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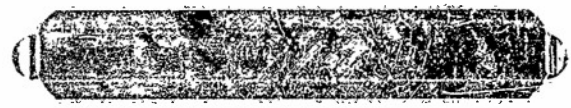
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U S NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO 1066

DEVELOPMENT AND TEST OF
CONTROLLED FRAGMENTATION PROJECTILES

6th Partial Report.

FRAGMENTATION TEST OF 3" / 50 ROD PROJECTILES
EX 26 MOD I AND EX 27 MOD I

FINAL Report

Task Assignment NPG-Re3b-229-2-53

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NPG REPORT NO. 1066

Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

PART A

SYNOPSIS

1. This test was conducted to determine the minimum rod fragment velocity obtainable from 3"/50 Rod Projectiles EX 26 Mod 1 and EX 27 Mod 1 having various diameter cores of TNT, initiated by Mk 54 auxiliary detonators.

2. TNT cores of 1" diameter or less were unsatisfactory in producing low velocity rods. When cores less than 1" in diameter were used, the detonation wave died out somewhere along the core length, leading to erratic results and failure to break up. Cores of 1" diameter produced rod fragments at 1400 ft./sec. velocity in EX 26-1 projectiles (2 rounds), but produced erratic rod velocities in EX 27-1 projectiles (2 rounds).

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PART B

INTRODUCTION

1. AUTHORITY:

This test was authorized by reference (a) and conducted under Task Assignment NPG-Re3b-229-2-53, reference (b).

2. REFERENCES:

- a. BUORD Conf ltr NOrd 12129 Re3b-RS:mt Ser 40105 of 2 Jun 1952
- b. BUORD Conf ltr NP9 Re3b-RS:mt Ser 43058 of 4 Aug 1952
- c. NPG Conf Report No. 857 of 13 Oct 1951

3. BACKGROUND:

Reference (c) reported the fragmentation characteristics of 3"/50 Rod Projectiles EX 26 Mod 1 having various fuze combinations and various types of loading with the objective of producing full length rods.

4. OBJECT OF TEST:

This test was conducted to determine the minimum rod fragment velocity obtainable from 3"/50 Rod Projectiles EX 26 Mod 1 and EX 27 Mod 1 having various diameter cores of TNT, initiated by Mk 54 auxiliary detonators.

5. PERIOD OF TEST:

- | | |
|-------------------------------------|--------------|
| a. Date Project Letter | 2 June 1952 |
| b. Date Necessary Material Received | 19 June 1952 |
| c. Date Commenced Test | 1 July 1952 |
| d. Date Test Completed | 2 July 1952 |

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EX 26 Mod 1 and EX 27 Mod 1

PART C

DETAILS OF TEST

6. DESCRIPTION OF ITEM UNDER TEST:

a. Projectile Body:

(1) 3"/50 Rod Projectile EX 26 Mod 1, composed of 18 individual rods. Each rod is 5'31 long with a 1'55 threaded nose end and 1'8 base end making an 8'66 overall length. The rods are joined together by copper brazing.

(2) 3"/50 Rod Projectile EX 27 Mod 1, Bureau of Ordnance Sketch 329178 (LN 103), grooved internally with 18 longitudinal cuts 20° apart. Each groove is 0'125 wide to a depth of 0'193 and tapers to a V bottom at a depth of 0'300. The wall thickness is 0'485. Approximately 6" of the body length is grooved as described from the base of the nose threads to the forward end of the rotating band.

b. Projectile Loading:

Each projectile was loaded with epsom salts and TNT at Naval Mine Depot, Yorktown, Virginia in June 1952. A 1/2" thick base of TNT (to rupture the projectile base section from the rods) and various diameter cores of TNT were loaded with an epsom salts annulus. Figure 1. TNT cores of 1/4", 1/2", 3/4", and 1" diameters were tested in both types of projectiles.

c. Projectile Fuzing:

Both types of projectiles were fuzed with Mk 54 Mod 1 ADF and Mk 30 PDF modified for static detonation.

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

d. Projectile Weight and General Data:

<u>Rd.</u>	<u>Proj.</u>	<u>Serial No.</u>	<u>TNT Core Diam.</u>	<u>Core Wt. (lbs.)</u>	<u>Total Proj. Wt. (lbs.)</u>
WQ 1	EX 26-1	32	1/4"	.09	13.05
WQ 2	"	20	1/4"	.09	13.03
WQ 3	"	26	1/2"	.11	13.03
WQ 4	"	12	1/2"	.13	13.01
WQ 5	"	30	3/4"	.21	13.02
WQ 6	"	11	3/4"	.22	13.00
WQ 7	"	1	1"	.32	13.03
WQ 8	"	33	1"	.33	13.05
WR 1	EX 27-1	5	1/4"	.06	11.92
WR 2	"	3	1/2"	.11	11.90
WR 3	"	6	1/2"	.10	11.94
WR 4	"	4	3/4"	*	11.93
WR 5	"	7	3/4"	*	11.92
WR 6	"	1	1"	.28	11.96
WR 7	"	2	1"	.27	12.03

* Core weights were not marked on these projectiles.

7. PROCEDURE:

Rod velocity, length, and angular distribution were obtained in a 30 foot radius arena. Each projectile was placed nose up in the center of the arena with its axis vertical and the center of the projectile 6-1/2 feet above ground level. Cane fiberboard panels 8' high and 4' wide were placed around the circumference of the arena in longitudinal zones 350° to 50° and 123° to 183° so that the impacts on the fiberboard could be distinguished on the 35mm Fastax film. One camera viewed zone 350° to 50° and the other camera viewed zone 123° to 183°. A photograph of the arena and test setup is shown in Figure 2.

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

8. RESULTS AND DISCUSSION:

a. Detailed rod fragment lengths, angular distribution, and velocities are listed in Tables I to IV, inclusive. All recovered fragments are shown in Figures 3 to 6, inclusive.

The summarized data are as follows:

<u>Rd.</u>	<u>Proj.</u>	<u>Core Diam.</u>	<u>Rod Lengths</u>	<u>Some Rod Clumping</u>	<u>Rod Velocity (ft./sec.)</u>	<u>TNT Action</u>
WQ 1	EX 26-1	1/4"	4" - 6"	Yes	140	Partial HO
WQ 2	"	1/4"	6"	Yes	120	"
WQ 3	"	1/2"	6"	Yes	30	"
WQ 4	"	1/2"	6"	Yes	30 - 220	"
WQ 5	"	3/4"	4" - 6"	No	260	"
WQ 6	"	3/4"	4" - 6"	No	240	"
WQ 7	"	1"	4"	No	1460	HO
WQ 8	"	1"	4"	No	1380	HO
WR 1	EX 27-1	1/4"	8"	Yes	170	Partial HO
WR 2	"	1/2"	2 large clumps		---	"
WR 3	"	1/2"	Approx. 6 clumps		---	"
WR 4	"	3/4"	5 1/2" - 7"	No	870	HO
WR 5	"	3/4"	7"	Yes	190	Partial HO
WR 6	"	1"	7"	No	240 - 750	"
WR 7	"	1"	6" - 7"	*Yes	670 - 1390	"

* Evidence of one (1) double rod fragment; others were single rod fragments.

b. The TNT cores were unsatisfactory in producing consistent fragment velocity and projectile break-up. This was due to the failure of the TNT core to detonate completely, the detonation wave stopping somewhere along the core's length. The 1" TNT cores detonated satisfactorily in the EX 26 Mod 1 projectiles.

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c. The EX 27 Mod 1 notched projectiles had a greater tendency to produce clumps of rod-like fragments at the lower velocities than the EX 26 Mod 1-brazed projectiles.

PART D

CONCLUSIONS

9. TNT cores of 1" diameter or less were unsatisfactory in producing low velocity rods. When cores less than 1" in diameter were used, the detonation wave died out somewhere along the core length, leading to erratic results and failure to break up. Cores of 1" diameter produced rod fragments at 1400 ft./sec. velocity in EX 26-1 projectiles (2 rounds), but produced erratic rod velocities in EX 27-1 projectiles (2 rounds).

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

The tests upon which this report is based were conducted by:

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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Sixth Partial Report
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Development and Test of
Controlled Fragmentation Projectiles

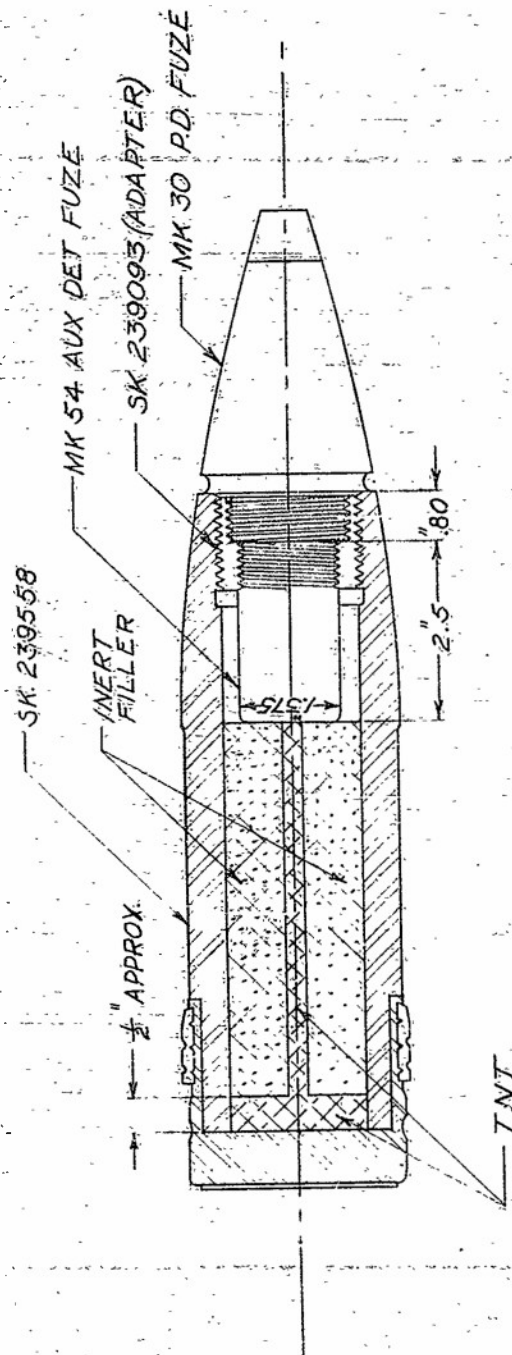
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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

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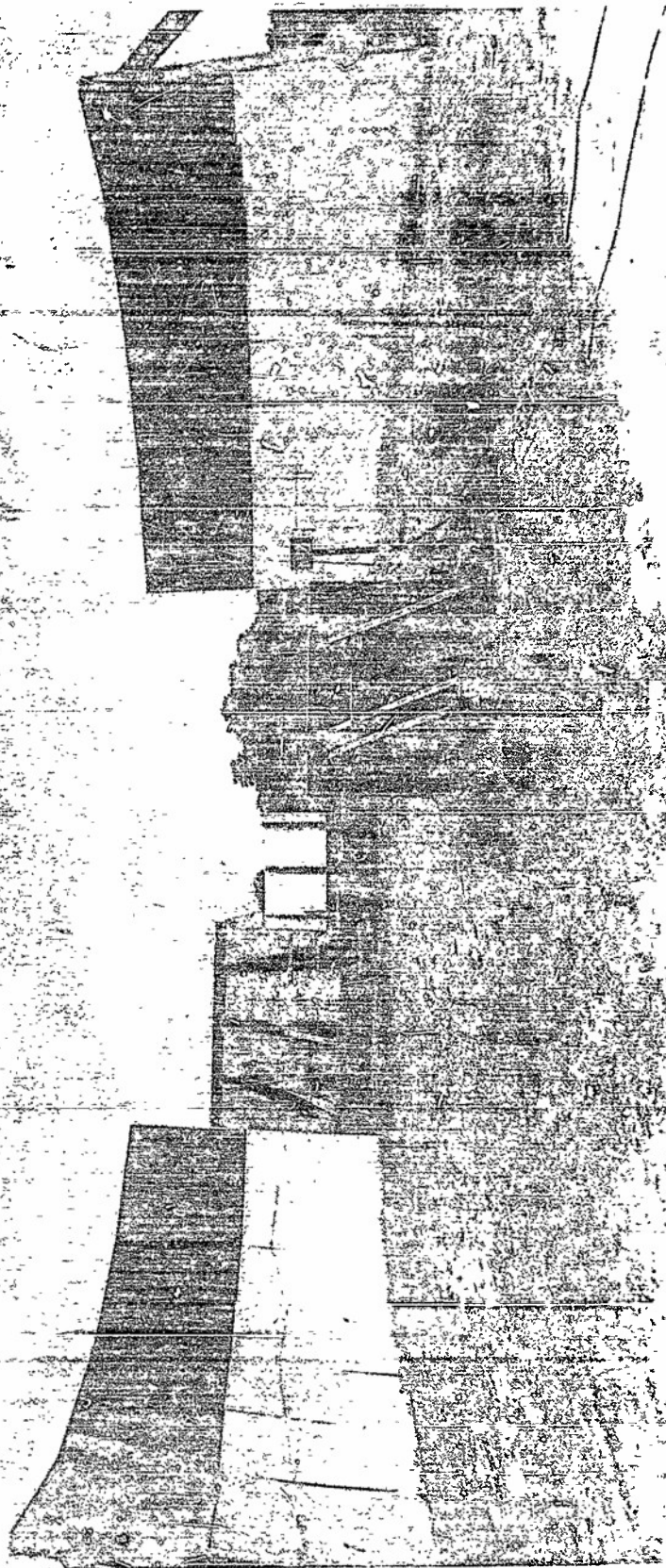
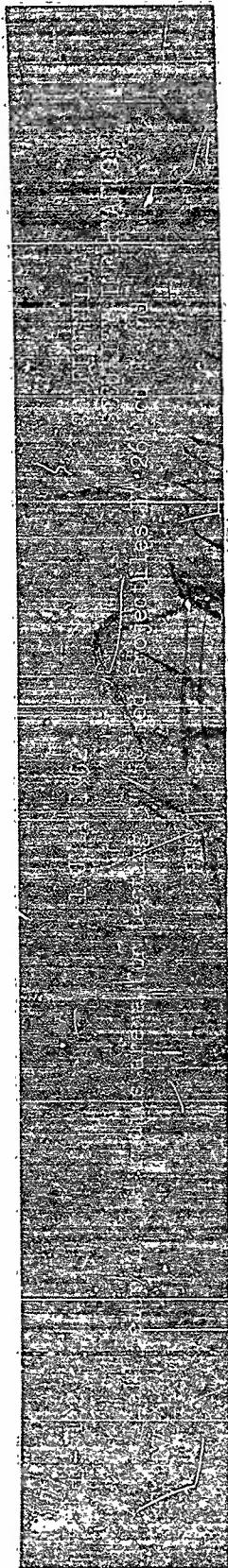
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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE I

ROD SPACE DISTRIBUTION DATA

30' RADIUS ARENA - 3"/50 ROD PROJECTILE EX 26 MOD 1

<u>Rd.</u>	<u>Core Diam.</u>	<u>Rod Hits on Arena Panel at 30' (zone)</u>	<u>Remarks</u>
WQ 1	1/4"	13°, 123°	Others hit ground 5' to 15' from center.
WQ 2	1/4"	357°, 14°, 30°, 44°, 93°, 145°	Others hit ground 5' to 30' from center.
WQ 3	1/2"	155°	"
WQ 4	1/2"	135°, 142°, 157°	"
WQ 5	3/4"	7°, 126°, 141°, 166°	Others hit ground 20' to 60' from center.
WQ 6	3/4"	20°, 34°, 126°, 140°, 180°	Others hit ground at 10' to 30' from center.
WQ 7	1"	355°, 18°, 38°, 138°, 138°, 158°, 160°, 179°	- - -
WQ 8	1"	9°, 32°, 50°, 138°, 151°, 170°	- - -

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APPENDIX C

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE II

ROD SPACE DISTRIBUTION DATA30' RADIUS ARENA - 3"/50 ROD PROJECTILE EX 27 MOD 1

<u>Rd.</u>	<u>Core Diam.</u>	<u>Rod Hits on Arena Panel at 30' (zone)</u>	<u>Remarks</u>
WR 1	1/4"	355°, 85°	Hits consist of clumps of rods.
WR 2	1/2"	None	2 clumps of rods hit ground at 5° and 25°.
WR 3	1/2"	None	3 clumps of rods hit ground at 25°, 25°, and 60°.
WR 4	3/4"	357°, 27°, 44°, 126°, 148°, 164°	All single rod hits.
WR 5	3/4"	25°, 133°, 180°	Hits consist of clumps of rods.
WR 6	1"	2°, 23°, 45°, 125°, 148°, 158°	All single rod hits.
WR 7	1"	6°, 35°, 124°, 145°, 170°	35° hit was double rod; others were single.

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APPENDIX C

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Fragmentation Test of 3¹/₂" 50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE III

FRAGMENT VELOCITY DATA

Batt. Lt.: WQ-1

Date Fired: 1 July 1952

30 Ft. Radius Arena

2880 Frames per sec.

35mm Fastax Camera #1

Filler: 1/4" TNT core

Rd. 3¹/₂" 50 EX 26-1

Filler Weight: .09 Lbs.

Total Weight: 13.05 Lbs.

<u>Zone</u>	<u>Frame in Which Hit Occurred</u>	<u>No. Rods</u>	<u>Velocity (f/s)</u>
13°	630	1	140

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE III (Continued)

Batt. Ltr. WQ-2 Date Fired: 1 July 1952
30 Ft. Radius Arena 2880 Frames per sec.
35mm Fastax Camera #1 Filler: 1/4" TNT core
Rd. 3"/50 EX 26-1 Filler Weight: .09 Lbs.
Total Weight: 13.03 Lbs.

<u>Zone</u>	<u>Frame in Which Hit Occurred</u>	<u>No. Rods</u>	<u>Velocity (f/s)</u>
44°	665	1	130
14°	791	1	110
35mm Fastax Camera #2		2115 Frames per sec.	
145°	482	1	130

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE III (Continued)

Batt. Ltr. WQ-3

Date Fired: 1 July 1952

30 Ft. Radius Arena

2040 Frames per sec.

35mm Fastax Camera #2

Filler: 1/2" TNT core

Rd. 3"/50 EX 26-1

Filler Weight: .11 Lbs.

Total Weight: 13.03 Lbs.

<u>Zone</u>	<u>Frame in Which Hit Occurred</u>	<u>No. Rods</u>	<u>Velocity (f/s)</u>
155°	1756	1	30

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE III (Continued)

Batt. Ltr. WQ-4

Date Fired: 1 July 1952

30 Ft. Radius Arena

2190 Frames per sec.

35mm Fastax Camera #2

Filler: 1/2" TNT core

Rd. 3"/50 EX 26-1

Filler Weight: .13 Lbs.

Total Weight: 13.01 Lbs.

<u>Zone</u>	<u>Frame in Which Hit Occurred</u>	<u>No. Rods</u>	<u>Velocity (f/s)</u>
135°	294	1	220
142°	1200	1	50
157°	1912	1	30

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE III (Continued)

Batt. Ltr. WQ-5

Date Fired: 2 July 1952

30 Ft. Radius Arena

2880 Frames per sec.

35mm Fastax Camera #1

Filler: 3/4" TNT core

Rd. 3"/50 EX 26-1

Filler Weight: .21 Lbs.

Total Weight: 13.02 Lbs.

<u>Zone</u>	<u>Frame in Which Hit Occurred</u>	<u>No. Rods</u>	<u>Velocity (f/s)</u>
7°	336	1	260
35mm Fastax Camera #2		2520 Frames per sec.	
166°	273	1	280
141°	273	1	280
126°	316	1	240

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE III (Continued)

Batt. Ltr. WQ-6

Date Fired: 2 July 1952

30 Ft. Radius Arena

2900 Frames per sec.

35mm Fastax Camera #1

Filler: 3/4" TNT core

Rd. 3"/50 EX 26-1

Filler Weight: .22 Lbs.

Total Weight: 13.00 Lbs.

<u>Zone</u>	<u>Frame in Which Hit Occurred</u>	<u>No. Rods</u>	<u>Velocity (f/s)</u>
20°	330	1	260
34°	368	1	240
35mm Fastax Camera #2		2520 Frames per sec.	
180°	295	1	260
126°	306	1	250
140°	386	1	200

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE III (Continued)

Batt. Ltr. WQ-7

Date Fired: 2 July 1952

30 Ft. Radius Arena

3240 Frames per sec.

35mm Fastax Camera #1

Filler: 1" TNT core

Rd. 3"/50 EX 26-1

Filler Weight: .32 lbs.

Total Weight: 13.03 lbs.

<u>Zone</u>	<u>Frame in Which Hit Occurred</u>	<u>No. Rods</u>	<u>Velocity (f/s)</u>
18°	65	1	1500
355°	67	1	1450
38°	68	1	1430
38°	70	1	1390
35mm Fastax Camera #2		3120 Frames per sec.	
138°	62	1	1510
160°	62	1	1510
138°	63	1	1490
158°	65	1	1440

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Fragmentation Test of 3rd/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE III (Continued)

Batt. Ltr. WQ-8

Date Fired: 2 July 1952

50 Ft. Radius Arena

2900 Frames per sec.

35mm Fastax Camera #1

Filler: 1st TNT core

Rd. 3rd/50 EX 26-1

Filler Weight: .33 Lbs.

Total Weight: 13.05 Lbs.

<u>Zone</u>	<u>Frame in Which Hit Occurred</u>	<u>No. Rods</u>	<u>Velocity (f/s)</u>
9°	56	1	1550
50°	57	1	1530
32°	58	1	1500
35mm Fastax Camera #2		2400 Frames per sec.	
138°	52	1	1380
170°	62	1	1160
151°	63	1	1140

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE IV

FRAGMENT VELOCITY DATA

Batt. Ltr. WR-1

Date Fired: 1 July 1952

30 Ft. Radius Arena

2370 Frames per sec.

35mm Fastax Camera #1

Filler: 1/4" TNT core

Rd. 3"/50 EX 27-1

Filler Weight: .06 Lbs.

Total Weight: 11.92 Lbs.

<u>Zone</u>	<u>Frame in Which Hit Occurred</u>	<u>No. Rods</u>	<u>Velocity (f/s)</u>
355°	410	1	170

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE IV (Continued)

Batt. Ltr WR-2

Date Fired: 1 July 1952

30 Ft. Radius Arena

Filler: 1/2" TNT core

Rd. 3"/50 EX 27-1

Filler Weight: .11 Lbs.

Total Weight: 11.90 Lbs.

No velocity data was obtained.

Projectile broke into two (2) pieces (Figure 4) which struck the ground at 20 feet.

Batt. Ltr. WR-3

Date Fired: 1 July 1952

30 Ft. Radius Arena

Filler: 1/2" TNT core

Rd. 3"/50 EX 27-1

Filler Weight: .10 Lbs.

Total Weight: 11.94 Lbs.

No velocity data was obtained.

Projectile broke into approximately 6 pieces (Figure 4), none of which struck the velocity panels.

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE IV (Continued)

Batt. Ltr. WR-4

Date Fired: 2 July 1952

30 Ft. Radius Arena

2900 Frames per sec.

35mm Fastax Camera #1

Filler: 3/4" TNT core

Rd. 3"/50 EX 27-1

Filler Weight: * Lbs.

Total Weight: 11.93 Lbs.

<u>Zone</u>	<u>Frame in Which Hit Occurred</u>	<u>No. Rods</u>	<u>Velocity (f/s)</u>
44°	93	1	940
27°	94	1	930
357°	96	1	910
35mm Fastax Camera #2		2400 Frames per sec.	
164°	87	1	830
126°	88	1	820
148°	92	1	780

* Not available, estimated at 0.20 lbs.

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE IV (Continued)

Batt. Ltr. WR-5

Date Fired: 2 July 1952

30 Ft. Radius Arena

2580 Frames per sec.

35mm Fastax Camera #1

Filler: 3/4" TNT core

Rd. 3"/50 EX 27-1

Filler Weight: *Lbs.

Total Weight: 11.92 Lbs.

<u>Zone</u>	<u>Frame in Which Hit Occurred</u>	<u>No. Rods</u>	<u>Velocity (f/s)</u>
25°	457	1	170
35mm Fastax Camera #2		2640 Frames per sec.	
180°	372	1	210
133°	408	1	190

* Not available, estimated at 0.20 lbs.

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE IV (Continued)

Batt. Ltr. WR-6

Date Fired: 2 July 1952

30 Ft. Radius Arena

2040 Frames per sec.

35mm Fastax Camera #1

Filler: 1" TNT core

Rd. 3"/50 EX 27-1

Filler Weight: .28 Lbs.

Total Weight: 11.96 Lbs.

<u>Zone</u>	<u>Frame in Which Hit Occurred</u>	<u>No. Rods</u>	<u>Velocity (f/s)</u>
45°	108	1	570
23°	254	1	240
35mm Fastax Camera #2		2980 Frames per sec.	
125°	120	1	750
148°	200	1	450

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE IV (Continued)

Batt. Ltr. WR-7

Date Fired: 2 July 1952

30 Ft. Radius Arena

2900 Frames per sec.

35mm Fastax Camera #1

Filler: 1" TNT core

Rd. 3"/50 EX 27-1

Filler Weight: .27 Lbs.

Total Weight: 12.03 Lbs.

<u>Zone</u>	<u>Frame in Which Hit Occurred</u>	<u>No. Rods</u>	<u>Velocity (f/s)</u>
6°	106	1	820
35°	110	1	790
35mm Fastax Camera #2		2040 Frames per sec.	
124°	44	1	1390
145°	68	1	900
170°	92	1	670

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Fragmentation Test of 3"/50 Rod Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

TABLE IV (Continued)

Batt. Ltr. WR-7

Date Fired: 2 July 1952

30 Ft. Radius Arena

2900 Frames per sec.

35mm Fastax Camera #1

Filler: 1" TNT core

Rd. 3"/50 EX 27-1

Filler Weight: .27 Lbs.

Total Weight: 12.03 Lbs.

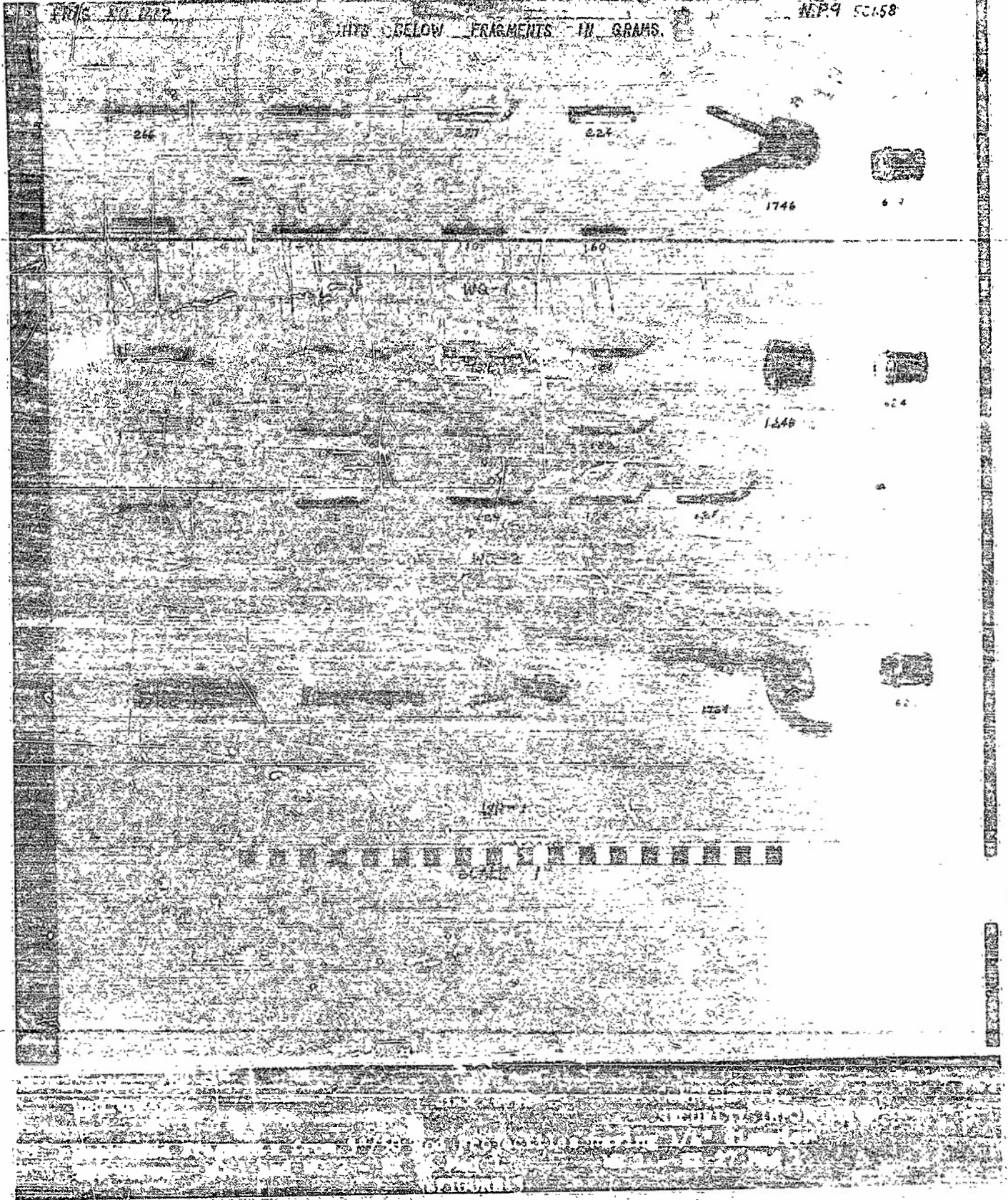
<u>Zone</u>	<u>Frame in Which Hit Occurred</u>	<u>No. Rods</u>	<u>Velocity (f/s)</u>
6'	106	1	820
35°	110	1	790
35mm Fastax Camera #2		2040 Frames per sec.	
124°	44	1	1390
145°	68	1	900
170°	92	1	670

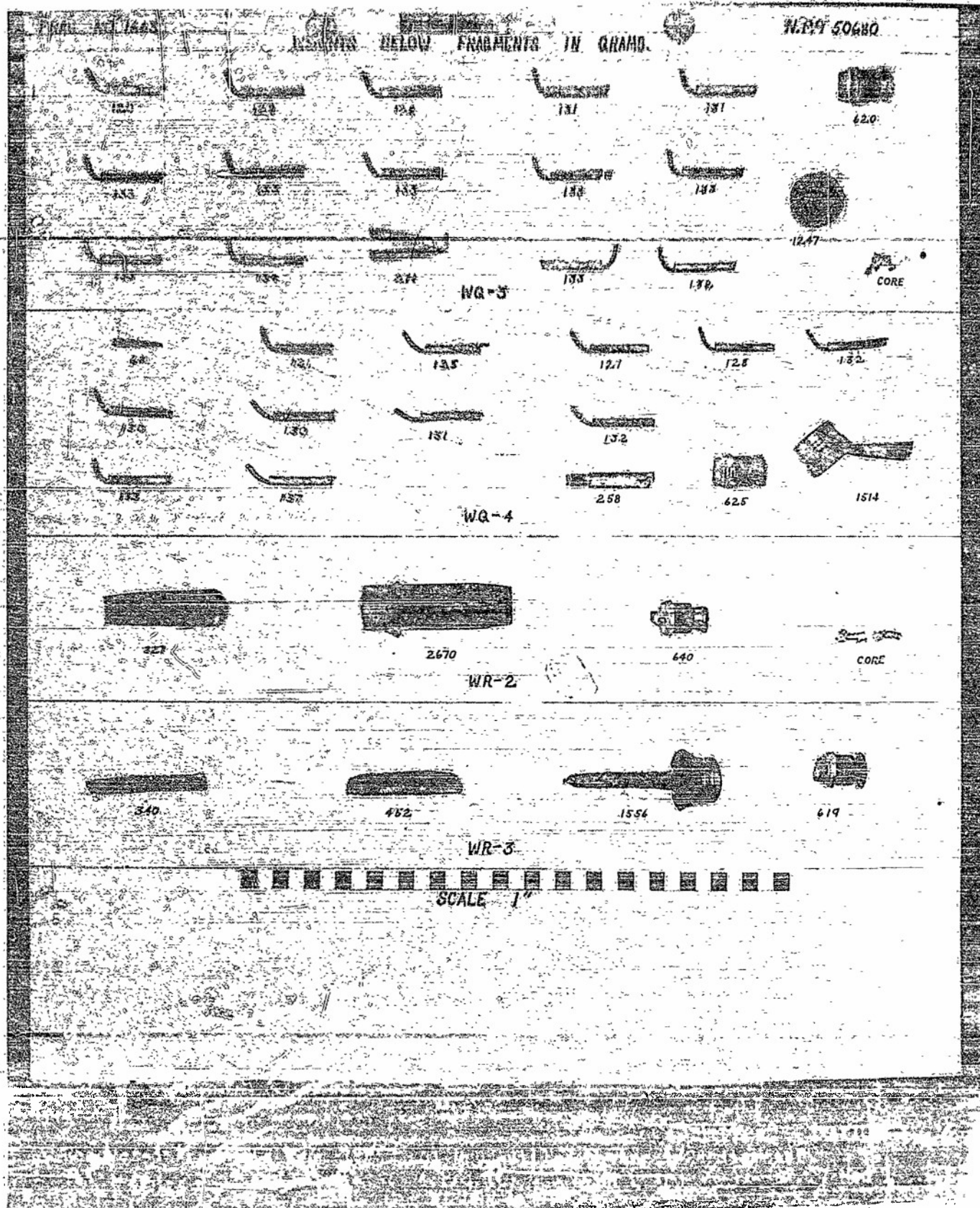
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INITS BELOW FRAGMENTS IN GRAMS.

MP9 50158

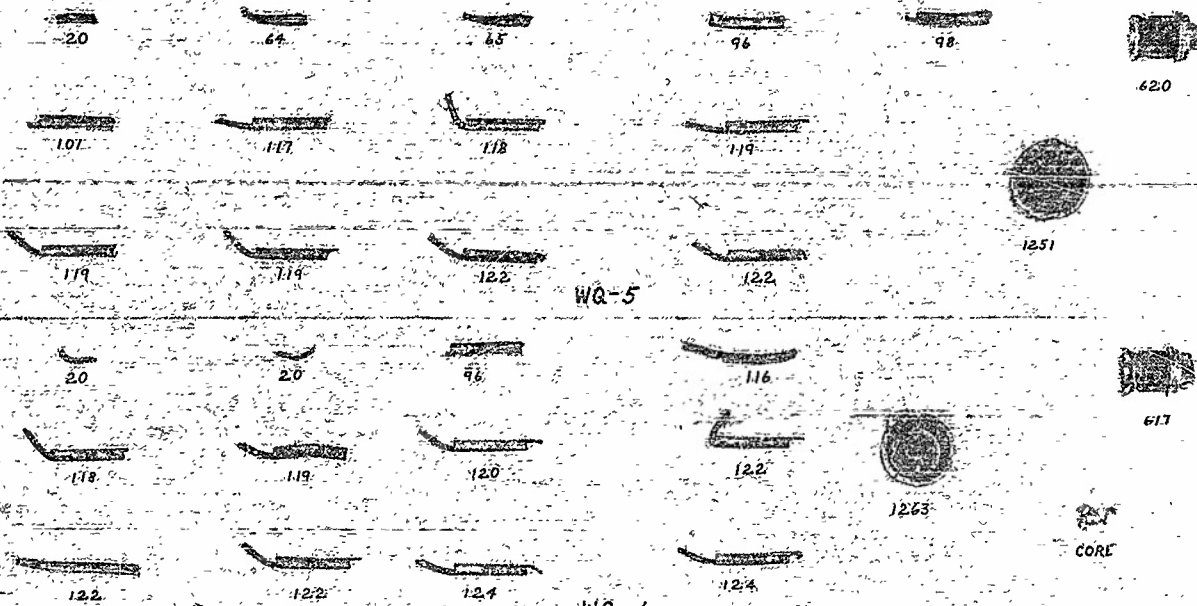




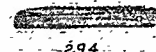
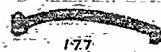
FRAG NO 1664

N.P. 50697

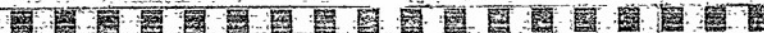
WEIGHTS BELOW FRAGMENTS IN GRAMS.



WR-4



WR-5



SCALE 1"

FRAG NO 1665

WEIGHTS BELOW FRAGMENTS IN GRAMS

N.P. 50702

16

46

102

342

847

WG-8

147

150

151

151

1160

WR-6

127

588

1051

WR-7

SCALE

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Fragmentation Test of 3"/50 Red Projectiles,
EX 26 Mod 1 and EX 27 Mod 1

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