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U. S. NAVAL PROVING GROUND

Dahlgren, Virginia

REPORT NO. 16-43

EFFECT OF CAP DESIGN ON 3-INCH PROJECTILE PERFORMANCE - PARTIAL REPORT

14 December 1943.

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APPROVED:

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COMMANDING OFFICER

PREFACE

AUTHORIZATION

This study was authorized as part of Naval Proving Ground Research Project APL-6, in Bureau of Ordnance letter NT9/A9(Re3) dated 9 January, 1943.

OBJECT

This report describes the results of firing of 3-inch experimental capped projectiles against Class "A" and homogeneous plate, conducted as part of a study of the effect of cap design on projectile performance.

SUMMARY

This investigation was initiated with the view of determining the effect of the different cap variables upon projectile penetration of Class "A" armor under the widest practicable ranges of obliquity and of e/d.

Eight different projectiles were tested. The Army 3-inch M79 monoblock shot was used as a standard of reference. Six projectiles were provided by the Bethlehem Steel Company, comprising verious cap designs applied to Bethlehem Type A-1 projectile body; the eighth projectile was a model of the 8-inch Mark 11 projectile provided by the Crucible Steel Company.

CLASS "A" PLATE - Against Class "A" plate at 20° obliquity for an e/d of 1.08 (3"25) the unmodified M61 capped projectile gave the lowest limit and was recovered in the best condition of any of the projectiles. The other projectiles all were badly broken on impact and all but the 8" Mark 11 type were rendered ineffective. It was apparent that the projectiles were not of suitable quality for quantitative tests against Class "A" armor. Accordingly, firing with these projectiles was carried out against homogeneous plate under various conditions to gain additional information on the effect of cap design.

HOMOGENEOUS PLATE - At low obliquity (less than 30°) and at e/d values for which the projectile is undeformed, a cap will decrease the ability of a projectile to penetrate homogeneous plate. At 0° obliquity for e/d of 0.65

(1"95) the percentage increase in F(e/d,θ) - value over the uncapped (M79) value is approximately equal to the cap weight in percentage of the total projectile weight, regardless of cap shape or cap hardness for the ranges used in these variables. At e/d of 1.0 (3.0) F(e/d,θ) increases with cap weight but not as rapidly as at e/d of 0.65 (1"95).

With two exceptions, the F-values were found to be larger for capped projectiles than for M79 projectiles at 30° obliquity. The two projectiles which gave better performance than M79 projectiles were the 8" Mk. 11 type (Dwg. 3001 6% cap) which gave 98% of the M79 value at e/d of 0.65 (1"95) and the 37mm M51B2 type with a hard cap (DA-302, 11% cap) which gave 95% of M79 value at e/d of 0.24 (0"73). These differences may be the result of a type of punching failure of the plate.

At 60° obliquity capped projectiles gave better performance in every case than uncapped projectiles. A blunt angular cap (M61, Dwg. DA-301) resulted in a lower limit than longer more rounded caps (Heavy Type A-1, Dwg. DA-304) of the same weight.

Soft caps were uniformly worse than hard caps with the exception of the attack of homogeneous plate at e/d of .65 (1"95) at 0° obliquity, where a 2% superiority was indicated for the soft cap.

Recommendations are included in the report for additional tests against Class "A" plate with better quality projectiles. It is recommended that projectiles be included of designs similar to modern 8-inch and 14-inch projectiles.

CONTENTS

LIST OF FIGURES

NPG Photo No. 800 APL.
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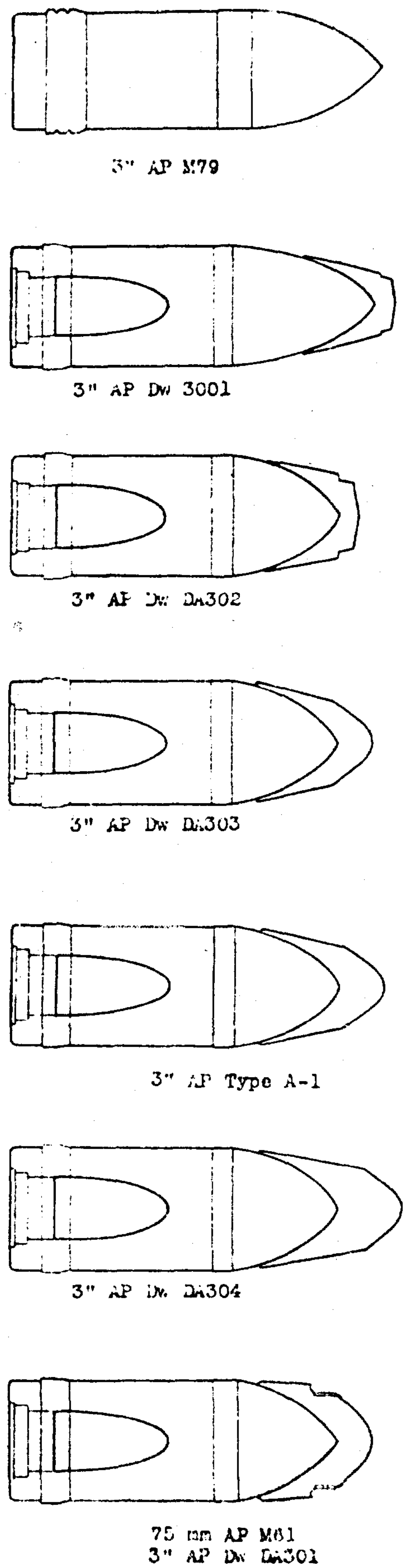


Fig. 1. Experimental Cap Design. 3" AP Projectiles.

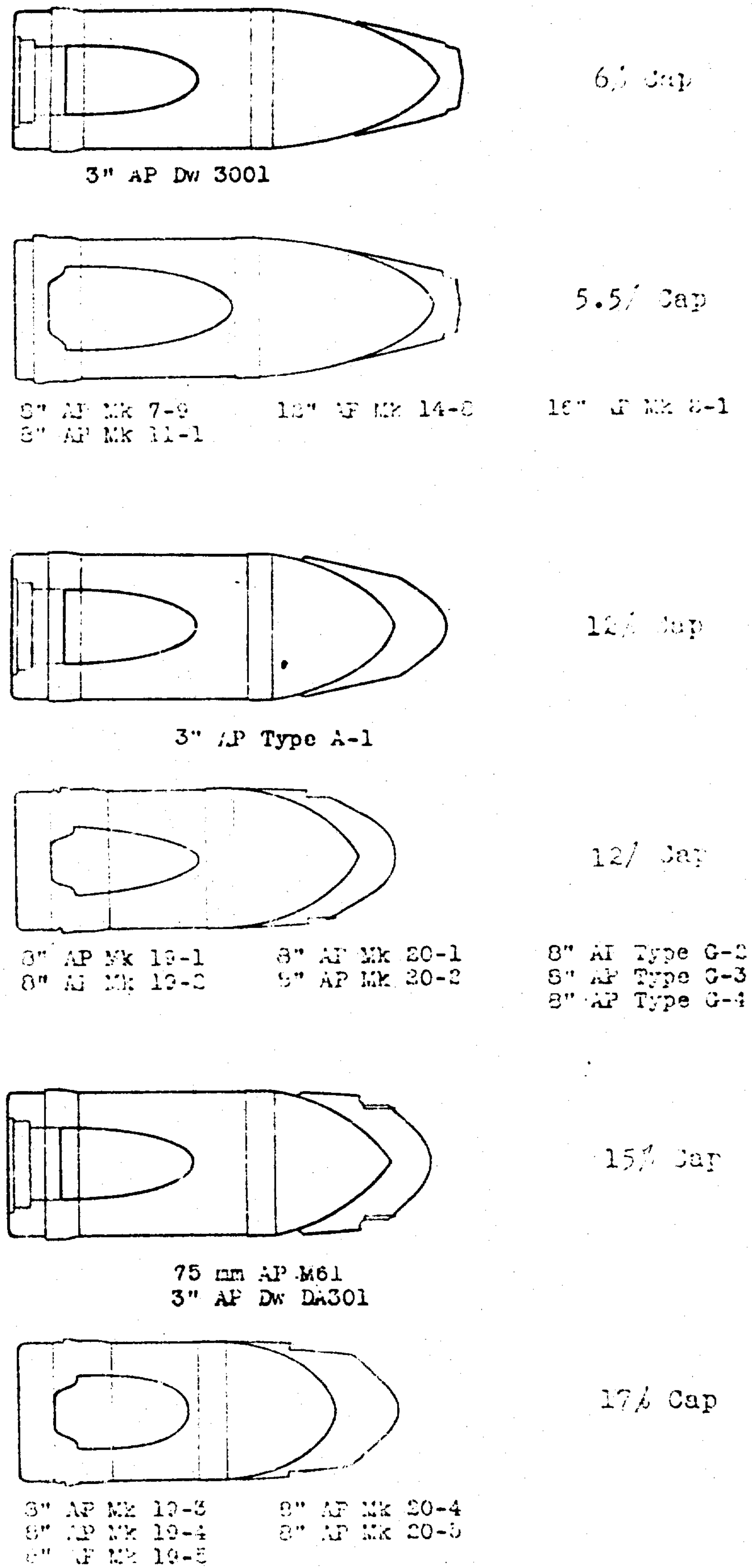


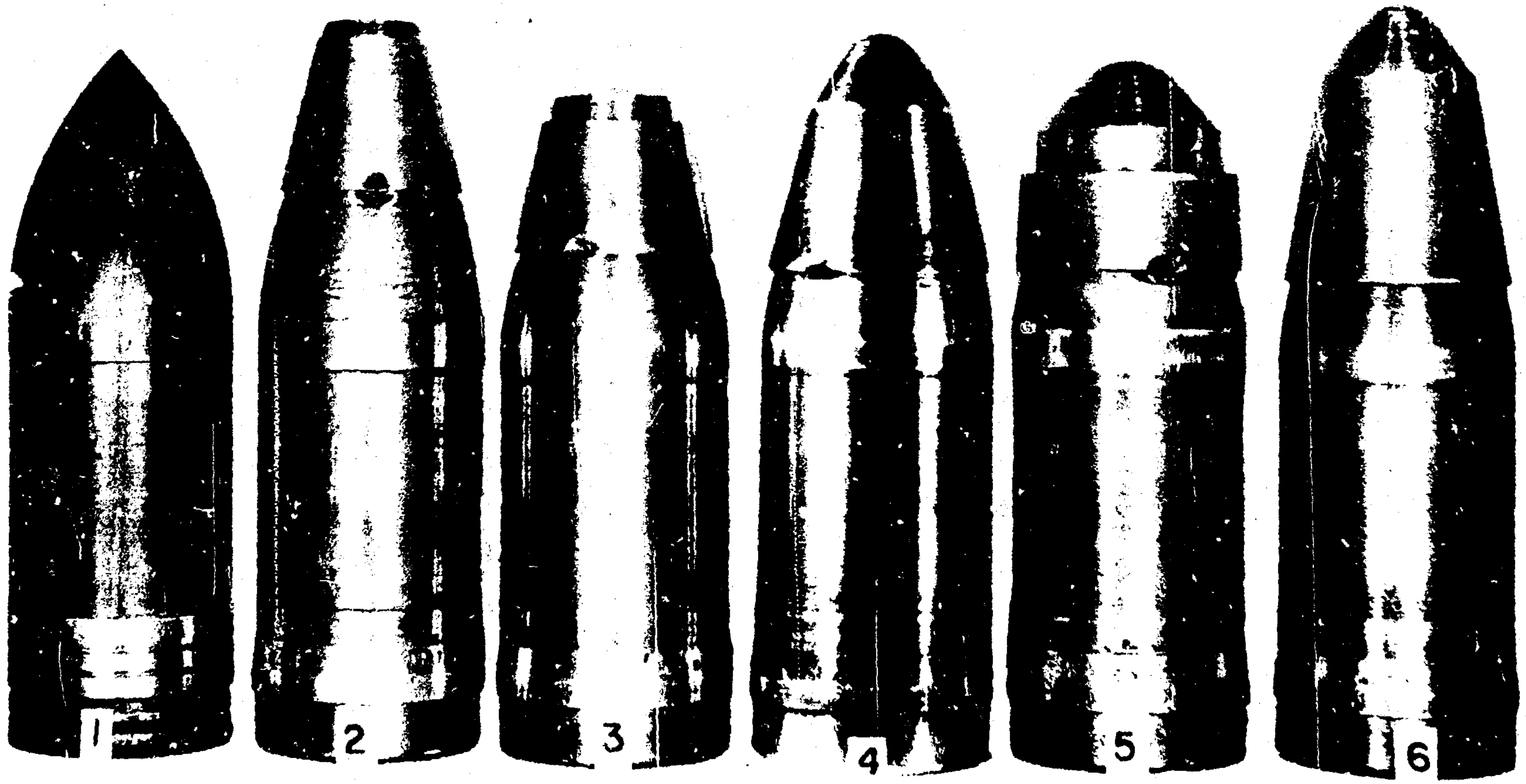
Fig. 2 Comparison of 3" and 8" AP Projectiles of comparable cap weight.

NPG PHOTO NO. 743 (APL)

Experimental Capped Projectiles

		% Cap
1.	Frankford Arsenal 3" M/9 AP Projectile	0
2.	Crucible Steel 3" Model of 8" Mk.11 projectile Dr.3001	6
3.	Bethlehem Steel. Dwg.No.DA-302 Hard and Soft Caps	11
4.	Bethlehem Steel. Type A-1 Dwg. 267805	12
5.	Bethlehem Steel M61 Dwg. DA-301	15
6.	Bethlehem Steel. Dwg. DA-304	17

June 9, 1943. - CONFIDENTIAL -



I INTRODUCTION.

Experimental and acceptance testing of plates and projectiles carried out at the Naval Proving Ground has indicated that the observed ballistic limit of a plate under given test conditions may depend on the weight, hardness and shape of the cap. A cap is placed on a projectile primarily to permit penetration of Class "A" armor in an effective exploding condition. However the cap also serves two other useful functions, namely, it reduces the limit velocity required for penetration of homogeneous plate (STS and Class "B") at high obliquity, and also makes possible the penetration of Class "B" plate at high e/d values and low obliquity for which the uncapped projectile would be badly deformed or shattered. In order to investigate systematically the effect of the cap variables on the F-coefficient under various test conditions, it was proposed to carry out a program at 3" scale. Accordingly, after conference at the Naval Proving Ground and on directions from the Bureau of Ordnance, the Bethlehem Steel Company and the Crucible Steel Company supplied 3-inch capped projectiles having various cap designs and weights. One design was supplied with both hard and soft caps. The present report describes the results of the firing of these projectiles under varied conditions as carried out by the Armor and Projectile Laboratory at the Naval Proving Ground.

II MATERIALS AND METHODS:

Projectiles:

Eight different types of 3-inch projectiles were supplied for the subject tests. The Army 3-inch M79 shot, which does not have a cap, was the standard uncapped projectile with which the other projectiles were compared. One projectile was a model of the 8-inch Mark 11 projectile manufactured by Crucible Steel Company. The remaining six projectiles were submitted by Bethlehem Steel Company and were prepared by placing various caps on the same projectile body. The profiles of all projectiles are shown in Fig. 1 (NPG Photo. No. 800 (AFL)). In Fig. 2 (NPG Photo. No. 817 (AFL)) 3-inch and 8-inch projectiles of the same percentage cap weight are compared in profile. Fig. 3 (NPG Photo. No. 743 (AFL)) is a photograph showing all projectiles except DA-303. Further data on the projectiles are given below:

Projectile	% Cap	Proj. Weight	Manufacturer
M79	0	15.00	Frankford Arsenal
Model of 8" Mk. 11 Dwg. 3001	6	14.50	Crucible Steel Co.
Model of 37mm M51B2 Dwg. DA-302			
Hard Cap (BHN-485)	11	13.60	Bethlehem Steel Co.
Soft Cap (BHN-210)	11	13.60	Bethlehem Steel Co.
Type A-1 Light Cap Dwg. DA-303	10	12.90	Bethlehem Steel Co.
Type A-1 Regular Dwg. 267805	12	13.90	Bethlehem Steel Co.
Type A-1 Heavy Cap Dwg. DA-304	16	14.65	Bethlehem Steel Co.
M61 Dwg. DA-301	15	14.20	Bethlehem Steel Co.

No information was furnished by the manufacturers on the composition, heat treatment, or hardness of any of the experimental projectiles. Measurements at the Proving Ground on the two caps furnished under Drawing 302 gave a hardness of BHN-485 for the hard cap and of BHN-210 for the soft cap.

Plate and Test Conditions.

0"73 STS Carnegie-Illinois No. 694385 (Tensile Strength = 130,300 psi) at 30° and 60° obliquity.

1"94 STS Carnegie-Illinois No. X12904 (Tensile Strength = 123,000 psi) at 0° and 30° obliquity.

3"19 STS Carnegie-Illinois No. X9021 (Tensile Strength = 120,000 psi) at 0° obliquity.

3"25 Class "A" Carnegie-Illinois No. EE630 (35% chill) at 30° obliquity.

The performances of the several projectiles are compared by the procedure described in reference 1, in which solid shot having various ogives were tested against homogeneous plate. For convenience that procedure is repeated here.

$F(e/d,\theta)$ values are calculated for each test condition, where $F(e/d,\theta)$ is defined as follows:

$$F(e/d,\theta) = \frac{41.57M^{1/2}V\cos\theta}{e^{1/2}\,d}$$

where M is the projectile mass in pounds, V is the limit velocity in feet per second (the minimum velocity required for a projectile to pass completely through the plate) θ, the obliquity, is the angle between the normal to the plate and the line of flight, e is the plate thickness at the point of impact in inches, and d is the projectile diameter in inches. The calculated $F(e/d,\theta)$-value for each projectile under each test condition is then compared with the standard Navy $F(e/d,\theta)$-values as given by the 1931 empirical formula.

$$F(e/d,\theta) = 6(e/d - 0.45)(\theta^2 + 2000) + 40{,}000$$

where e and d are in the same units and θ is in degrees. The calculated value of F is expressed in the tables in the Appendix as a percentage of this empirical F.

The limit velocities for complete penetrations are calculated from the residual velocities by a method of measurement developed at the Naval Proving Ground at 3" scale and described in reference 2. Estimates are also made of limits from depth of penetration for incomplete penetrations. In case a good estimate of the limit is not available, the value of $F(e/d,\theta)$ is calculated by using in place of the limit velocity, the highest striking velocity giving incomplete penetration, or lowest striking velocity giving a complete penetration, and the result is marked with a plus or minus sign to indicate that the true value is higher or lower.

III RESULTS:

The results given in detail in the Appendix are summarized below:

TABLE I

RESULTS OF FIRING OF EXPERIMENTAL CAPPED PROJECTILES AGAINST 3"25 (e/d of 1.08) Class "A" ARMOR AT 20° OBLIQUITY

The results are given in F(e/d,θ)- values expressed as percentages of the Navy empirical F(e/d,θ)-values taken from Buord Sk. 78841.

Dwg. 3001	Dwg. DA-302	Dwg. 267805	Dwg. DA-304	Dwg.DA-301
8" Mk. 11 Type	37mm M51B2 Type Hard Cap	Type A-1	Type A-1 Heavy Cap	M61
116	114+	113	117+	107

TABLE II

SUMMARY OF BALLISTIC RESULTS OF FIRING OF EXPERIMENTAL CAPPED PROJECTILES AGAINST HOMOGENEOUS ARMOR

The results here are given in F(e/d,θ) as % of the value for M79 under same test conditions.

Projectile	% Cap	0° Obliq.		30° Obliq.		60° Obliq.
"e"...........		1"94	3"	0"73	1"94	0"73
e/d...........		.65	1.0	.24	.65	.24
M79	0	100	100	100	100	100
Dwg. 3001 (8" Mk.11 Type)	6	106+	101	101	98	96
Dwg. DA-302 (37mm M51B2 Type)						
Hard Cap	11	111	107	95	102	99
Soft Cap	11	109	107	109+	106	--
Dwg. DA-303 Type A-1, (Light Cap)	10	111	--	--	108	91
Dwg. 267805 (Type A-1)	12	112	106	100+	110	91±5
Dwg. DA-304 Type A-1 (Heavy Cap)	16	116	109	104	113	95
Dwg. DA-301 (M61)	15	116	112	103	114	86

IV DISCUSSION.

For 3"25 (e/d of 1.08) Class "A" plate at 20° the standard M61 gave a 6% lower limit than any of the others tested and was the only projectile that penetrated the plate in a whole condition. The remaining projectiles were rather badly broken by the impact with only one of them, the 8" Mk. 11 Type (Dwg. 3001) penetrating in an effective bursting condition. For the condition of the projectiles after penetrating this plate, see Figs. 4 and 5 (NPG Photos. Nos. 614-615 (AL)) opposite page 6). Because of the considerable inferiority of the experimental projectiles to the standard M61, it was not possible to get quantitative information on effect of cap variables against Class "A" armor. Accordingly, in order to extend information on the homogeneous plate, the remaining projectiles were fired against such plate under various conditions.

Against homogeneous plate at 0° obliquity for the subject plate thicknesses, i.e., for e/d of .65 (1"95) and 1.0 (3"0), the use of capped projectiles resulted in higher F(e/d,θ)-values than were obtained for uncapped projectiles against the same plate. For e/d of 0.65 (1"95) the F(e/d,θ) values increased, within experimental error, at a rate proportional to the cap weight. For e/d of 1.0 (3"0) F(e/d,θ) also increased with cap weight but not as rapidly as at lower e/d. Differences in cap weight for the same cap shape such as between DA-302 and DA-303, and between drawings DA-304 and DA-301 did not have any appreciable effect on the observed limit. For the same cap of different hardnesses the soft cap gave better performance at e/d of .65 (1"95) than the hard cap, while at e/d of 1.0 (3"0) both caps gave the same limit.

At 30° obliquity for e/d values of 0.24 (0"73) and 0.65 (1"95) the trends were somewhat different than those of the 0° results. With the exception of DA-302 (Hard 11% cap) at e/d of 0.24 (0"73) and Dwg. 3001 (8" Mk. 11 type with 6% cap) at e/d of 0.65 (1"95) the F-values increased with cap weight, the difference between the M79 projectile and projectiles having 15-16% cap (DA-304 and DA-301) being 3-4% at e/d of 0.24 (0"73) and 13-14% at e/d of 0.65 (1"94). Thus at 30° obliquity at low e/d the cap effect is not as great as at higher e/d, which may be a result of the greater cap deformation at the higher e/d value. DA-302 (Hard Cap) which has a relatively flat cap, gave an F-value 5% below the M79 value at e/d of 0.24 (0"73), the best performance of any projectiles tested under those conditions. At e/d of 0.65 (1"95) the 8" Mk. 11 type (Dwg. 3001) was 2% better

NPG PHOTO NO. 614 (APL) - APL Plate 209 (Carn.-Ill. 3" Class A plate EE630 vs. Crucible and Bethlehem experimental 3" capped AP projectiles at 20° obl. FRONT VIEW. See NPG Photo 615 (APL) for back view and data on impacts 1209-1212.

B.I.No.	"e"	"θ"	S.V., f.s.	Pene.	Projectile Dwg.	Weight	Condition.
1204 APL	3"17	20°20'	1987	Inc.	267805	13.9 lb.	Ineffective
1205	3"17	20°30'	2055	CP	267805	13.9	"
1206	3"16	20°30'	2037	CP	DA-304	14.65	"
1207	3"17	20°10'	2050	Partial	DA-302	13.6	"
1208	3"20	20°20'	2046	CP	3001	14.5	Effective

15 January, 1943.

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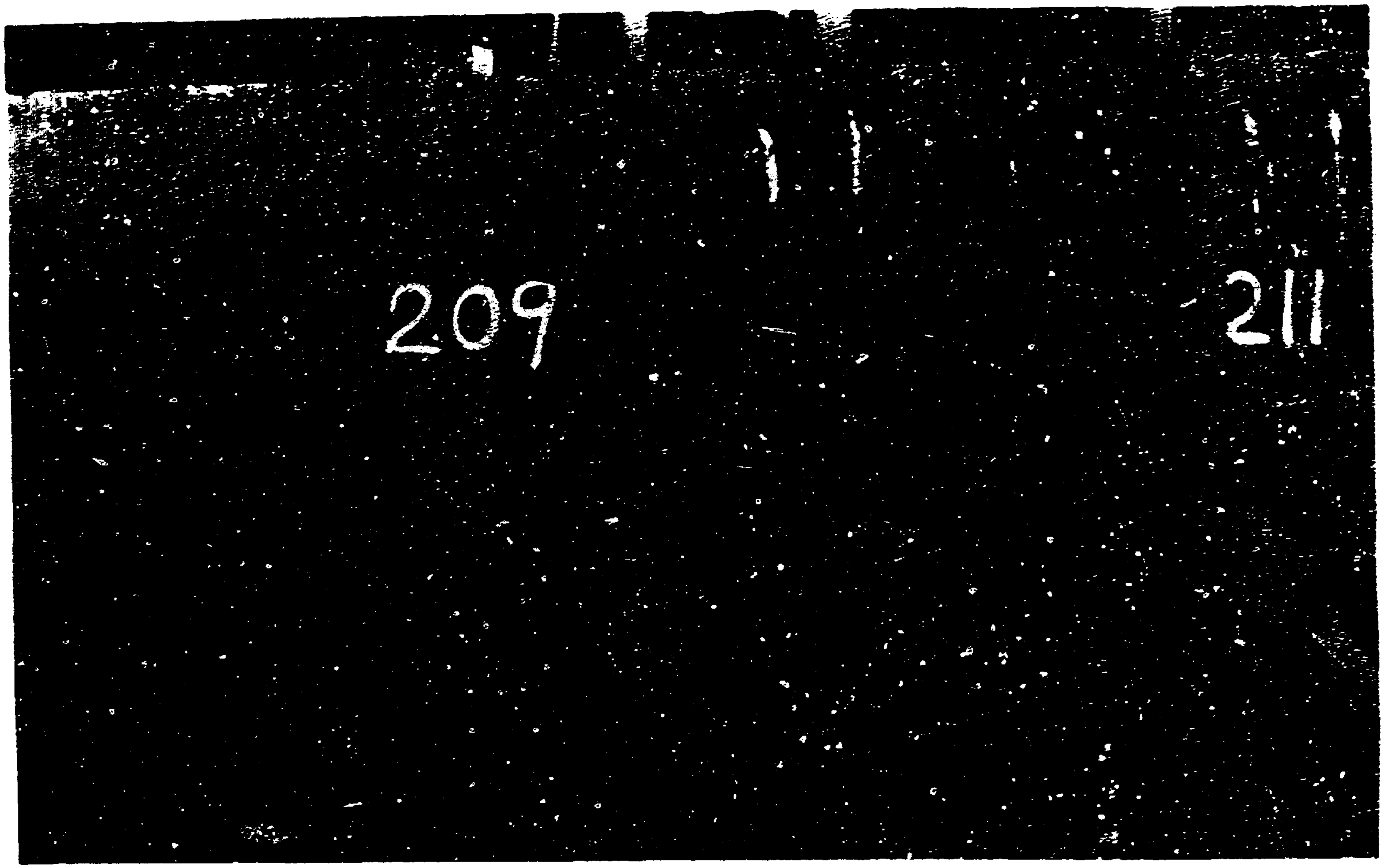

NPG PHOTO NO. 615 (APL) - APL Plate No. 209 (Carn-Ill. 3" Class A plate EE630) vs. 3" Bethlehem and Crucible experimental capped AP projectiles at 20° obl. BACK VIEW. See NPG Photo 614 (APL) for front view and data on impacts 1204-1208.

B.I.No.	"e"	"θ"	S.V., f.s.	Pene.	Projectile	Wt.	Condition
1209 (APL)	3".18	20°20'	2045	Comp.	M61	14.2	Effective.
1210	3".23	20°10'	1924	"	"	"	"
1211	3".22	19°45'	1771	7/8"	"	"	Ineffective.
1212	3".21	19°25'	1874	1-1/4"	"	"	"

15-16 January 1943

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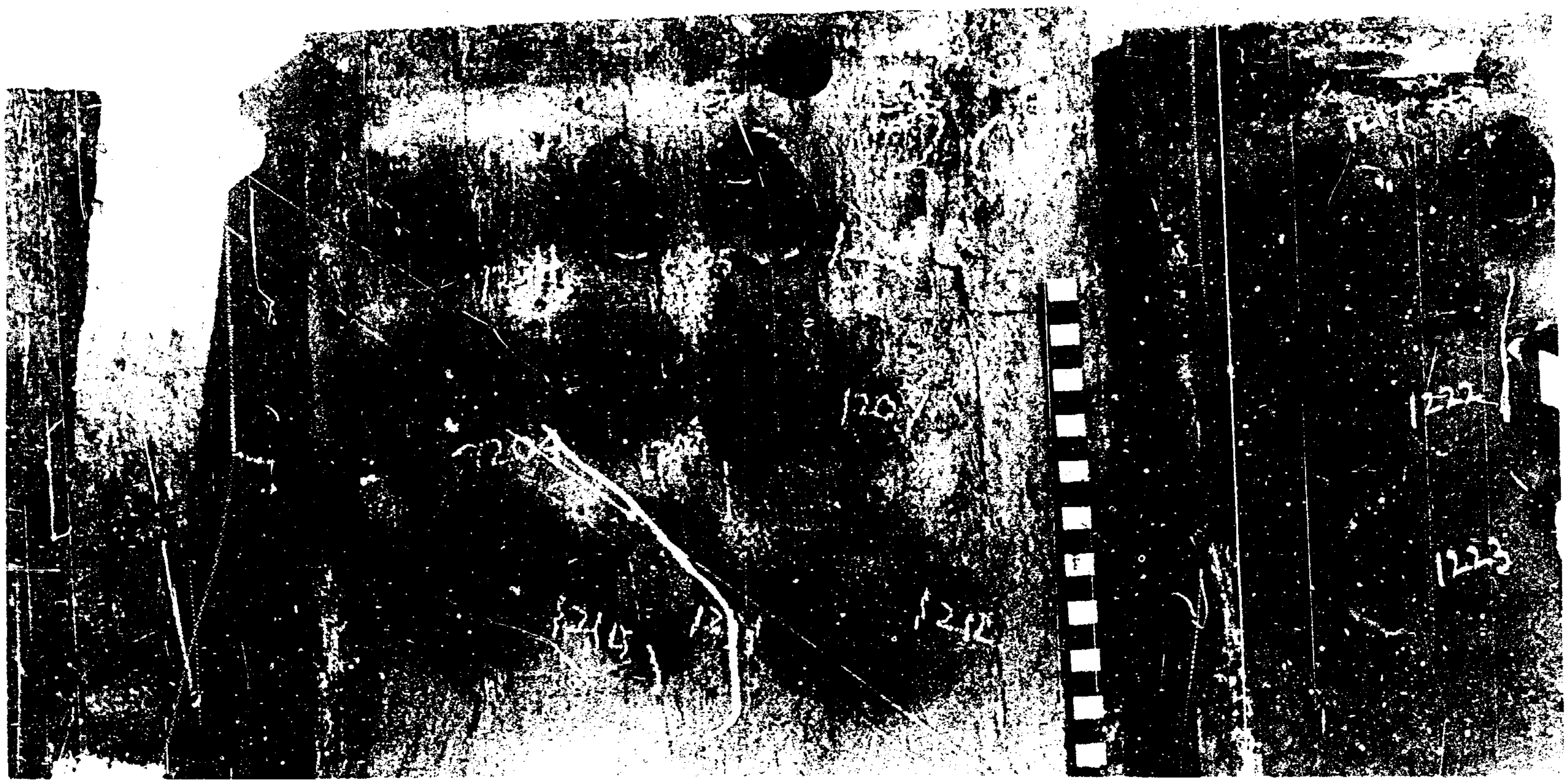

than the M79. The reasons for the superior performance of these two projectiles under the given conditions are not apparent from the firin . It may be a result of a type of punching action but from an inspection of the impact it was not possible to determine with certainty whether there was any punching or not. The soft cap on DA-302 was distinctly inferior to the hard cap especially at e/d of 0.24 (0"73) in which the difference between F-values for hard and soft caps (DA-302) was more than 14%.

At 60° obliquity for e/d of 0.24 (0"73) the M79 gave the worst performance of any of the projectiles tested. In general at this obliquity and e/d the heavier the cap weight the lower is the F-value. The effect of cap shape was clearly shown by the comparison of DA-304 and DA-301 which have about the same cap weight, 16% and 15% respectively, but different shapes. DA-301, the standard M61, gave 9% better performance than DA-304. This difference is the result of the blunter and more angular character of the M61 cap which enables that projectile to "bite" the plate better than the DA-304 (Heavy Type A-1) which has a smoother, more pointed contour.

The results given here are in general qualitative agreement with observations for 8" firing at the Plate Battery against homogeneous plate. In Fig. 2 the profiles of three 8" projectiles are compared with 3" projectiles of the same cap weight. For 8-inch projectiles at obliquities less than 40° and at e/d of 0.25 there is little difference between the three 8" projectiles of Fig. 2, whereas at 60° the performance is better in order of increasing cap weight, as was also the observed behavior of the 3" projectiles having a similar series of percentage cap weights.

V CONCLUSIONS.

1. Subject to confirmation against Class "A" armor, the most desirable cap shape of those tested and reported herein seems to be the blunt, angular variety similar to the M61, 8" Mk. 11 or 37mm M51B2 types.

2. The advantage of suitable cap shape arises at high obliquity impacts against thin plate, where improved performance as great as 14 per cent is observed.

3. Caps interfere with penetration of homogeneous plate at low obliquity (up to 30°) in proportion to their relative weights.

(a) The cap weight effect falls off at low and high e/d values.

(b) The interference with penetration is not influenced by cap shape.

VI RECOMMENDATIONS.

Additional experimental tests are desirable, especially against Class "A" armor, to study the effect of cap shape and projectile nose shape. It is recommended that arrangements be made to obtain 3" projectiles similar in design to the 8" A.P. Mark 19-4, and 14" A.P. Mk. 16 Mods. 4 and 8 in order to simulate Plate Battery test conditions at 3" scale. The heat-treatment of experimental caps and projectile bodies should follow the best current practice.

VII REFERENCES.

1. The effect of Nose Shape on the Ballistic Performance of 15-lb. 3" A.P. Solid Shot against Homogeneous Armor. U.S. Naval Proving Ground Report No. 2-43 dated 26 February, 1943.

2. Penetration of Homogeneous Armor by 3-inch Flat nosed projectiles. U.S. Naval Proving Ground Report No. 7-43 dated 19 April, 1943.

VIII APPENDIX.

BALLISTIC DATA
Symbols

e.....Plate thickness at impact in inches.

θ.....Obliquity. Angle between trajectory and normal to plate at impact.

M.....Projectile mass in lbs.

V_S....Striking Velocity in feet per second.

Pene..Depth of penetration in inches measured from front surface normal to plane of the plate.

V_R....Residual Velocity after penetration of plate.

F(e/d,θ)....Thompson F-coefficient defined by the relation.

$$F = \frac{41.57 \, M^{1/2} V_L \cos\theta}{e^{1/2} d}$$

where V_L = limit velocity (minimum velocity for complete penetration).

%.....% of empirical F(e/d,θ) value (Buord Sk. 78841).

CP....Complete penetration. Projectile completely through the plate.

Inc...Incomplete penetration. Projectile rejected.

SIP...Projectile stuck in plate.

PROJECTILE CONDITION

E.....Excellent.
NB....Nose shattered. (Less than half of the projectile shattered.)
X.....Shattered. (More than half of the projectile shattered.)
BD....Base dent.
B-2...Broken in two.

APL Impact No.	APL Plate No.	Proj.	e in.	θ	W lbs.	V_S f.s.	Pene. in.	V_R f.s.	F(e/d,θ)	%	Proj. Cond.
				3"25 Class "A" at 20° Obliquity							
1211	209	DA-301	3.22	19°45'	14.20	1771	1"	-			NB
1212			3.21	19°25'	14.20	1874	Inc.	-			X
1210			3.23	20°10'	14.20	1924	CP	-			BD
1209			3.18	20°20'	14.20	2045	CP	-	52,300±400	106.5	BD
1204		267805	3.17	20°20'	13.90	1987	Inc.				X
1205			3.17	20°30'	13.90	2055	CP		55,500±1000	113±2	NB
1206		DA-304	3.16	20°30'	14.65	2037	CP		57,300+	117+	X
1207		DA-302 Hard Cap	3.17	20°10'	13.60	2050	SIP		55,600+	114+	X
1208		3001	3.20	20°20'	14.50	2046	CP		56,900-	116-	NB

APL Impact No.	APL Plate No.	Proj.	e in.	θ	M lbs.	V_S fs	Pene. in.	V_R fs	F(e/d,θ)	%	Proj. Cond.
0".73 STS at 30° obliquity											
1239	214	DA-301	.730	29°50'	14.20	723	CP	272			E
1238	214	DA-301	.729	29°50'	14.20	670	CP	169	35,200±300	96.5	E
1240	214	DA-304	.728	29°35'	14.65	645	2"	-			E
1289	215	DA-304	.729	29°40'	14.65	655	1-7/8"	-			E
1292	215	DA-304	.723	30°10'	14.65	650	CP		35,500±200	97	E
1241	214	267805	.723	30°10'	13.90	651	1-3/4"		34,400+	94+	E
1242	214	DA-302 Hard Cap	.724	30°35'	13.60	624	1-3/4"				E
1290	215	"	.728	29°40'	13.60	630	CP		32,700±300	90	E
1291	215	DA-302 Soft Cap	.723	30°20'	13.60	647	1/8"-R*				E
1293	215	"	.723	30°00'	13.60	707	1/4"-R		37,300+	102.3	E
1243	214	3001	.725	30°30'	14.50	642	CP	30	34,500±200	95	E
1244	215	M79	.728	29°50'	14.90	629	CP	45	34,300±200	94	E

R* - Ricochet.

APL Impact No.	APL Plate No.	Proj.	e in.	θ	H lbs.	V_S f.s.	Pene. in.	V_R f.s.	F(e/d,θ)	ε	Proj. Cond.
						0"73 STS at 60° obliquity					
1267	220	M79	.73[illegible]	60°00'	14.99	1318	1"	--			B-2
1268			.732	59°55'	14.97	1364	3/4"	--			B-2
1269			.731	59°50'	14.96	1413	CP	--			E
1245	216		.731	60°00'	15.05	1415	CP	1037			E
								(Mean) F =	43,800±400	132	
1248	216	DA-301	.736	59°50'	14.20	1188	1"	--			ED
1265			.728	60°05'	14.20	1240	CP	484			E
1266			.735	60°05'	14.20	1245	CP	--			E
1249			.733	59°50'	14.20	1252	CP	--			E
1247			.737	59°50'	14.20	1303	CP	1092			E
1246			.729	60°05'	14.20	1426	CP	--	37,700±200	114	E
1270	220	DA-304	.728	59°05'	14.65	1377	CP	864	41,800±400	126	E
1271	221	267805	.727	60°00'	13.90	1246	5/8"	--			
1281	221		.733	60°00'	13.90	1373	CP	--	40,000±2000	121	E
1280	221	DA-303	.733	60°00'	13.90	1359	1-1/2"		41,500±300	125	ED
1272	220		.727	60°05'	13.90	1385	CP				E
1278	221	DA-302 Hard Cap	.735	59°55'	13.60	1445	CP		43,500-	131	E
1279	221	3001	.733	59°55'	14.50	1352	1-3/4"		42,200±200	127	ED

APL Impact No.	APL Plate No.	Proj.	e in.	θ	M lbs.	Vs f.s.	Pene. in.	V_R f.s.	F(e/d,θ)	%	Proj. Cond.
					1"94 STS at 0° Obliquity						
1237	213	DA-301	1.938	2°05'	14.20	1443	CP	248	53,650±200	126.5	E
1235	213	267805	1.938	0°30'	13.90	1461	CP	454	51,900±300	122	E
1236	213	DA-304	1.938	1°30'	14.65	1396	SIP 6"	--	53,700±200		E
1234	212	DA-303	1.937	4°25'	12.90	1484	CP	537	51,500±400	121.5	E
1232		DA-302 Hard Cap	1.937	4°20'	13.6	1368	3"	--			E
1233		"	1.937	3°45'	13.6	1533	CP	627	51,600±500	122	E
1230		3001	1.936	2°20'	14.50	1223	3"	--			E
1231		"	1.936	3°20'	14.50	1287	3-1/4"	--	49,100+	116+	E
1229		M79	1.936	1°50'	15.00	1238	CP	316	46,300±300	109	E
1304	213	DA-302 Soft Cap	1.940	1°10'	13.6	1456	CP	511	50,400±400	119	E

APL Impact No.	APL Plate No.	Proj.	e in.	θ	M lbs.	V_S f.s.	Pene. in.	V_R f.s.	F(e/d,θ)	%	Proj Cond.
					1".94 [illegible] at 30° Obliquity						
1217	211	DA-301	1.937	30°00'	14.2	1438	2-1/4"				E
1218			1.937	29°[illegible]'	14.2	1611	CP	466			E
1219			1.937	29°40'	14.2	1552	CP	294			E
1220			1.940	29°30'	14.2	1540	CP	81			E
1221			1.942	30°10'	14.2	1604	CP	390			E
1222			1.942	29°50'	14.2	1778	CP	864	50,400±200	116	E
1223		267805	1.942	30°20'	13.90	1569	CP	397	48,900±200	112	E
1224		DA-304	1.942	30°00'	14.65	1566	CP	425	50,000±300	115	E
1225		DA-303	1.942	29°50'	13.90	1533	CP	423	47,600±300	109	E
1226	212	DA-302 Hard Cap	1.937	30°00'	13.60	1540	CP	612	45,300±400	104	E
1305	213	DA-302 Soft Cap	1.940	29°50'	13.60	1451	2-3/4"				E
1306	213	"	1.938	29°50'	13.60	1514	CP	318	47,000±200	108	E
1227	212	3001	1.937	29°40'	14.50	1492	CP	724	43,200±400	11[illegible]	E
1228		M79	1.937	29°45'	15.00	1338	CP	160	44,300±200	102	E

APL Impact No.	APL Plate No.	Proj.	e in.	θ	M lbs.	VS f.s.	Pene. in.	V_R f.s.	F(e/d,θ)	%	Proj. Cond.
3" Class "B" at 0° Obliquity											
1302	223	M79	3.192	0°20'	15.10	1681	5-1/2"		50,800+	107+	E
1295		DA-301	3.185	0°00'	14.20	1954	CP	190	57,300±200	121	E
1296		DA-304	3.185	0°10'	14.65	1997	CP	700	55,700±400	117	E
1297		DA-302 Hard Cap	3.184	0°30'	13.60	1936	CP	350	54,800±200	115.5	E
1298		DA-302 Soft Cap	3.188	0°00'	13.60	1940	CP	346	55,000±200	116	E
1299		3001	3.187	0°00'	14.50	1722	4-1/4"	--			E
1300			3.189	0°10'	14.50	1769	CP	263	52,000±200	110	E
1301		267805	3.194	0°20'	13.87	1914	CP	450	54,100±300	114	E