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Development and Proof Services

REPORT NO. DPS TB4-005.1

AUTOMOTIVE DIVISION

REPORT ON

BALLISTIC EVALUATION OF ALUMINUM ARMOR (U)

First Report On Ordnance Project No. TB4-005

(AD-1274)

T. J. GRIFFIN

AUGUST 1959

Aberdeen Proving Ground
Maryland

DEVELOPMENT AND PROOF SERVICES
ABERDEEN PROVING GROUND
MARYLAND

AUTHORITY: ORDBA-1320
PRIORITY : 1A

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BALLISTIC EVALUATION OF ALUMINUM ALLOY ARMOR

First Report on Ordnance Project No. TB4-005

(AD-1274)

Dates of Test: March to June 1959

ABSTRACT (U)

Thirteen aluminum alloy armor plates varying in thickness from 1/2 to 1-3/4 inches were furnished by Frankford Arsenal for ballistic evaluation. Protection ballistic limits were obtained for a number of obliquity - thickness conditions with caliber .30 AP, ball, and fragment-simulating projectiles, and caliber .50 AP and ball projectiles.

CONTENTS (U)

1. (U) INTRODUCTION

Aluminum armor is not new to Ordnance. Specifications for aluminum of the 2024 type have been in existence for approximately fifteen years. These specifications are for plate of minimum weight whose purpose is to defeat and protect against shell fragments and small-arms projectiles. Unfortunately the 2024 type aluminum does not lend itself to the construction of vehicles because of the welding difficulties encountered when conventional techniques are used. Therefore weldable types of aluminum (5083) which offer good protection against fragments have been selected for the M113 full-tracked personnel carrier. This selection of aluminum over steel armor was to obtain air-transportability for this vehicle.

Ballistic tests have been conducted at several arsenals and at this Proving Ground on aluminum alloy armor which is high in magnesium content. These alloys have been primarily types 5083 and 5456. To supplement existing data Frankford Arsenal requested that ballistic limits be obtained on several thicknesses of type 5083 aluminum armor at four obliquities with several projectiles. The ballistic tests conducted on these plates are the subject of this report.

2. (U) DESCRIPTION OF MATERIEL

2.1 Material

The thirteen aluminum alloy armor plates, type 5083, furnished by Frankford Arsenal were identified as given in Table I.

Table I. Aluminum Alloy Armor Plates Furnished by Frankford Arsenal

Lot Number	Nominal Thickness, inches	Actual Thickness Taken at APG, inches	Size of Plate, inches
198211	1/2	0.530	30 by 30
008711	1/2	.517	18 by 36
008712	1/2	.522	18 by 36
183702	3/4	.794	30 by 30
734-881-1	3/4	.766	18 by 36
734-881-2	3/4	.768	18 by 36
J6293-1	1	1.02	30 by 30
J6293-2	1	a	30 by 30
M6289-4C	1-1/2	1.50	18 by 36
M6288-4A	1-1/2	1.50	18 by 36
M6285-2	1-1/2	a	18 by 36
734-871-2	1-3/4	1.77	18 by 36
734-871-3	1-3/4	a	18 by 36

[a]Plates not gaged or used in test.

2.2 Projectiles

The projectiles used are listed below:

Projectile, Fragment-Simulating, Caliber .30, weight 44 grains. hardness 29-31 Rc.
Projectile, Ball, M2, Caliber .30, weight 150 grains.
Projectile, Ball, M2, Caliber .50, weight 703 grains.
Projectile, AP, M2, Caliber .30, weight 164 grains.
Projectile, AP, M2, Caliber .50, weight 710 grains.

2.3 Rifles

The rifles used are listed below:

Rifle, Accuracy, Mann type, Caliber .30, No. 1402245.
Rifle, Accuracy, Mann type, Caliber .30, No. 1512536.
Rifle, Accuracy, .300 Magnum, Caliber .30, No. 44747.
Rifle, Accuracy, Mann type, Caliber .50, No. 22.

3. (CMH) DETAILS OF TEST

3.1 Procedure and Results

The aluminum plates were gaged for thickness prior to firing. Each plate was mounted in a rigid plate butt for testing at the desired angle of obliquity. Attempts were made to obtain one ballistic limit (protection) for each of the conditions listed in Table II.

Table II. Conditions for PBL

Thickness of Plate, inches	Projectile	Obliquity of Fire, degrees			
1/2	Cal .30 Ball	0	30	45	60
1/2	Cal .30 AP, M2	0	30	45	60
1/2	Cal .30 F.S.	0	-	-	-
3/4	Cal .30 Ball	0	30	45	60
3/4	Cal .30 AP, M2	-	-	-	60
3/4	Cal .30 F.S.	0	-	-	-
3/4	Cal .50 Ball	a	a	a	a
3/4	Cal .50 AP, M2	-	30	-	-
1	Cal .30 Ball	0	30	45	60
1	Cal .30 AP, M2	0	30	45	60
1	Cal .50 AP, M2	-	-	-	60

Table II cont'd

Thickness of Plate, inches	Projectile	Obliquity of Fire, degrees			
1-1/2	Cal .30 Ball	0	30	-	-
1-1/2	Cal .30 AP, M2	-	30	-	-
1-1/2	Cal .50 Ball	a	a	a	a
1-1/2	Cal .50 AP, M2	-	30	-	60
1-3/4	Cal .30 Ball	0	-	-	-
1-3/4	Cal .30 AP, M2	-	30	-	-
1-3/4	Cal .50 Ball	a	a	a	a
1-3/4	Cal .50 AP, M2	-	30	-	-

F.S. = Fragment-Simulating Projectile.

[a]These conditions were to be ballistically evaluated only if limited firings revealed a significant difference between the ballistic limits obtained with Cal .50 Ball, M2 and Cal .50 AP, M2 projectiles.

V_{50} ballistic limits (protection) were computed throughout the test by averaging the three lowest velocities resulting in complete penetration and the three highest velocities resulting in partial penetration with a velocity spread not exceeding 125 fps for all rounds used in the calculation. Where it was impossible to calculate a ballistic limit without exceeding the 125-fps spread the five lowest velocities resulting in complete penetration and the five highest velocities resulting in partial penetration were averaged to calculate the ballistic limit. No limit was placed on the velocity spread for this ten-round calculation.

The firing procedures and methods for determining partial and complete penetrations under the protection criterion followed those outlined in Ordnance Proof Manual pamphlets 50-30 and 50-10. For the different test conditions the gun-to-plate distances varied and were recorded in the round-by-round data sheets. On all firings with the fragment-simulating projectiles this distance was limited to approximately 30 feet or less to prevent yaw and tumbling of this blunt-nosed projectile.

The round-by-round tabulations of firing data may be found in Appendix C. A summary of the test results is given in Table III.

Table III. Summary of Test Results

Plate No.	Thickness, inches	Projectile	Obliquity, degree	Ballistic Limit (Protection), fps
Group I (1/2-inch)				
198211	0.530	Cal .30 Ball, M2	0	1564
198211	.530	Cal .30 Ball, M2	30	1903
198211	.530	Cal .30 Ball, M2	45	2173
008711	.517	Cal .30 Ball, M2	60	2715
008712	.522	Cal .30 AP, M2	0	[a]1370
008712	.522	Cal .30 AP, M2	30	1499
008712	.522	Cal .30 AP, M2	45	1731
008711	.517	Cal .30 AP, M2	60 1st	[a]2546
008712	.522	Cal .30 AP, M2	60 2nd	[a]2788
008712	.522	Cal .30 F.S.	0	2382
Group II (3/4-inch)				
734-881 (2)	.768	Cal .30 Ball, M2	0	1711
734-881 (2)	.768	Cal .30 Ball, M2	30	2292
734-881 (2)	.768	Cal .30 Ball, M2	45	2690
183701	.794	Cal .30 Ball, M2	60	3595 HP
734-881 (1)	.766	Cal .30 AP, M2	60	3196
183701	.794	Cal .30 F.S.	0	3493 HP
734-881 (1)	.766	Cal .50 Ball, M2	30	1301
734-881 (1)	.766	Cal .50 AP, M2	30	1367
Group III (1-inch)				
J6293 (1)	1.024	Cal .30 Ball, M2	0	2221
J6293 (1)	1.024	Cal .30 Ball, M2	30	2974
J6293 (1)	1.024	Cal .30 Ball, M2	45	3424
		Cal .30 Ball, M2	60	[b]
J6293 (1)	1.024	Cal .30 AP, M2	0	1995
J6293 (1)	1.024	Cal .30 AP, M2	30	2222
J6293 (1)	1.024	Cal .30 AP, M2	45	2754
J6293 (1)	1.024	Cal .30 AP, M2	60	3468 HP
J6293 (2)	1.024	Cal .50 AP, M2	60	3104 HP
Group IV (1-1/2 inch)				
H6289-4C	1.497	Cal .30 Ball, M2	0	3398
H6288-4A	1.497	Cal .30 Ball, M2	30	3427 HP
H6289-4C	1.497	Cal .30 AP, M2	30	2668
H6289-4C	1.497	Cal .50 Ball, M2	30	1942
H6288-4A	1.497	Cal .50 Ball, M2	60	2866 HP
H6289-4C	1.497	Cal .50 AP, M2	30	1915
H6288-4A	1.497	Cal .50 AP, M2	60	3116 HP

Table III cont'd

Plate No.	Thickness, inches	Projectile	Obliquity, degree	Ballistic Limit (Protection), fps
Group V (1-3/4 inch)				
734-871 (2)	1.767	Cal .30 Ball, M2	0	3485 HP
734-871 (2)	1.767	Cal .30 AP, M2	30	2834
734-871 (2)	1.767	Cal .50 Ball, M2	30	2103
734-871 (2)	1.767	Cal .50 AP, M2	30	1969

[a]Ten-round ballistic limit.
[b]Condition not fired - limit of gun reached on a thinner material.

HP - No ballistic limit obtained. High partial penetration (protection) shown.

Two ballistic limits were obtained on the 1/2-inch plates at 60° obliquity with the caliber .30, AP, M2 projectile. Twenty-eight rounds were fired on plate number 008711 and a ten-round limit was estimated to be 2546 fps with a 218-fps spread. Due to the large spread and number of rounds fired, a second limit was attempted on the same plate. Limited area prevented completion of another limit on plate 008711, therefore, a second plate, 008712, was used. The ballistic limit obtained on this plate was 2788 fps (ten-round) with a 217-fps spread.

An attempt was made to obtain a ballistic limit for each projectile obliquity - thickness condition, although the maximum safety level of the gun limited this objective. In several instances the limit of the gun was reached before complete penetrations were obtained. In another instance where no complete penetrations were reached at one obliquity, attempts were not made to determine a ballistic limit at a higher obliquity with the same projectile. It should also be noted that on some of the firings near the maximum limit of the gun the powder charge was not varied as required in the "up and down" method (see OPM 50-30, par. 3.3.2.e), for a ballistic limit which is statistically correct (see Appendix B). This condition could not be prevented without abandoning the test or exceeding the maximum safety level of the weapon. Since the velocities were spread over a 91-fps range without a change in propelling charge it is suspected that the error is small.

Some of the data generated from the firings contained in this report have been presented graphically in Figures 1 through 3.

The test plan described earlier included sample firings with caliber .50 ball ammunition to determine if there would be any difference between these ballistic limits and those taken with caliber .50 AP. Figure 1 indicates that the curves for each projectile follow one another very closely. This firing confirms earlier tests conducted at Frankford Arsenal. Due to the similarity shown in Figure 1 all conditions with caliber .50 ball were not fired.

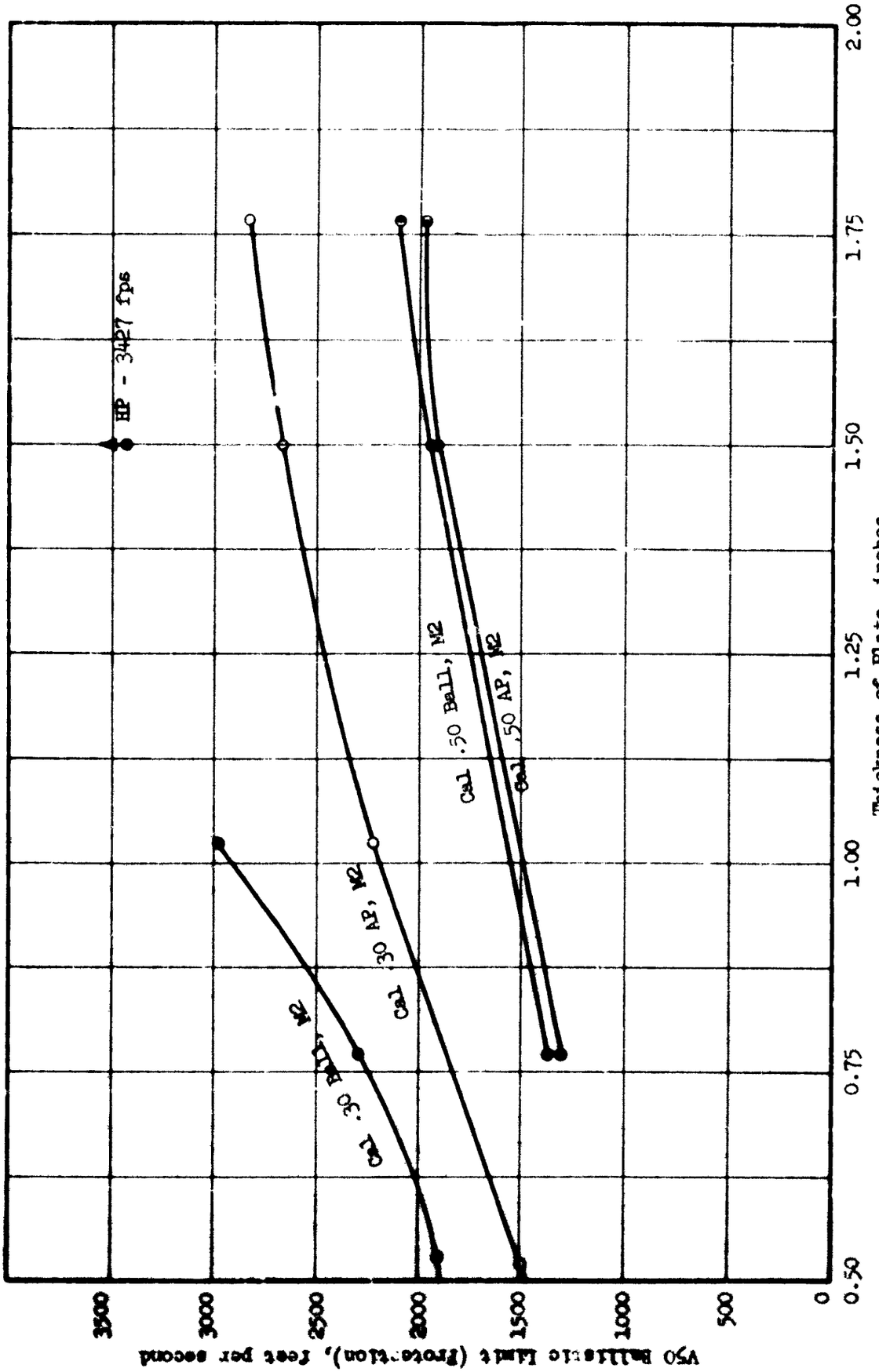

Figure 1: Comparison of Ballistic Limits Obtained on Aluminum (5083) Plate of Varying Thicknesses at 30° Obliquity.

Figure 1

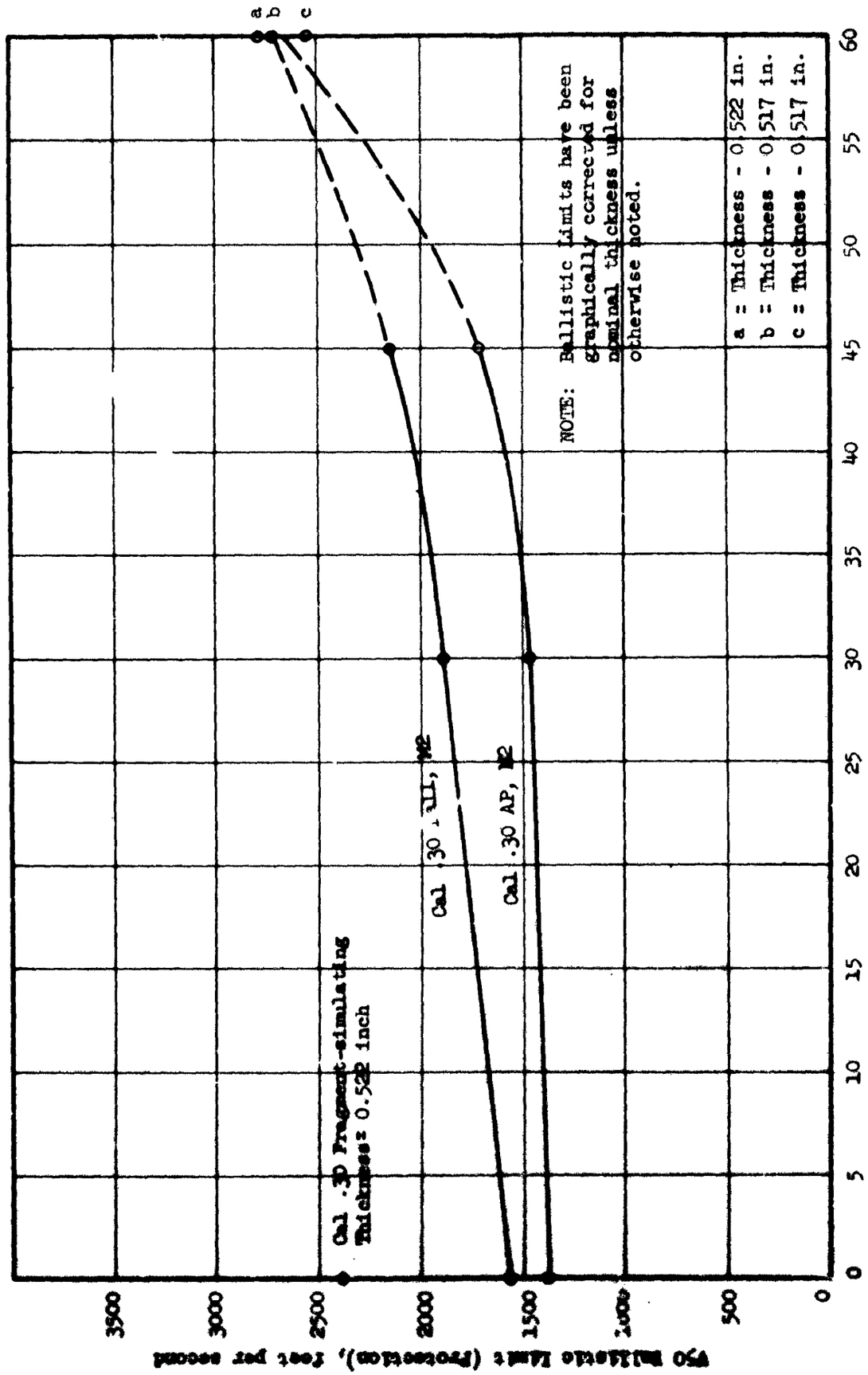

Figure 2: Ballistic Performance of One-Half Inch Aluminum (5083) Plate Against Cal .30 AP, Ball, and Fragment-Simulating Projectiles.

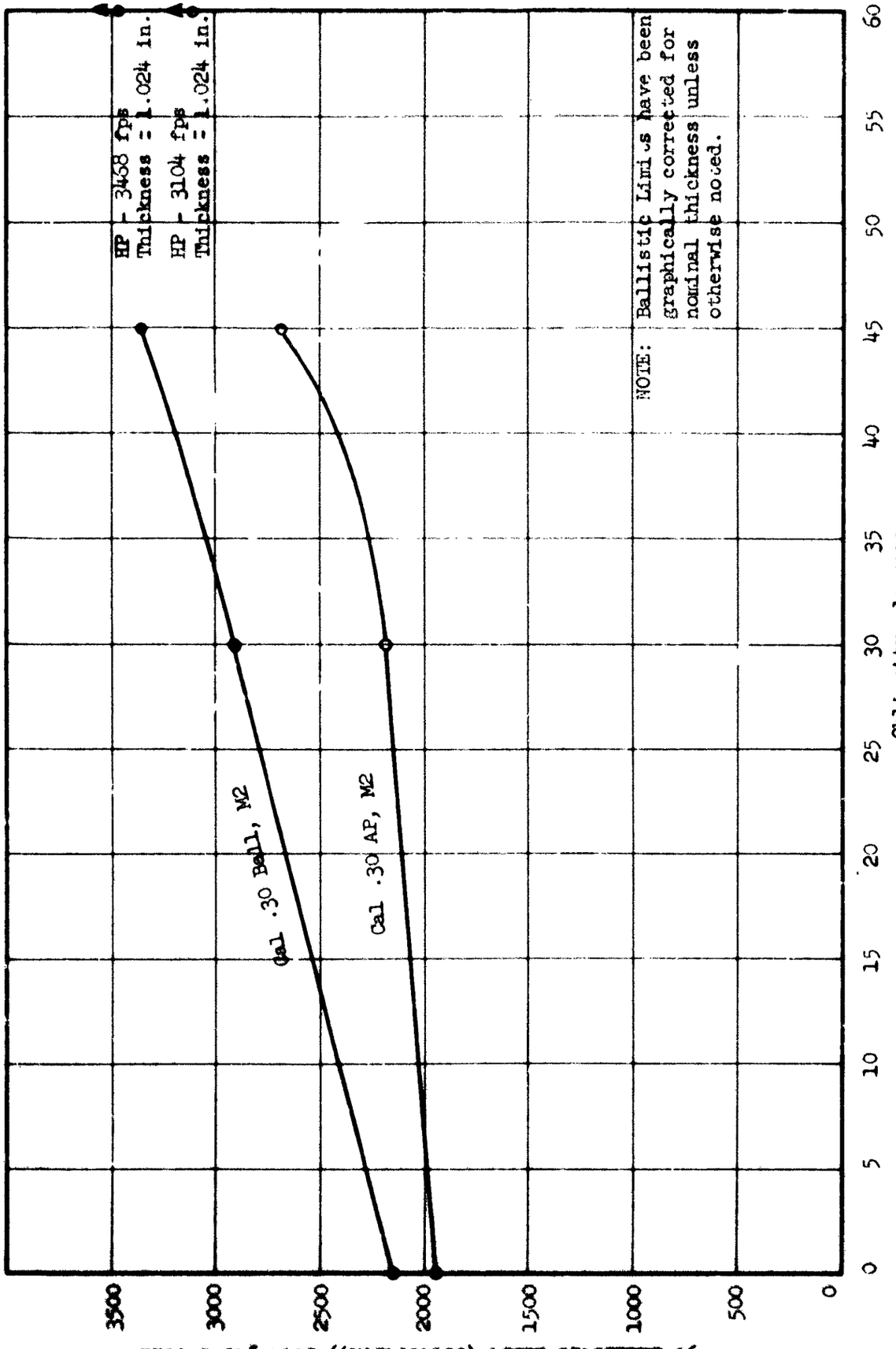

Figure 3: Ballistic Performance of One Inch Aluminum (5083) Plate Against Cal .30 AP and Ball Projectiles.

Figure 3

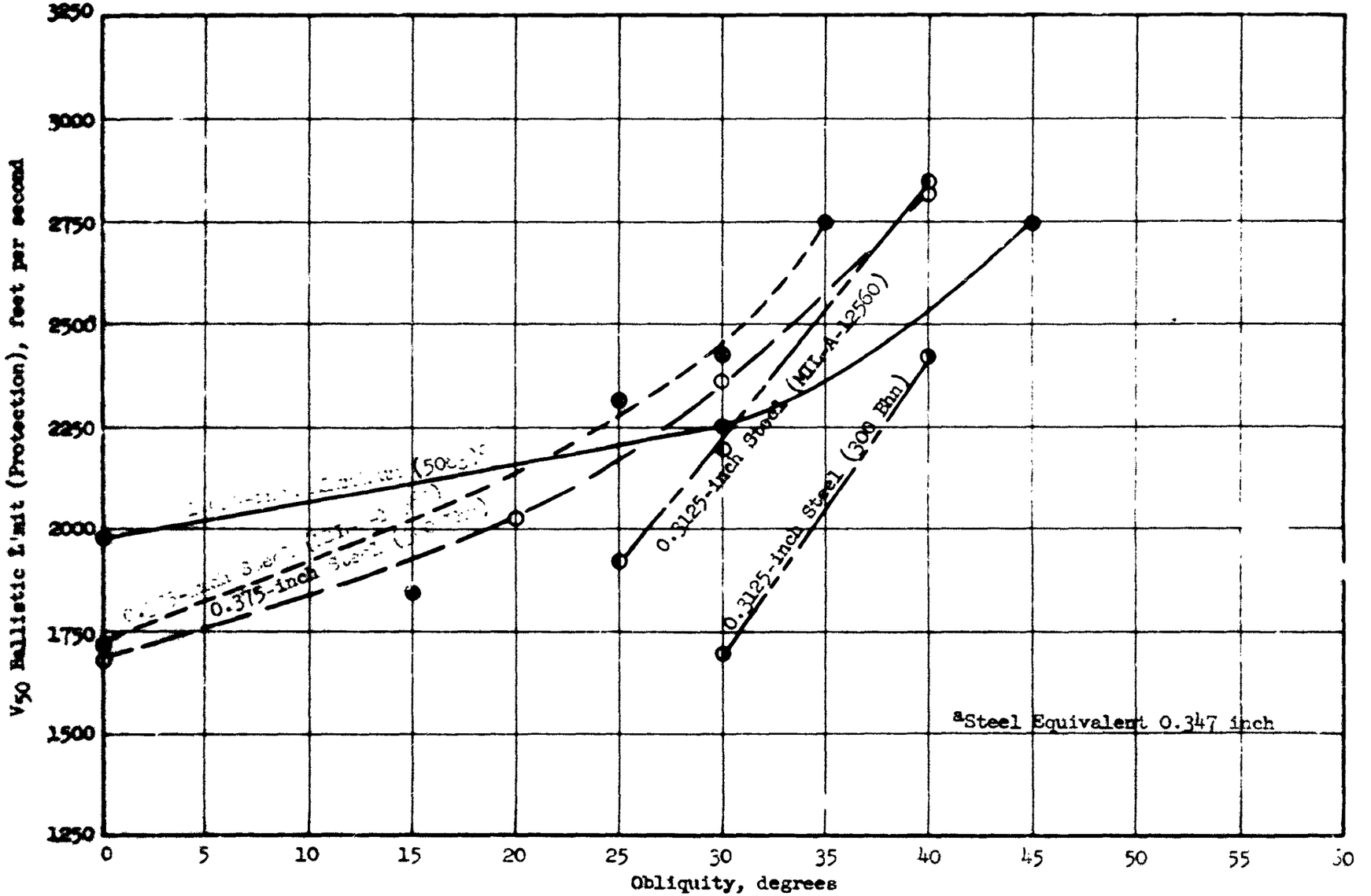

Figure 4: Ballistic Performance of Aluminum Plate (5083) and Steel (MIL-A-12560 and 300 Bhn) Against Caliber .30 AP, M2 Projectiles.

Figure 4

Figure 4 presents the performance of the aluminum alloy type 5083 with respect to approximate weights of MIL-A-12560 steel (hardness 363-401 Bhn) and 300 Bhn steel armor. The performance of the aluminum armor exceeded that for the steel up to about 25° obliquity. Insufficient data beyond 45° obliquity prevented comparison at the high obliquities. It is realized that aluminum armor primarily is considered as desirable for protection against steel fragments, but the aluminum does give a superior performance to steel at the low obliquities against caliber .30 AP projectiles.

3.2 Observations

In the course of the test it appeared that the aluminum alloy plates used in this test were not homogeneous throughout. There were instances where complete penetrations were obtained on one area of a plate at a given velocity and partial penetrations were obtained on another area at the same or slightly higher velocity. This indicated the aluminum alloy plates might not be homogeneous.

4. (CMH) CONCLUSION

It is concluded from the limited data obtained herein, that the aluminum alloy armor (type 5083) gave a superior performance to an equal weight of steel at obliquities up to 25° when attacked with caliber .30 AP projectiles.

5. (CMH) RECOMMENDATION

Although aluminum alloy armor (type 5083) is considered primarily for steel-fragment protection, ballistic data should be obtained on promising aluminum alloys with small-arms projectiles.

SUBMITTED:

T. J. GRIFFIN
Pfc, Ord Corps
Test Director

REVIEWED:

WM. C. PLESS
Chief, Armor Branch

W. A. GROSS, JR.
Chief, Automotive Division

APPROVED:

for H. A. NORIE
Assistant Deputy Director
for Engineering Testing
Development and Proof Services

APPENDICES

APPENDIX A

Correspondence

Mr. Kleppinger/mca/7120

ORDBA-1320

SUBJECT: Ballistic Tests of Aluminum Plates

TO: Commanding General
Aberdeen Proving Ground
Maryland
ATTN: D & PS, Mr. W. C. Pless

1. In accordance with the telephone conversation on 17 March 1959 between Mr. W. C. Pless of APG and Mr. D. H. Kleppinger of FA, a shipment of aluminum alloy plates will be made to APG within the next week for ballistic testing.

2. The shipment will include the following plates, each plate identifiable by a lot number:

	Number	Size of Plate	Lot Number
1/2" Thickness	1 ea.	30" x 30"	198211
	1 ea.	18" x 36"	008711
	1 ea.	18" x 36"	008712
3/4" Thickness	1 ea.	30" x 30"	183701
	1 ea.	18" x 36"	734-881-1
	1 ea.	18" x 36"	734-881-2
1-1/2" Thickness	1 ea.	18" x 36"	H6285-2
	1 ea.	18" x 36"	H5238-41
	1 ea.	18" x 36"	H5289-40
1-3/4" Thickness	1 ea.	18" x 36"	734-871-2
	1 ea.	18" x 36"	734-871-3

3. It is desired that APG personnel test these plates to obtain ballistic limits under conditions of projectile attack as listed in the following tabulation:

ORDMA-1320
SUBJECT: Ballistic Tests of Aluminum Plates

	Projectile	Obliquity of Fire			
1/2" Plate	Cal. .30 Ball	0°	30°	45°	60°
	Cal. .30 AP M2	0°	30°	45°	60°
	Cal. .30 I.S.	0°	-	-	-
3/4" Plate	Cal. .30 Ball	0°	30°	45°	60°
	Cal. .30 AP M2	-	-	-	60°
	Cal. .30 I.S.	0°	-	-	-
	Cal. .50 Ball	*	*	*	*
	Cal. .50 AP M2	-	30°	-	-
1-1/2" Thickness	Cal. .30 Ball	0°	30°	-	-
	Cal. .30 AP M2	-	30°	-	-
	Cal. .50 AP M2	-	30°	-	60°
	Cal. .50 Ball	*	*	*	*
1-3/4" Thickness	Cal. .30 Ball	0°	-	-	-
	Cal. .30 AP M2	-	30°	-	-
	Cal. .50 AP M2	-	30°	-	-
	Cal. .50 Ball	*	*	*	*

4. It will be noted that in this tabulation, firings of Cal. .50 Ball ammunition have been marked with an asterisk. It is believed from past experience that these projectiles will function essentially as AP ammunition against this target material. It is suggested that "screening" firings be made at high and low obliquity in an attempt to verify this belief. If the ballistic limits of the Cal. .50 Ball are not significantly different from the Cal. .50 AP M2 in these screenings, further firings of the Cal. .50 Ball is not warranted. The decision of whether to continue firing of the Cal. .50 Ball is left to your experience and judgement.

5. Tests of 1-inch plate mentioned in the phone conversation will be made at a later date. One-inch plate on hand at this arsenal is not representative of the quality of plate which can be produced at this time.

6. It is understood that funds for project TB4-005 from OCO are available at APG for these firings.

7. In line with the decision reached at OTAC on 4 March, firings of 1-1/4 inch plate using 20mm I.S. at 0° are in progress at this arsenal. These plates will be forwarded to APG in the next two weeks for confirmatory firings.

FOR THE COMMANDER:

R. Martens
Assistant

ORDNANCE CORPS
FRANKFORD ARSENAL
PHILADELPHIA 37,
PENNSYLVANIA

Mr.Kleppinger/mca/3120

IN REPLY
REFER TO: ORDBA-1320

SUBJECT: Ballistic Tests of Aluminum Plates

TO: Commanding General
Aberdeen Proving Ground
Maryland
ATTN: D & PS, Mr. W. C. Pless

1. In a letter dated 19 March 1959, this arsenal requested APG to ballistically test a group of aluminum alloy plates. Paragraph 5 of that letter indicated that 1 inch plates would be tested at a later date because representative quality plates were not available at that time.

2. Two plates 30" x 30" x 1" of Al-Mg alloy representing material identified by lot number J6293 have been obtained for these tests, and will be shipped to your installation within the next week.

3. It is requested that these plates be tested in accordance with the following firing schedule using available TB4-005 funding.

	Projectile	Obliquity			
1" Plate	Cal. .30 Ball	0°	30°	45°	60°
	Cal. .30 APM2	0°	30°	45°	60°
	Cal. .50 APM2	-	-	-	60°

4. It is requested that fired plates be retained for possible mechanical and metallurgical tests.

FOR THE COMMANDER:

H.P. GEORGE
Assistant

APPENDIX B
Detailed Test Data Sheets

ROUND-BY-ROUND DATA

FIRING RECORD No.

DATE: 2 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: .530" x 30' x 30"
[redacted]
Plate No. 198211
[redacted]

Projectile: Cal .30 Ball M2
Gun to 1st Screen: 60.65'
1st Screen to 2d Screen: 49.57'
2d Screen to Plate 182.07'
Obliquity: 0°
Powder: 4759
Gun No.: 1402245

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	24	1852	Disr.				
2	24	1682	Disr.				
3	24	1766	CP(P)				
4	23	1653	CP(P)				
5	22	Lost	PP(P)				
6	22	1517*	PP(P)				
7	22	1616*	CP(P)				
8	22	Lost	CP(P)				
9	22	1565*	CP(P)				
10	22	Lost	PP(P)				
11	22	Lost	PP(P)				
12	22	Lost	CP(P)				
13	22	Lost	PP(P)				
14	22	1536*	PP(P)				
15	22	1560*	PP(P)				
16	22	1656	CP(P)				
17	22	1509*	CP(P)				

*V50 Ballistic Limit (Protection) = 1564 fps
High Partial Penetration = 1560 fps
Low Complete Penetration = 1565 fps
Spread = 99 fps

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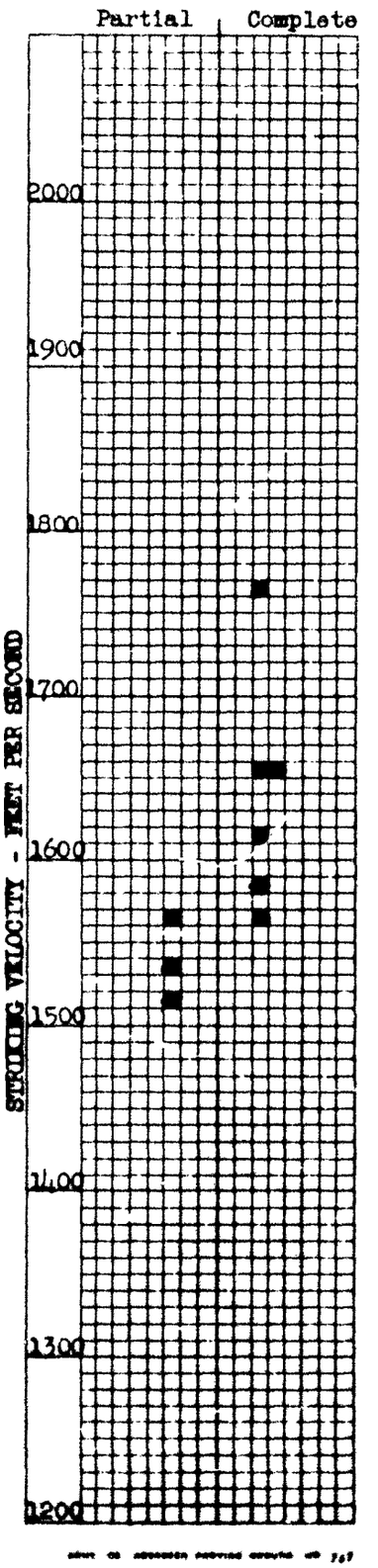


ROUND-BY-ROUND DATA

FIRING RECORD NO.

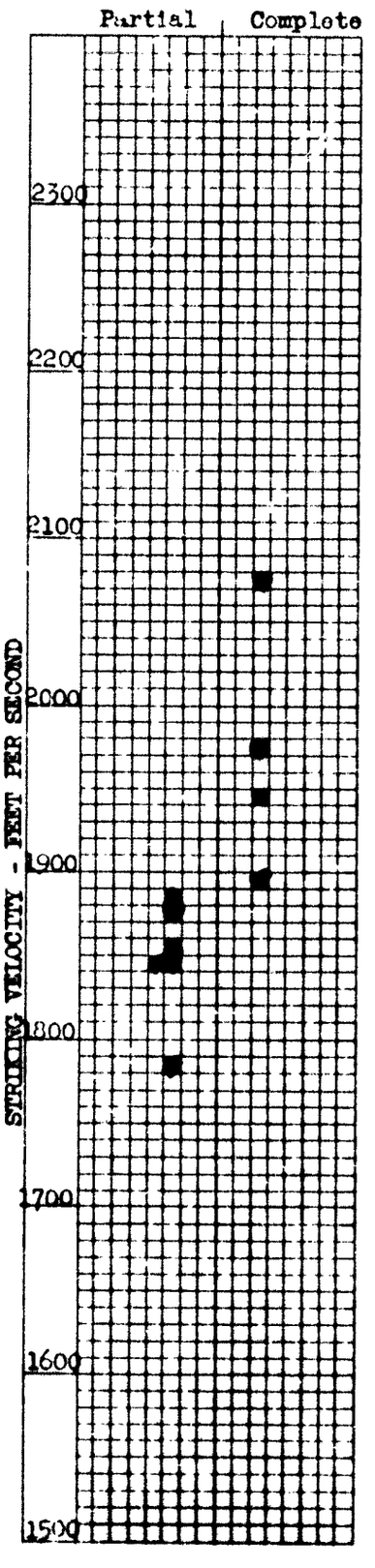
DATE: 2 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: .530" x 30" x 30"
~~Finish~~ Plate No.
~~Total Weight~~ 198211
~~Weight Ox/Fix~~

Projectile: Cal .30 Ball M2
Gun to 1st Screen: 60.65'
1st Screen to 2d Screen: 49.57'
2d Screen to Plate 183.67'
Obliquity: 30°
Powder: 4759
Gun No.: 140245

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	30	2072	CP(P)				
2	28	1970*	CP(P)				
3	26	1788	PP(P)				
4	27	1897*	CP(P)				
5	27	1845	PP(P)				
6	27	1844	PP(P)				
7	27	1899	Disr.				
8	27	1870*	PP(P)				
9	27 +	1850*	PP(P)				
10	27	1885*	PP(P)				
11	28	1935	Disr.				
12	28	1943*	CP(P)				

*V50 Ballistic Limit (Protection) = 1903 fps
High Partial Penetration = 1885 fps
Low Complete Penetration = 1897 fps
Spread = 120 fps



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MODIFIED HANDLING AUTHORIZED ROUND RESERVED

FIRING RECORD NO.

DATE: 1 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: .530" x 30" x 30"
[redacted] Plate No.
[redacted] 198211

Projectile: Cal .30 Ball M2
Gun to 1st Screen: 60.65'
1st Screen to 2d Screen: 49.57'
2d Screen to Plate 188.46'
Obliquity: 45°
Powder: 4759
Gun No.: 44747

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	25	1791	PP(P)				
2	30	1993	PP(P)				
3	34	2300	CP(P)				
4	32	Lost	CP(P)				
5	32	2166*	PP(P)				
6	32	Lost	PP(P)				
7	32	Lost	CP(P)				
8	32	Lost	CP(P)				
9	32	2181*	CP(P)				
10	32	2136*	PP(P)				
11	32	2113	PP(P)				
12	32+	2221*	CP(P)				
13	32+	2151*	PP(P)				
14	32+	2185*	CP(P)				

*V50 Ballistic Limit (Protection) = 2173 fps
High Partial Penetration = 2166 fps
Low Complete Penetration = 2181 fps
Spread = 85 fps

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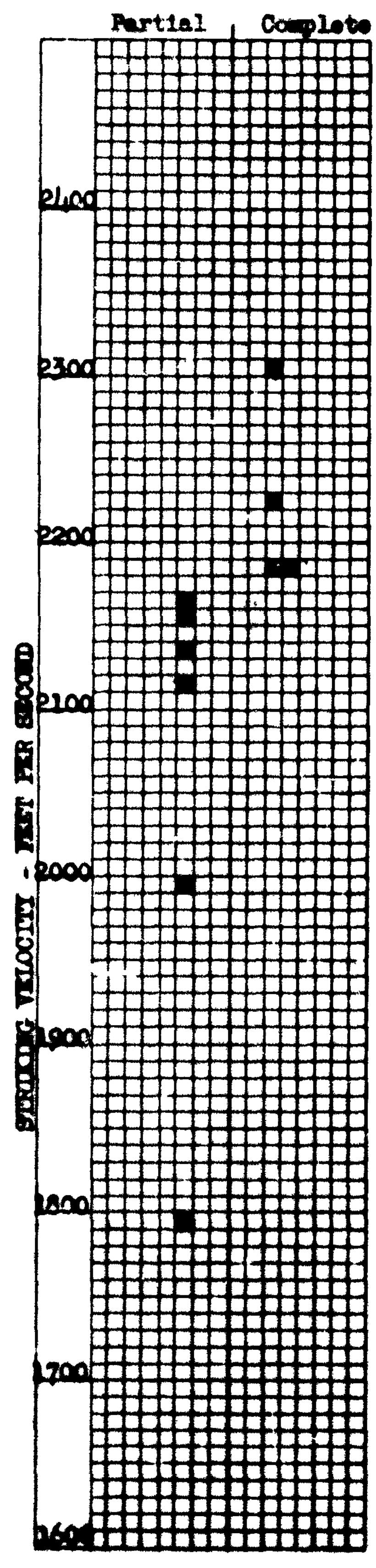

CONFIDENTIAL--MODIFIED HANDLING AUTHORIZED

MODIFIED ROUND-BY-ROUND AUTHORIZED

FIRING RECORD NO.

DATE: 1 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: .517" x 18" x 36"
[redacted] Plate No.
[redacted] 008711

Projectile: Cal .30 Ball M2
Gun to 1st Screen: 60.65'
1st Screen to 2d Screen: 49.45'
2d Screen to Plate 188.46'
Obliquity: 60°
Powder: 24664
Gun No.: 44747

Rd No.	Charge	Velocity	Result	Rd No.	Charge	Velocity	Result
	Grains	fps					
1	58	2702	Disp.				
2	58	2554	PP(P)				
3	62	Lost	CP(P)				
4	60	Lost	PP(P)				
5	60	2617	PP(P)				
6	61	2715*	PP(P)				
7	62	2797	CP(P)				
8	61	2761*	CP(P)				
9	61	2695*	CP(P)				
10	61	2678*	PP(P)				
11	61	2665*	PP(P)				
12	61	2775*	CP(P)				

*V50 Ballistic Limit (Protection) = 2715 fps
High Partial Penetration = 2715 fps
Low Complete Penetration = 2695 fps
Spread = 110 fps

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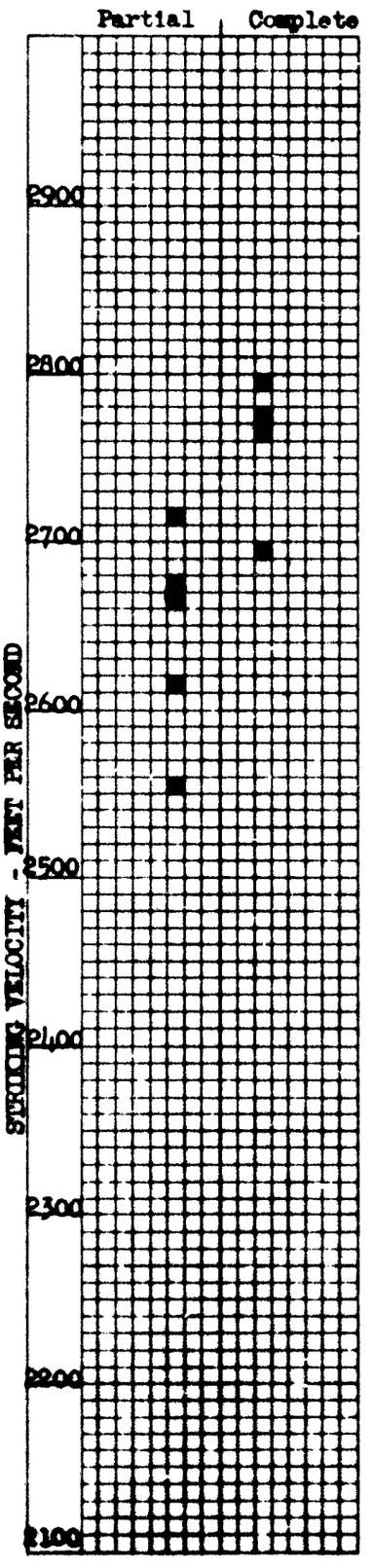

ROUND-BY-ROUND DATA

FIRING RECORD NO.

DATE: 31 March 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: .522" x 18" x 36"
Plate No. 008712

Projectile: Cal .30 AP M2
Gun to 1st Screen: 23.83'
1st Screen to 2d Screen: 32.62'
2d Screen to Plate 235.83'
Obliquity: 0°
Powder: 4759
Gun No.: 1402245

Rd No.	Charge	Velocity	Result	Rd No.	Charge	Velocity	Result
	Grains	fps					
1	16	1129	PP(P)				
2	22	1535	CP(P)				
3	20	1383*	CP(P)				
4	18	1282*	CP(P)				
5	19	1342*	PP(P)				
6	20	1487*	CP(P)				
7	19	1362*	CP(P)				
8	19	1427*	CP(P)				
9	18	1253	PP(P)				
10	19	1284*	PP(P)				
11	20	1465*	PP(P)				
12	19	1331*	PP(P)				
13	19.5	1339*	PP(P)				

*V50 Ballistic Limit (Protection) = 1370 fps
High Partial Penetration = 1465 fps
Low Complete Penetration = 1282 fps
Spread = 205 fps

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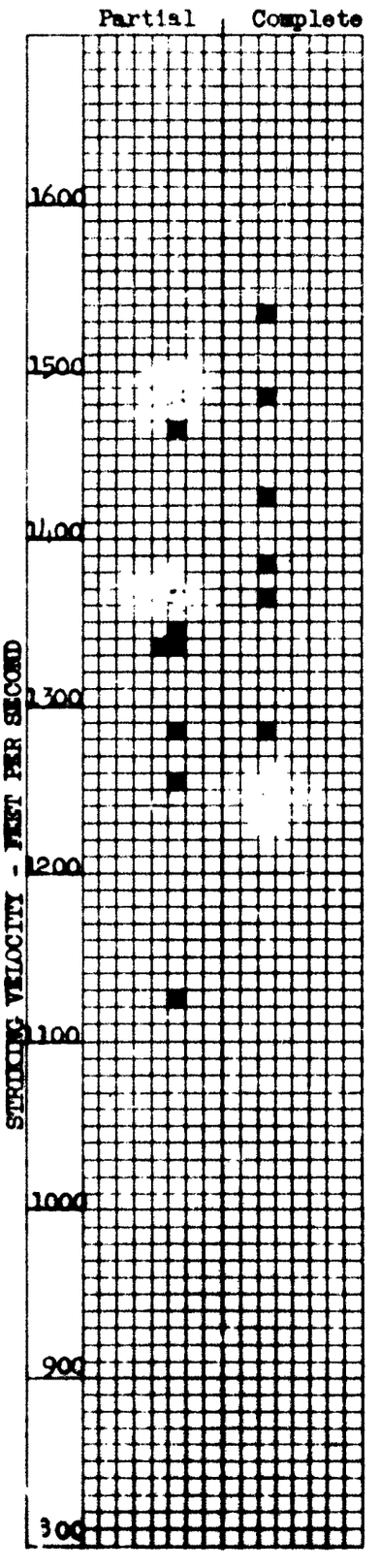


MODIFIED ROUND-BY-ROUND AUTHORIZED

FIRING RECORD NO.

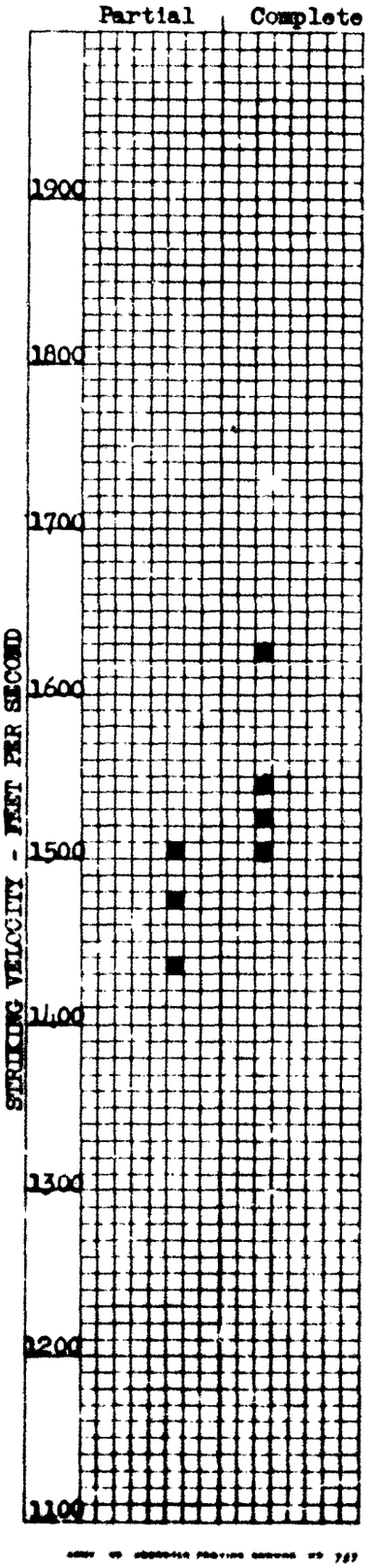
DATE: 31 March 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: .522" x 18" x 36"
[redacted] Plate No. 008712

Projectile: Cal .30 AP M2
Gun to 1st Screen: 25.83'
1st Screen to 2d Screen: 32.62'
2d Screen to Plate 237.43'
Obliquity: 30°
Powder: 4759
Gun No.: 1402245

Rd No.	Charge	Velocity	Result	Rd No.	Charge	Velocity	Result
	Grains	fps					
1	22	1625	CP(P)				
2	21	1442*	PP(P)				
3	21 +	1502*	CP(P)				
4	21 +	1508*	PP(P)				
5	21	1475*	PP(P)				
6	22 -	1540*	CP(P)				
7	22 -	1529 *	CP(P)				

*V50 Ballistic Limit (Protection) = 1499 fps
High Partial Penetration = 1508 fps
Low Complete Penetration = 1502 fps
Spread = 92 fps



CONFIDENTIAL
MODIFIED HANDLING AUTHORIZED

MODIFIED-BY-ROUND DATA AUTHORIZED FIRING RECORD NO.

DATE: 31 March 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: .522" x 18" x 36"
[redacted] Plate No.
[redacted] 008712

Projectile: Cal .30 AP M2
Gun to 1st Screen: 23.83'
1st Screen to 2d Screen: 32.62'
2d Screen to Plate 240.48'
Obliquity: 45°
Powder: 4759
Gun No.: 1402245

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	24	1730	Dist.				
2	24	1559	PP(P)				
3	24	1719*	PP(P)				
4	25	1716*	CP(P)				
5	25	1678*	PP(P)				
6	26	1874	CP(P)				
7	25	1780*	CP(P)				
8	25-	1698*	PP(P)				
9	25+	1797*	CP(P)				

*V50 Ballistic Limit (Protection) = 1731 fps
High Partial Penetration = 1719 fps
Low Complete Penetration = 1716 fps
Spread = 119 fps

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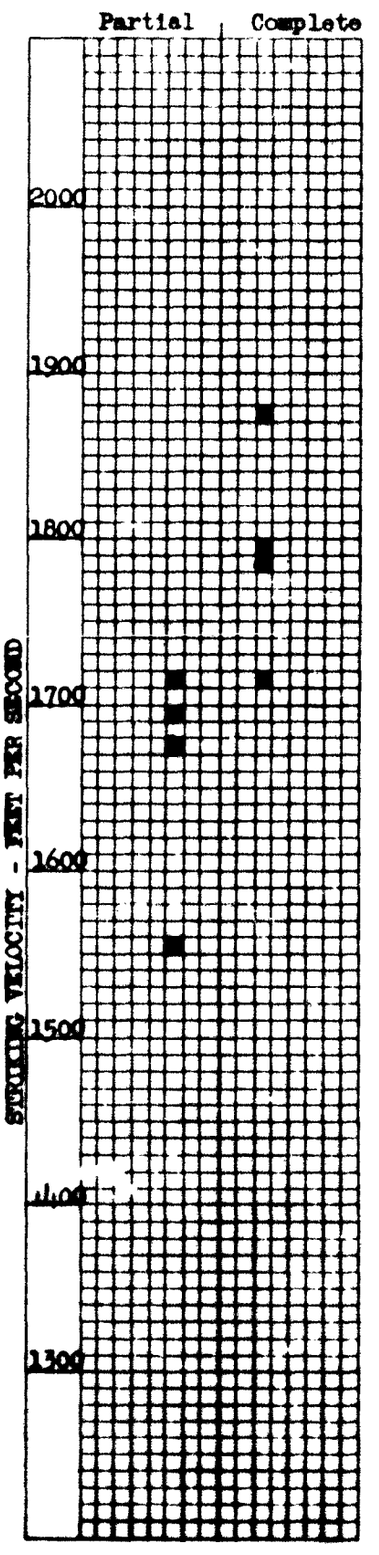


MODIFIED ROUND-BY-ROUND DATA

FIRING RECORD NO.

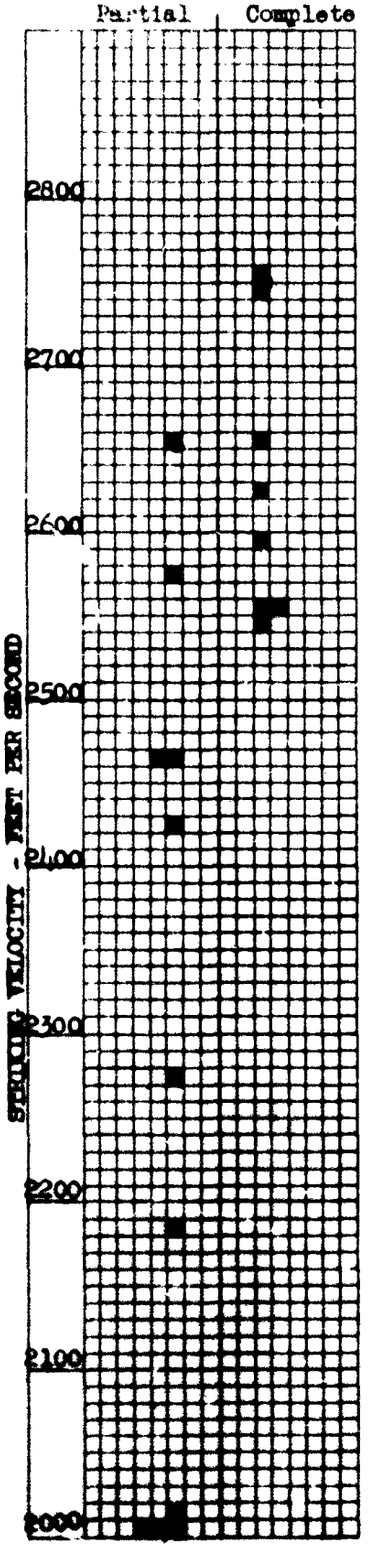
DATE: 31 March - 1 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: .517" x 18" x 36"
Pl. No. 008711

Projectile: Cal .30 AP, M2
Gun to 1st Screen: 23.83'
1st Screen to 2d Screen: 32.62'
2d Screen to Plate 242.23'
Obliquity: 60°
Powder: 4759 - 24664
Gun No.: 1402245 - 44747

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge Grains	Velocity fps	Result
1	27	1941	PP(P)	16	61	2753	CP(P)
2	28	1926	PP(P)	17	60	2711	Dis.
3	29	2016	Dis.	18	59	2627*	CP(P)
4	29	1973	PP(P)	19	58	Lost	CP(P)
5	32	2186	PP(P)	20	58	2550*	CP(P)
6	36	2270	PP(P)	21	58	Lost	PP(P)
7	38.5	2421*	PP(P)	22	58	2590	Dis.
8	40	Lost	PP(P)	23	58	2558*	CP(P)
CHANGED GUN TO .300 MAGNUM NO. 44747				24	58	2595*	CP(P)
9	58	2469*	PP(P)	25	58	Lost	PP(P)
10	62	2916	Dis.	26	58	2462*	PP(P)
11	62	2746	CP(P)	27	58	2546*	CP(P)
12	60	2656*	PP(P)	28	58	2577*	PP(P)
13	61	Lost	PP(P)				
14	61	2653	CP(P)				
15	62	2748	Dis.				

*V50 Ballistic Limit (Protection) = 2546 fps
High Partial Penetration = 2656 fps
Low Complete Penetration = 2546 fps
Spread = 235 fps



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ROUND-BY-ROUND DATA

FIRING RECORD NO.

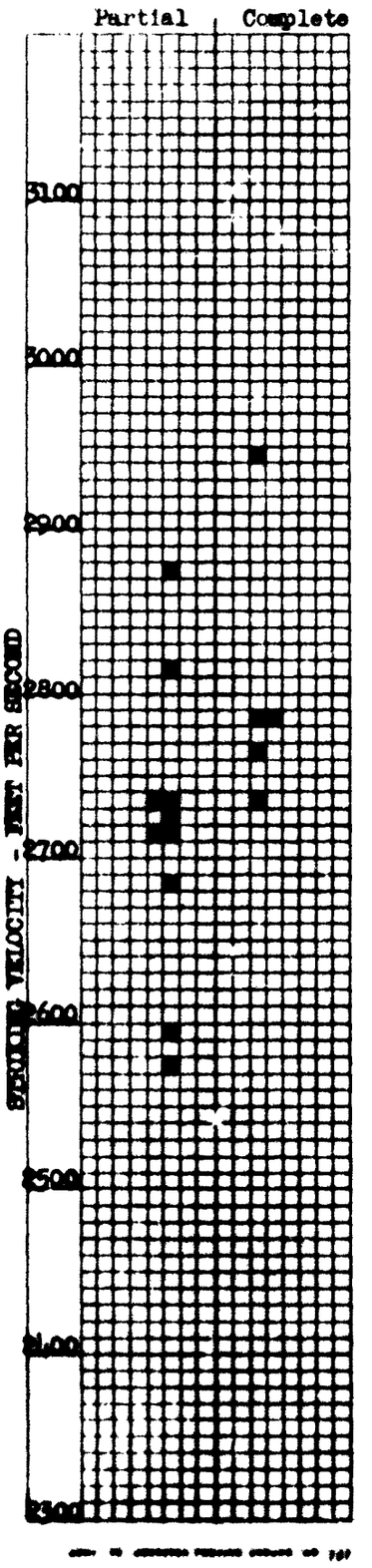
DATE: 24 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: .522" x 18" x 36"
[redacted] Pl. No. 008712

Projectile: Cal .30 AP, M2
Gun to 1st Screen: 8.07'
1st Screen to 2d Screen: 11.92'
2d Screen to Plate 16.35'
Obliquity: 60°
Powder: 24664
Gun No.: 44747

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	58	2942*	CP(P)				
2	56	2782*	CP(P)				
3	53	2593	PP(P)				
4	54	2764*	CP(P)				
5	53	2571	PP(P)				
6	54	Lost	PP(P)				
7	54	2688	PP(P)				
8	54	2738*	PP(P)				
9	54	2719	PP(P)				
10	55	2713	PP(P)				
11	55	2732*	PP(P)				
12	56	2870*	PP(P)				
13	56	2815*	PP(P)				
14	56	2725*	PP(P)				
15	56	2782*	CP(P)				
16	56	2738*	CP(P)				

*V50 Ballistic Limit (Probection) = 2788 fps
High Partial Penetration = 2870 fps
Low Complete Penetration = 2732 fps
Spread = 217 fps



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ROUND-BY-ROUND DATA

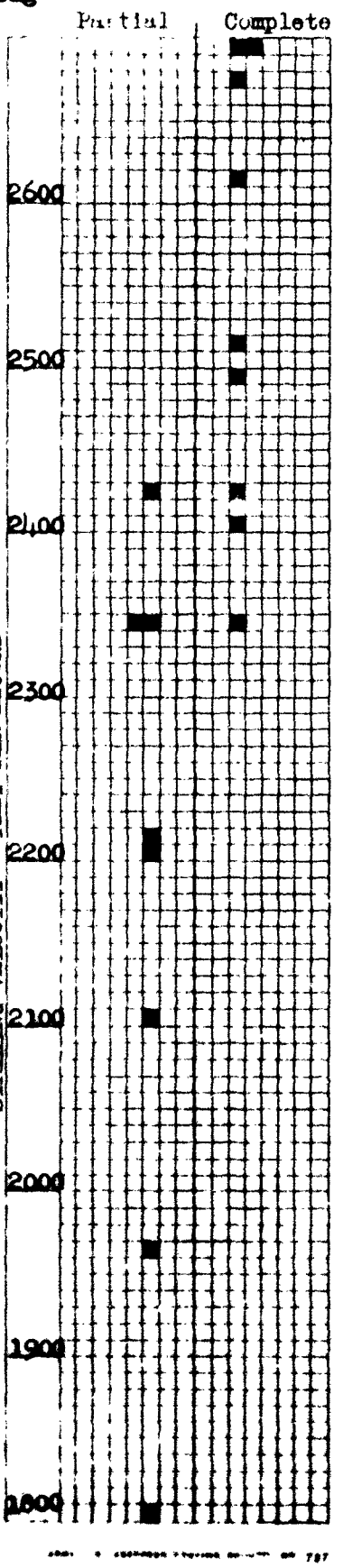
DATE: 13 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: .522"x18"x36"
[redacted] Pl. No. 008712
[redacted]

Projectile: Cal .30 Fragment-Simulating
Gun to 1st Screen: 11.66'
1st Screen to 2d Screen: 10.02'
2d Screen to Plate 9.00'
Obliquity: 0°
Powder: 4759
Gun No.: 1402245

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge Grains	Velocity	Result
1	40	3465	CP(P)	17	22	2409*	CP(P)
2	30	3037	CP(P)	18	22	2378	Dis.
3	25	2678	CP(P)	19	22	2427*	CP(P)
4	20	1967	PP(P)				
5	22	2611	CP(P)				
6	20	2214	PP(P)				
7	21	2427*	PP(P)				
8	21	2343*	CP(P)				
9	21	2204	PP(P)				
10	21	2109	PP(P)				
11	22	2499	CP(P)				
12	22	2513	CP(P)				
13	21	1551	PP(P)				
14	21	2214	Dis.				
15	22	2343*	PP(P)				
16	22	2343*	PP(P)				

*V50 Ballistic Limit (Protection) = 2382 fps
High Partial Penetration = 2427 fps
Low Complete Penetration = 2343 fps
Spread = 84 fps



ROUND-BY-ROUND DATA

FIRING RECORD

DATE: 2 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: .768" x 18" x 36"
[redacted] Pl. No. 734-881(2)

Projectile: Cal .30 Ball M2
Gun to 1st Screen: 60.65'
1st Screen to 2d Screen: 49.57'
2d Screen to Plate 182.07'
Obliquity: 0°
Powder: 4759
Gun No.: 1402245

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	30	2103	CP(P)				
2	27	1933	CP(P)				
3	25	1677*	PP(P)				
4	26	1799	Dis.				
5	26	1808	CP(P)				
6	25 +	1899	CP(P)				
7	25 +	1814	CP(P)				
8	26	1830	CP(P)				
9	25	1807	CP(P)				
10	25	1694*	PP(P)				
11	25	1799*	CP(P)				
12	25	1699*	CP(P)				
13	25	1681	Dis.				
14	25	Lost	CP(P)				
15	25	1701*	CP(P)				
16	25	1694*	PP(P)				

*V50 Ballistic Limit (Protection) = 1711 fps
High Partial Penetration = 1694 fps
Low Complete Penetration = 1699 fps
Spread = 22 fps

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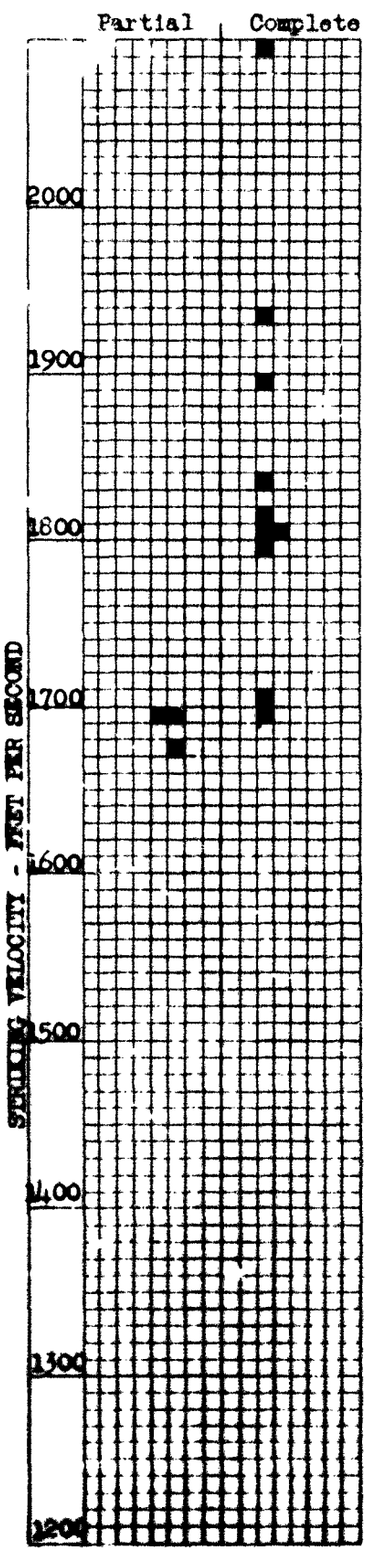


ROUND-BY-ROUND DATA

FIRING RECORD No.

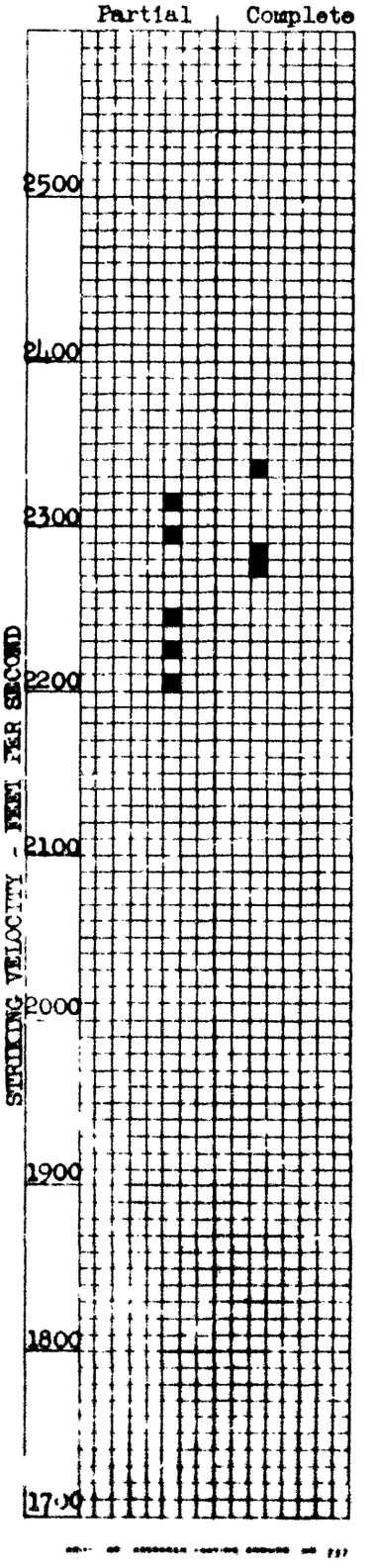
DATE: 2 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: .768"x18"x36"
[redacted] Pl. No.
[redacted] 734-881(2)
[redacted]

Projectile: Cal..30 Ball M2
Gun to 1st Screen: 60.65'
1st Screen to 2d Screen: 49.57'
2d Screen to Plate 183.67'
Obliquity: 30°
Powder: 4759
Gun No.: 1402245

Rd No.	Charge grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	30	Lost	PP(P)				
2	32	Lost	PP(P)				
3	34	Lost	CP(P)				
4	34	Lost	CP(P)				
5	34	2324	Dist.				
6	33	2222	PP(P)				
7	34	2338*	CP(P)				
8	34	2202	PP(P)				
9	34	2248*	PP(P)				
10	34	2287	Dist.				
11	34	2292*	PP(P)				
12	34 +	2275*	CP(P)				
13	34 +	2313*	PP(P)				
14	34 +	2285*	CP(P)				

*V50 Ballistic Limit (Protection = 2292 fps
High Partial Penetration = 2313 fps
Low Complete Penetration = 2275 fps
Spread = 90 fps



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ROUND-BY-ROUND DATA

FIRING RECORD NO.

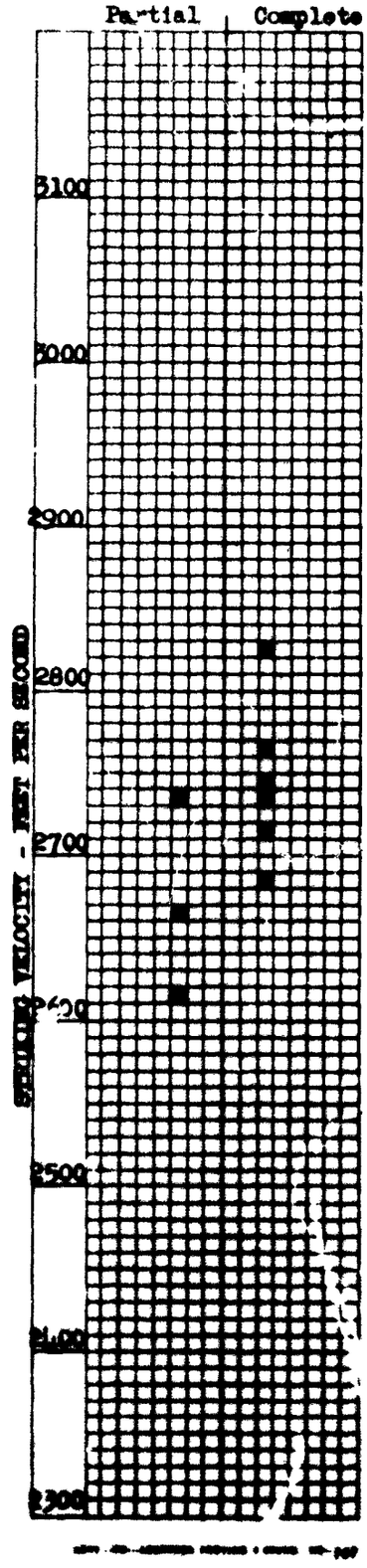
DATE: 3 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: .768" x 18" x 36"
[redacted] Pl. No. 734-881 (2)
[redacted]

Projectile: Cal .30 Ball, M2
Gun to 1st Screen: 60.65'
1st Screen to 2d Screen: 49.57'
2d Screen to Plate 187.07'
Obliquity: 45°
Powder: 4759 - 24664
Gun No.: 1402245 - 44747

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	40	2614*	PP(P)				
CHANGED GUN TO 300 MAGNUM NO. 44747							
2	62	2822	CP(P)				
3	60	2666*	PP(P)				
4	61	2683*	CP(P)				
5	61	2730*	PP(P)				
6	61	2736*	CP(P)				
7	61	2748	CP(P)				
8	61	2760	CP(P)				
9	60	2713*	CP(P)				

*V50 Ballistic Limit (Protection) = 2690 fps
High Partial Penetration = 2730 fps
Low Complete Penetration = 2683 fps
Spread = 122 fps



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ROUND-BY-ROUND DATA

FIRING RECORD NO.

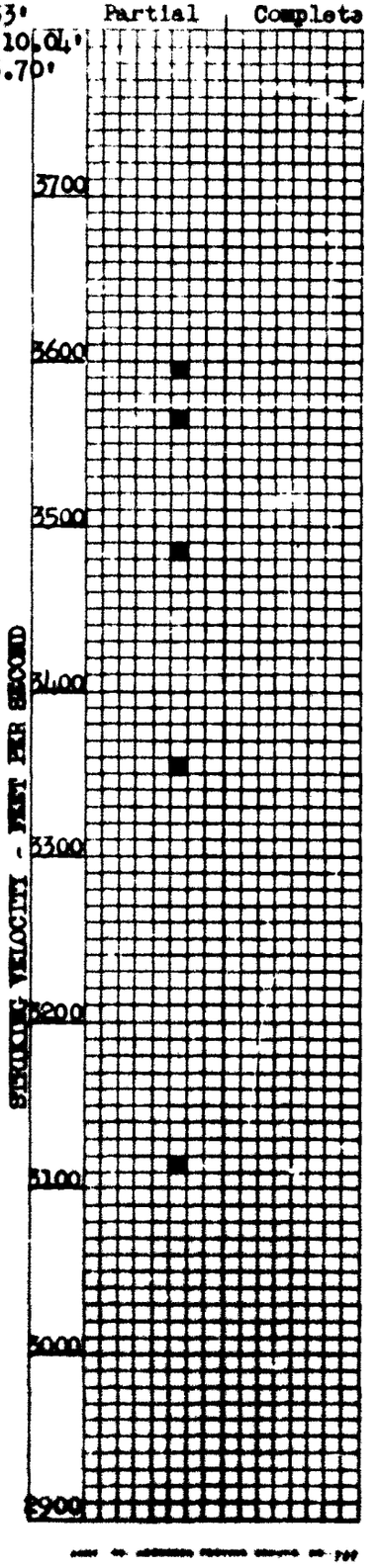
DATE: 3 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: .766" x 18" x 36"
[redacted] Pl. No. 734-881(1)
[redacted]

Projectile: Cal .30 Ball, M2
Gun to 1st Screen: 60.65' 11.53'
1st Screen to 2d Screen: 49.57' - 10.04'
2d Screen to Plate 188.46' - 15.70'
Obliquity: 60°
Powder: 24664
Gun No.: 44747

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	70	3123	PP(P)				
CHANGED DISTANCES, NEW PLATE NO. 183701, SIZE .794"x30"x30"							
2	70	3352	PP(P)				
3	72	3481	PP(P)				
4	74	3569	PP(P)				
5	75	3595	PP(P)				

No Ballistic Limit obtained
High Partial Penetration = 3595 fps



ORDBG-1303 (Rev) 3 Dec 52

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ROUND-BY-ROUND DATA

FIRING RECORD NO.

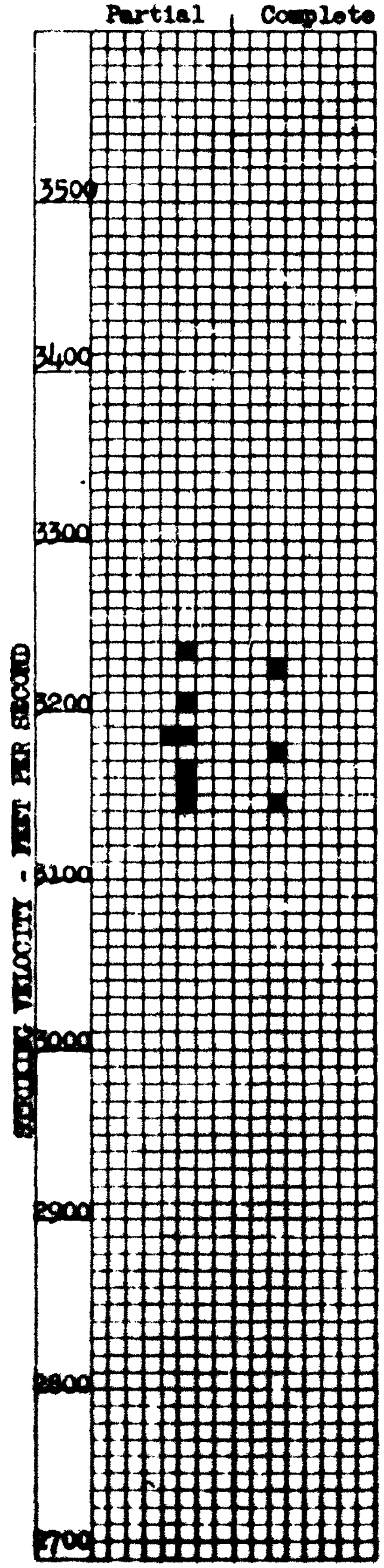
DATE: 3 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: .766" x 18" x 36"
[illegible] Plate No.
[illegible] 734-881(1)
[illegible]

Projectile: Cal .30 AP M2
Gun to 1st Screen: 60.65'
1st Screen to 2d Screen: 49.57'
2d Screen to Plate 188.46'
Obliquity: 60°
Powder: 24664
Gun No.: 44747

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	70	Lost	Disr.				
2	70	3219	Disr.				
3	70	3203	PP(P)				
4	70	3175*	CP(P)				
5	70	3142*	CP(P)				
6	70	3146	PP(P)				
7	70	3168	PP(P)				
8	70	3152	PP(P)				
9	70 +	3181	PP(P)				
10	70 +	3189*	PP(P)				
11	70 ++	3233*	PP(P)				
12	70 ++	3218*	PP(P)				
13	70 ++	3224*	CP(P)				

*V50 Ballistic Limit (Protection) = 3196 fps
High Partial Penetration = 3233 fps
Low Complete Penetration = 3142 fps
Spread = 91 fps



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ROUND-BY-ROUND DATA

FIRING RECORD NO.

DATE: 10 April 1959

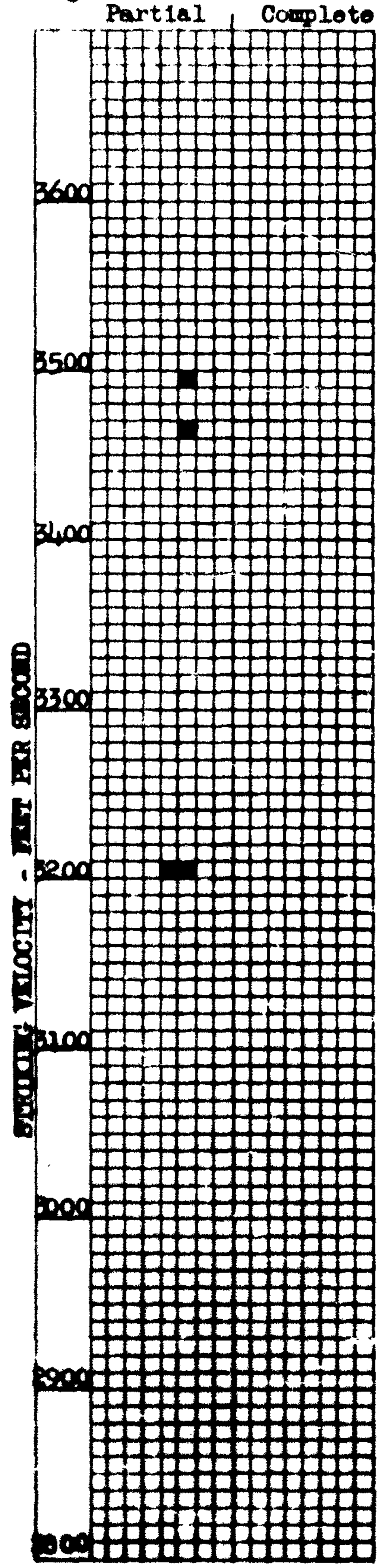
Material: Al[illegible]um
Submitted by: [illegible]ford Ars.
Type of Test: Development
Size: .794" x 30" x 30"
[redacted] Pl. No.
[redacted] 183701
[redacted]

Projectile: Cal .30 Fragment-Simulating
Gun to 1st Screen: 11.65'
1st Screen to 2d Screen: 10.03'
2d Screen to Plate 8.93'
Obliquity: 0°
Powder: 4759 - 24664
Gun No.: 1402245 - 44747

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	40	3493	PP(P)				
2	40	3467	PP(P)				
CHANGED GUN TO .300 MAGNUM NO. 44747							
3	60	Lost	PP(P)				
4	65	3206	PP(P)				
5	70	3206	PP(P)				

No Ballistic Limit obtained
High Partial Penetration = 3493 fps

Partial | Complete



(ORDC 303 (Rev) 2 Dec 52)

MODIFIED ROUND-BY-ROUND DATA AUTHORIZED

FIRING RECORD NO.

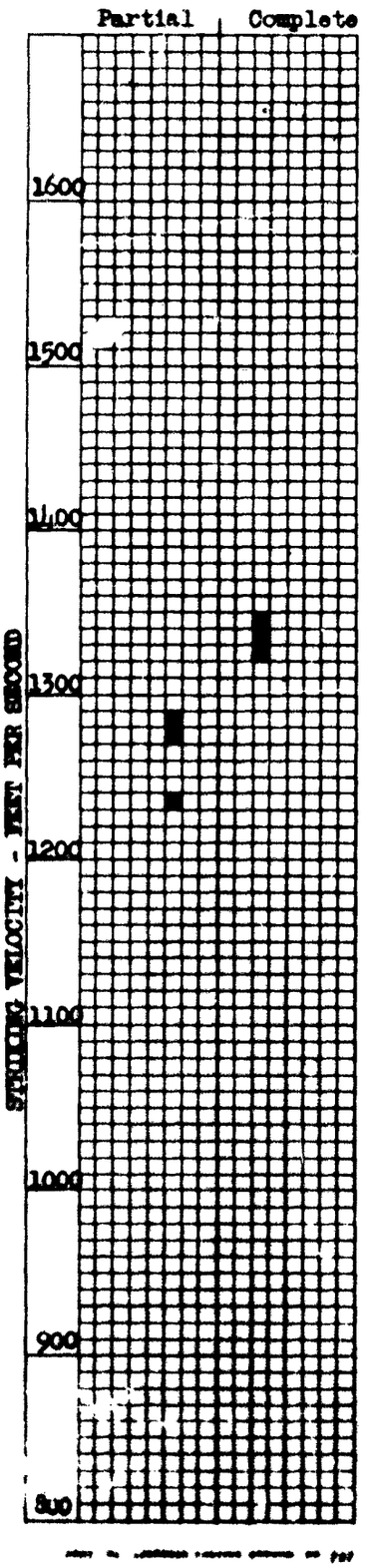
DATE: 7 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: .766" x 18" x 36"
[redacted] Plate No.
[redacted] 734-881 (1)
[redacted]

Projectile: Cal .50 AP M2
Gun to 1st Screen: 60.63'
1st Screen to 2d Screen: 49.71'
2d Screen to Plate 183.29'
Obliquity: 30°
Powder: 35683
Gun No.: 22

Rd No.	Charge	Velocity	Result	Rd No.	Charge	Velocity	Result
	Grains	Fps					
1	80	1347*	CP(P)				
2	70	1214	Disr.				
3	75	1275*	PP(P)				
4	80	1335*	CP(P)				
5	75	1283*	PP(P)				
6	75	1238*	PP(P)				
7	80	1328*	CP(P)				

*V50 Ballistic Limit (Protection) = 1301 fps
High Partial Penetration = 1283 fps
Low Complete Penetration = 1328 fps
Spread = 109 fps



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ROUND-BY-ROUND DATA

FIRING RECORD NO.

DATE: 7 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: .766" x 18" x 36"
[redacted] Plate No.
[redacted] 734-881(1)
[redacted]

Projectile: Cal .50 Ball M2
Gun to 1st Screen: 60.63'
1st Screen to 2d Screen: 49.71'
2d Screen to Plate 183.29'
Obliquity: 30°
Powder: 35683
Gun No.: 22

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	100	1603	Disr.				
2	90	1461	CP(P)				
3	70	1234	Disr.				
4	70	1236	PP(P)				
5	80	Lost	PP(P)				
6	80	1340	Disr.				
7	80	1316*	PP(P)				
8	85	1404	Disr.				
9	85	1351*	PP(P)				
10	88	1410*	CP(P)				
11	85	1407*	CP(P)				
12	83	1392*	CP(P)				
13	80	1326*	PP(P)				

*V50 Ballistic Limit (Penetration) = 1367 fps
High Partial Penetration = 1351 fps
Low Complete Penetration = 1392 fps
Spread = 94 fps

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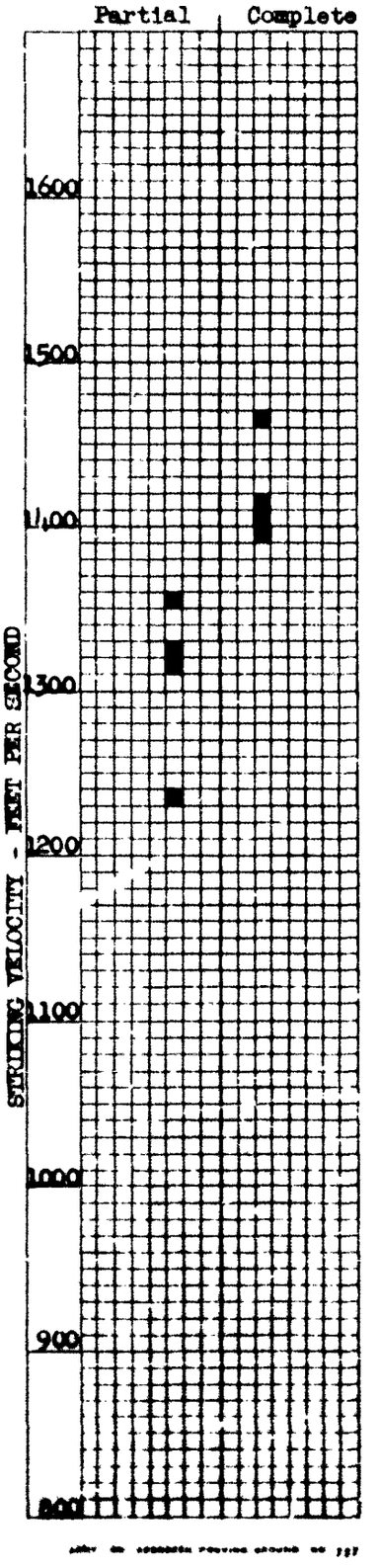


ROUND-BY-ROUND DATA

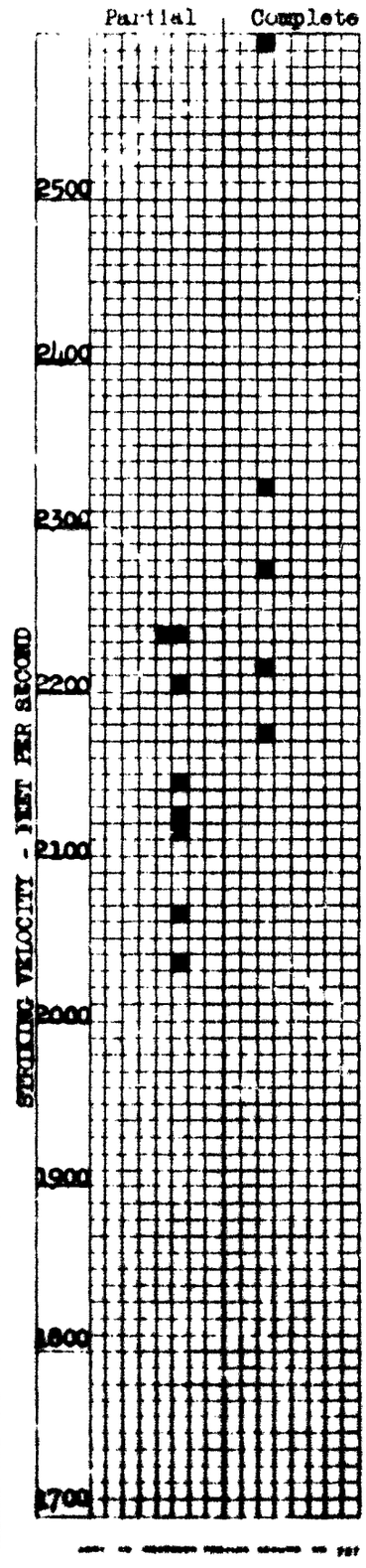
DATE: 14 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: 1.024" x 30" x 30"
[redacted] Pl. No.
[redacted] J6293 Pl #1
[redacted]

Projectile: Cal .30 Ball M2
Gun to 1st Screen: 11.68'
1st Screen to 2d Screen: 10.04'
2d Screen to Plate 8.94'
Obliquity: 0°
Powder: 4759
Gun No.: 1512536

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	34	2604	CP(P)				
2	31	2329	CP(P)				
3	28	2215*	CP(P)				
4	26	2176*	CP(P)				
5	24	2034	PP(P)				
6	25	2063	PP(P)				
7	26	2116	PP(P)				
8	26 +	2125	PP(P)				
9	27	2144	PP(P)				
10	28	2205*	PP(P)				
11	28 +	2230*	PP(P)				
12	29	2271*	CP(P)				
13	29	2230*	PP(P)				

*V50 Ballistic Limit (Protection
High Partial Penetration = 2230 fps
Low Complete Penetration = 2176 fps
Spread = 96 fps



ROUND-BY-ROUND DATA

FIRING RECORD No.

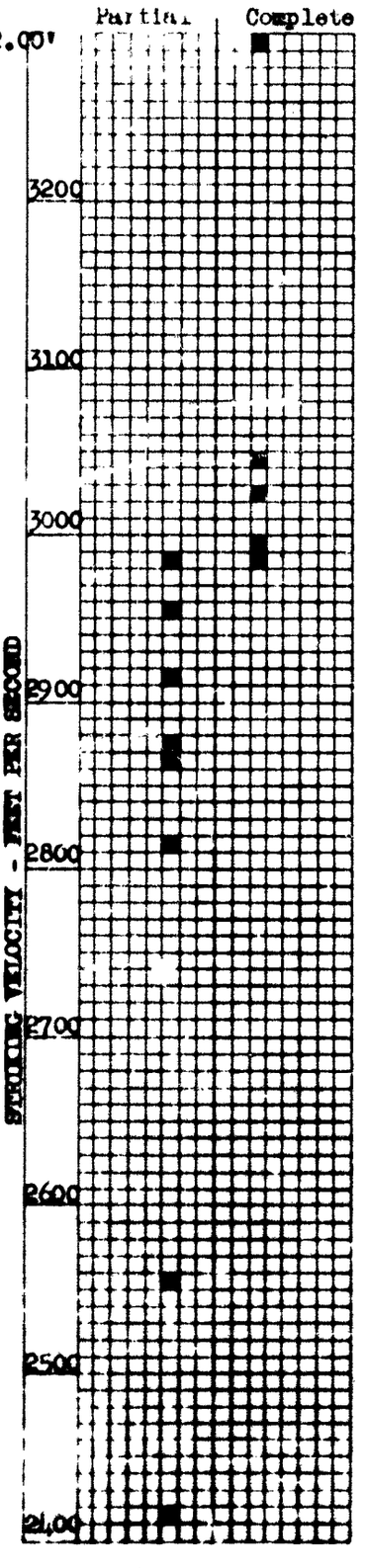
DATE: 14 April 19[illegible]
16 April 19

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: 1.024" x 30" x 30"
[redacted] Pl. No.
[redacted] J6293 Pl. #1
[redacted]

Projectile: Cal .30 Ball, M2
Gun to 1st Screen: 11.68' 7.95'
1st Screen to 2d Screen: 10.04' 12.00'
2d Screen to Plate 10.34' 10.65'
Obliquity: 30°
Powder: 4759 - 21664
Gun No.: 1512536 - 44747

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	32	2419	PP(P)				
2	35	2556	PP(P)				
3	40	2816	PP(P)				
CHANGED GUN, .300 MAGNUM NO. 44747							
4	70	3496	CP(P)				
5	68	3048	CP(P)				
6	57	2837	Dis.				
7	59	2980*	CP(P)				
8	57	2865	PP(P)				
9	58	2879	PP(P)				
10	59	2914*	PP(P)				
11	60	3025*	CP(P)				
12	59	2950*	PP(P)				
13	59	2980*	PP(P)				
14	59 +	2995*	CP(P)				

*V50 Ballistic Limit (Protection) = 2974 fps
High Partial Penetration = 2980 fps
Low Complete Penetration = 2980 fps
Spread = 111 fps



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MODIFIED HANDLING AUTHORIZED

ROUND-BY-ROUND DATA

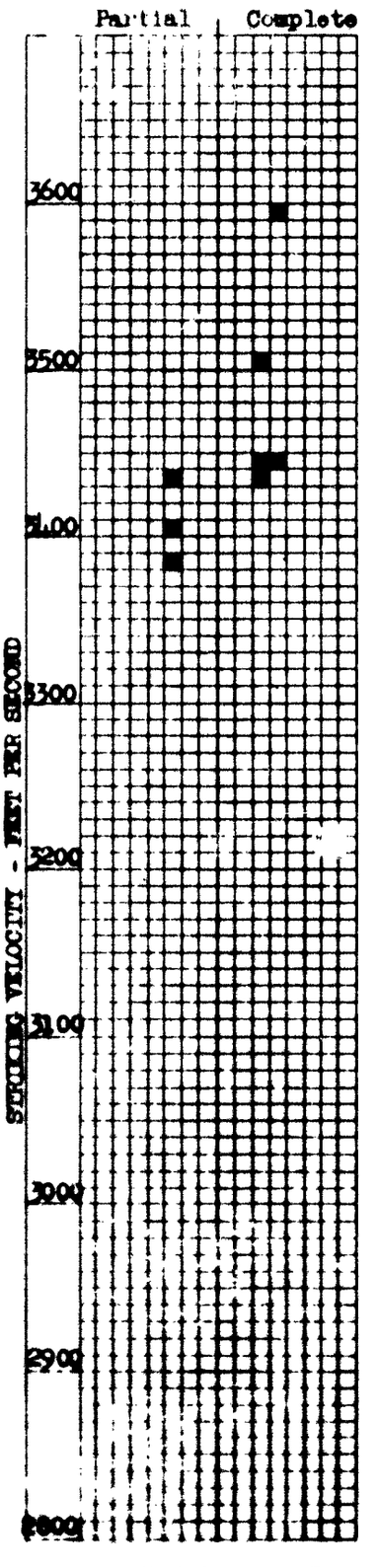
DATE: 15 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: 1.024" x 30" x 30"
[redacted] Pl. No.
[redacted] J6293 Pl. #1
[redacted]

Projectile: Cal .30 Ball, M2
Gun to 1st Screen: 11.68'
1st Screen to 2d Screen: 10.04'
2d Screen to Plate 13.74'
Obliquity: 4.9°
Powder: 21664
Gun No.: 44747

Rd No.	Charge	Velocity	Result	Rd No.	Charge	Velocity	Result
	Grains	Fps					
1	70	3385*	PP(P)				
2	75	3593	CP(P)				
3	73	3432*	CP(P)				
4	72	3504	CP(P)				
5	70	3432*	PP(P)				
6	70	3444*	CP(P)				
7	70	3444*	CP(P)				
8	69	3400*	PP(P)				

*V50 Ballistic Limit (Protection) = 3424 fps
High Partial Penetration = 3432 fps
Low Complete Penetration = 3432 fps
Spread = 59 fps



ROUND-BY-ROUND DATA

FIRING RECORD NO.

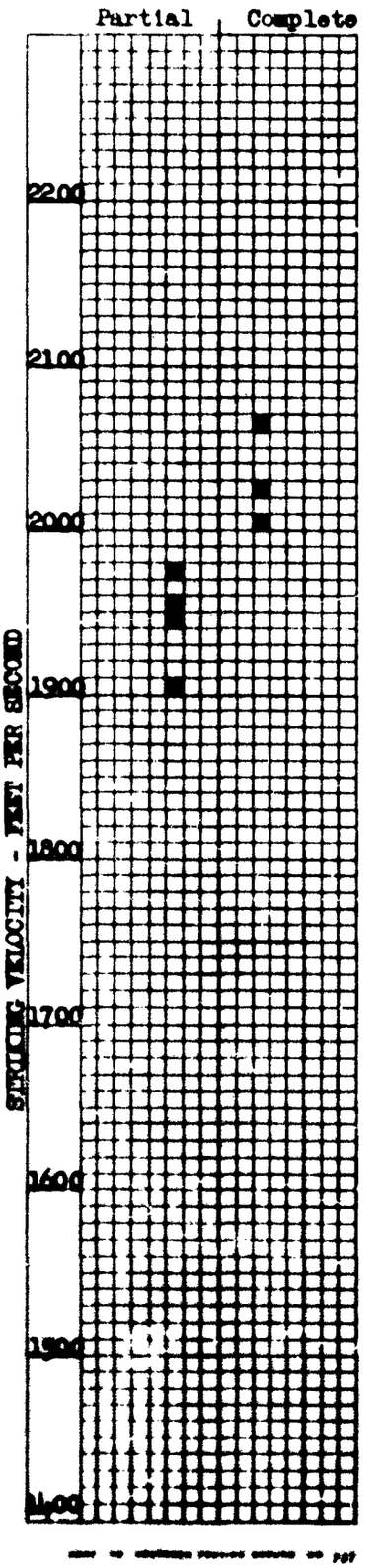
DATE: 13 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: 1.024" x 30" x 30"
[redacted] Pl. No.
[redacted] J6293 Pl. #1
[redacted]

Projectile: Cal .30 AP, M2
Gun to 1st Screen: 11.66'
1st Screen to 2d Screen: 10.02'
2d Screen to Plate 9.00'
Obliquity: 0°
Powder: 4759
Gun No.: 1512536

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	30	2009*	CP(P)				
2	26	[illegible]48	Ms.				
3	24	1952*	PP(P)				
4	25	2028*	CP(P)				
5	24	1904	PP(P)				
6	25	1975*	PP(P)				
7	25+	1944*	PP(P)				
8	26	2061*	CP(P)				

*V50 Ballistic Limit (Protection) = 1995 fps
[redacted] Partial Penetration = 1975 fps
Low Complete Penetration = 2009 fps
[redacted] = 117 fps



[redacted] MODIFIED HANDLING AUTHORIZED

ROUND-BY-ROUND DATA

FIRING RECORD NO.

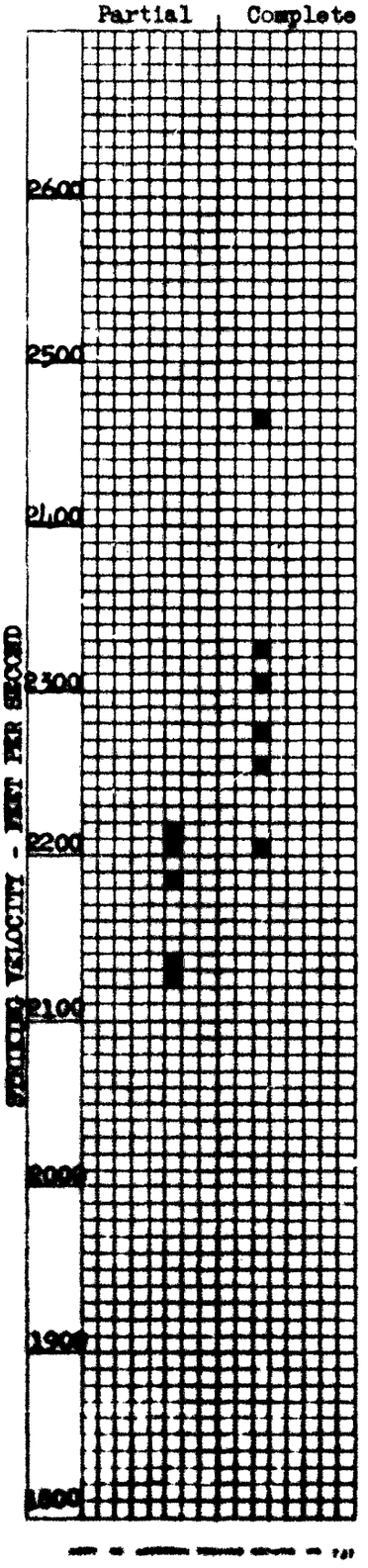
DATE: 14 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: 1.024" x 30" x 30"
[illegible] Pl. No.
[illegible] J6293 Pl. #1
[illegible]

Projectile: Cal .30 AP, M2
Gun to 1st Screen: 11.68'
1st Screen to 2d Screen: 10.04'
2d Screen to Plate 10.34'
Obliquity: 30°
Powder: 4759
Gun No.: 1512536

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	34	2463	CP(P)				
2	32	2325	CP(P)				
3	31	2309	CP(P)				
4	28	2122	PP(P)				
5	29	2256*	CP(P)				
6	28	2135	PP(P)				
7	29	2182*	PP(P)				
8	29 +	2216*	PP(P)				
9	30	2272*	CP(P)				
10	29 +	2206*	PP(P)				
11	30	2201*	CP(P)				

*V50 Ballistic Limit (Protection) = 2222 fps
High Partial Penetration = 2216 fps
Low Complete Penetration = 2201 fps
Spread = 90 fps



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ROUND-BY-ROUND DATA

FIRING RECORD NO.

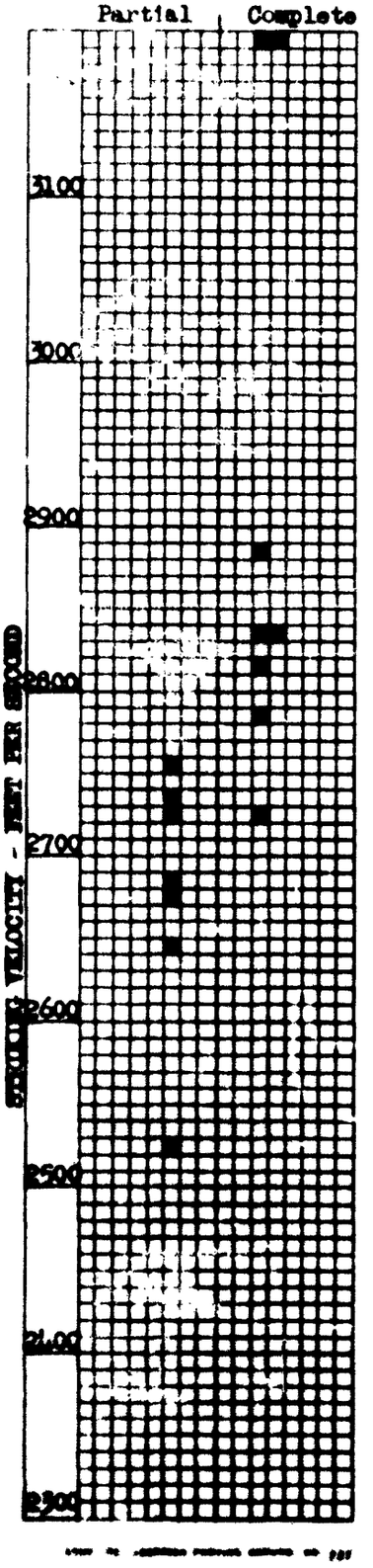
DATE: 14 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: 1.024" x 30" x 30"
Armor Pl. No.
Manufacturing Facility J6293 Pl. #1
Manufacturing Method

Projectile: Cal .30AP, M2
Gun to 1st Screen: 11.68'
1st Screen to 2d Screen: 10.04'
2d Screen to Plate 13.74'
Obliquity: 45°
Powder: 4759 - 21664
Gun No.: 1512536 - 44747

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge Grains	Velocity fps	Result
1	36	2529	PP(P)	17	56	Lost	Dis.
2	40	2723*	PP(P)	18	56	2781*	CP(P)
CHANGED GUN .300 MAGNUM NO. 44747							
3	70	3433	Dis.	19	56	2735*	PP(P)
4	73	3433	Dis.				
5	70	3386	CP(P)				
6	65	3264	CP(P)				
7	60	Lost	CP(P)				
8	56	2812*	CP(P)				
9	54	2647	PP(P)				
10	56	2750*	PP(P)				
11	57	2836	CP(P)				
12	56	2886	CP(P)				
13	56	2836	CP(P)				
14	55	2780*	CP(P)				
15	54	2683	PP(P)				
16	55	2676	PP(P)				

*V50 Ballistic Limit (Protection) = 2754 fps
High Partial Penetration = 2730 fps
Low Complete Penetration = 2720 fps
Spread = 32 fps



ROUND-BY-ROUND DATA

FIRING RECORD NO.

DATE: 15 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: 1.024" x 30" x 30"
[redacted] Pl. No.
[redacted] J6293 Pl. #1
[redacted]

Projectile: Cal .30 AP, M2
Gun to 1st Screen: 11.68'
1st Screen to 2d Screen: 10.04'
2d Screen to Plate 15.34'
Obliquity: 60°
Powder: 24664
Gun No.: 44747

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	70	3408	PP(P)				
2	73	3468	PP(P)				

No Ballistic Limit Obtained
High Partial Penetration - 3468 fps

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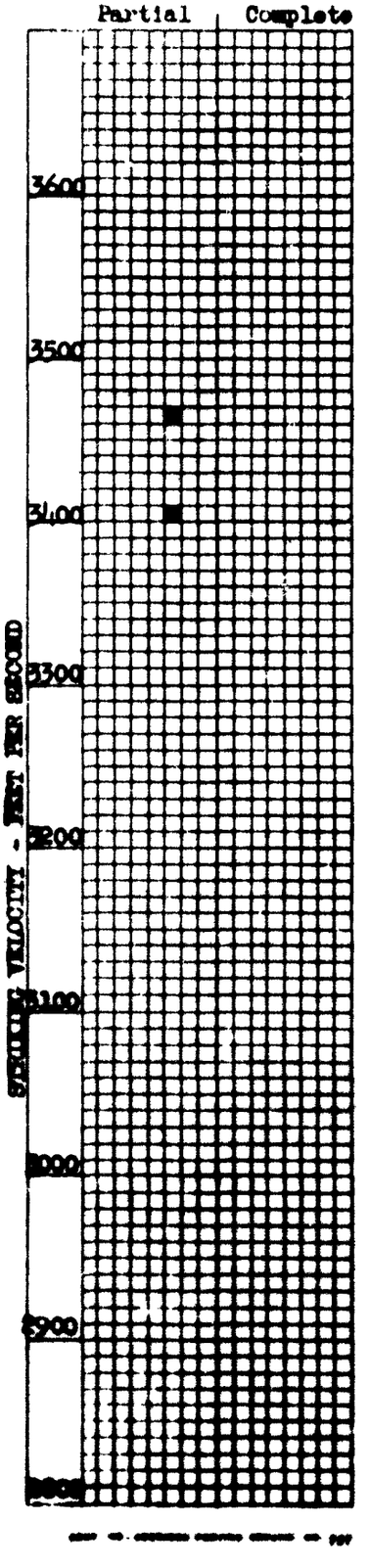

ROUND-BY-ROUND DATA

FIRING RECORD NO.

DATE: 16 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: 1.024" x 30" x 30"
[redacted] Pl. No.
[redacted] J6293 Pl. #2

Projectile: Cal .50 AP, M2
Gun to 1st Screen: 7.65'
1st Screen to 2d Screen: 12.02'
2d Screen to Plate 16.50'
Obliquity: 60°
Powder: 35683
Gun No.: 22

Rd No.	Charge (grains)	Velocity (fps)	Result	Rd No.	Charge	Velocity	Result
1	180	2604	PP(P)				
2	210	2951	PP(P)				
3	220	3104	PP(P)				

No Ballistic Limit Obtained
High Partial Penetration = 3104 fps

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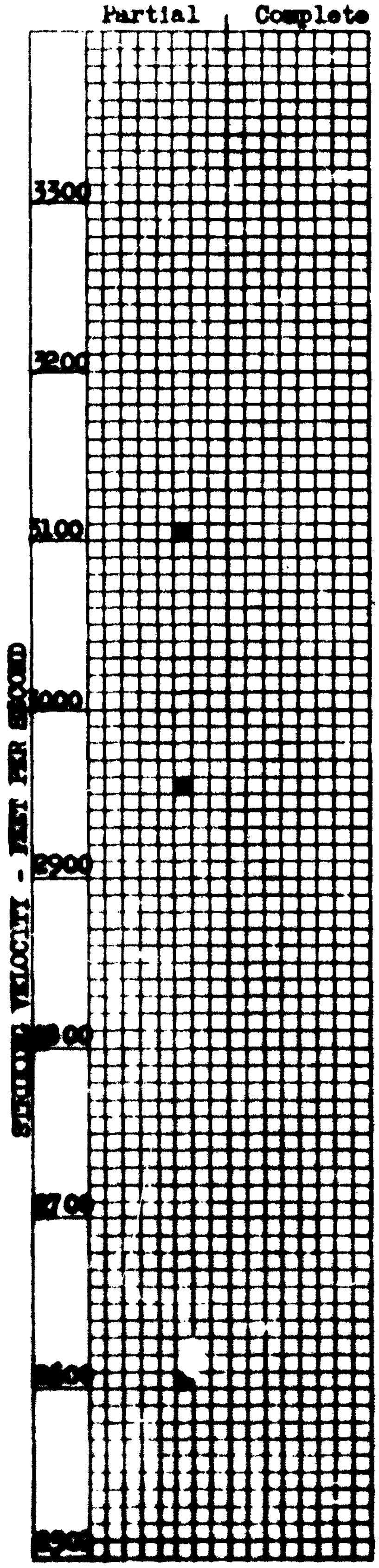

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ROUND-BY-ROUND DATA

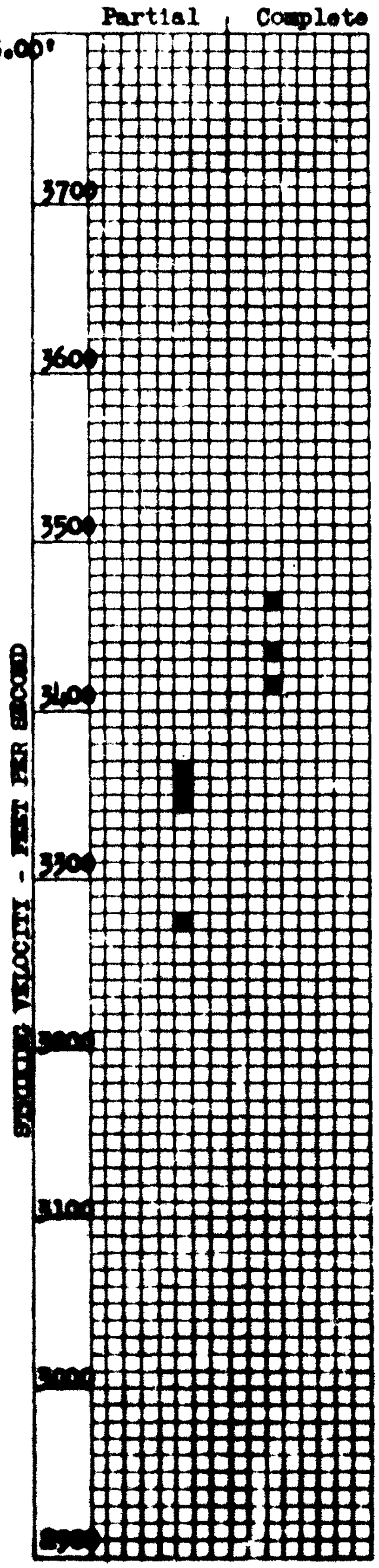
FIRING RECORD NO.

DATE: 5 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: 1.407"x18"x36"
[illegible] Pl. No.
[illegible] M6289-4C
[illegible]

Projectile: cal .30 Ball M2
Gun to 1st Screen: 60.65' 21.65'
1st Screen to 2d Screen: 49.57' 15.00'
2d Screen to Plate 182.07' 18.40'
Obliquity: 0°
Powder: 4664
Gun No.: 4747

Rd No.	Charge	Velocity	Result	Rd No.	Charge	Velocity	Result
1	70	3273	PP(P)				
2	70	Lost	PP(P)				
New Plate No. M6288-4A, Size 1.407"x18"x36"							
3	70	3339*	PP(P)				
4	70	3367*	PP(P)				
5	70	3344*	PP(P)				
6	70	3413*	CP(P)				
7	70	Lost	CP(P)				
8	70+	Lost	Disr.				
9	70+	Lost	CP(P)				
10	71	Lost	CP(P)				
11	71	3460*	CP(P)				
12	71	Lost	CP(P)				
13	71	3436*	CP(P)				
*V50 Ballistic Limit (Protection)					3398 fps		
High Partial Penetration					3367 "		
Low Complete Penetration					3413 "		
Spread					[illegible] "		



ROUND-BY-ROUND DATA

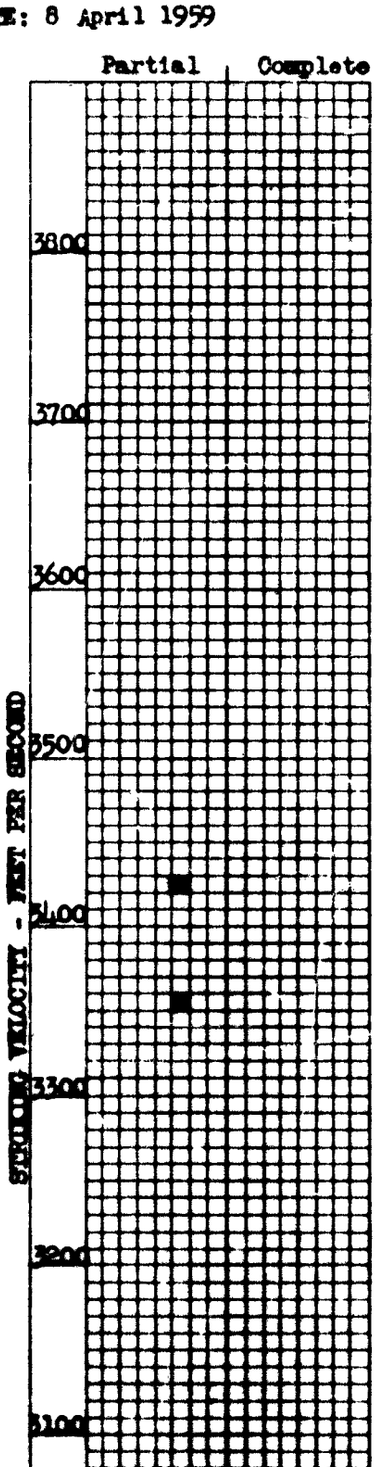
FIRING RECORD NO.

DATE: 8 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: 1.497" x 18" x 36"
[redacted] Plate No.
[redacted] M6288-4A
[redacted]

Projectile: Cal .30 Ball M2
Gun to 1st Screen: 21.65'
1st Screen to 2d Screen: 15.00'
2d Screen to Plate 13.45'
Obliquity: 30°
Powder: 24664
Gun No.: 44747

Rd No.	Charge	Velocity	Result	Rd No.	Charge	Velocity	Result
	Grains	fps					
1	70	3427	PP(P)				
2	70	3357	PP(P)				
No ballistic limit obtained. High Partial Penetration = 3427 fps							



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ROUND-BY-ROUND DATA

FIRING RECORD NO.

DATE: 3 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: 1.497" x 18" x 36"
Plate No. H6289-4C

Projectile: Cal .30 AP M2
Gun to 1st Screen: 60.65'
1st Screen to 2d Screen: 49.57'
2d Screen to Plate 182.07'
Obliquity: 30°
Powder: 24664
Gun No.: 44747

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	70	Lost	Dist.				
2	70	3175	CP(P)				
3	66	3000	CP(P)				
4	62	2839	CP(P)				
5	56	2462	PP(P)				
6	59	2591	PP(P)				
7	60	2732*	CP(P)				
8	59	Lost	PP(P)				
9	59	2634*	PP(P)				
10	60	2650	Dist.				
11	60	2573	PP(P)				
12	60	2615	PP(P)				
13	61	2776	CP(P)				
14	60	2638*	CP(P)				
15	60 +	2664*	PP(P)				
16	60 + +	2682*	PP(P)				
17	60 + +	2698*	CP(P)				
*V50 Ballistic Limit (Protection) = 2668 fps							
High Partial Penetration = 2682 fps							
Low Complete Penetration = 2638 fps							
Spread = 108 fps							

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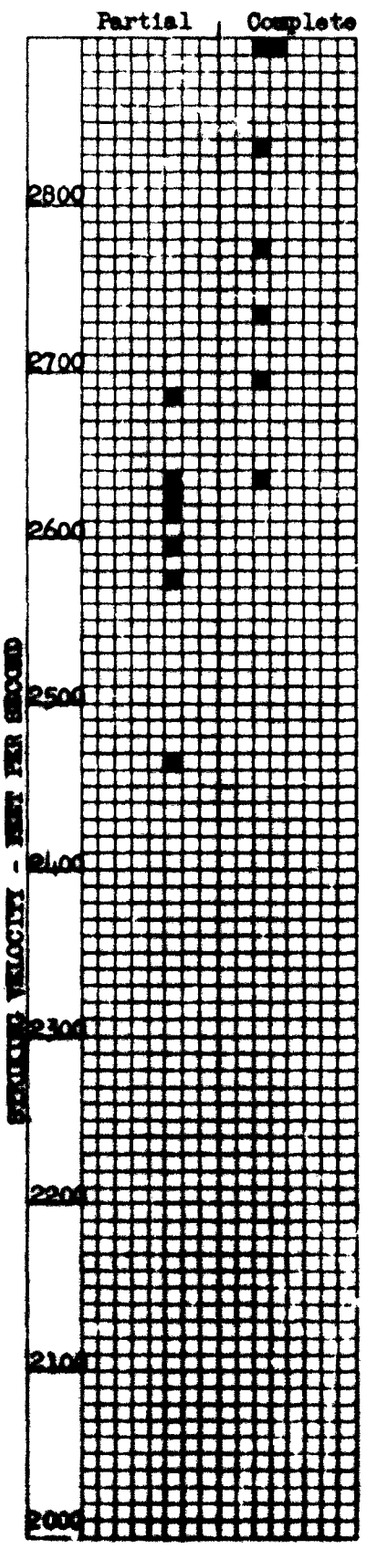

ROUND-BY-ROUND DATA

FIRING RECORD No.

DATE: 6 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: 1.497" x 18" x 36"
Plate No. H6289-4C

Projectile: Cal .50 Ball M2
Gun to 1st Screen: 60.68'
1st Screen to 2d Screen: 49.71'
2d Screen to Plate 183.24'
Obliquity: 30°
Powder: 35683
Gun No.: 22

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	140	2040	CP(P)				
2	135	1984	Dier.				
3	135	1946	Dier.				
4	135	1978*	PP(P)				
5	138	2037	CP(P)				
6	135	1980*	CP(P)				
7	132	1962*	CP(P)				
8	130	1941*	CP(P)				
9	125	1888*	PP(P)				
10	127	1904*	PP(P)				

*V50 Ballistic Limit (Protection) = 1942 fps
High Partial Penetration = 1978 fps
Low Complete Penetration = 1941 fps
Spread = 92 fps

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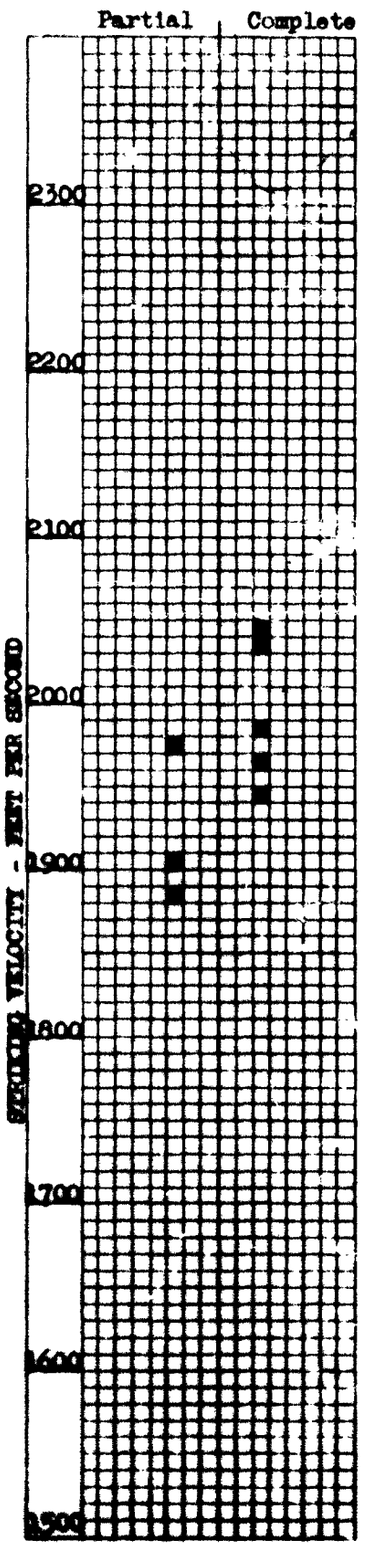

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FIRING RECORD NO.

DATE: 6 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: 1.497" x 18" x 36"
[redacted] Plate No.
[redacted] M288-4A
[redacted]

Projectile: Cal .50 Ball M2
Gun to 1st Screen: 60.68'
1st Screen to 2d Screen: 49.71'
2d Screen to Plate 187.24'
Obliquity: 60°
Powder: 35683
Gun No.: 22

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	210	2966	PP(P)				
2	210	2964	PP(P)				

Ballistic limit obtained.

High Partial Penetration = 2966 fps.

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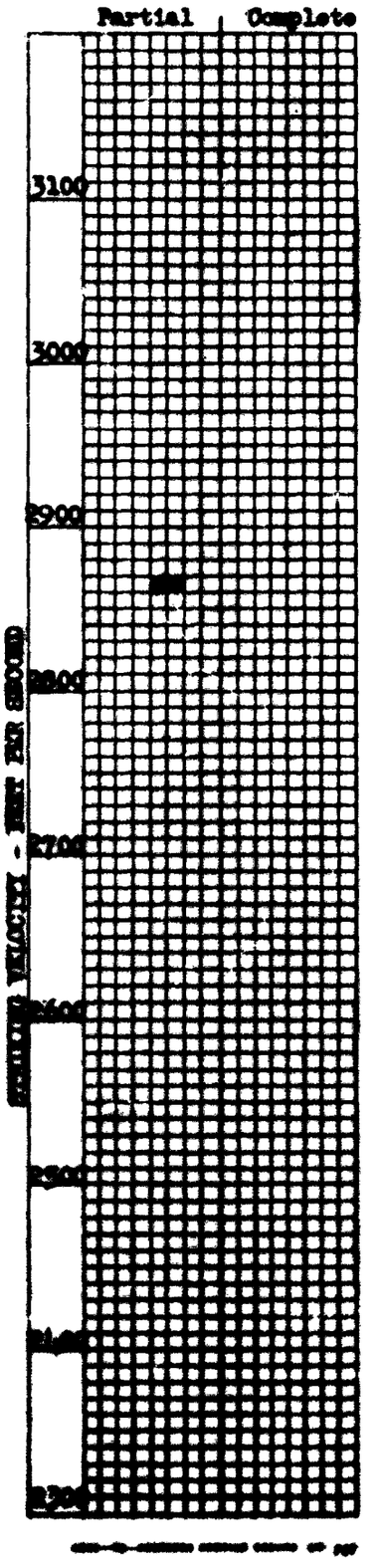


MODIFIED GROUND-TO-GROUND DATA

FIRING RECORD NO.

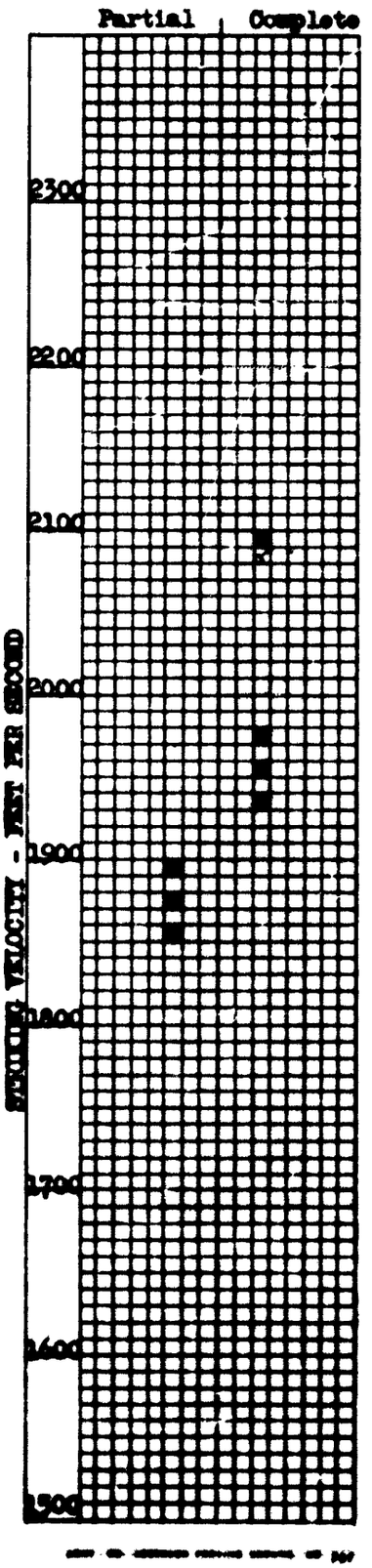
DATE: 6 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: 1.497" x 18" x 36"
[illegible] Plate No.
[illegible] M289-40
[illegible]

Projectile: Cal .50 AP M2
Gun to 1st Screen: 60.68'
1st Screen to 2d Screen: 49.71'
2d Screen to Plate 183.24'
Obliquity: 30°
Powder: 35683
Gun No.: 22

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	145	2090	CP(P)				
2	135	1977*	CP(P)				
3	125	1872*	PP(P)				
4	130	1932*	CP(P)				
5	125	1857*	PP(P)				
6	128	1887	Dist.				
7	128	1897*	PP(P)				
8	132	1948	Dist.				
9	132	1940	Dist.				
10	132	1955	Dist.				
11	132	1953*	CP(P)				

*V50 Ballistic Limit (Protection) = 1915 fps
High Partial Penetration = 1897 fps
Low Complete Penetration = 1932 fps
Spread = 35 fps



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ROUND-BY-ROUND DATA

FIRING RECORD NO.

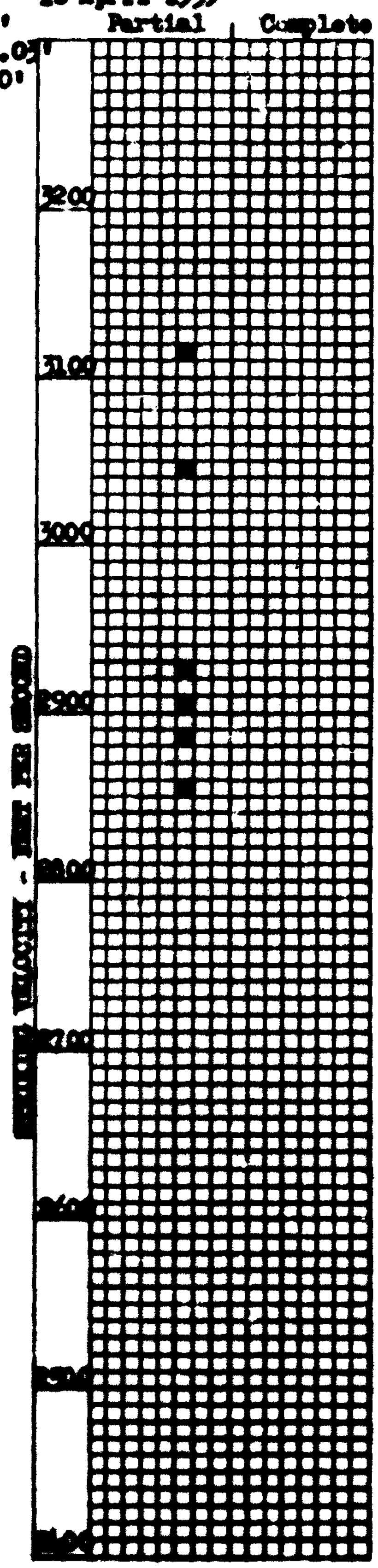
DATE: 6 April 1959
10 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: 1.497" x 18" x 36"
[illegible] Pl. No.
[illegible] M6288-4A
[illegible]

Projectile: Cal .50 AP, M2
Gun to 1st Screen: 60.68' 10.03'
1st Screen to 2d Screen: 49.71 10.03'
2d Screen to Plate 157.24' 15.70'
Obliquity: 60°
Powder: 35683
Gun No.: 22

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	210	2859	PP(P)				
2	210	2875	Dis.				
3	210	2884	PP(P)				
4	210	2905	PP(P)				
5	210	2928	PP(P)				
CHANGED DISTANCES							
6	215	3040	PP(P)				
7	220	3116	PP(P)				

No Ballistic Limit obtained
High Partial Penetration = 3116 fps



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ROUND-BY-ROUND DATA

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FIRING RECORD NO.

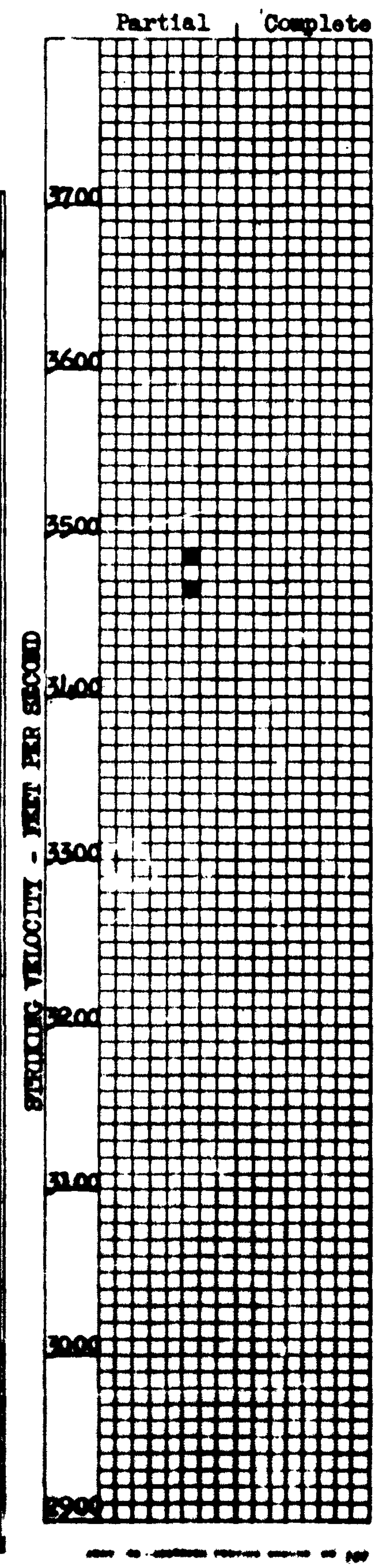
DATE: 9 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: 1.767" x 18" x 36"
[redacted] Pl. No.
[redacted] 734-871 (2)

Projectile: Cal .30 Ball, M2
Gun to 1st Screen: 11.53'
1st Screen to 2d Screen: 20.00'
2d Screen to Plate 9.05'
Obliquity: 0°
Powder: 4664
Gun No.: 4747

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	72	3461	PP(P)				
2	72	3485	PP(P)				

No Ballistic Limit Obtained
High Partial Penetration = 3485 fps



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ROUND-BY-ROUND DATA

FIRING RECORD NO.

MODIFIED HANDLING AUTHORIZED

DATE: 9 April 1959

Material: Aluminum
Submitted by: Frankford Ars.
Type of Test: Development
Size: 1.767" x 18" x 36"
Pl. No. 734-871(2)

Projectile: Cal .50 AP, M2
Gun to 1st Screen: 11.53'
1st Screen to 2d Screen: 10.00'
2d Screen to Plate 10.45'
Obliquity: 30°
Powder: 21664
Gun No.: 44747

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge Grains	Velocity fps	Result
1	70	3333	CP(P)	17	62	2968	CP(P)
2	66	3214	CP(P)	18	61	2833	Dis.
3	60	2798*	CP(P)	19	62	2933	CP(P)
4	58	2775	PP(P)	20	61	2849*	CP(P)
5	60	2847*	CP(P)				
6	58	2678	PP(P)				
7	59	Lost	Dis.				
8	59	Lost	PP(P)				
9	59	2799	PP(P)				
10	60	2830*	PP(P)				
11	60 +	2806*	PP(P)				
12	61	2806	PP(P)				
13	62	2799	PP(P)				
14	62	Lost	Dis.				
15	62	Lost	CP(P)				
16	60	2814*	PP(P)				

*V50 Ballistic Limit (Protection) = 2814 fps
High Partial Penetration = 2838 fps
Low Complete Penetration = 2798 fps
Spread = 76 fps

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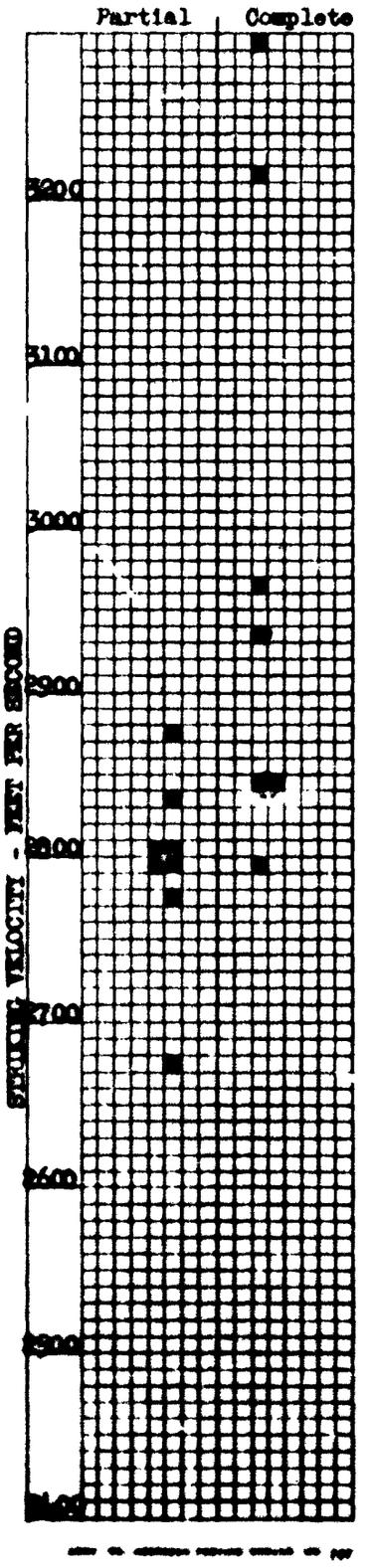

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ROUND BY ROUND DATA

FIRING RECORD NO.

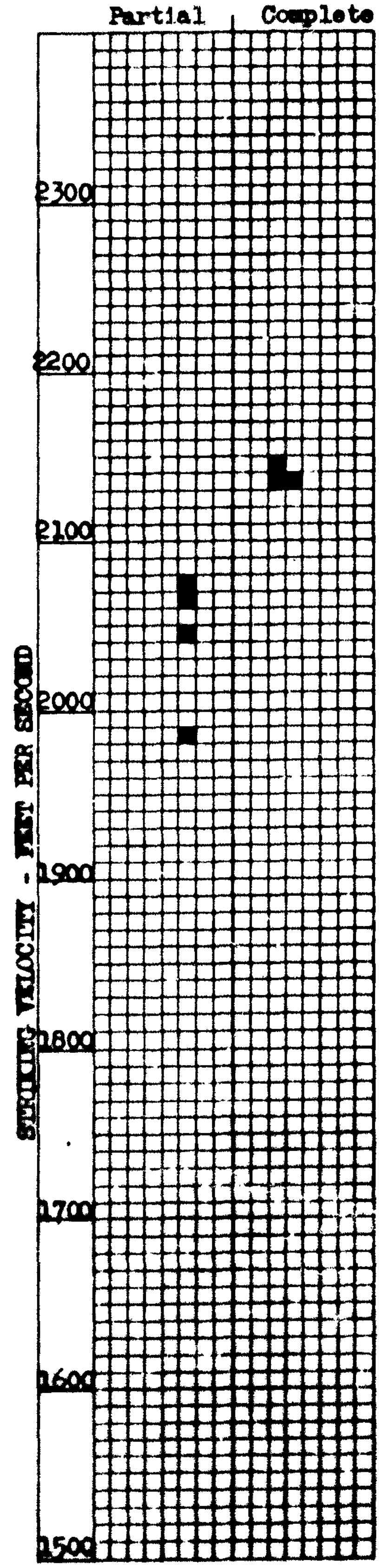
DATE: 7 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: 1.767" x 18" x 36"
[illegible] Plate No.
[illegible] 734-871)2)
[illegible]

Projectile: Cal .50 Ball M2
Gun to 1st Screen: 60.63'
1st Screen to 2d Screen: 49.71'
2d Screen to Plate 183.29'
Obliquity: 30°
Powder: 35683
Gun No.: 22

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	135	1981	PP(P)				
2	140	2047*	PP(P)				
3	143	2068*	PP(P)				
4	150	2136*	CP(P)				
5	145	2079*	PP(P)				
6	150	2138*	CP(P)				
7	150	2148*	CP(P)				

*V50 Ballistic Limit (Protection) = 2103 fps
High Partial Penetration = 2079 fps
Low Complete Penetration = 2136 fps
Spread = 101 fps



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ROUND-BY-ROUND DATA

FIRING RECORD NO.

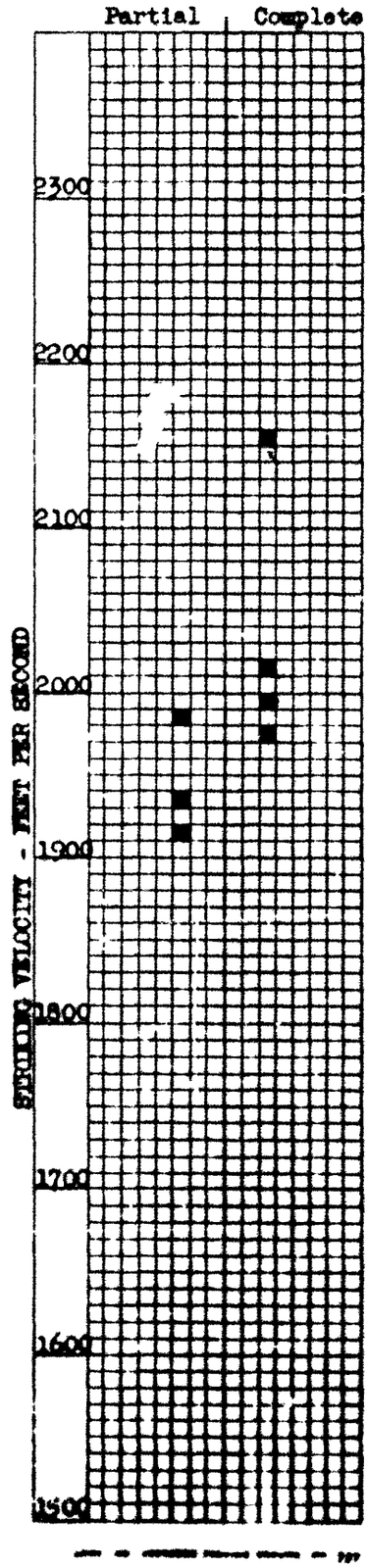
DATE: 6 April 1959

Material: Aluminum
Submitted by: Frankford
Type of Test: Development
Size: 1.767" x 18" x 36"
Plate No. 734-871(2)

Projectile: Cal .50 AP M2
Gun to 1st Screen: 60.68'
1st Screen to 2d Screen: 49.71'
2d Screen to Plate 183.24'
Obliquity: 30°
Powder: 35683
Gun No.: 22

Rd No.	Charge Grains	Velocity fps	Result	Rd No.	Charge	Velocity	Result
1	145	2150	CP(P)				
2	135	2014*	CP(P)				
3	132	1981*	PP(P)				
4	134	1974*	CP(P)				
5	135	1992*	CP(P)				
6	130	1913*	PP(P)				
7	132	1937*	PP(P)				

*V50 Ballistic Limit (Protection) = 1969 fps
High Partial Penetration = 1981 fps
Low Complete Penetration = 1974 fps
Spread = 101 fps



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