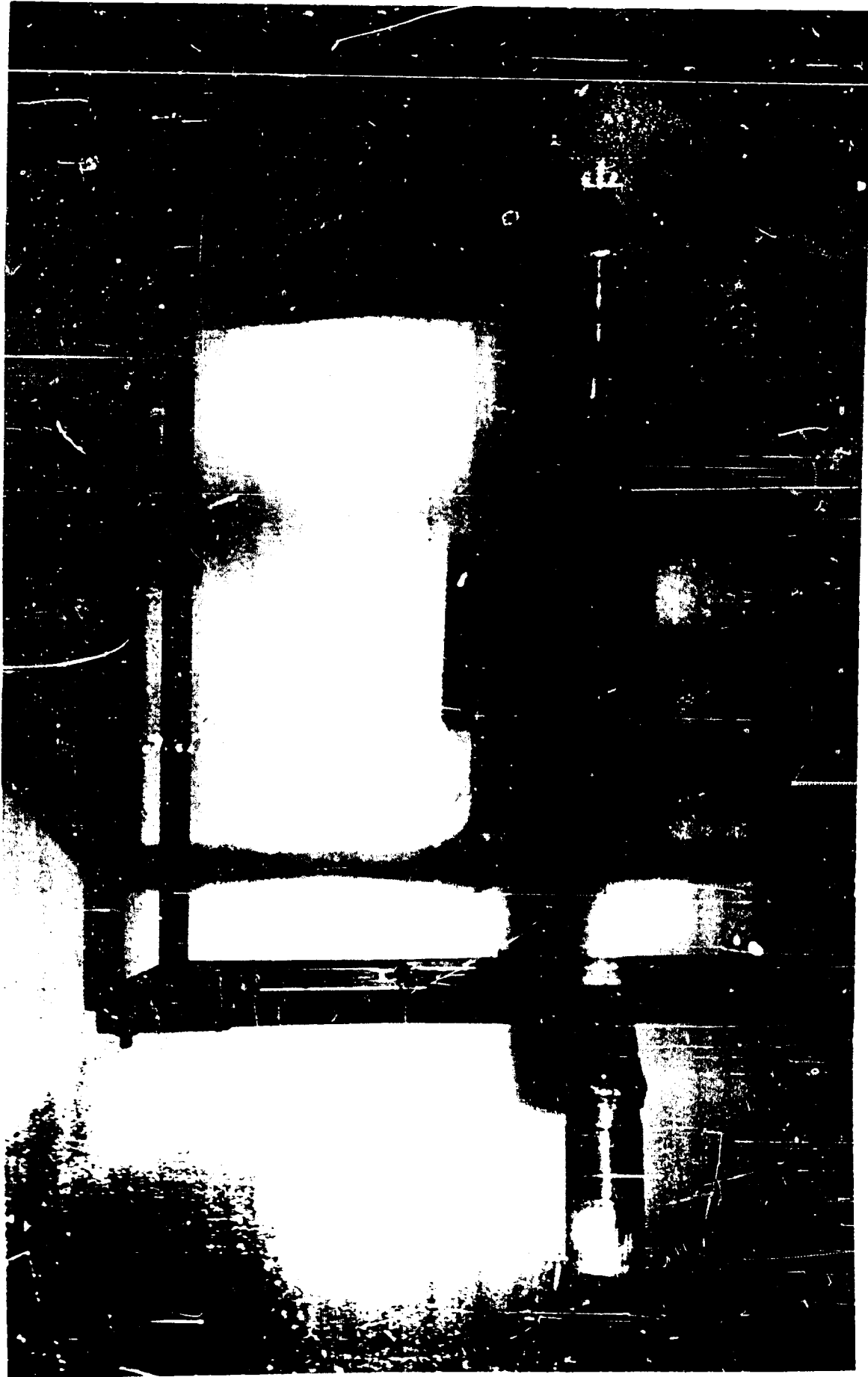


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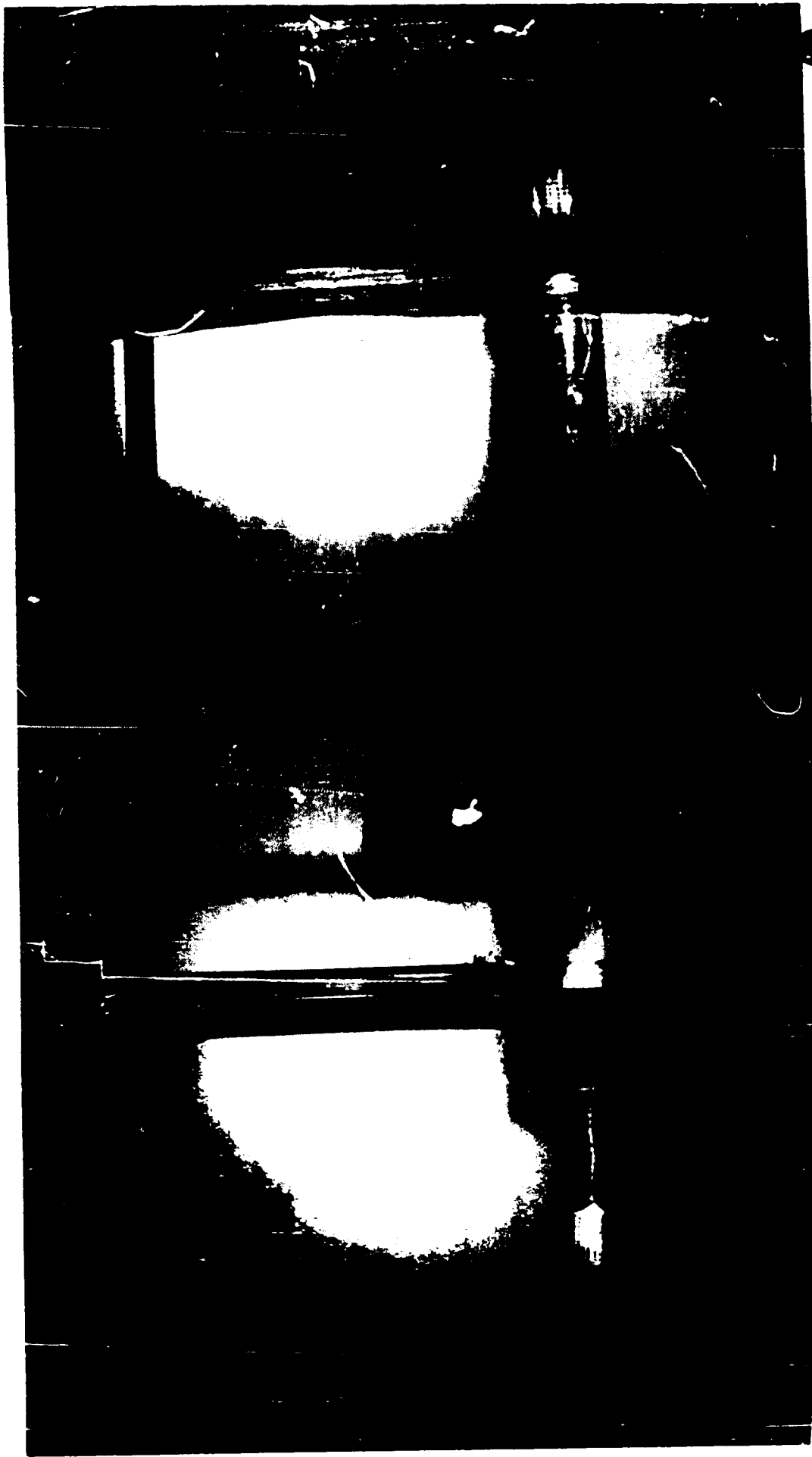


NP9 42953 - Microflash picture of 5" 2875 Reformatable Projectile No. 431
in flight. Fired with muzzle squeezer.
22 June 1950

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MP9 42954 - Microflash picture of 5"/37.75 Reformatable Projectile No. 492
in flight. Fired with muzzle squeezer.
22 June 1950
Figure 13



NP9 42955 - Microflash picture of 5"/375 Deformable Projectile No. 499
in flight. Fired with muzzle squeezer. Figure 19
22 June 1950

CONFIDENTIAL

NP9 42312 - Microflash picture of 5"/3"75 Deformable Projectile No. 436
in flight. Fired with muzzle squeezer.

10 August 1950 Figure 20

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NP9 42310 - Microflash picture of 5"/3"75 Deformable Projectile No. 434
in flight. Fired with muzzle squeezer.

10 August 1950

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Figure 21



NY 44211 - Microfilm picture of 5"/3"75 Deformable Projectile No. 437
in 11 August 1950
11 August 1950

CONFIDENTIAL

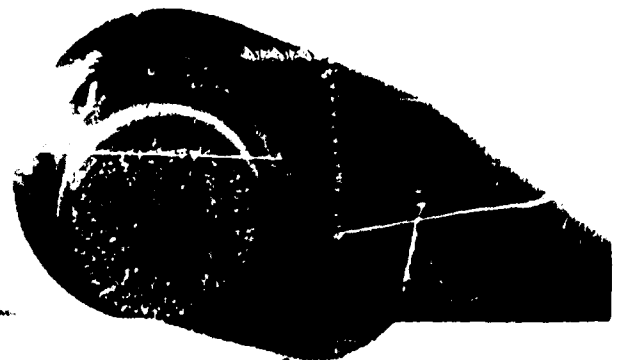


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in flight. Fired with muzzle squeezer.
11 August 1950

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2

1 - Fracture Surfaces of Tensile AA Steel Tensile
specimens.

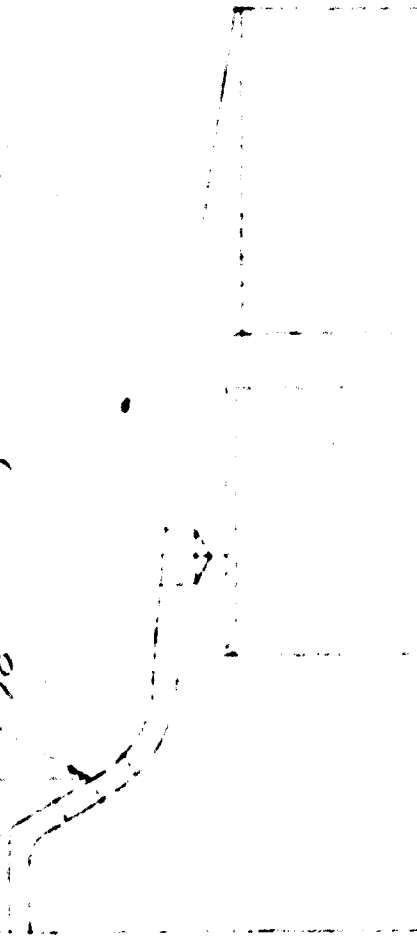
Jul 1950

Figure 21

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71 APPROX.

3/8" DRILL, 4 HOLES EQUALLY SPACED



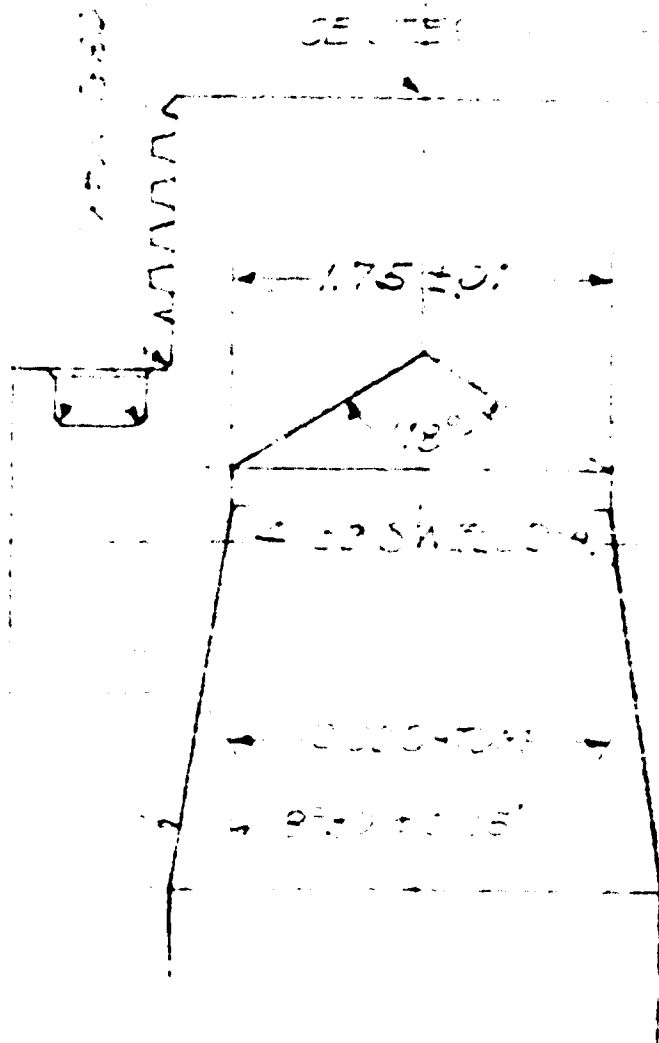
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3.748 - 005

3.341 + 002

2.55 MAX.

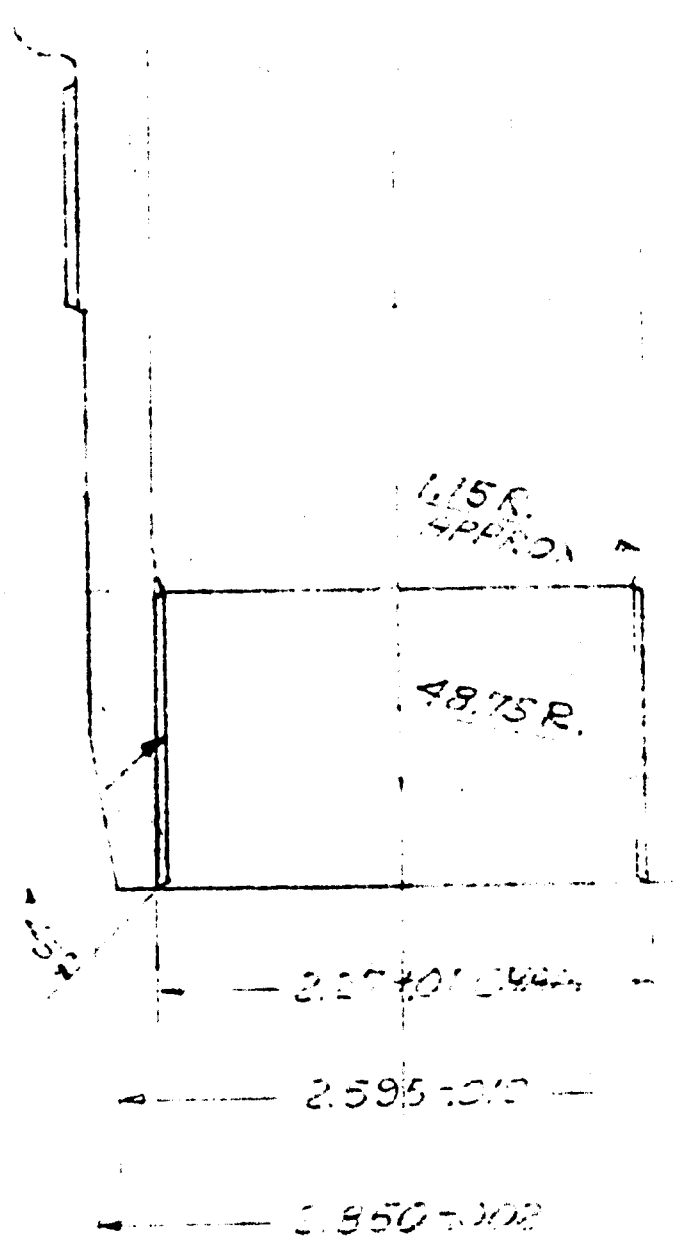
CENTER



3.748 - 005
3.341 + 002
2.55 MAX.
CENTER

2.55 MAX.
2.55 MAX.
2.55 MAX.
2.55 MAX.





2.25
 2.595
 1.850
 1.15 R. APPROX.

2.25 + 0.1044
 2.595 + 0.10
 1.850 + 0.08

2

NP9 42533

5 7/3" 75 GUN TYPE A MOD.O NO.14765

Bore Enlargement of Squeeze Attachment No.2
(Heed No.1208-3)

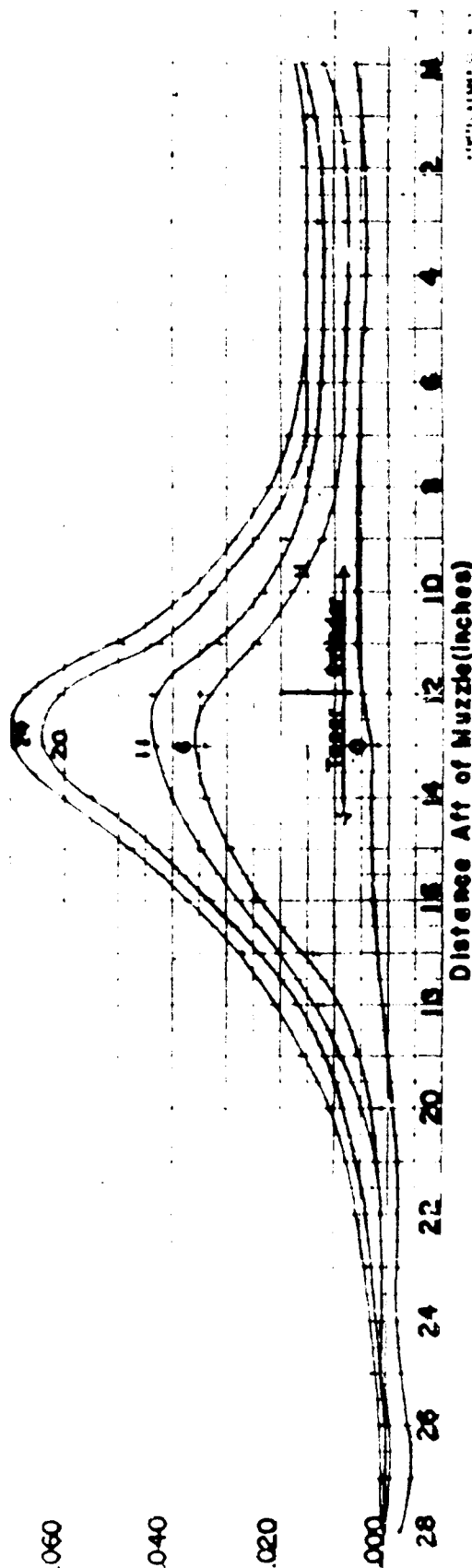
V₃₈

Distance Aft of Muzzle

Bore Enlargement (inches)

Figure 27

M - Indicates gun hot when gauged
Number of rounds fired is shown by figure adjacent to curve.



NP9 42533 - Projectiles of this test lie between rounds 15 to 24 inclusive.

3 November 1950

CONFIDENTIAL

Recovery Firing of 5"/375 Deformable
Projectiles with Forward Skirts

TABLE II

Strain Measurements
on 5"/375 Squeeze-Bore Gun No. 14765
22 June 1950

Strain Gage Position
(Distance from Muzzle)

Maximum Tangential Strain
(Micro-inch per inch)

Projectile No. 432

Projectile No. 433

4675

3275

2575

1875

1175

670

420

510

916

1030

1575

475

577

720

828

1200

MOUSE

51325

5

1976

3	163	3	176
1	160		176
2	158		170
3	158		171
4	156		173
5	157		172
6	157		172
7	157		173
8	161		174
9	165		173
10	176		190
11	188		201
12	207		223
13	213		252
14	270		274
15	284		289
16	113		312
17	223		334
18	160		354
19	184		361
20	402		4012
21	4010		4010
22	4010		4010
23	100		100
24	132		132
25	160		160
26	191		191
27	222		222
28	253		253

Q

Q

Met. 11 readings taken each before leaving

Aug. 10, 1976

W. B.

5/3/75

A

14765

4	103	762	3	773
1		766		774
2		757		772
3		758		772
4		737		772
5		757		770
6		756		771
7		758		770
8		766		774
9		768		779
10		777		786
11		787		796
12		817		815
13		843		850
14		872		871
15		888		888
16		910		905
17		933		933
18		941		958
19		987		984
20		1017		1010
21		1017		1010
22		870		870
23		882		897
24		831		839
25		860		859
26		891		889
27		222		221
28		253		252
		2		2

Most measurements taken after 1st round
 then lost

Aug 14 1975
 1013

5/3/5

4

1965

3 762
0 762
0 760
0 759
0 758
0 757
0 758
0 766
0 762
0 768
0 772
0 787
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0 847
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160
130
158
91
272
253
Y

Made at after 2nd round in 1965

10-105

10-12

MUSIC

53 75

9

14765

11/10/53	765	3	77
11/11/53	761		172
11/12/53	760		173
11/13/53	760		173
11/14/53	759		174
11/15/53	760		175
11/16/53	758		175
11/17/53	760		177
11/18/53	761		178
11/19/53	770		178
11/20/53	777		179
11/21/53	773		181
11/22/53	773		180
11/23/53	770		185
11/24/53	770		186
11/25/53	772		189
11/26/53	774		183
11/27/53	735		184
11/28/53	762		189
11/29/53	788		187
11/30/53	781		1812
12/1/53	770		1820
12/2/53	772		1850
12/3/53			189
12/4/53	31		181
12/5/53	32		181
12/6/53	41		183
12/7/53	223		223
12/8/53	254		253

Notes: Not after 1st record in library 150

11 Aug 1953

11/13

53

7

476

3	765
1	762
2	760
3	759
4	760
5	758
6	759
7	761
8	764
9	773
10	786
11	792
12	807
13	850
14	875
15	873
16	912
17	935
18	943
19	988
20	9016
21	1000
22	1000
23	102
24	133
25	100
26	103
27	225
28	205
	2

3	775
	773
	774
	775
	779
	776
	774
	779
	782
	787
	795
	807
	826
	860
	877
	894
	917
	938
	963
	988
	4015
	5000
	4000
	079
	131
	162
	172
	223
	254
	2

Note that up to 2nd round 11 Aug 1952
 all measurements taken with standard units.

Recovery Firing of 5"/375 Deformable
Projectiles with Forward Skirts
-----Wire Impression Method of Determining Spin

Two screens are set up 4175 apart, each screen consisting of a metal frame with wood inserts, holding an array of parallel equidistant vertical copper wires. The spacing of the wires is 1/2" for the first screen and 3/4" for the second. The projectile is fitted with a flat-nosed dummy nose plug or the equivalent, so that after passing through the screens it bears two sets of impressions of the wires. The angle between the two sets of impressions is measured and from this measurement the rifling of the gun, the muzzle velocity, and the velocity at the spin screens, is computed the percentage of nominal spin. It is assumed that over the short distances involved the spin retardation is negligible.

Recovery Firing of 5"/3775 Deformable
Projectiles with Forward Skirts

Heat Treatment of Rytense AA Steel
for 5"/3775 Squeezebore Projectiles

1. The Rytense AA bar stock from which the projectile bodies were made was treated as follows:

1550°F	4 hours	Oil quench cold
1000°F	4 hours	Water quench cold

2. Following heat treatment both chemical analysis and tensile tests were taken from the quarter point and the results of these tests are listed below:

Chemical Analysis:

<u>C</u>	<u>Mn</u>	<u>P</u>	<u>S</u>	<u>Si</u>
.47	1.60	.020	.11	.10

Physical Properties:

<u>Y.S. (.01% offset*)</u>	<u>Y.S. (.1%)</u>	<u>T.S.</u>	<u>% El.</u>	<u>% R.A.</u>
67,400 psi	70,700 psi	113,800	13.5	25.4
68,400	72,400	115,100	15.5	31.8

3. The fractures shown by the tensile test were considered to be unusual in that the center was fibrous and the outside was crystalline. Figure 24 (Appendix (B)) presents these fractures.

* Approximately equal to proof stress.