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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 1112

SEVEN SHOT 30MM BALLISTICS GUN

FINAL Report

Copy No. 5

Task
Assignment NPG-Re8a-115-2-52

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Seven Shot 30mm Ballistics Gun
-----PART ASYNOPSIS

1. The object of this test was to obtain experimental data on the interior and exterior ballistics of a gun firing several projectiles from a common cartridge case through parallel bores drilled in one (1) piece of metal.

2. Based on the limited number of rounds fired from the Seven Shot 30mm Ballistics Gun, it is concluded that:

a. Firing identical 30mm "Aden" projectiles, there is a variation of about 4.5 percent in the velocities of the leading and trailing projectiles.

b. Firing identical 30mm "Aden" projectiles, the center projectile usually emerges first, has the highest velocity, and the least yaw.

c. Yaw as high as 31° occurs at 150 feet.

d. Weighting the center projectile so that it emerges last does not improve the pattern of the others or correct the excessive yaw.

e. The average maximum dispersion is 28.6 mils at 2000 inches.

Seven Shot 30mm Ballistics Gun
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Seven Shot 30mm Ballistics Gun
-----PART BINTRODUCTION

1. AUTHORITY:

Bureau of Ordnance letter NP9-Re8a-JOW:mts, Serial 25921 of 20 September 1951 established Task Assignment Number NPG-Re8a-115-2-52 for the test of a 30mm Ballistic Gun.

2. OBJECT OF TEST:

The object of this test was to obtain experimental data on the interior and exterior ballistics of seven (7) 30mm projectiles when fired from a common case through seven (7) parallel rifled bores.

3. REPRESENTATIVES PRESENT:

Mr. Frank R. Marquardt of Re8a, Bureau of Ordnance, the Liaison Officer designated in the Task Assignment, was present during the firings.

PART CDETAILS OF TEST

4. DESCRIPTION OF ITEM UNDER TEST:

The Seven Shot 30mm Ballistic Gun was manufactured by the Naval Gun Factory, and consists of the following major parts.

- a. Barrel (Bureau of Ordnance Sketch 147748)
- b. Breech (Bureau of Ordnance Sketch 147749)
- c. Receiver (Bureau of Ordnance Sketch 147750)
- d. Rear Support (Bureau of Ordnance Sketch 147751)
- e. Front Support (Bureau of Ordnance Sketch 147752)
- f. Front Support Plate (Bureau of Ordnance Sketch 147753)
- g. Yoke (Bureau of Ordnance Sketch 147754)
- h. Tray (Bureau of Ordnance Sketch 148856)

Seven Shot 30mm Ballistics Gun

This gun is basically an experimental device designed to permit the firing of seven (7) 30mm projectiles from a common case through seven (7) parallel rifled holes drilled in one (1) barrel. It is a single shot weapon with its cup like breech secured to the barrel by means of interrupted threads. The recoil is cushioned by four (4) 40mm hydraulic buffers and counterrecoil is accomplished by a 3"/50 barrel spring. Six (6) of the rifled holes are arranged in a circle, 60° apart, around the seventh, which is centered. There is 15/64 inches of metal between the grooves of each bore and those adjacent to it. The length of the barrel is 59-1/2 inches and the total weight of this experimental gun is 827 pounds. The gun is shown in Figures 1 and 2.

Ammunition consists of modified 3"/50 cases which have been turned down as shown in Figure 3, and shortened to an overall length of 6-1/2 inches. A brass plate 1/2 inch thick, having seven (7) 30mm diameter holes matching the holes in the barrel, properly positions the seven (7) 30mm British "Aden" ball projectiles. A Mk 27 electric 3 inch caliber primer was used to initiate the propellant charge.

5. PROCEDURE:

As the normal muzzle velocity of the 30mm British "Aden" projectiles used in this test is 2150 feet per second when fired in the "Aden" gun, calculations were made to determine the proper charge weight to approximate this velocity. A graph of the results of these calculations is given as Table I. This graph, based on IMR 4903 powder, showed that .85 pounds of propellant should give the desired velocity, and this charge weight was used in all rounds fired as it was found to give satisfactory pressures and velocities. Two (2) copper crusher gages were strapped to the primer extension tube in each of the first three (3) rounds fired, but were not used thereafter as the pressures were found to be well within the designed limit of the breech. Complete firing data are given in Table II.

Each projectile was painted with a design so that it could be identified in high speed photographs. The projectiles and rifled holes were also numbered, starting with No. 1 at the one o'clock position looking at the breech of the gun and then clockwise around the outer ring with No. 7 in the center. The first designs, as shown in Figures 3 and 4, were changed after the first 5 rounds, as the projectiles could not be properly identified in the photographs, and the designs shown in Figures 5 and 6 were used thereafter.

Seven Shot 30mm Ballistics Gun

A shorting muzzle contact and a shorting double screen of copper wire were used to start and stop a Potter Counter Chronograph and obtain the time of flight of the leading projectile. From this the average velocity of this leading projectile over a fixed distance was computed. On the first two (2) rounds, the screen was placed 25 feet from the muzzle but when it was found that blast upset the screen it was moved to 140 feet on rounds 3, 4, and 5, and 145 feet on rounds 6, 7, and 8. A Ballistic Synchro camera was set up 6 inches in front of the muzzle and 6 feet to the right of the line of fire to record the emergence of the projectiles. The film speed of this camera was 900 inches per second and the results obtained are shown in Figure 7. To obtain a group picture of the projectiles in flight, an experimental Ballistic Drum Camera with a film speed of 1050 inches per second was set up 133 feet in front of the muzzle and 49 feet to the right of the line of fire. These photographs are given as Figures 8 through 13 and computed velocities of each projectile are given in Table III. A description and discussion of the Ballistic Synchro Camera is included as Appendix (G).

Patterns of the first five (5) rounds were taken at 2000 inches and the yaw of each projectile was measured. These patterns with the yaw indicated are given as Figures 14 through 18. In an attempt to improve the patterns and decrease yaw, the No. 7 or center projectile was weighted to .73 pounds on round 4 and to .74 pounds on round 5 so that it would emerge last. The average weight of the normal projectiles is .61 pounds. It was thought that the shock wave from this projectile was effecting the flight of the others, but this did not prove to be correct.

6. RESULTS AND DISCUSSION:

The results of this investigation are presented in the form of photographs, diagrams, graphs and Tables in Appendices (A) through (F).

PART D

CONCLUSIONS

7. Based on the limited number of rounds fired from the Seven Shot 30mm Ballistics Gun, it is concluded that:

a. Firing identical 30mm "Aden" projectiles, there is a variation of about 4.5 percent in the velocities of the leading and trailing projectiles.

Sover. Shot 30mm Ballistics Gun

- b. Firing identical 30mm "Aden" projectiles, the center projectile usually emerges first, has the highest velocity, and has the least yaw.
- c. Yaw as high as 31° occurs at 150 feet.
- d. Weighting the center projectile so that it emerges last does not improve the pattern of the others or correct the excessive yaw.
- e. The average maximum dispersion is 28.6 mils at 2000 inches.

PART ERECOMMENDATIONS

8. Because of the unsatisfactory exterior ballistics obtained in these firings, it is recommended that no further tests be conducted on this gun firing "Aden" projectiles, as it is thought that these projectiles may be unstable when fired from a single barrel gun. If additional information is desired on a multibore weapon, it is recommended that firings be conducted with projectiles designed for higher velocities.

PART FDISPOSITION OF MATERIALS

9. The gun and remaining ammunition components are being held at the Naval Proving Ground pending disposition instructions from the Bureau of Ordnance.

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NPG REPORT NO. 1112

Seven Shot 30mm Ballistics Gun

The investigation upon which this report is based was conducted by:

L. D. RUCKER, Lieutenant Commander, USNR
Aircraft Armament Officer
Aviation Ordnance Department

This report was prepared by:

L. D. RUCKER, Lieutenant Commander, USNR
Aircraft Armament Officer
Aviation Ordnance Department

This report was reviewed by:

JOHN PINKER, Jr., Head Engineer
Aircraft Armament Division
Aviation Ordnance Department
J. C. TALLEY, Director of Research
Aviation Ordnance Department
F. A. NUSOM, Captain, USN
Aviation Ordnance Officer
Aviation Ordnance Department
C. C. BRANBLE, Director of Research, Ordnance Group

APPROVED: J. F. BYRNE
Captain, USN
Commander, Naval Proving Ground


E. A. RUCKNER
Captain, USN
Ordnance Officer
By direction

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NPG REPORT NO. 1112

U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Final Report

on

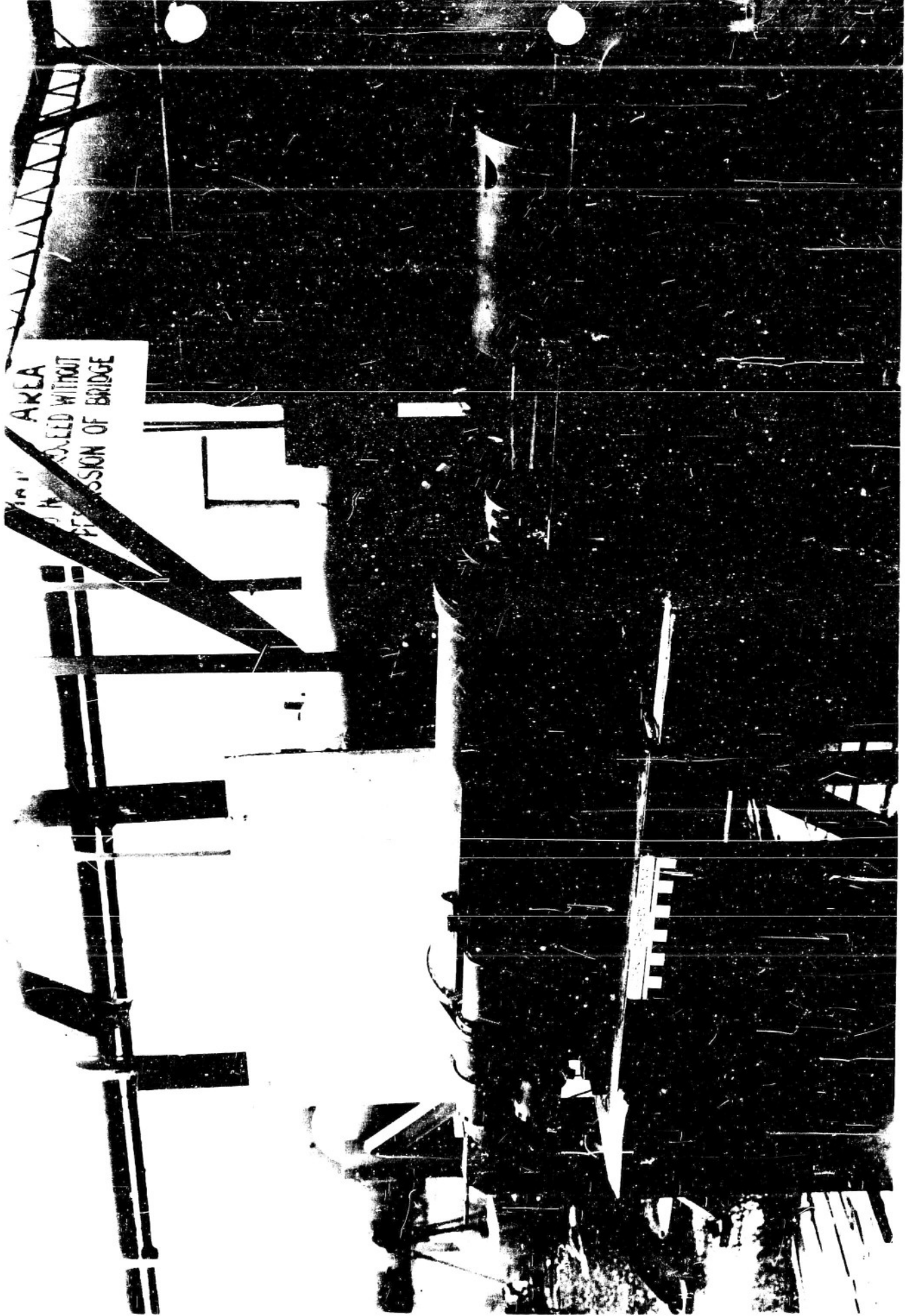
Seven Shot 30mm Ballistics Gun

Project No.: NPG-Re8a-115-2-52
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Date: APR 9 1953

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View of Muzzle of Seven Shot 30mm Ballistic Gun.

Figure 2

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APPENDIX A





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Figure 3

Photograph of projectiles assembled in case, rounds 1 through 5.

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APPENDIX A

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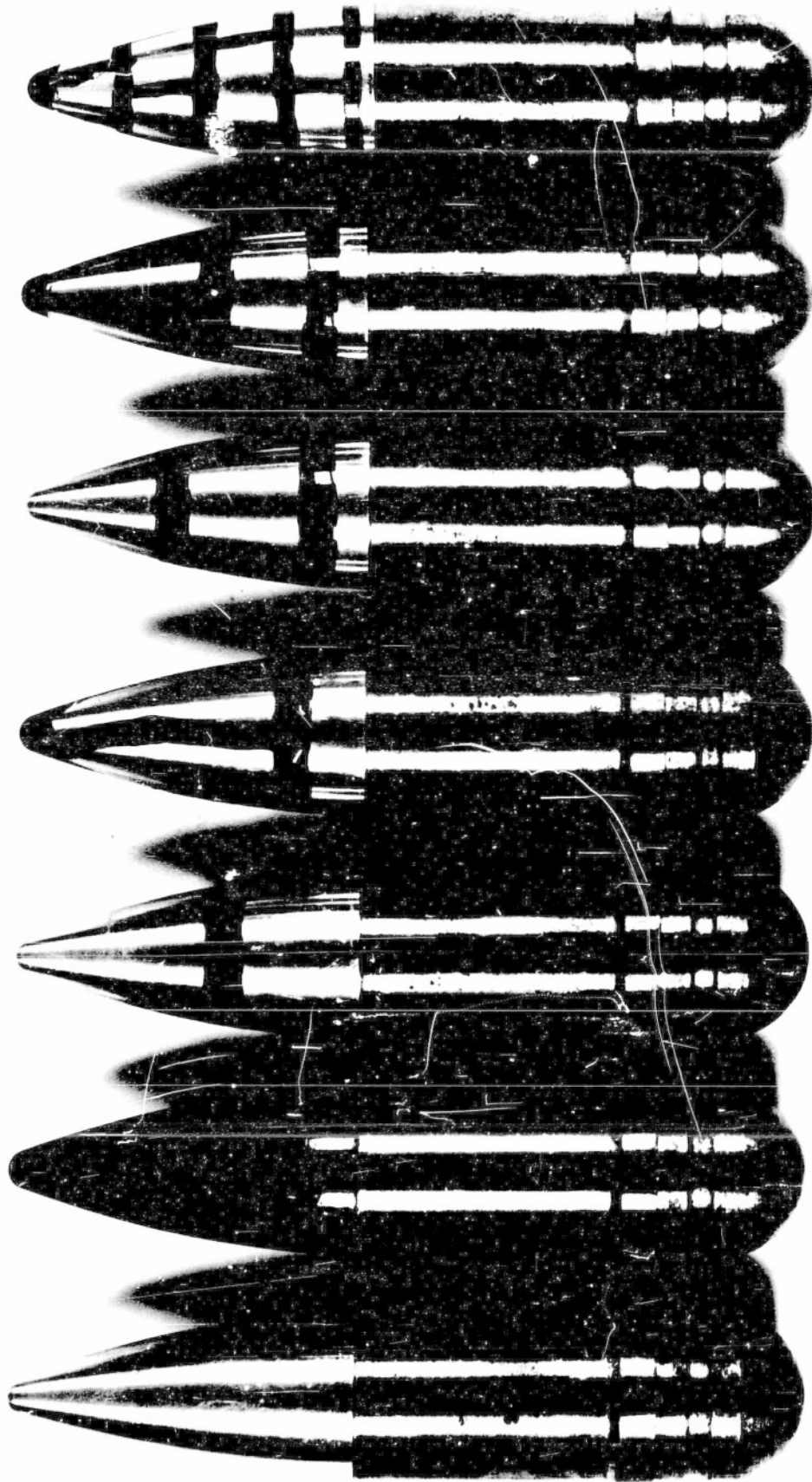
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3

4

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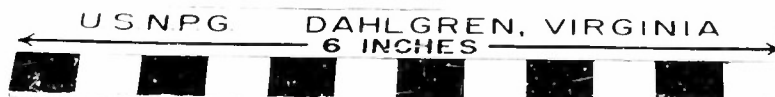
6

7

U.S.N.P.G. DAHLGREN, VIRGINIA

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Figure 5

Photograph of projectiles assembled in case, rounds 6, 7, and 8.

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APPENDIX A

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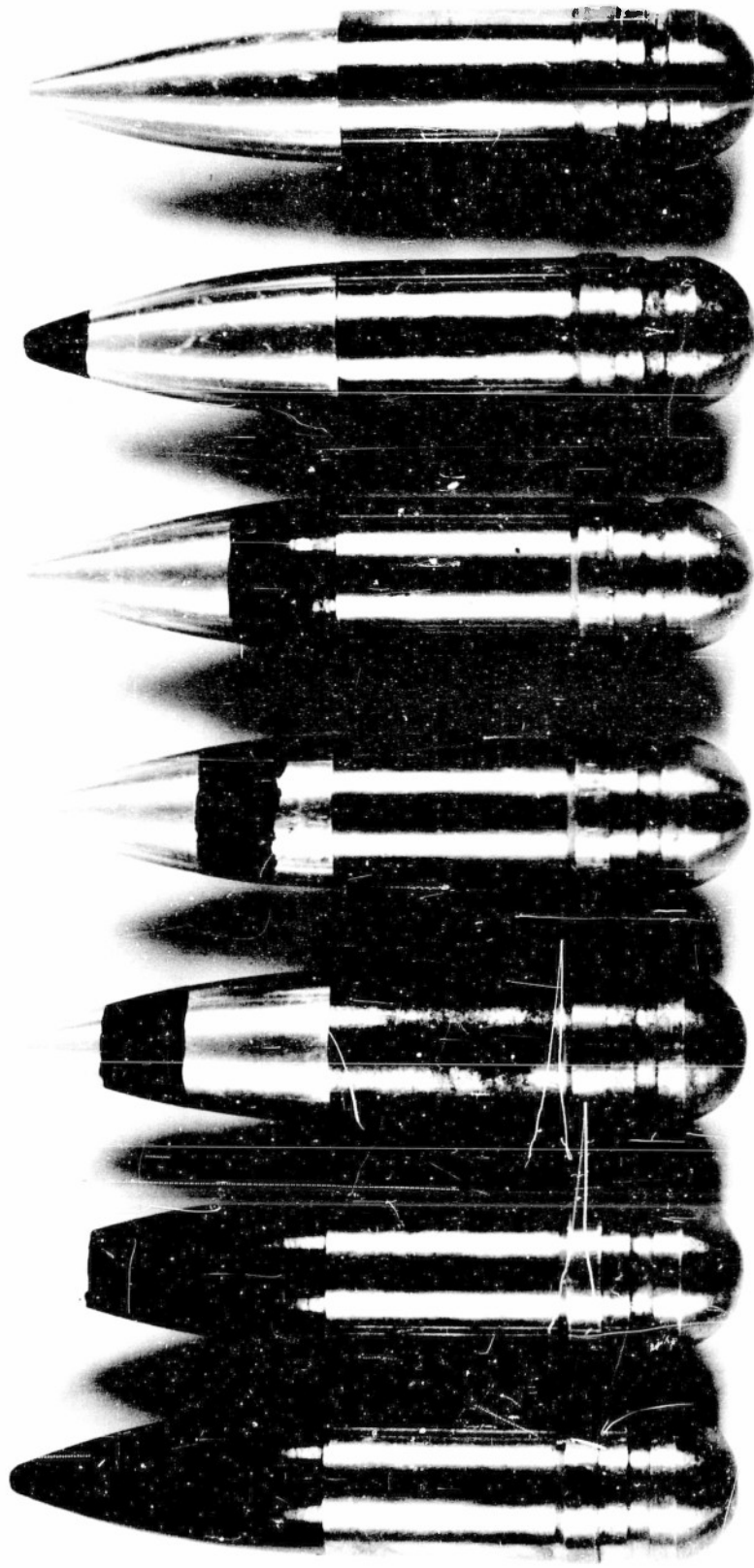
Figure 6

Photograph showing markings on Projectiles, rounds 6, 7, and 8.

APPENDIX A

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UNITED STATES

~~Warfare Projectiles~~

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Figure 8.
Ballistic Synchro Photograph of first six projectiles in round No. 4. Center
projectiles (No. 7) has been weighted and trails (See Figures 9 and 10).

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APPENDIX B

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02



Figure 9

Figure 9
Ballistic Stachro Photograph of Center Projectile
distance between No. 7 and balance of projectiles

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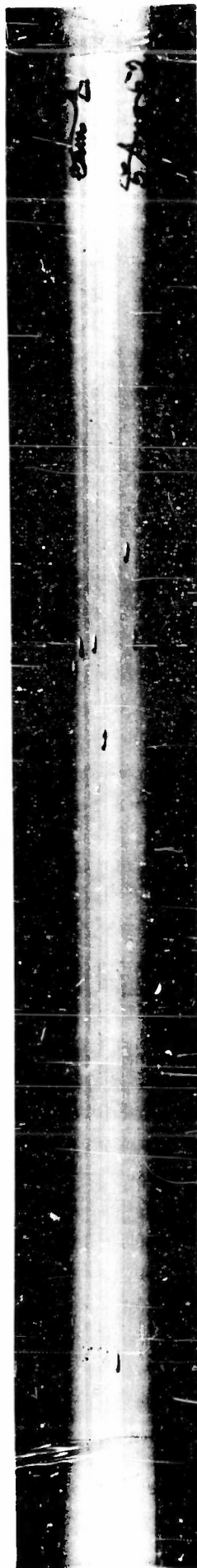
o. 7) Young to. 4, for
(Securing 10).
APPENDIX

NP9-62303

Figure 10

Strip Ballistic Synchro Photographs of Projectiles fired from rounds 4 and 5, showing relative position of trailing weighted (No. 7) projectiles. APPENDIX B

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ROUND NO 4



ROUND NO 5

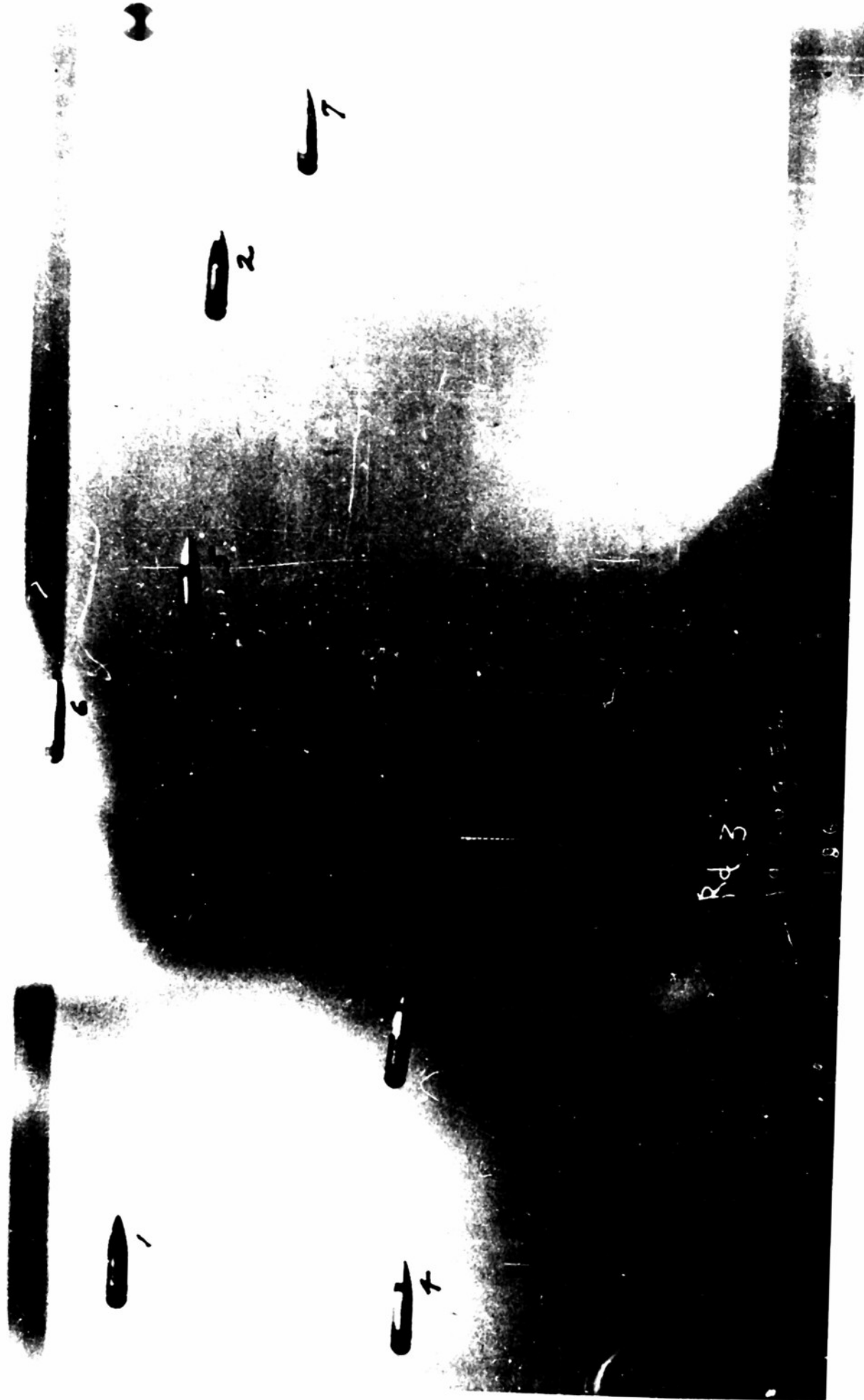
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Figure 11

Ballistic Synchro Photograph of projectiles fired from round no. 1.
APPENDIX E

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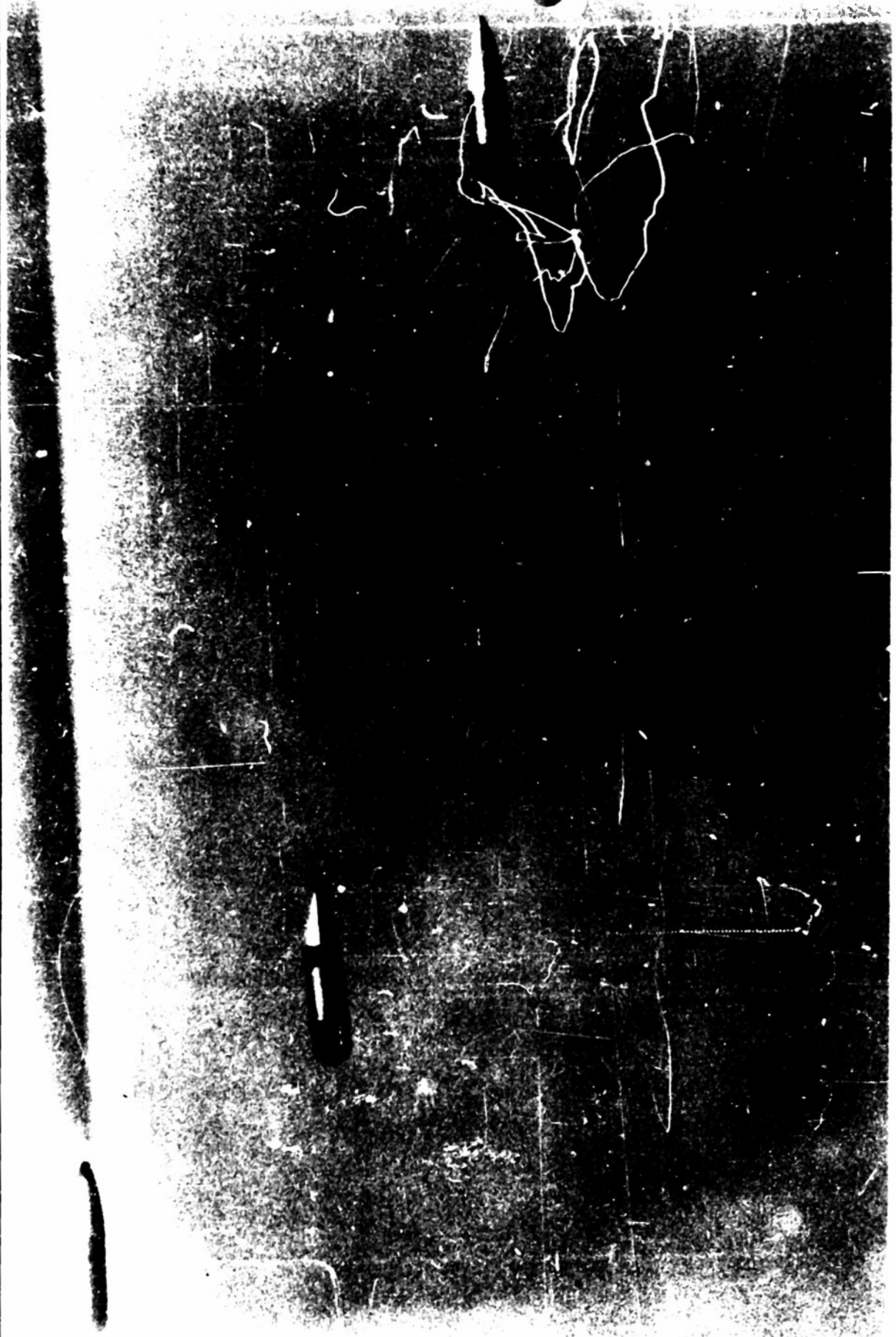
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NP9-62301 Figure 12
Enlargement of first four projectiles, Figure 11.

APPENDIX B

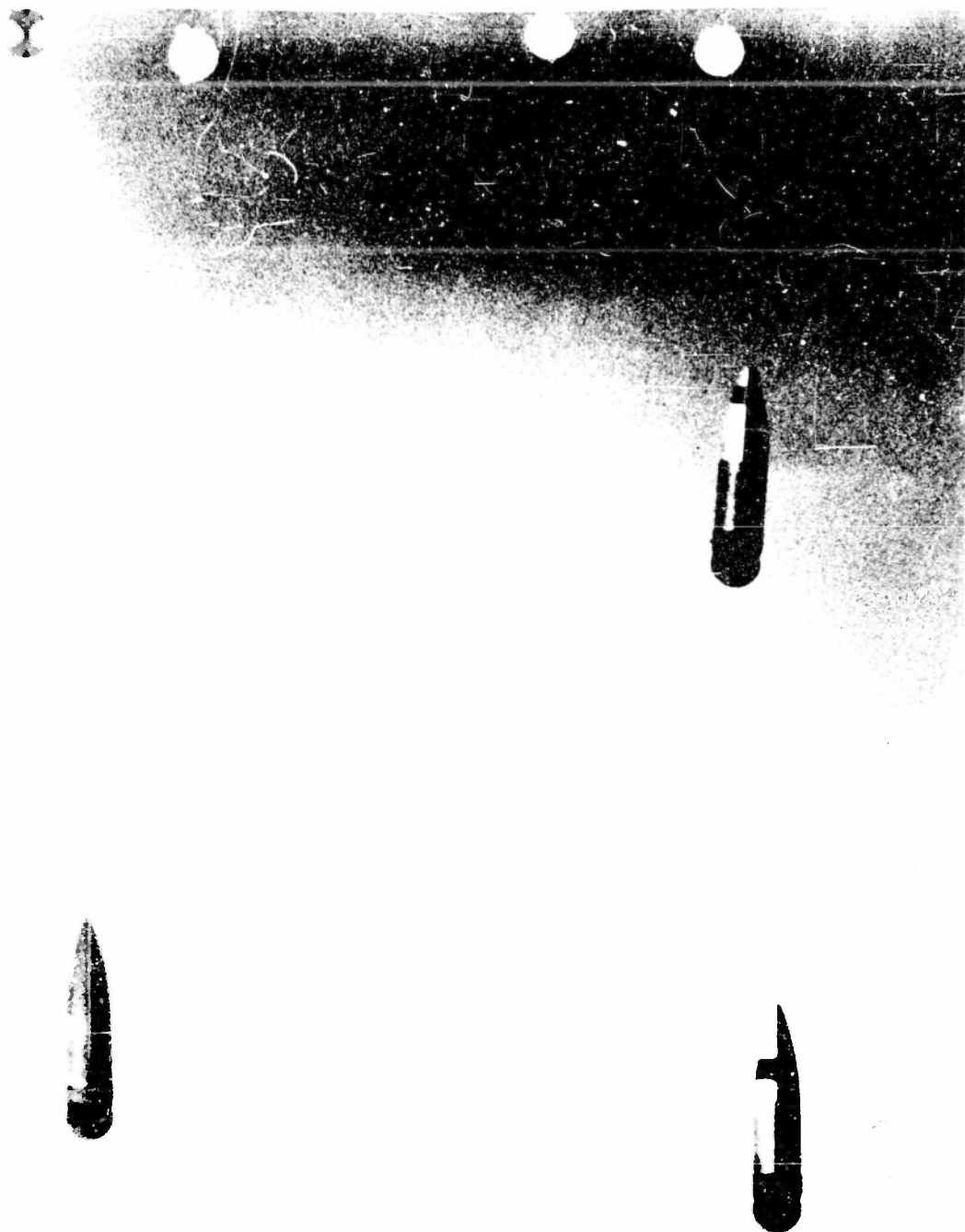


NP9-62302

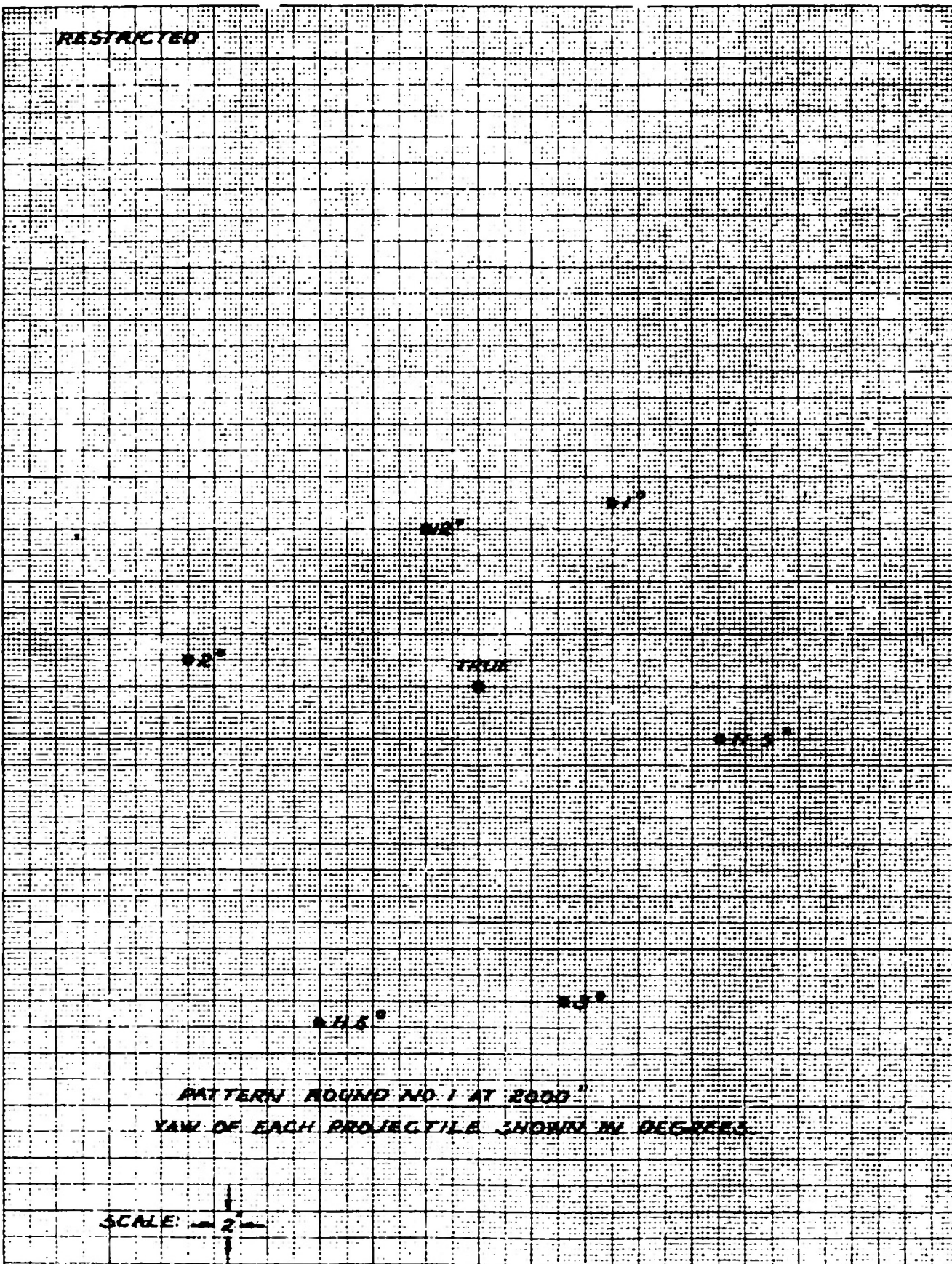
Figure 13
Enlargement of last three projectiles, Figure 11.

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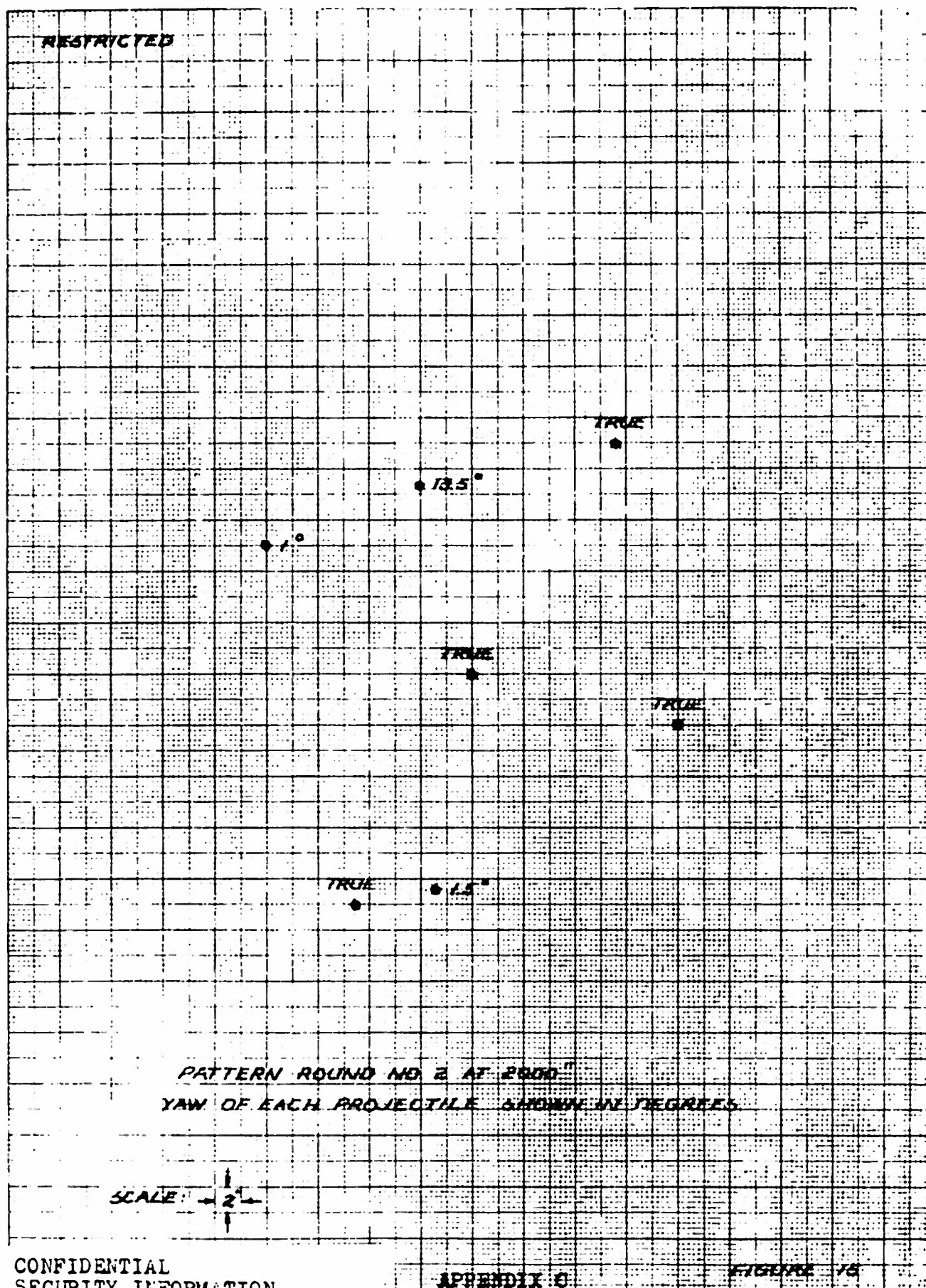
APPENDIX B



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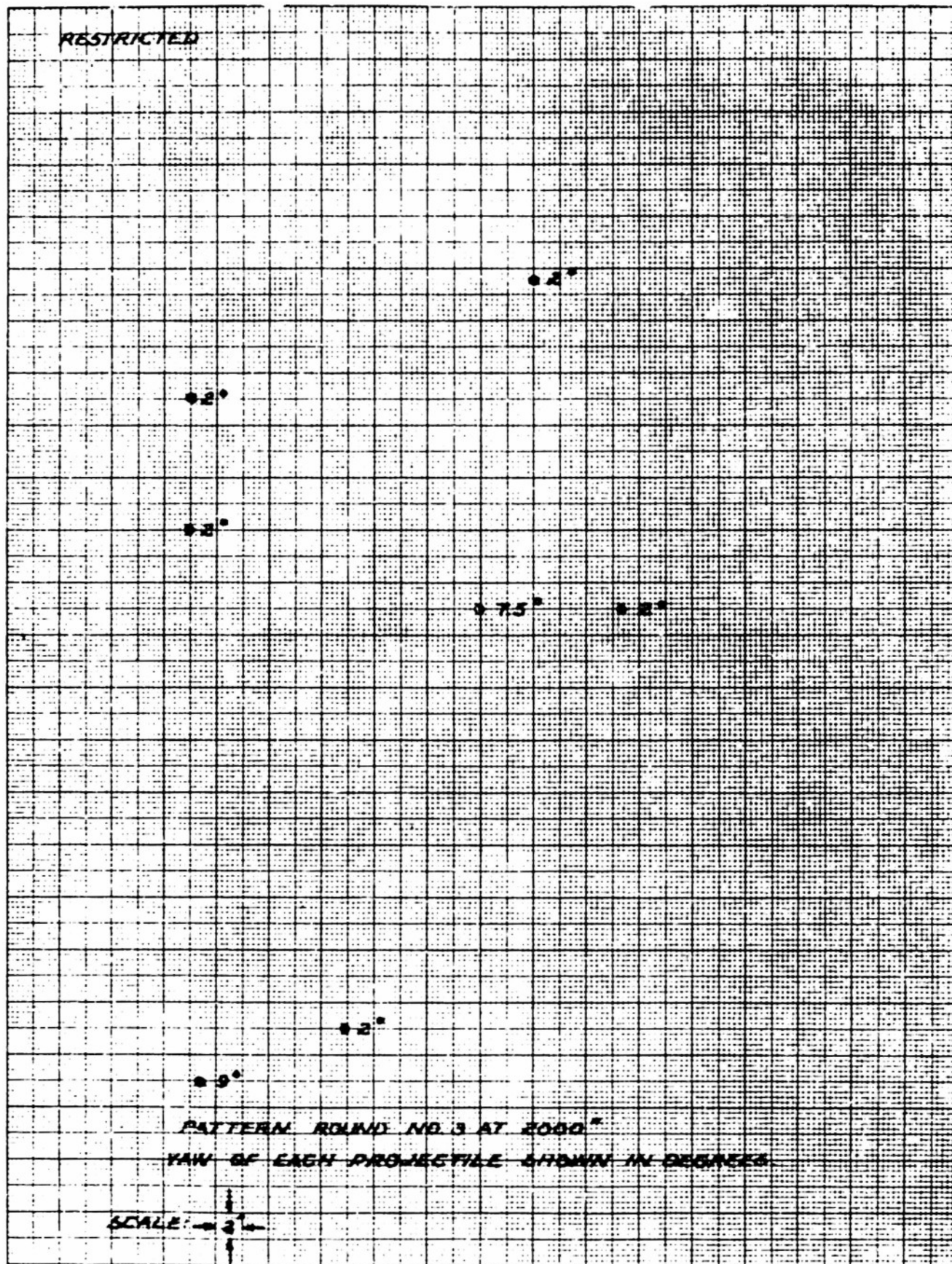


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APPENDIX C

FIGURE 18

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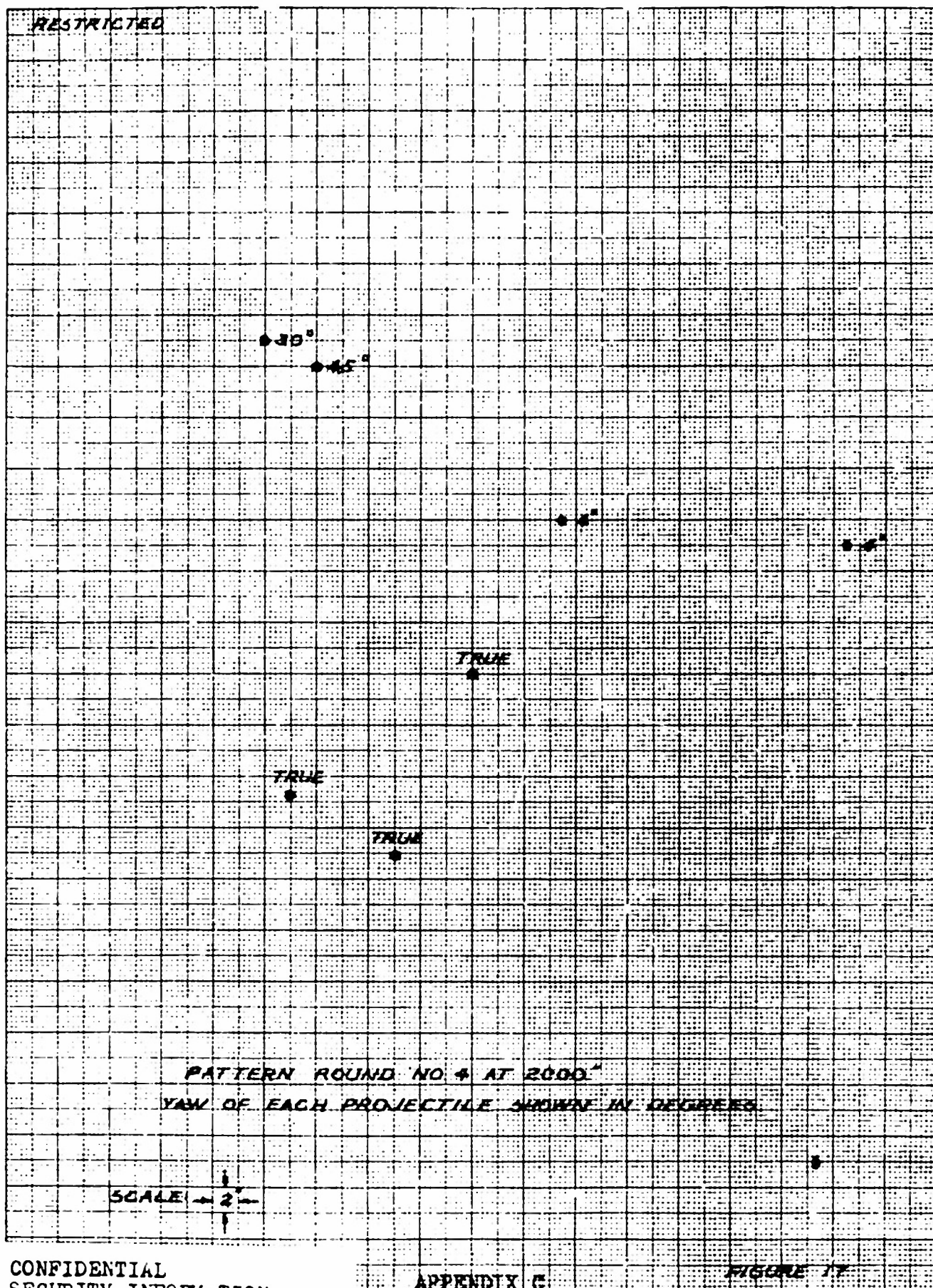


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APPENDIX C

FIGURE 10

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APPENDIX C

FIGURE 17

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4.3°

TRUE

TRUE

TRUE

4.5°

4.4°

4.2°

PATTERN ROUND NO. 5 AT 2000'
YAW OF EACH PROJECTILE SHOWN IN DEGREES

SCALE: 2"

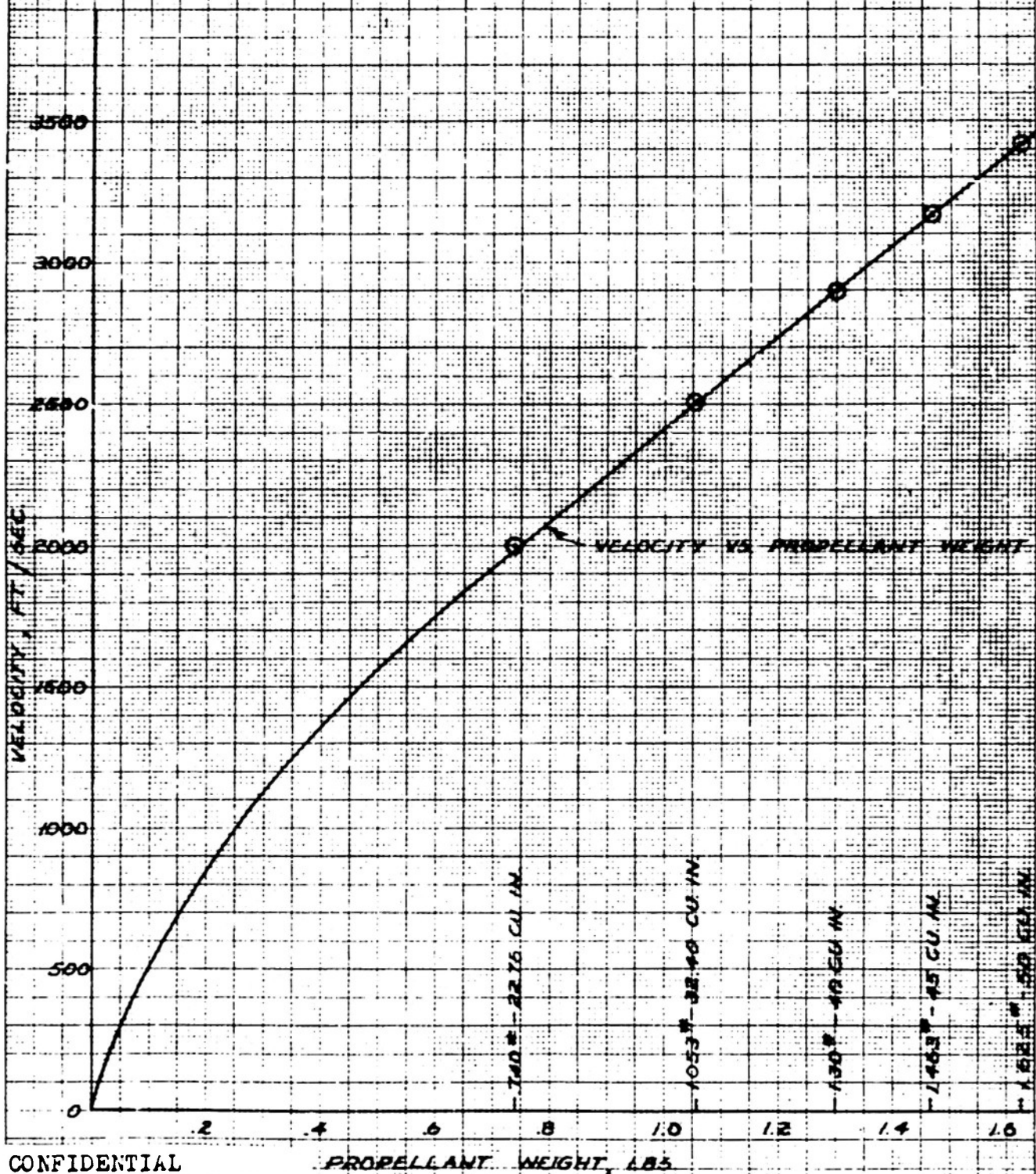
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APPENDIX C

FIGURE 10

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CONSTANT DENSITY LOADING
VOLUME VARIES WITH CHARGE WEIGHT
20 MM POWDER, INR 4903



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TABLE 1

APPENDIX D

TABLE II

FIRING RECORD

Caliber: 30mm			Type:		Prototype					
Serial: Sketch 147750			Manufacturer:		Naval Gun Factory					
5 Previous Rounds										
Date 1952	Rd. No.	Time	Temp.	Recoil	Powder Pressure		Velocity	*Action Time (milliseconds)	Remarks	
					(psi) GA #1	(psi) GA #2				
						First Projectile (at Ft)				
						(fps)				
8/4	1	1510	82°	5 7/8"	12,500	16,000	Lost	12 1/2'	Lost	Pattern and yaw, See Figure 14.
8/5	2	1050	78°	5 15/16"	10,100	11,400	2183	12 1/2'	2123	Pattern and yaw, See Figure 15.
8/5	3	1330	82°	6"	10,200	12,600	2081	70'	1913	Pattern and yaw, See Figure 16.
8/5	4	1350	82°	6 3/16"	---	---	2118	70'	3132	Center (No. 7) projectile weighted to .73 lb. Pattern and yaw, See Figure 17.
8/5	5	1420	82°	6 1/16"	---	---	2111	70'	---	Center (No. 7) projectile weighted to .74 lb. Pattern and yaw, See Figure 18.
8/19	6	1430	88°	5 3/4"	---	---	Lost	70 1/2'	---	
8/19	7	1514	90°	5 7/8"	---	---	2109	72 1/2'	---	
8/19	8	1532	92°	5 7/8"	---	---	2134	72 1/2'	---	

* Action time is time from firing impulse to emergence of first projectile.

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Seven Shot 30mm Ballistics Gun

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TABLE III

CALCULATED VELOCITIESRound No. 4Projectile Number

Velocity ft./sec. at 120'

Muzzle velocity

Velocity differential, ft./sec. from Leading Projectile

Percent of Velocity of Leading Projectile

4	3	1	6	5	2	(Weighted) 7
2144	2139	2113	2109	2084	2052	1864
2214	2209	2183	2179	2154	2122	1934
0	5	31	35	60	92	280
100	99.8	98.6	98.4	97.3	95.8	87.4

Round No. 5 (Identification difficult)Projectile Number

Velocity ft./sec. at 120'

Muzzle velocity

Velocity differential, ft./sec. from Leading Projectile

Percent of Velocity of Leading Projectile

?	1	?	2	?	?	(Weighted) 7
2142	2139	2113	2109	2084	2052	1864
2212	2209	2183	2179	2154	2122	1954
0	3	29	33	58	90	258
100	99.9	98.7	98.5	97.4	95.9	88.3

Round No. 8Projectile Number

Velocity at 13314, ft./sec.

Muzzle velocity

Velocity differential, ft./sec. from Leading Projectile

Percent of Velocity of Leading Projectile

(Not Weighted) 7	2	5	6	3	1	4
2116	2102	2075	2064	2038	2019	2016
2193	2180	2153	2141	2115	2096	2093
0	13	40	52	78	97	100
100	99.4	98.2	97.6	96.4	95.6	95.5

(NOTE: The probable error of a single velocity is ± 20 ft./sec.)CONFIDENTIAL
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APPENDIX F

Seven Shot 30mm Ballistics Gun
-----DESCRIPTION AND DISCUSSION OF THE BALLISTIC SYNCHRO CAMERA

The Ballistic Synchro Camera, with which the pictures of the 30mm projectiles were taken, operates by matching the velocity of the IMAGE of the projectile with that of a film moving behind a slit placed transversely across the film. Since the image speed is lower than the object speed by the same ratio as the image is smaller than the object, it follows that by taking a small enough picture, the image speed can be reduced to a point where it is possible to match this speed with the speed of the film. It also follows that if the film can be moved faster the ratio between object distance and image distance can be manipulated to give a larger picture. If the matching is perfect, and the projectile not spinning, a point on the projectile image will remain on the same point of the film during the time the image crosses the slit.

For a spinning projectile the cross motion of a point on the projectile surface must be limited, by the width of the slit, to an amount which will cause no more blur than can be tolerated. Calculation shows that this cross motion is only one eighth ($1/8$) of the forward motion for a projectile with a spin of one (1) turn in twenty five (25) calibers. Therefore, eight (8) times as long an exposure can be used with the Ballistic Synchro camera as would have to be used to "stop" the projectile with other types of cameras.

The size of picture which can be taken of a small object is limited by the highest speed at which the film can be transported. For a large object, the size of picture obtainable is also limited by the width of the film. The group of projectiles under consideration covers a good deal of space, which increases as it gets farther from the muzzle. It must therefore be considered as a large object, and since the individual projectiles are small, a large image is especially desirable in order to see as much detail as possible. A Ballistic Synchro Camera of the drum type, which moves a film 3.5 inches wide at a maximum speed of 1500 inches a second was therefore provided for the pictures taken 126 feet from the muzzle of the gun. This camera is equipped with a lens which has a focal length of 23.6 inches. It has an opening of $f/3.5$. The camera can therefore be placed far enough from the trajectory to be safe, and at the same time obtain a good sized image. The film speed used for the first picture was 1050 inches per second. The greater film speed possible will provide for taking pictures of projectiles which have a velocity of 3000 ft/sec at the same ratio of image to object used for this picture. (1:24)

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Seven Shot 30mm Ballistics Gun

DESCRIPTION AND DISCUSSION OF THE BALLISTIC SYNCHRO CAMERA

The picture of the projectiles emerging from the muzzle taken with a camera having a 35mm film moving at 900 inches. The focal length of the lens used on this camera was 2 inches. The maximum film speed for this camera is 1020 inches a second. The ratio of image to object for the muzzle camera was 1:28.

Since the gun was under a canopy, a rack of flash bulbs to cover the time of emergence. The light from these bulbs about 50 milliseconds, which is enough to cover the passage of projectiles through the field of view of the muzzle camera. auxiliary illumination was needed for the larger camera, although the sun was obscured by a light overcast.