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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

REPORT NO. 1095

RECOVERY FIRING OF 40MM PROJECTILE
COATED WITH MOLYBDENUM DISULFIDE

FINAL Report

Copy No. 10

Task

Assignment NGF-13-Re5a-27-2

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NPG REPORT NO. 1095

Recovery Firing of 40mm Projectile
Coated with Molybdenum Disulfide

PART A

SYNOPSIS

1. Twenty (20) 40mm T1E1 projectiles were fired for recovery in the Army 40mm M1 barrel No. 60449. At various stages of the test, the projectiles or the bore of the gun or both were coated with molybdenum disulfide to obtain information on its use as a gun bore lubricant and to arrive at a suitable method of application for a future gun life test.
2. No definite conclusions could be arrived at from the results of this limited test as to the effect of molybdenum disulfide as a gun bore lubricant. However, the best method of application tested was judged to be wiping on the dry material to cover the projectile band and body without coating the gun. This method was preferred because of its simplicity.

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PART B

INTRODUCTION

1. AUTHORITY:

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

2. REFERENCES:

- a. BUORD ltr S74-1 (40mm) Re5a-FBW:11h Ser 13308 to SUPT NGF and COM NAVPROV of 6 November 1951
- b. BUORD ltr NP7 Re5a-FBW:11h to SUPT NGF and COM NAVPROV of 5 June 1951
- c. NGF Request for Performance of Work 171-0323-P1-261-178 of 18 July 1951
- d. U. S. Army Projectile Drwg. 75-2-304 40mm T1E1 Projectiles

3. BACKGROUND:

In March 1951 the Proving Ground fired a small number of 3"/70 AA projectiles with the bands lubricated with molybdenum disulfide in an attempt to improve band performance. The effect on the bands was not significant, but it was suggested to the Bureau of Ordnance that an evaluation program be conducted to determine whether the observed lubrication of the bore would be a factor in increasing the life of the gun. This program was initiated by reference (b), modified by reference (a) and fired under reference (c).

4. OBJECT OF TEST:

The object of this test was to determine the best method of applying molybdenum disulfide to 40mm projectiles for use in a future life test of a gun.

5. PERIOD OF TEST:

- | | |
|------------------------|-----------------|
| a. Date of Directive | 6 November 1951 |
| b. Date Test Commenced | 3 April 1952 |
| c. Date Test Completed | 4 April 1952 |

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**Recovery Firing of 40mm Projectile
Coated with Molybdenum Disulfide**

c. Three (3) rounds slow fire with band and body of the projectile coated and an uncoated barrel.

d. Three (3) rounds slow fire with uncoated projectile and the barrel initially coated.

e. Three (3) rounds slow fire with band and body of the projectile coated and the barrel initially coated.

f. Three (3) rounds slow fire with band and body of the projectile coated and the barrel coated before each round. Coating of the band and the projectiles was accomplished by wiping with a swab impregnated with dry molybdenum disulfide powder.

Transverse strain gage measurements taken at four (4) points on the gun barrel are included as Table II, Appendix (C). One (1) point was as near the muzzle as possible with another as far aft as was convenient. The remaining two (2) points were equally spaced between these.

9. RESULTS AND DISCUSSION:

Complete before and after firing data are given in Table I (Appendix (A)), and photographs of the recovered projectiles are included as Figures 1-20, inclusive. Strain gage measurements taken at four (4) points along the gun barrel are included as Table II. Photographs of the oscillograph records are included as Figures 22-27, inclusive.

As a result of the limited scope of this test it was not expected that any appreciable superiority would be shown for any one (1) lubrication method and this expectation was borne out by the data. For this reason the simplest method tested, that of merely wiping the dry powder on the band and on the body forward of the band, was judged best.

As far as visual inspection could tell, the band appeared to be well coated with molybdenum disulfide after the test. Traces of molybdenum disulfide were noted on the shell cases and a deposit was noted in the gun chamber after firing. It is felt that this deposit resulted from swabbing the barrel and is not to be expected if only the projectile band and body is coated.

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Concurrent tests conducted by the Naval Proving Ground on 3"/70 projectiles have demonstrated a more satisfactory way of applying molybdenum disulfide. In this method the powder is mixed with a plastic paint and painted on the projectile. It is then possible to get a uniform coating of sulfide of considerably greater thickness than can be obtained by wiping on the dry powder. In the 40mm gun life test it is possible that this method will be used to supplement the dry powder application.

PART D

CONCLUSIONS

10. No definite conclusions could be arrived at from the results of this limited test as to the effect of molybdenum disulfide as a gun bore lubricant. However, the best method of application tested was judged to be wiping on the dry material to cover the projectile band and body without coating the gun. This method was preferred because of its simplicity.

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Coated with Molybdenum Disulfide

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

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E. A. RUCKNER
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Ordnance Officer
By direction

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NPG REPORT NO. 1095

**U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA**

Final Report

on

Recovery Firing of 40mm Projectile

Coated with Molybdenum Disulfide

**Project No.: NGF-13-Re5a-27-2
Copy No.: 10
No. of Pages: 7**

Date:

MAR 4 1953

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Recovery Firing of 40mm Projectile Coated with Molybdenum Disulfide
-----**TABLE I****COMPLETE BEFORE AND AFTER FIRING DATA****Recovery Test of T1E1 40mm Projectiles
in Army 40mm M1 Gun Barrel No. 60449**

<u>Proj. No.</u>	<u>Firing Order 4/3/52</u>	<u>Firing Condition</u>	<u>Powder Charge (gms.) SPDN-8541</u>	<u>Pressure (t.s.i.)</u>	<u>Muzzle Velocity (ft./sec.)</u>	<u>Weight (lbs.)</u>
1170	1	Warming Round	305.3	20.6	2925	1.985
1171	2	A	"	20.6	2908	"
1172	3	A	"	----	2908	"
1173	4	A	"	20.3	2908	"
1174	5	B	"	20.6	2910	"
1175	6	B	"	19.3	2913	"
1176	7	B	"	19.3	2913	"
1177	8	C	"	----	2902	"
1178	9	C	"	20.3	2911	"
1179	10	C	"	19.1	2910	"
1180	4/4/52 1	Warming Round	"	21.3	2929	"
1181	2	D	"	21.1	2925	"
1182	3	D	"	20.8	2908	"
1183	4	D	"	19.6	2906	"
1184	5	E	"	21.3	2905	"
1185	6	E	"	20.6	2912	"
1186	7	E	"	20.0	2914	"
1187	8	F	"	20.6	2908	"
1234	9	F	"	19.6	2913	"
1235	10	F	"	20.8	2912	"

NOTES: Gun barrel was cleaned and oiled after first day's firing and was wiped free of oil before second day's firing.

A-Projectiles and barrel uncoated.

B-Projectile bands coated with molybdenum disulfide before firing.

C-Entire projectile coated with molybdenum disulfide before firing.

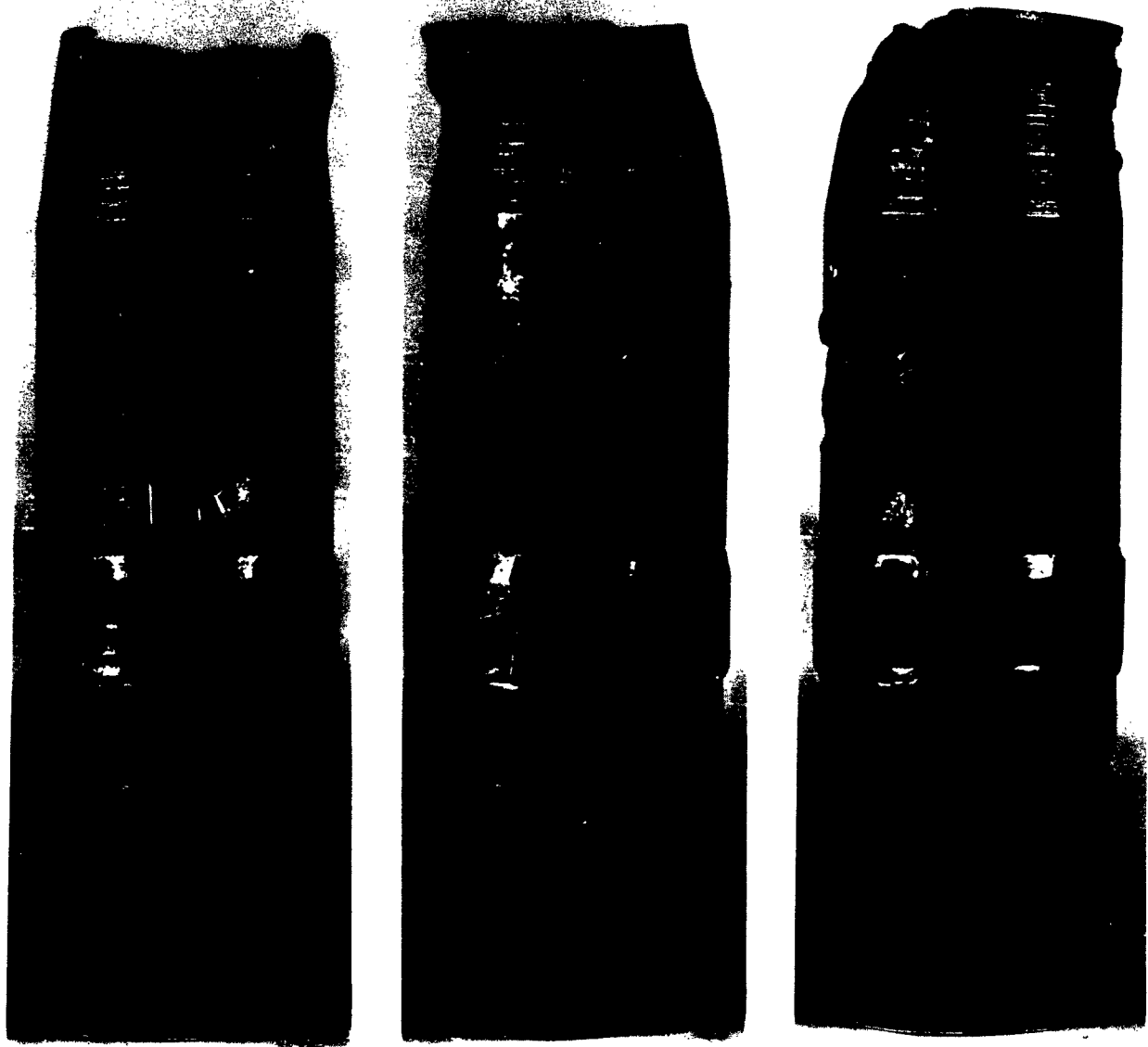
D-Barrel initially coated with molybdenum disulfide before firing.

E-Entire projectile coated and barrel initially coated with molybdenum disulfide before firing.

F-Entire projectile coated and barrel coated before each round with molybdenum disulfide.

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NP9-48796

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40mm T1E1 projectile

Three views (120° apart) of recovered
(warming round). Projectile No. 1170.

Figure 1

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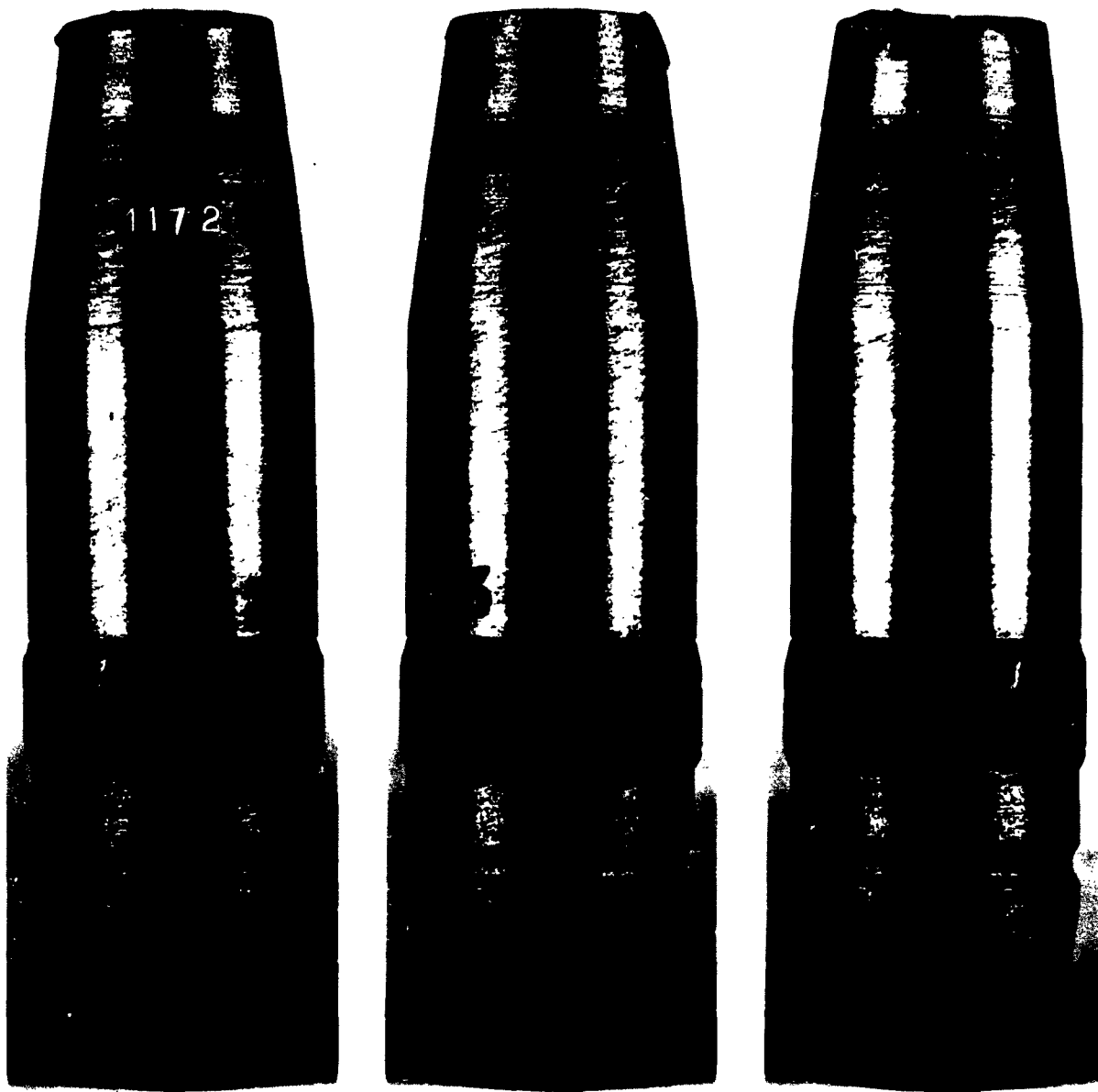
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Three views (120° apart) of recovered 40mm T1E1 projectile (uncoated projectile and barrel). Projectile No. 1171.

Figure 2

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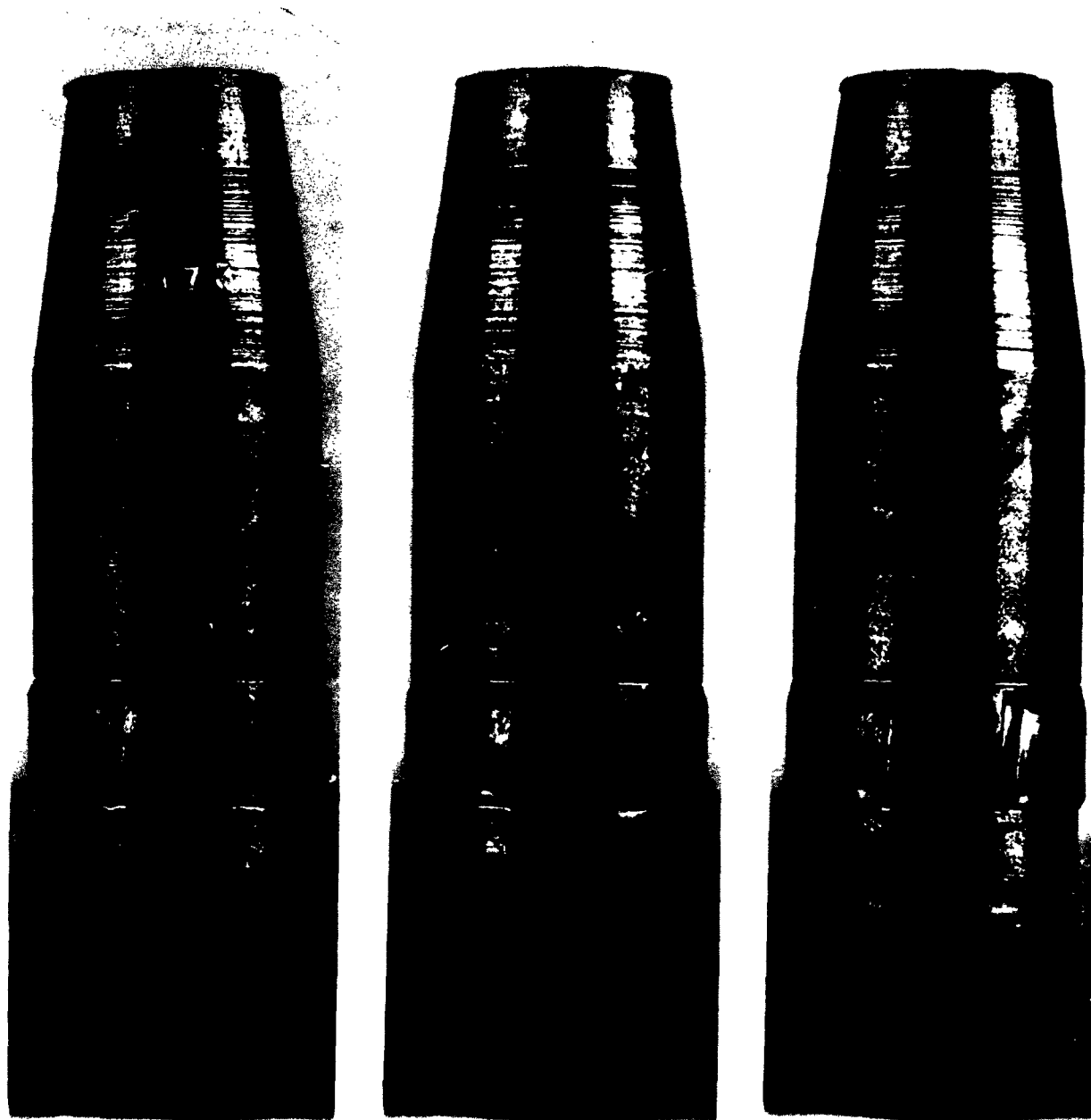
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Three views (120° apart) of recovered 40mm T1E1 projectile (uncoated projectile and barrel). Projectile No. 1172.

Figure 3



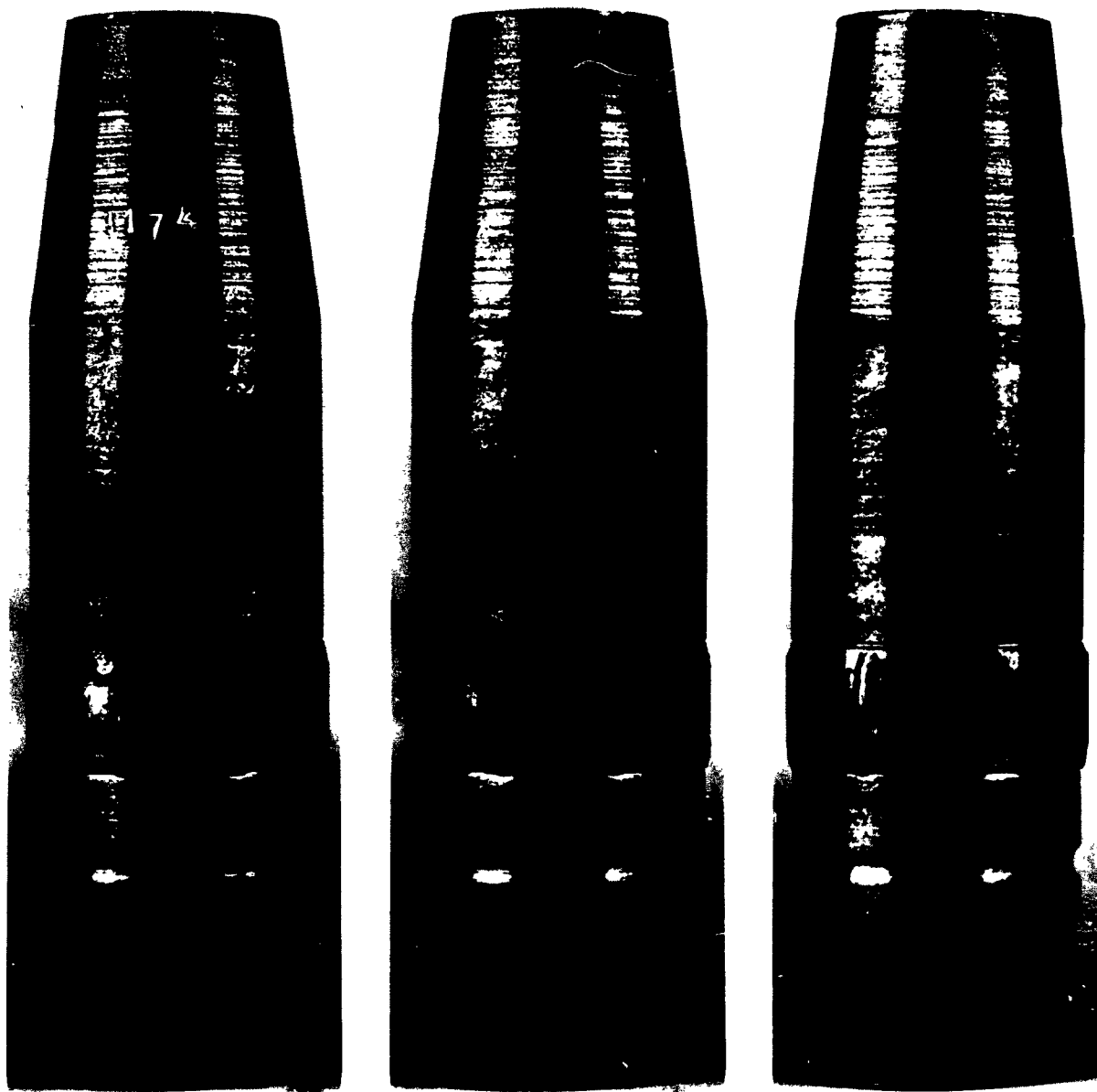
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Three views (120° apart) of recovered 40mm T1E1 projectile (uncoated projectile and barrel). Projectile No. 1173.

Figure 4



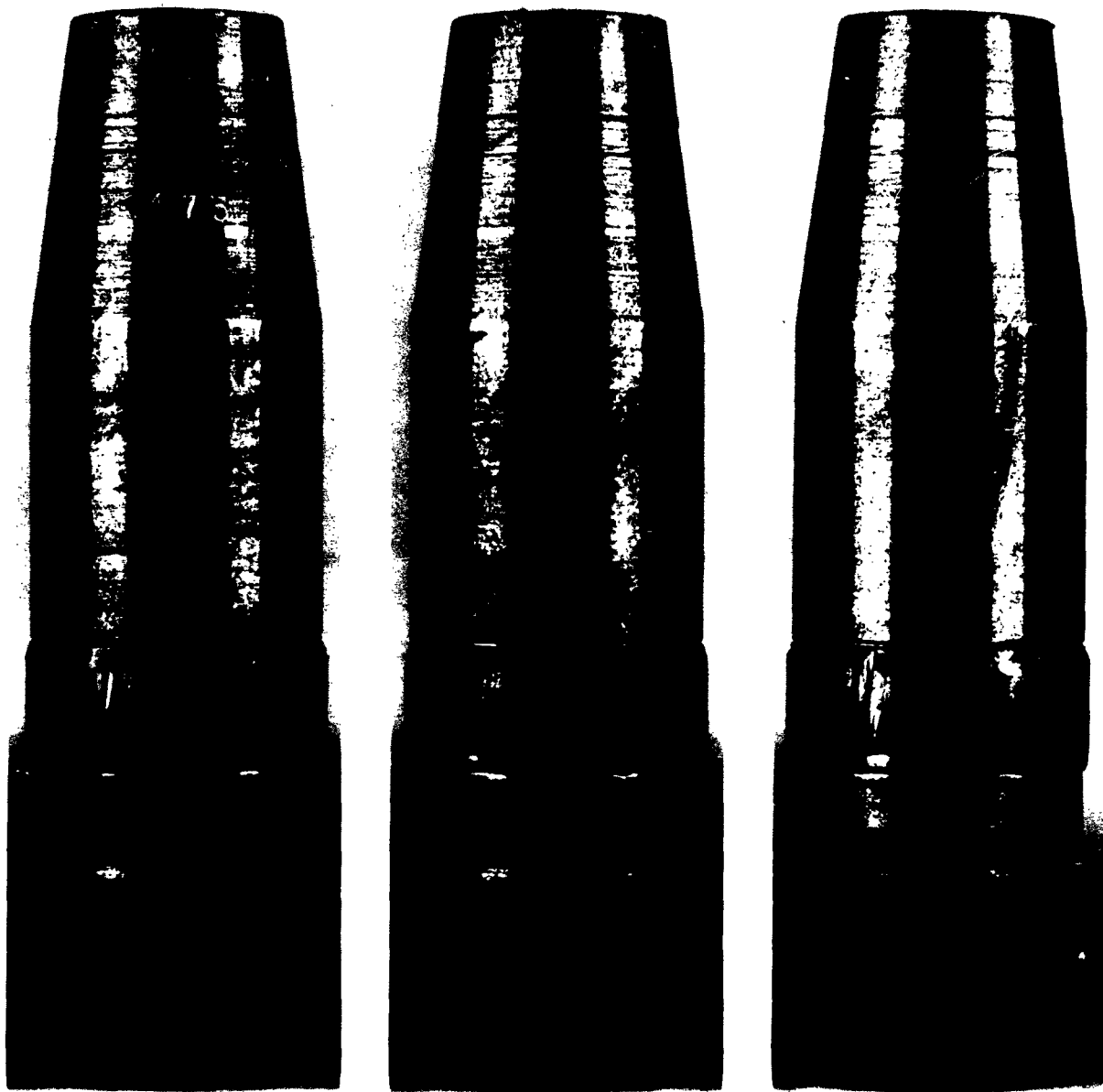
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Three views (120° apart) of recovered 40mm T1E1 projectile
(band of projectile coated, uncoated barrel). Projectile
No. 1174.

Figure 5



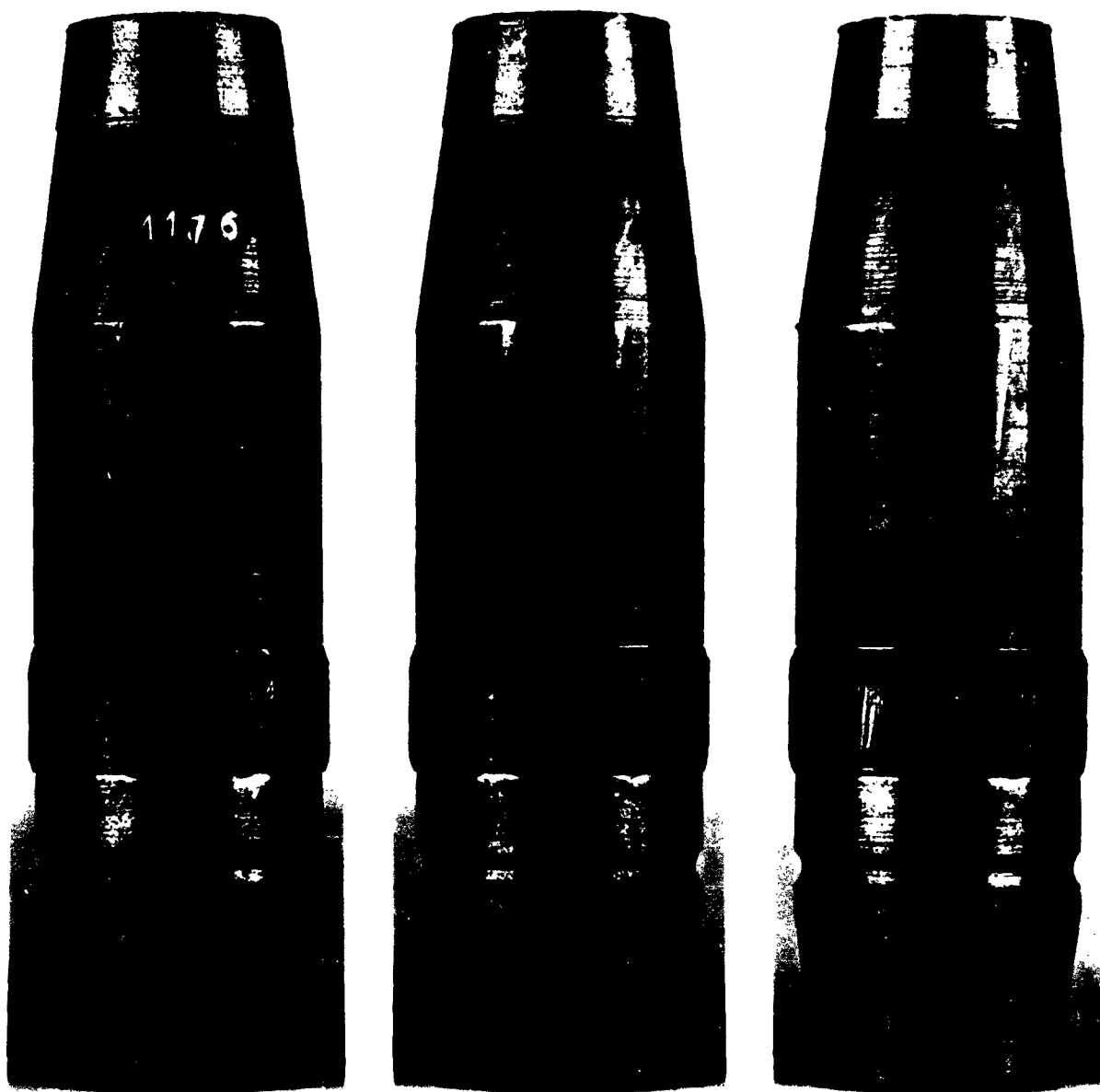
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Three views (120° apart) of recovered 40mm T1E1 projectile
(band of projectile coated, uncoated barrel). Projectile
No. 1175.

Figure 6



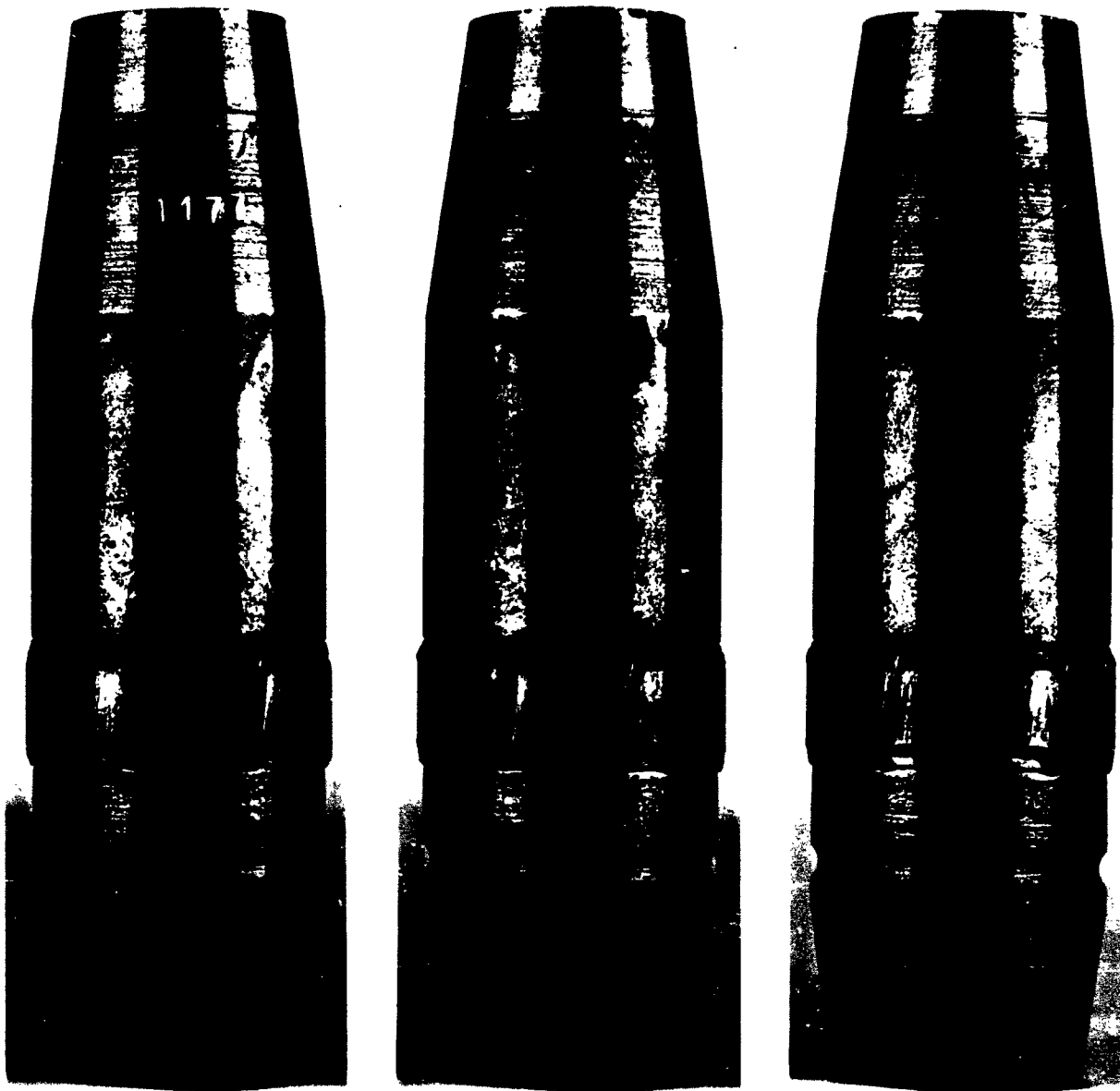
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Three views (120° apart) of recovered 40mm T1E1 projectile (band of projectile coated, uncoated barrel). Projectile No. 1176.

Figure 7



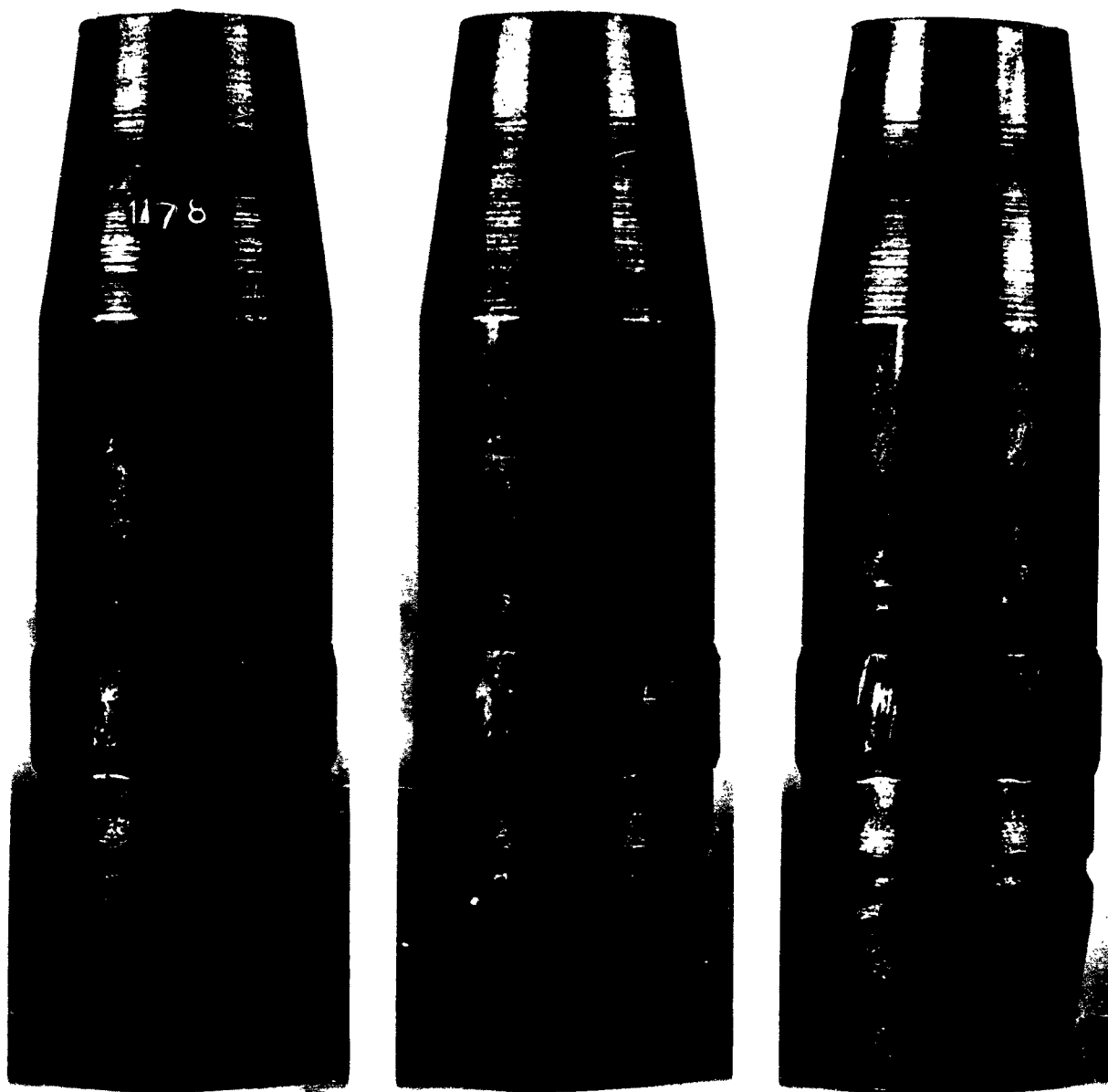
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Three views (120° apart) of recovered 40mm T1E1 projectile (entire projectile coated, uncoated barrel). Projectile No. 1177.

Figure 8



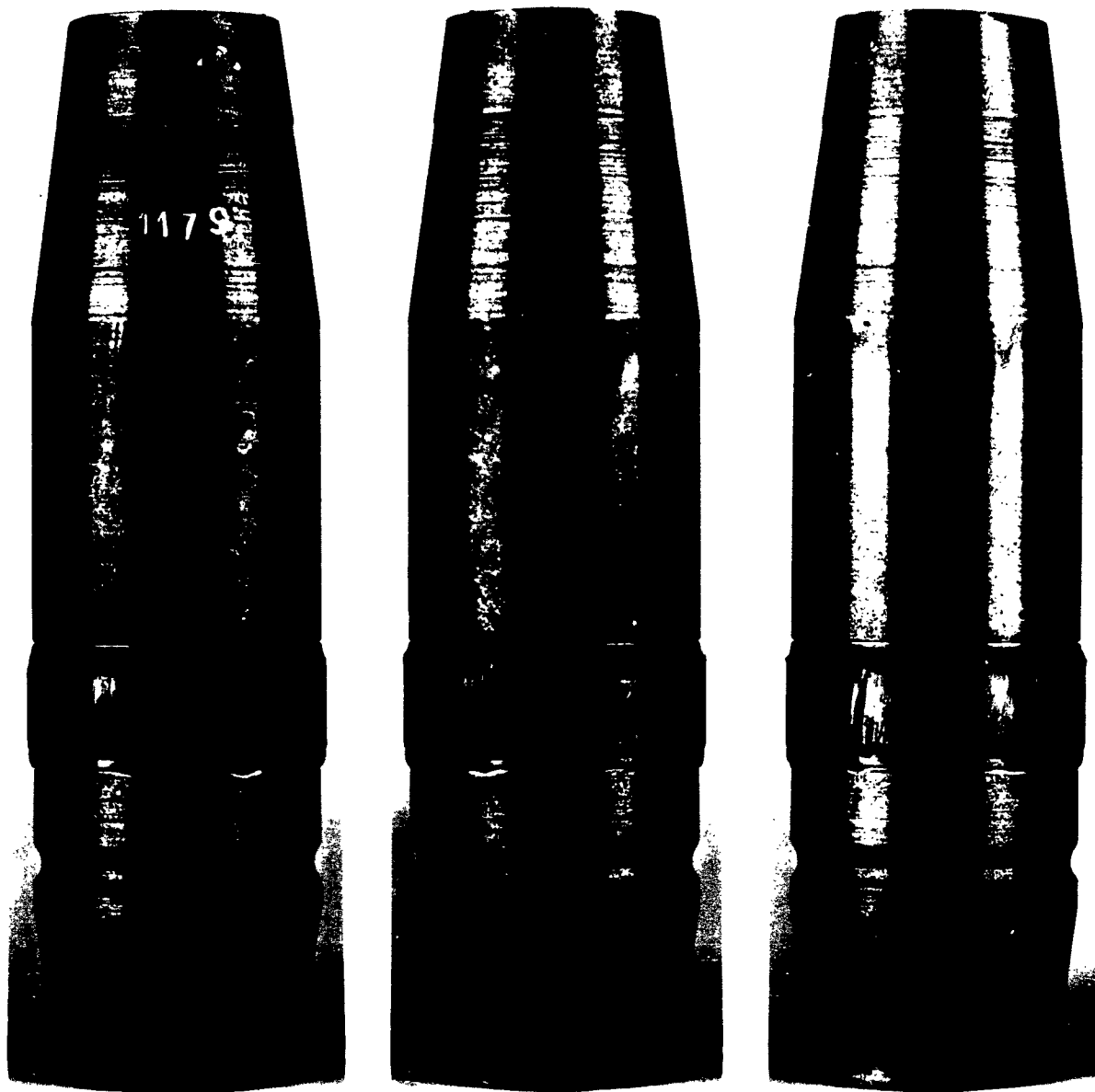
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Three views (120° apart) of recovered 40mm T1E1 projectile (entire projectile coated, uncoated barrel). Projectile No. 1178.

Figure 9



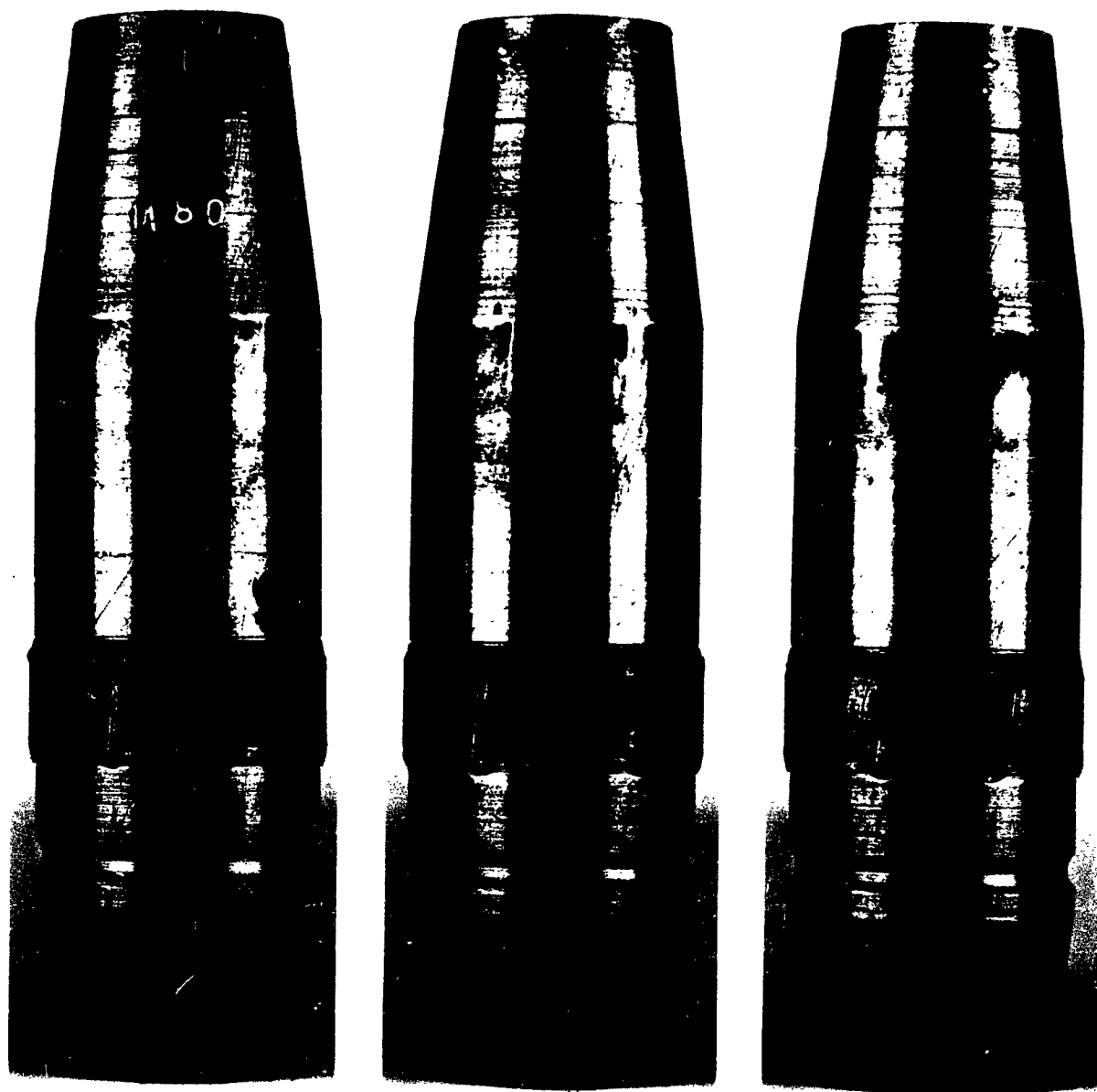
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Three views (120° apart) of recovered 40mm T1E1 projectile (entire projectile coated, uncoated barrel). Projectile No. 1179.

Figure 10



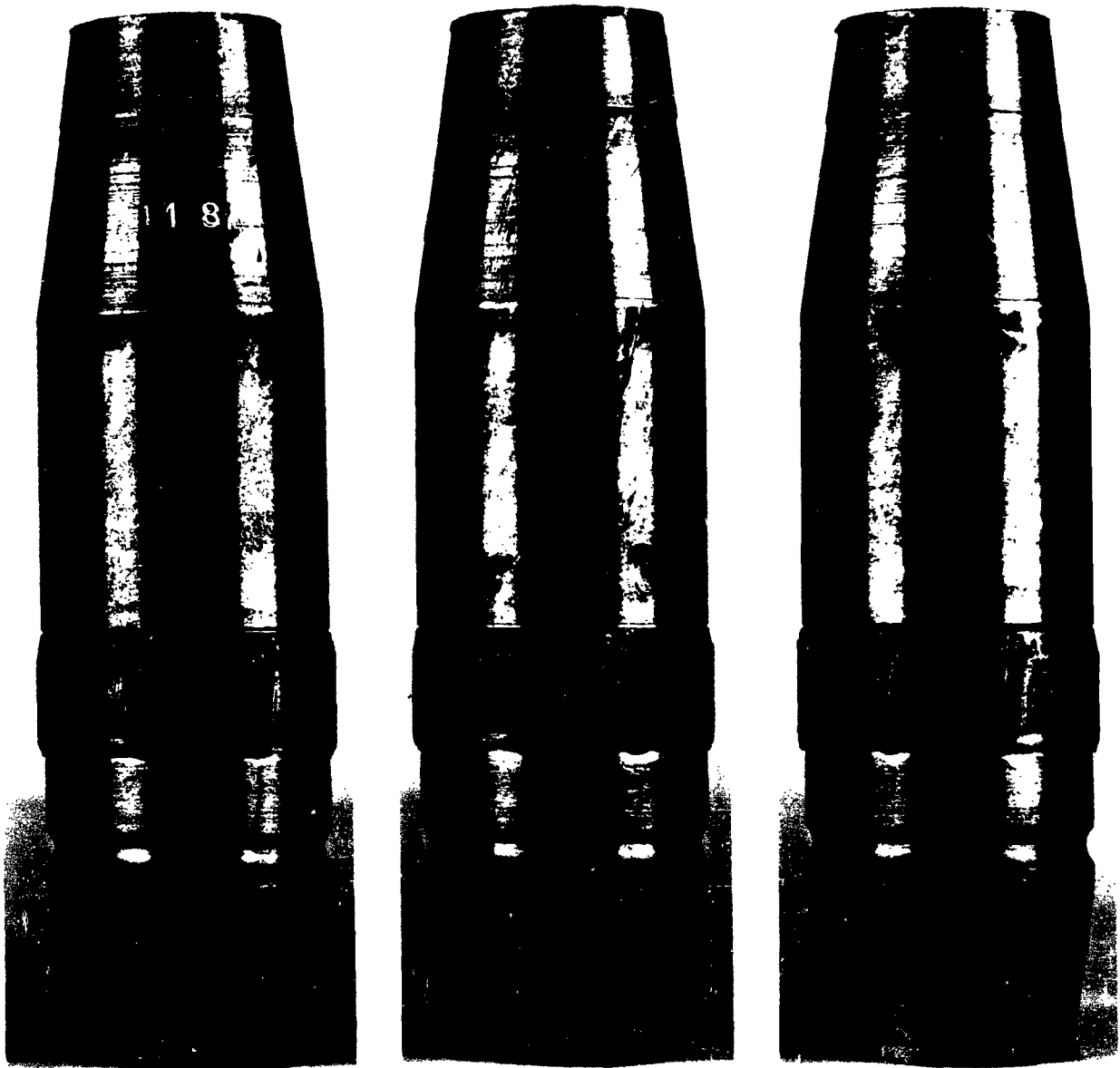
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Three views (120° apart) of recovered
(warming round). Projectile No. 1180.

Figure 11

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40mm T1E1 projectile



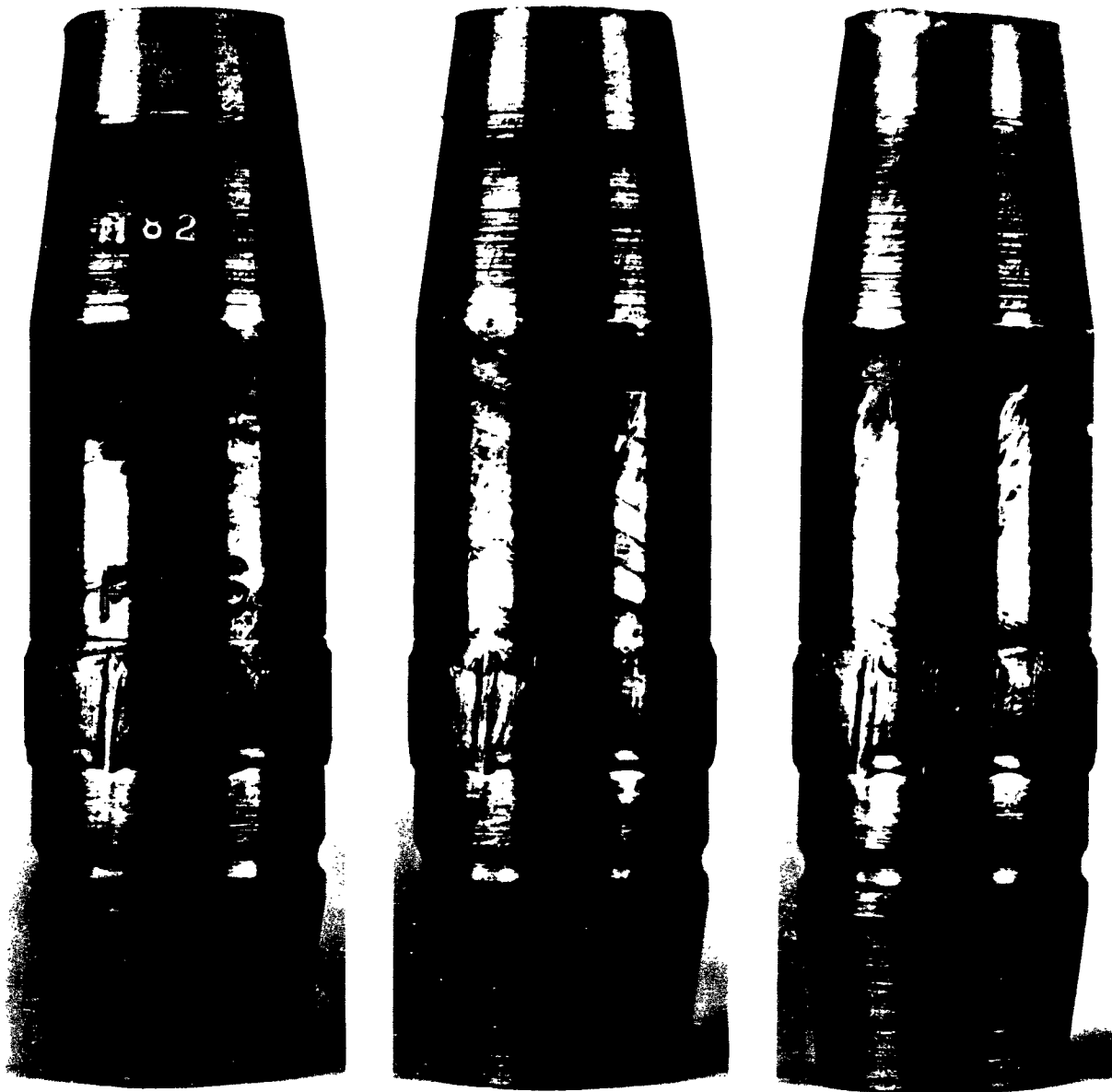
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Three views (120° apart) of recovered 40mm T1E1 projectile (uncoated projectile, barrel initially coated for three round group). Projectile No. 1181.

Figure 12



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Three views (120° apart) of recovered 40mm T1E1 projectile (uncoated projectile, barrel initially coated for three round group). Projectile No. 1182.

Figure 13



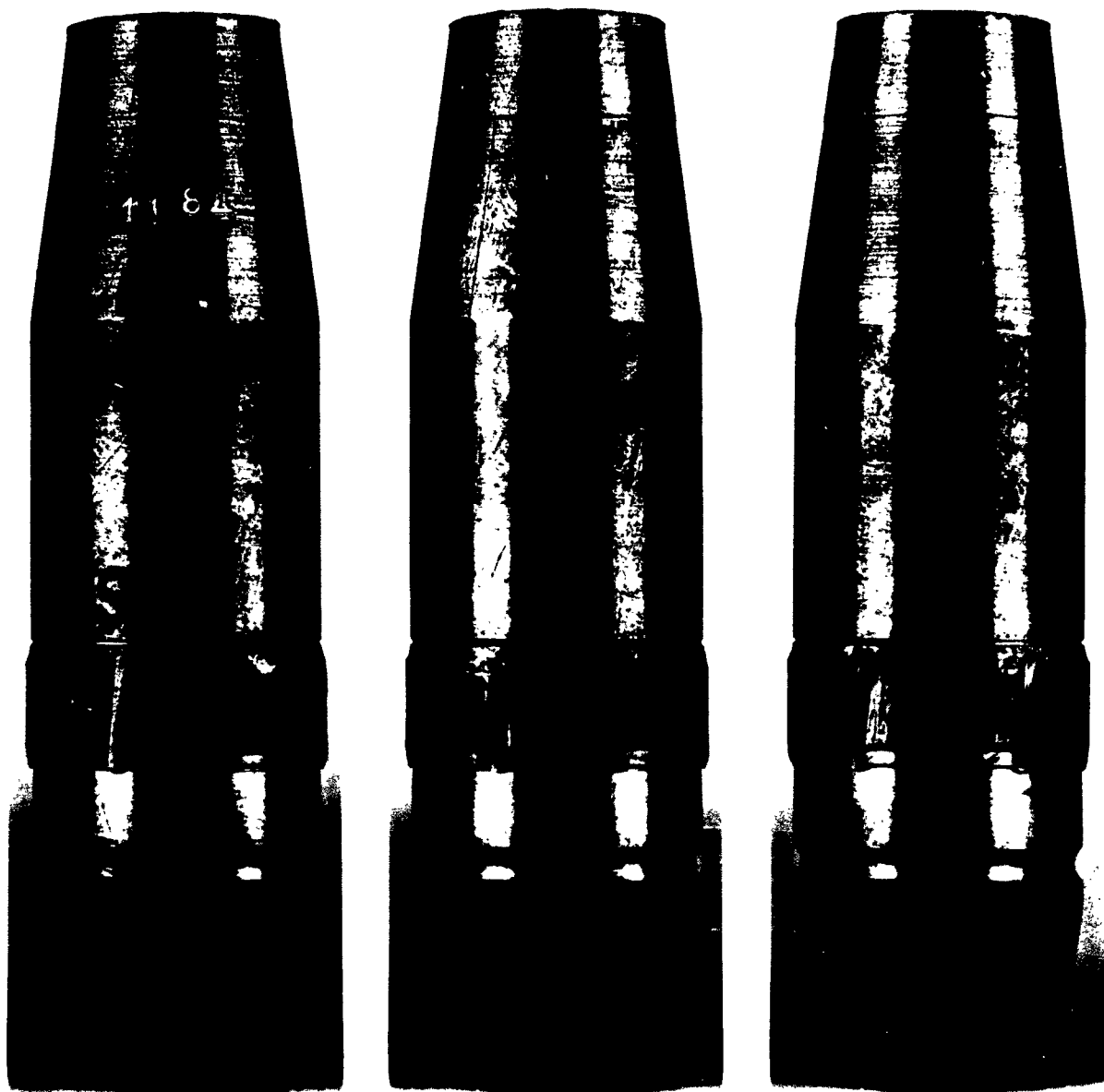
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Three views (120° apart) of recovered 40mm T1E1 projectile (uncoated projectile, barrel initially coated for three round group). Projectile No. 1183.

Figure 14



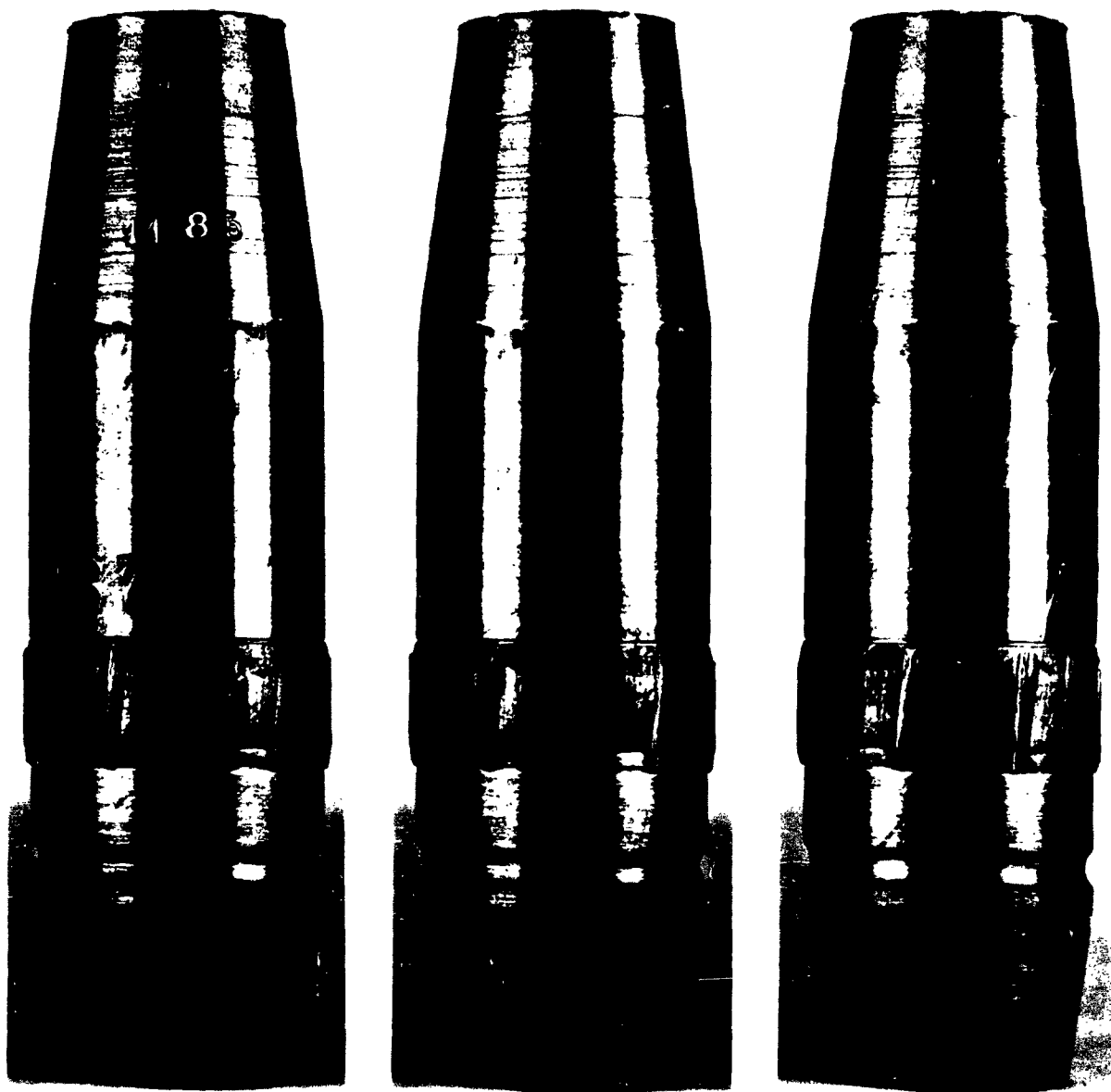
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Three views (120° apart) of recovered 40mm T1E1 projectile (projectile completely coated, barrel initially coated for three round group). Projectile No. 1184.

Figure 15



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Three views (120° apart) of recovered 40mm T1E1 projectile (projectile completely coated, barrel initially coated for three round group). Projectile No. 1185.

Figure 16



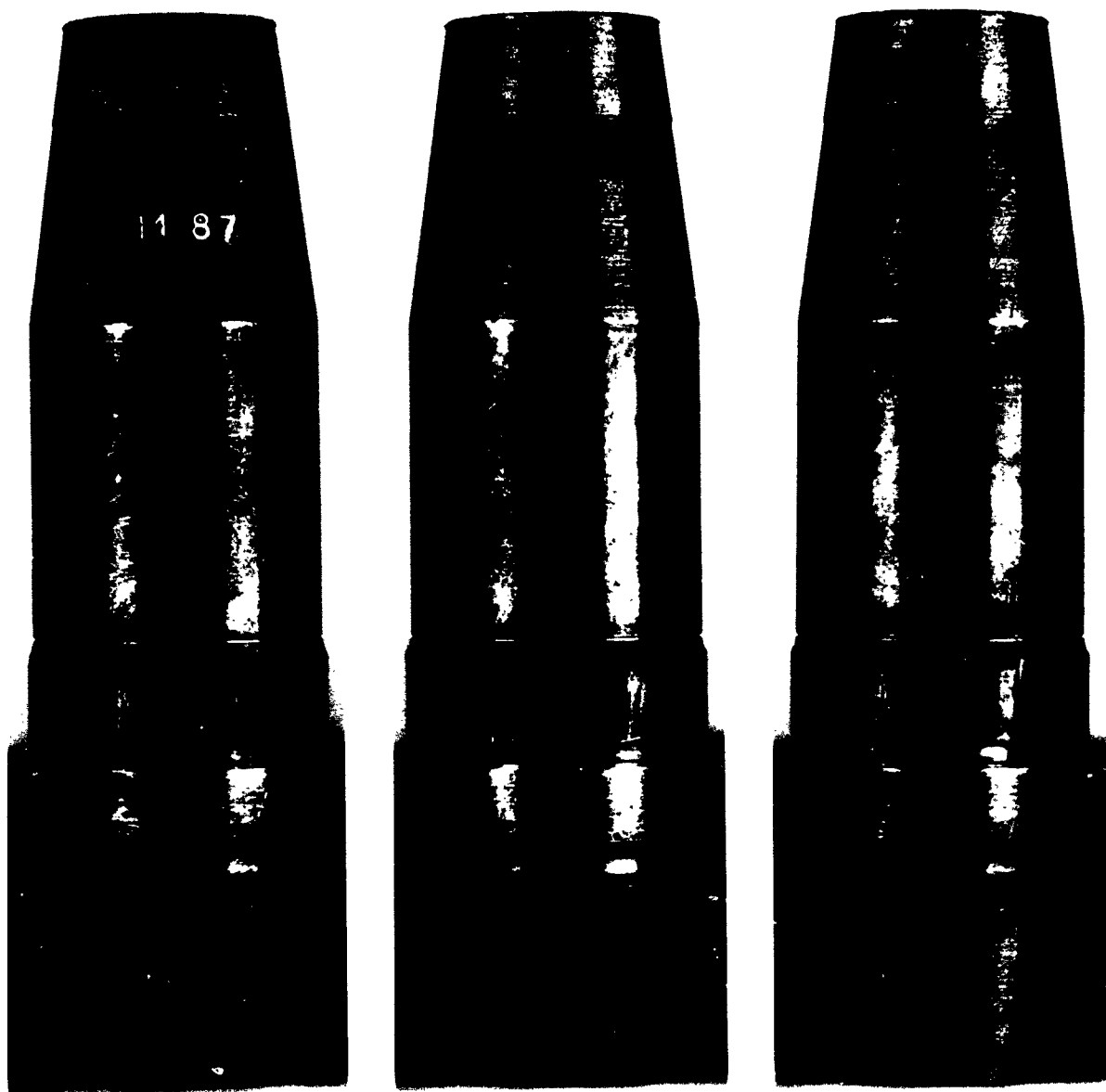
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Three views (120° apart) of recovered 40mm T1E1 projectile (projectile completely coated, barrel initially coated for three round group). Projectile No. 1186.

Figure 17



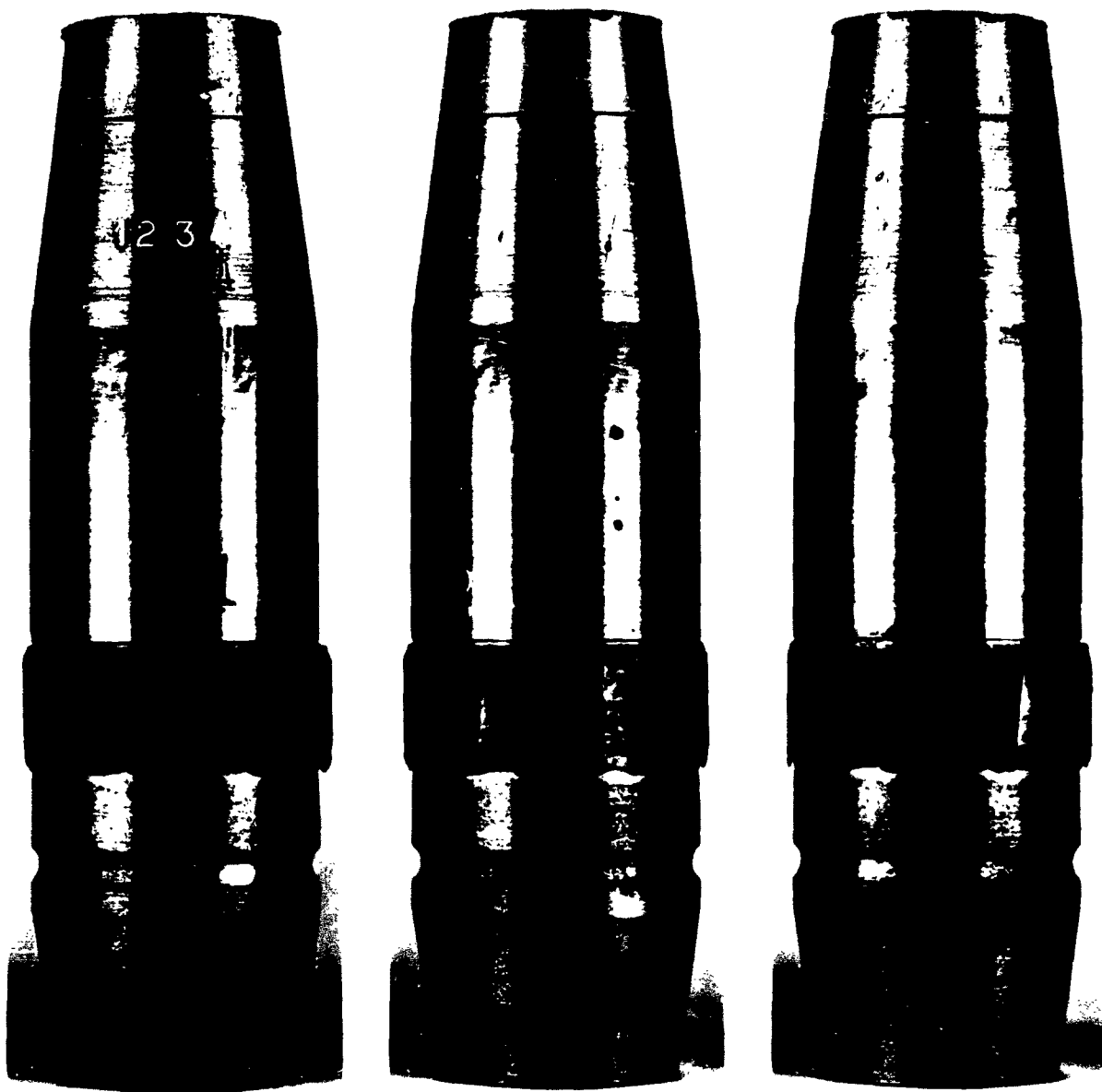
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Three views (120° apart) of recovered 40mm T1E1 projectile (projectile completely coated, barrel coated). Projectile No. 1187.

Figure 18



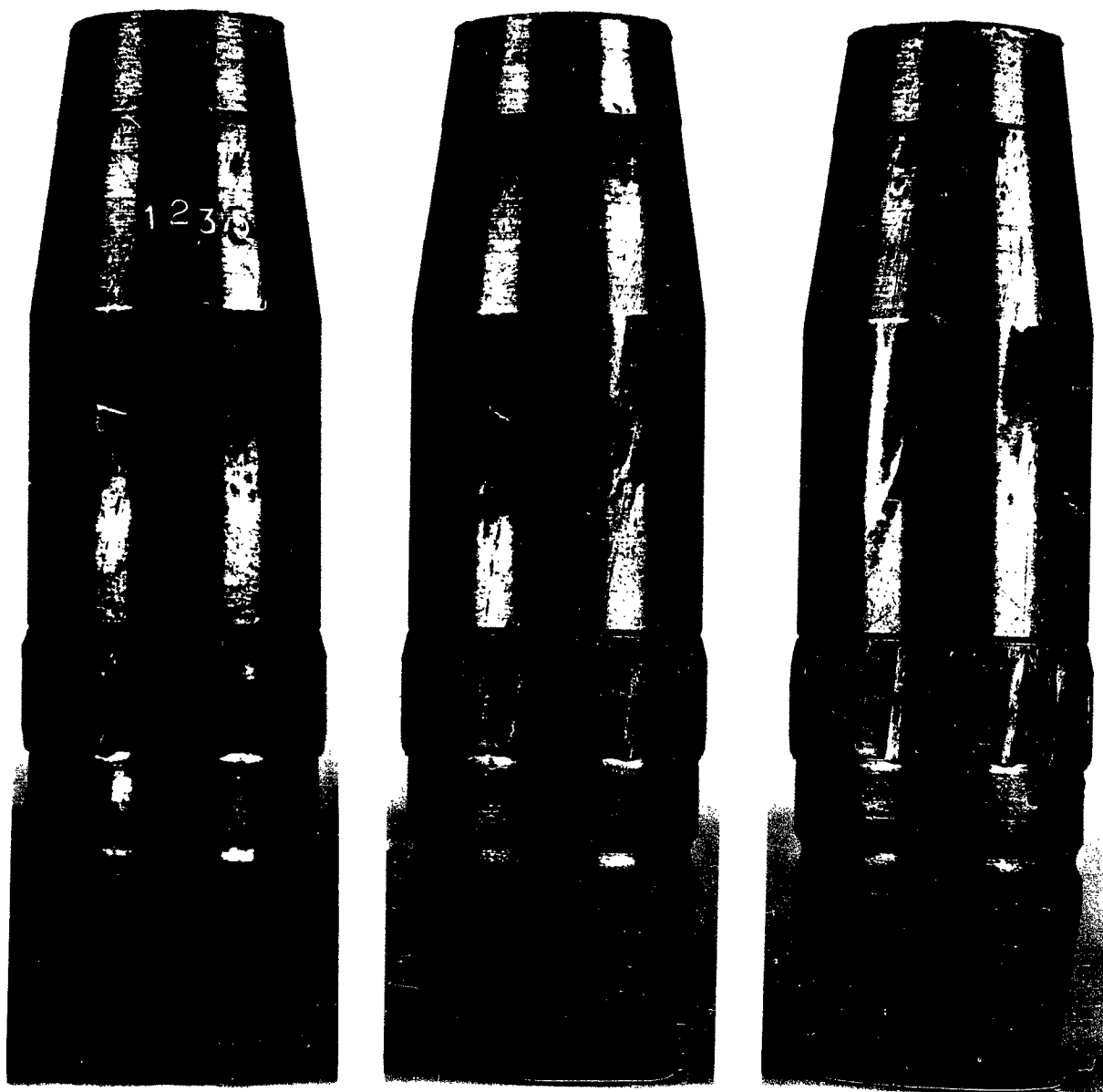
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Three views (120° apart) of recovered 40mm T1E1 projectile (projectile completely coated, barrel coated). Projectile No. 1234.

Figure 19



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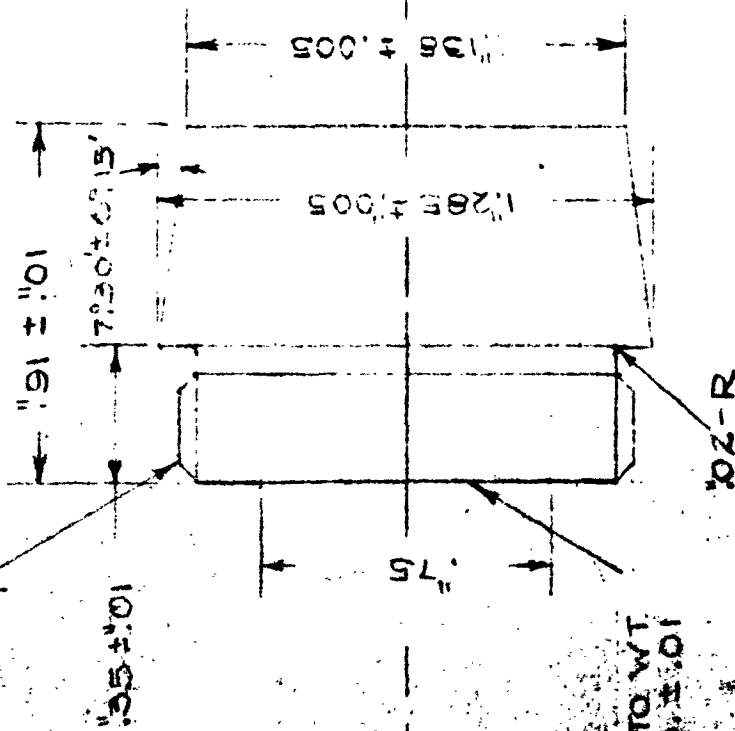
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Three views (120° apart) of recovered 40mm T1E1 projectile
(projectile completely coated, barrel coated). Projectile
No. 1235.

Figure 20

118-14 NS-2
 MAJOR DIA. 1.18 ± .0008
 PITCH DIA. 1.1356 ± .0036
 MINOR DIA. 1.0924 MAX.



DRILL TO WT
 WT 1.1518 ± .01

DUMMY NOSE PLUG
 FOR 40 MM PROJECTILE
 MAT'L: MEDIUM STEEL
 C1040 - C1137 OR SIMILAR

NOTE: REMOVE ALL BURRS

APL-170
 10/2/50
 a.b.m.

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Recovery Firing of 40mm Projectile Coated with Molybdenum Disulfide

TABLE II

40mm Barrel No. M1 - 60449, Test of Molybdenum Disulfide
 Strain Gage Measurements (Circumferentially)
 Powder: SPDN-8541; Proj.: T1E1 Blunt Nose, Copper Bands

Date	Rd.	Strain in # ins./in. at 56°75' from muzzle Peak	Strain in # ins./in. at 38°50' from muzzle Pla- teau Peak	Strain in # ins./in. at 20°25' from muzzle Pla- teau Peak	Strain in # ins./in. at 2°0' from muzzle Pla- teau Peak	Copper Crusher Pressure (tons)	Remarks
4/3	1	445	260 400	220 375		20.6	Warning Round
"	3	465	255 445	230 575		----	A
"	4	445	255 445	225 520		20.3	A
"	5	470	255 465	235 510		20.6	B
"	6	475	240 415	255 575		19.3	B
"	7	475	255 480	235 590		19.3	B
"	8	435	245 440	215 555		----	C
"	9	465	250 450	220 500	250* 440*	20.3	C
"	10	445	250 460	250 560		19.1	C
4/4	1	480	275 315	230 260	240* 445*	21.3	Warning Round
"	2	465	255 430	230 505		21.1	D
"	3	465	270 460	---	---	20.8	D
"	4	470	265 400	220 365	325* 605*	19.6	D
"	5	475	260 480	225 605	320* 635*	21.3	E
"	6	470	255 480	230 580		20.6	E
"	7	450	255 445	230 535		20.0	E
"	8	465	255 475	230 535	210* 600*	20.6	F
"	9	455	255 385	230 405		19.6	F
"	10	445	245 435	230 525	250* 600*	20.8	F

* These values are doubtful because of a defective strain gage. There were no other strain measurements obtained at the 2°0 position due to the defective gage.

NOTES: Gun barrel was cleaned and oiled after first day's firing and was wiped free of oil before second day's firing.

A-Projectiles and barrel uncoated.

B-Projectile bands coated with molybdenum disulfide before firing.

C-Entire projectile coated with molybdenum disulfide before firing.

D-Barrel initially coated with molybdenum disulfide before firing.

E-Entire projectile coated and barrel initially coated with molybdenum disulfide before firing.

F-Entire projectile coated and barrel coated before each round with molybdenum disulfide.

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U. S. Naval Proving Ground - 3 April 1952

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40MM Barrel No. M1-60449, Test of Molybdenum Disulfide
Strain Gage Measurements (Circumferentially)

Powder: SPDN 8541; Proj.: T1E1 Blunt Nose, Copper Bands

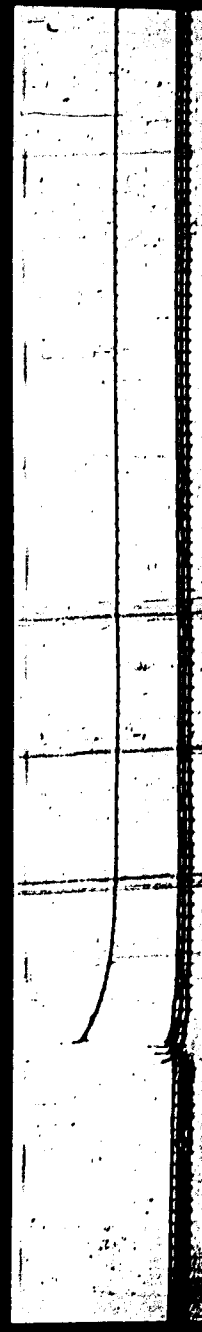
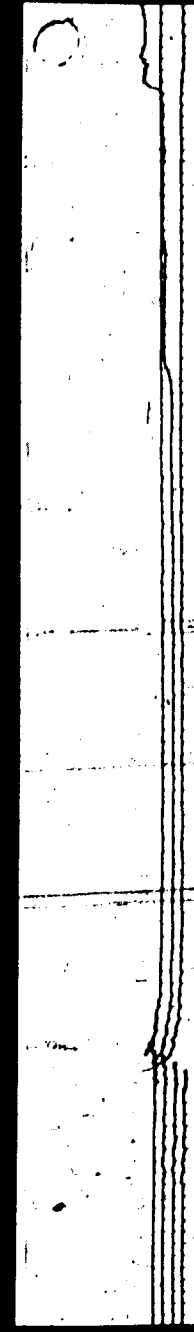
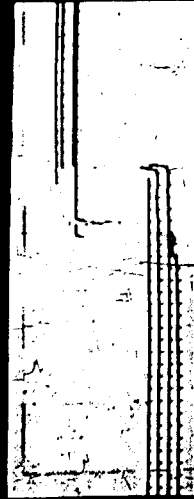
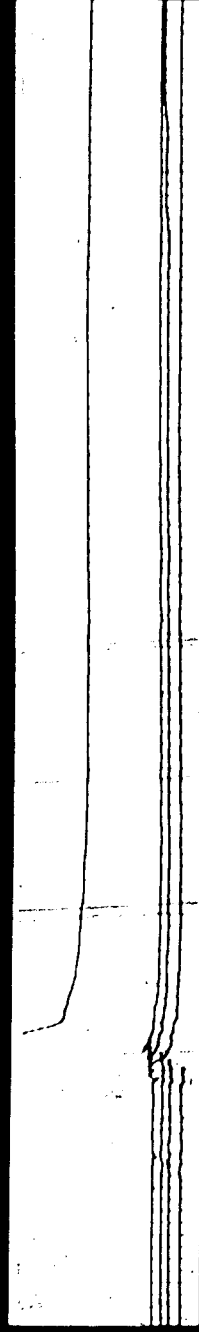
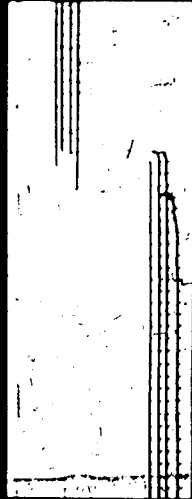
Timing Marks are at One Millisecond Intervals

Reading from top to bottom:

Strains in u ins./in. at 2:00 from Muzzle	Strains in u ins./in. at 20:25 from Plateau - Peak	Strains in u ins./in. at 38:50 from Muzzle	Strains in u ins./in. at 56:75 from Muzzle
--	---	---	---

Rd.	Plateau - Peak	Plateau - Peak	Plateau - Peak	Peak	Remarks
1	220	375	260	445	Warming round
3	230	575	255	465	Normal cond.
4	225	520	255	445	Normal cond.

(Figure 22)



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U. S. Naval Proving Ground - 3 April 1952

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40MM Barrel No. M1-60449, Test of Molybdenum Disulfide

Strain Gage Measurements (Circumferentially)

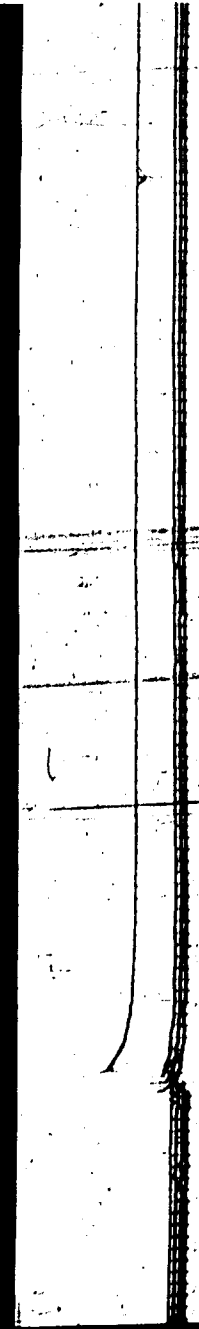
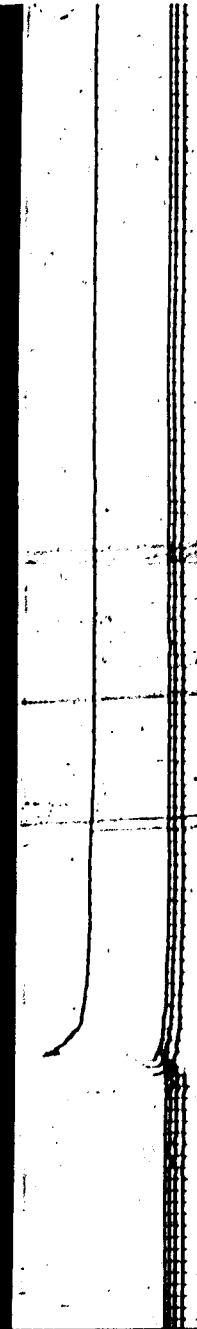
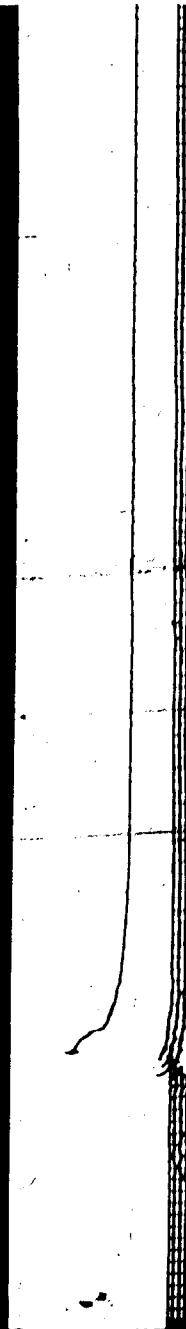
Powder: SPDN 8541; Proj.: T1E1-Blunt Nose, Copper Bands

Timing Marks are at One Millisecond Intervals

Reading from top to bottom:

Rd.	Strains in		Strains in		Strains in		R e m a r k s
	u ins./in. at 2400 from Muzzle	Plateau - Peak	u ins./in. at 2025 from Muzzle	Plateau - Peak	u ins./in. at 3850 from Muzzle	u ins./in. at 5675 from Muzzle	
5	235	510	255	465	470	Band moly coated.	
6	255	575	240	415	475	" "	
7	235	590	255	400	475	" "	

(Figure 23)



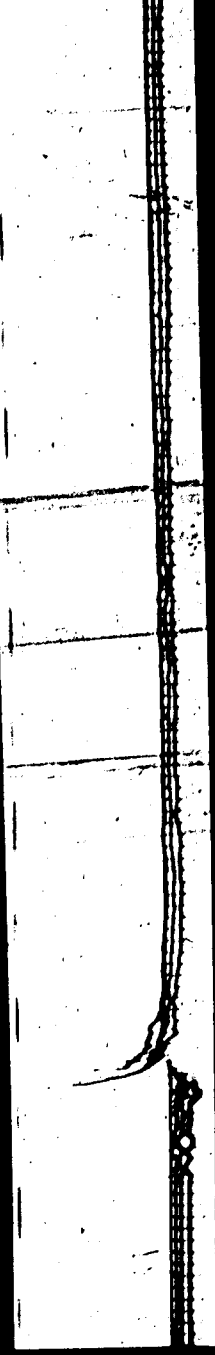
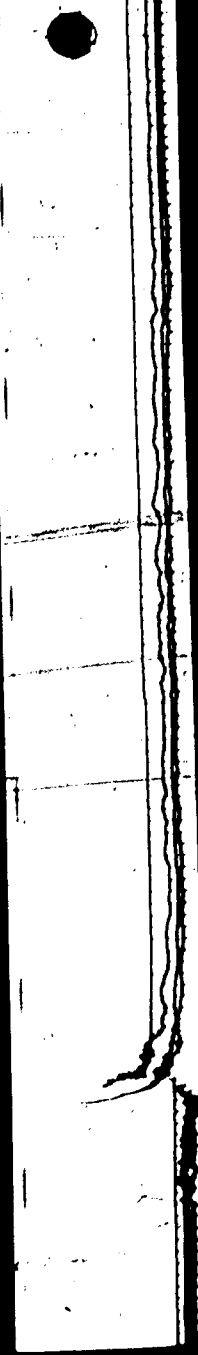
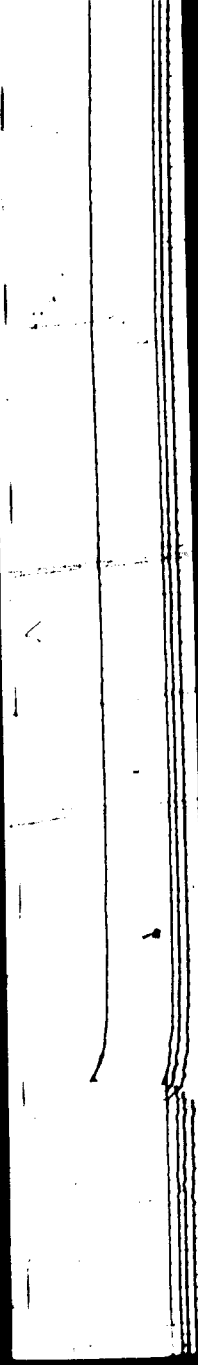
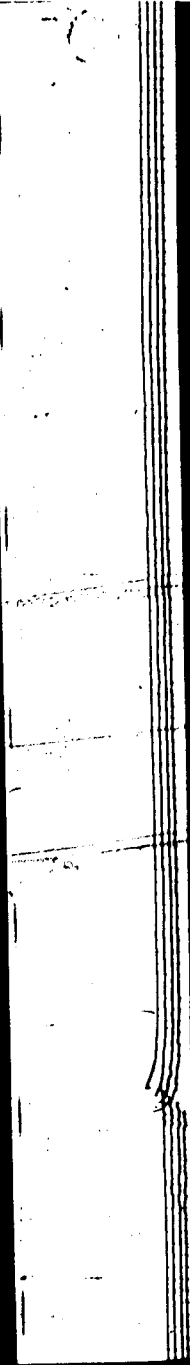
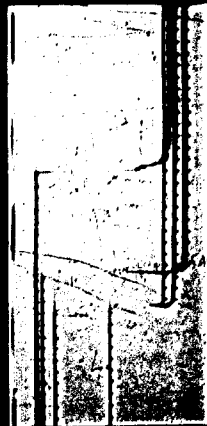
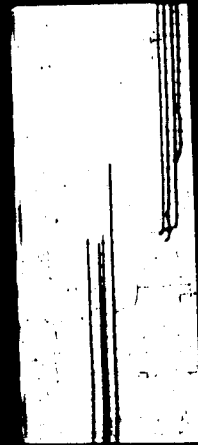
9-49061

U. S. Naval Proving Ground - 4 April 1952

40MM Barrel No. M1-60449, Test of Molybdenum Disulfide
Strain Gage Measurements (Circumferentially)

Powder: SPLN 8541; Proj.: T1E1 Blunt Nose, Copper Bands (Over please)
Timing Marks are at One Millisecond Intervals

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Reading from top to bottom:

	Strains in at 2400 from Muzzle	Strains in at 20425 from Muzzle	Strains in at 38450 from Muzzle	Strains in at 50775 from Muzzle	Remarks
1	445*	230	275	400	Warming round.
2		230	255	405	Bbl. moly. coated.
3		-	270	405	Normal cond.
4	325* 605*	220 365	205	470	Normal cond.

* These values are doubtful because of a defective strain gage.

NP9-49061 (Continued) (Figure 25)

MP9-49063

U. S. Naval Proving Ground - 4 April 1952

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40MM Barrel No. M1-60449, Test of Molybdenum Disulfide
Strain Gage Measurements (Circumferentially)
Powder: SPDN 8541; Proj.: T1E1 Blunt Nose, Copper Bands
Timing Marks are at One Millisecond Intervals

Reading from top to bottom:

Rd.	Strains in		Strains in		Strains in		Remarks
	u ins./in. at 2"00 from Muzzle	Plateau - Peak	u ins./in. at 20"25 from Muzzle	Plateau - Peak	u ins./in. at 38"50 from Muzzle	u ins./in. at 56"75 from Muzzle	
5	320*	635*	225	605	260	475	Proj. & bbl. moly coat
6			230	580	255	470	"
7			230	535	255	450	Proj. moly coated.

* These values are doubtful because of a defective strain gage.
(Figure 26)



NP9-49062

U. S. Naval Proving Ground - 4 April 1952

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40MM Barrel No. M1-60449, Test of Molybdenum Disulfide
Strain Gage Measurements (Circumferentially)

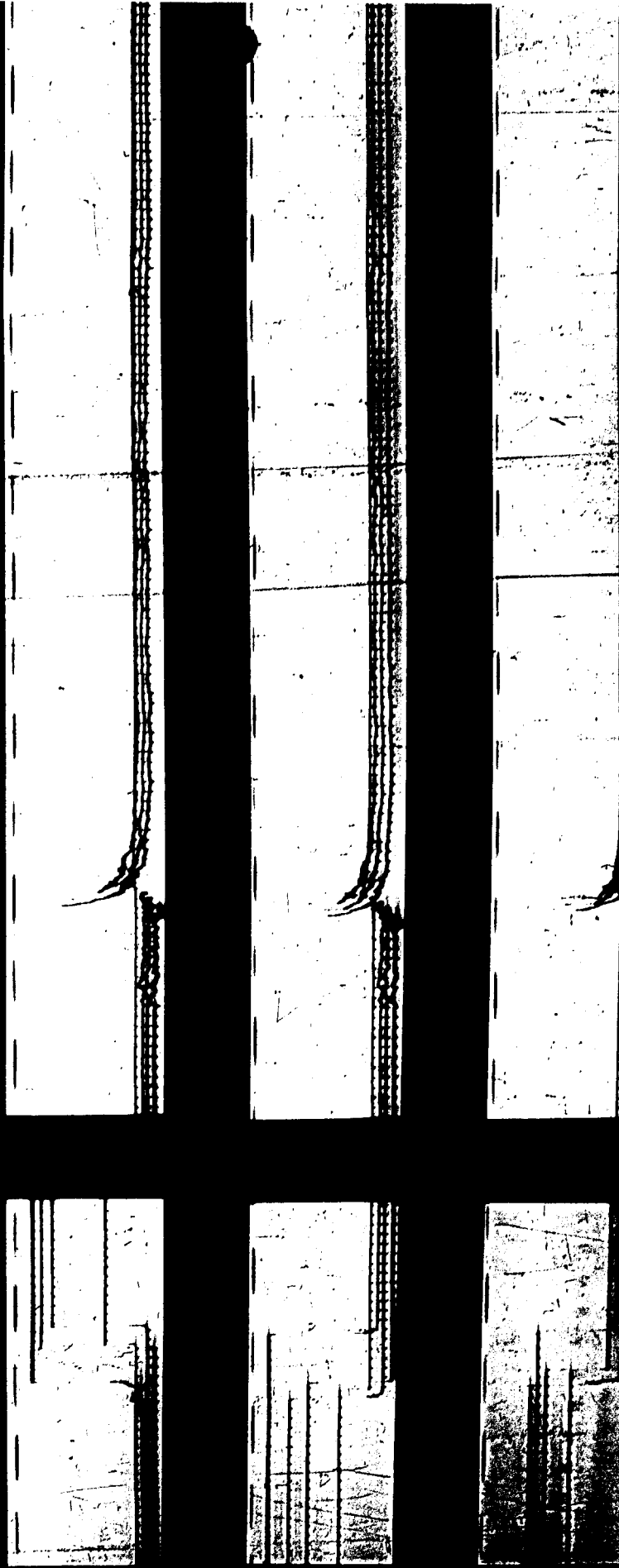
Powder: SPEN 9511; Proj.: T1E1 Blunt Nose, Copper Bands

Timing Marks are at One Millisecond Intervals

Reading from top to bottom:

Rd.	Strains in		Strains in		Strains in		Remarks
	at 2100 from	u ins./in.	at 20425 from	u ins./in.	at 56475 from	u ins./in.	
9	Muzzle		Muzzle		Muzzle		Proj. & bbl. molybdenum coated.
10	Plateau - Peak	600*	Plateau - Peak	600*	Plateau - Peak	600*	
		210*		230		465	
		250*		230		455	
				230		445	
				535		475	
				405		385	
				525		435	
				255		255	
				245		245	

* These values are correct because of a defective strain gage.
(Figure 27)



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NPG REPORT NO. 10

Recovery Firing of 40mm Projectile
Coated with Molybdenum Disulfide

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APPENDIX D