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U S NAVAL PROVING GROUND
DAHLGREN VIRGINIA

REPORT NO. 1077

PROJECTILE ROTATING BANDS AND RELATED COMPONENTS

4th Partial Report

TEST OF 3"/50 AA PROJECTILES WITH COPPER
WELDED-OVERLAY ROTATING BANDS

FINAL Report

Copy No 10

Task.

Assignment NPG-Rc3b-225-1-53

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Test of 3"/50 AA Projectiles with Copper
Welded-Overlay Rotating Bands

PART A

SYNOPSIS

1. The purpose of this test was to compare metallurgical and physical properties and ballistic performance of 3"/50 Mk 33 Mod 0 AA Projectiles having copper welded-overlay bands with the characteristics of standard Mk 33 Mod 0 projectiles having conventional bands.
2. It is concluded that:
 - a. The copper welded-overlay projectiles showed slightly better band engraving than the standard projectiles when fired from a new gun at either proof or service pressure.
 - b. In a worn gun, the standard projectiles showed slightly better band engraving than the overlay projectiles at service pressure, although both overlay and standard bands failed at proof pressure.
3. The cavity deformation under the band was somewhat greater for the overlay projectiles than for the standard projectiles when fired at both proof and service pressure from both new and worn guns.
4. The metallurgical and physical examination disclosed that the overlay bands had picked up 4.5% to 8.5% iron from the projectile during welding. This accounts for the hard spots that were found in the band hardness testing. It is believed that these hard spots (globules of steel) in the copper would increase gun wear.
5. Range firing of both copper welded-overlay and standard band projectiles produced approximately equal results when fired from both new and worn guns.
6. The bore and flight safety tests conducted on copper welded-overlay projectiles fired from both new and worn guns produced satisfactory results.

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PART B

INTRODUCTION

1. AUTHORITY:

This program was authorized by reference (a).

2. REFERENCES:

- a. BUORD ltr Re3b-MAS:lad Ser 15371 of 25 Apr 1952 to NAVPROV
- b. BUORD Drawing No. 563840 of Std. 3"/50 AA Mk 33 Mod 0 Projectile
- c. FoneCon BUORD (Re3b) with NAVPROV of 6 Aug 1952
- d. NPG Ranging Data Sheet No. 2661
- e. NPG Ranging Data Sheet No. 2662
- f. BUORD Restr ltr Re3b-MRH/MAS:mt S78-1(54) Ser 16746 of 15 Aug 1952

3. BACKGROUND:

The welded-overlay method of rotating band application has attracted considerable interest since its development was initiated by Frankford Arsenal. Briefly, it consists in applying an electric weld bead of band material to the periphery of the projectile, under an inert atmosphere, and machining the bead to the desired band contour. Its advantages include a considerable saving in band material, which would promote conservation of strategic metals, and the elimination of the band seat, which is a point of weakness, particularly in armor-piercing projectiles.

The welded-overlay method is not the only possible means by which a welded band may be applied to the projectile. Excellent results have been obtained on small samples subjected to pressure welding, and further investigation of such processes appears to be in order.

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4. OBJECT OF TEST:

The object of this test was to compare metallurgical results, physical properties and ballistic performance of 3"/50 Mk 33 Mod 0 projectiles having copper welded-overlay bands with the properties of standard Mk 33 Mod 0 projectiles.

5. PERIOD OF TEST:

a. Date of Directive	25 April 1952
b. Date Commenced Test	13 May 1952
c. Date Test Completed	9 September 1952

PART C

DETAILS OF TEST

6. DESCRIPTION OF ITEMS UNDER TEST:

a. 3"/50 AA Mk 33 Mod 0 projectiles, without band seats, having a deposition of unalloyed copper weld metal in the band position, and machined to the standard 3"/50 Mk 33 Mod 0 band contour, were supplied by the Youngstown Welding and Engineering Company.

b. Standard 3"/50 Mk 33 Mod 0 projectiles manufactured by Lansdowne Steel and Iron Company were in accordance with reference (b).

c. Standard projectiles used in the comparative ranging test with copper welded-overlay projectiles were manufactured by Mullins Company in accordance with reference (b), and stenciled Mk 33-0.

7. DESCRIPTION OF TEST EQUIPMENT:

a. The new gun used in this test was a 3"/50 Mk 21 Mod 0, Barrel No. 7418. This gun has conventional rifling of OV03 constant depth, uniform twist 1/32. At the beginning of the test, this gun had 455 ESR and OV037 origin enlargement.

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b. The worn gun used in this test was a 3"/50 Mk 22 Mod 0, Barrel No. 8889. This gun has conventional rifling of 0V03 constant depth, uniform twist 1/32, and is identical with the Mk 21 Mod 0 except for external dimensions. At the beginning of the test, this gun had 2861 ESR and 0V115 origin enlargement.

8. PROCEDURE:

Eight (8) projectiles, four (4) with copper welded-overlay and four (4) with standard bands, were fired for recovery at service and proof pressure in the new 3"/50 gun. Eight (8) projectiles, four (4) with copper welded-overlay and four (4) with standard bands, were also fired at proof and service pressure in the worn gun. The projectiles were fitted with flat nose plugs (Figure 17), and Epsom salt loaded to a total weight of 13 pounds. All projectiles were stenciled with Naval Proving Ground numbers to facilitate identification. A photograph of an unfired projectile is included as Figure 1. After-firing, photographs of each round appear as Figures 2 through 16. Measurements were taken of the cavity diameters and overall lengths before and after firing to determine the degree of deformation. Velocities, copper crusher gage pressures and spin measurements were taken. Spin was measured by the wire-impression method (Appendix (D)). All rounds were rubber crimped in the cases and three yaw cards were used to check the projectile flight.

Comparative range firings of Mk 33-0 projectiles with copper welded-overlay and standard rotating bands were also performed in both new and worn guns.

Mk 33-0 projectiles with welded-overlay bands were tested for bore and flight safety in both new and worn guns in accordance with reference (f).

Two (2) projectiles with copper welded-overlay and two (2) projectiles with standard copper bands were sectioned for metallurgical and physical testing. The projectiles were cut in half, ground and macro-etched, and microspecimens were taken from the band section. The hardness distribution on a longitudinal center section of each was determined, also complete hardness surveys were made on the deposited weld metal, the heat-affected base metal and the shell in general. Special attention was paid to the hardness of the overlay at the level of the bourrelet. This

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was indicative of the hardness encountered by the rifling of the gun barrel at the deepest region of engraving during firing. Rockwell (F) hardness readings were taken on the periphery of the overlays after machining to the normal band diameter. Drillings from the welded band were taken for chemical analysis. The Rockwell (F) scale was used for a general survey of the band, but the Diamond Pyramid Hardness scale (DPH) and Knoop Hardness Number were employed for the weld and surrounding region because of the importance of getting several readings within a small area.

For macrostudy, projectile sections were surface-ground, cleaned, and etched in ammonium persulfate solution. Microspecimens of the weld area were prepared in the normal manner and etched with nital, picral and ammonium hydroxide, plus hydrogen peroxide.

9. RESULTS AND DISCUSSION:

Complete before and after recovery firing data are given in Tables I and II (Appendix (A)). The results from the four (4) projectiles with copper welded-overlay and four (4) projectiles with standard bands fired from the new gun are reported in Table I. All rounds fired from this gun (See Table I, Appendix (A), for results) showed good flight to the recovery bin with only slight yaw, good spin, no fringing and uniform pressure and velocity. The recovered projectiles (Figure 2 to Figure 9, inclusive) indicate that the welded-overlay bands had slightly better engraving, and that the cavity deformation under the band was greater than recorded for the standard projectiles, although not so great as to be alarming. The increase in deformation under the band cavity of the welded-overlay can be attributed to the softening of the projectile wall from the heating and cooling during the welding process. It was noted that excessive body engraving appeared on the standard projectiles fired at proof pressure. The results from the four (4) projectiles with copper welded-overlay and four (4) with standard band fired from the worn gun are reported in Table II. All rounds fired from this gun (See Table II, Appendix (A), for results) showed slight yaw, no fringing, and uniform pressure and velocity. Good spin was noted on both overlay and standard projectiles fired at service pressure, although a decrease in spin was obtained with both types of projectiles when fired at proof pressure. The recovered projectiles (Figures 10 to 16, inclusive) indicate the standard projectiles have slightly better band engraving when fired at service pressure,

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although both types of bands failed when fired at proof pressure. Cavity deformation under the band was again greater with the copper welded-overlay bands.

Comparative ranging data of Mk 33-0 projectiles with overlay and standard bands are reported in Tables II and IV, Appendix (A). It is noted that the range results are approximately equal for both types of bands when fired from both new and worn guns.

The bore and flight safety test data of 3"/50 welded-overlay projectiles fired in both a new and worn gun are reported in Table V, Appendix (A). Observation of the results reported indicate the welded-overlay projectiles tested for bore and flight safety proved satisfactory.

Metallurgical, chemical and physical tests conducted on the sectioned projectiles produced the following results: The welding rod used consisted of essentially unalloyed copper. An investigation of the chemical analysis of the band material after deposition revealed the existence of steel in various amounts entrapped in the copper band, as illustrated in Figure 18. Microscopic examination revealed the entrapped steel to be of a hard martensitic structure (Figure 19). This accounts for the hard spots that were found in the band during the hardness testing. It is believed these globules of steel will cause increased gun wear. Microscopic examination of the heat-affected base metal indicated the existence of a hard martensitic area (Figure 20) adjacent to the weld zone produced as a result of the welding process. This is further illustrated from a comparison of the hardness distribution on the longitudinal center sections (Figure 21 and Figure 22) of the copper welded-overlay and standard band. To complete the hardness data, a section consisting of deposited weld metal, the heat-affected zone, and the shell body was surveyed with a Tukon Hardness Tester using a Knoop Indenter (See Figure 23 for results). A photomacrograph and a photomicrograph of an overlay cross-section (after machining) are shown in Figure 24. The fusion of the copper to the steel looked complete.

Further thought should be given to the possibility of heat-treating the shell after the band has been deposited. This method could prove to be a most effective means of:

- a. Decreasing the hardness of the entrapped steel globules in the deposited band material.

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- b. Avoiding the heat-affected zone caused by the welding process.
- c. Decreasing the band cavity deformation by eliminating the soft section of the projectile wall.

PART D

CONCLUSIONS

10. It is concluded that:

- a. The copper welded-overlay projectiles showed slightly better band engraving than the standard projectiles, when fired from a new gun at either proof or service pressure.
- b. In a worn gun, the standard projectiles showed slightly better band engraving than the overlay at service pressure, although both overlay and standard bands failed at proof pressure.
- c. The cavity deformation under the band was somewhat greater with the overlay projectiles than with the standard projectiles when fired at both proof and service pressure from both the new and worn guns.
- d. The metallurgical and physical examination disclosed that the overlay bands had picked up 4.5% to 8.5% of iron from the projectiles during welding. This accounts for the hard spots that were found in the band during hardness testing. It is believed that these hard spots (globules of steel) in the copper will cause increased gun wear.
- e. The bore and flight safety tests conducted on copper welded-overlay projectiles fired from both new and worn guns produced satisfactory results.
- f. Range firing of both copper welded-overlay and standard band projectiles produced approximately equal results when fired from both new and worn guns.

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U. S. NAVAL PROVING GROUND
DAHLGREN, VIRGINIA

Fourth Partial Report
on
Projectile Rotating Bands
and Related Components

Final Report
on
Test of 3"/50 AA Projectiles with Copper
Welded-Overlay Rotating Bands

Project No.: NPG-Re3b-225-1-53
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Date:

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TABLE I

BEFORE AND AFTER FIRING DATA

Recovery Test of 3"/50 Mk 33-0 Projectiles With Standard and Welded Overlay Bands in Gun Mk 21-0 No. 7418

Proj. No.	Firing Order 6/27/52	Powder Charge (lbs.) SPDN 6192	Average Pressure (t.s.i.)	Muzzle Velocity (ft./sec.)	Percent Nominal Spin	Band Type	Deformation	Hardness on Band Periphery (RF)
Warning round LK-1	1	4.05	15.2	2656	-----	Std.	-----	
1422	2	4.60	20.9	2932	98.8	Std.	-.006	69
1423	4	4.60	19.8	2908	98.5	Std.	-.003	71
1424	6	4.05	15.0	2680	98.9	Std.	-.003	71
1425	8	4.05	15.4	2680	98.7	Std.	-.005	69
1430	3	4.60	18.7	2934	98.8	Welded	-----	92
1431	5	4.60	19.7	2912	98.9	Welded	-.014	94
1432	7	4.05	15.1	2678	98.8	Welded	-.012	89
1433	9	4.05	14.7	2675	98.8	Welded	-0.016	89

Gun Mk 21-0 No. 7418 had 455 ESR and .037 bore enlargement at start of test.
Slight yawing was noted on above projectiles.

TABLE II

BEFORE AND AFTER FIRING DATA

Recovery Test of 3"/50 Mk 33-0 Projectiles with Standard and Welded Overlay Bands in Gun Mk 22 Mod 0 No. 8889

Proj. No.	Firing Order 8/6/52	Powder Charge (lbs.) SPDN 6195	Average Pressure (t.s.i.)	Muzzle Velocity (ft./sec.)	Percent Nominal Spin	Band Type	Deformation I.D.	Hardness on Band Periphery (HR)
1426	6	4.20	14.1	2671	99.4	Std.	-.010	72
1427	8	4.20	13.2	2666	99.5	Std.	-.015	71
1428	2	4.80	20.5	2943	Not Recovered	Std.		71
1429	4	4.80	19.8	2949	92.7	Std.	-.007	70
1434	7	4.20	14.6	2692	99.3	Welded	-.015	78-90
1435	9	4.20	13.9	2691	97.5	Welded	-.017	91-102
1436	3	4.80	20.4	2957	82.9	Welded	-.032	94
1437	5	4.80	19.0	2951	77.0	Welded	-.008	83-88

3"/50 Gun Mk 22 Mod 0 No. 8889 had 2861 RSR and .115 bore enlargement at start of test.
One warning round fired.
Slight yawing was noted on above projectiles.

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APPENDIX A

TABLE III

COMPARATIVE RANGING OF MK 33-O PROJECTILES WITH COPPER WELDED-OVERLAY ROTATING BANDS

Summary of Results of Ranging of Mk 33-O A. A. Projectiles with Copper Welded-overlay Rotating Bands fired on 12 and 13 June 1952 and reported in detail on Naval Proving Ground Ranging Data Sheets Nos. 2661 and 2662

Elevation: 15°
 Propellant: Powder Index SPDN-6192
 4.05 lbs.
 Projectiles: Mk 33-O Mullins Company
 Regular Projectiles
 Mk 33-O Ganary Brothers
 Welded-overlay Rotating Bands

Gun Data: 3"/50 Mk 21 Mod 0 Serial
 No. 12888
 Rounds before test: 137
 ESR: 1922 A Do .088 ESR: 1922.C0

Rds. Fired	Rds. Ranged	Projectile Type	Muzzle Velocity (ft./sec.)	Uncorrected Range (yds.)	Uncorrected Drift (yds.)	Corrected Range (yds.)	Uncorrected D/R (%)	Corrected D/R (%)
7	7	Standard	2643±3	10412±116	81±17	10265±115	1.11	1.12
5	5	Welded	2651±2	10320±39	88±5	10141±36	0.38	0.35
4	4	Standard	2658±4	10426±52	105±9	10335±40	0.50	0.39
5	5	Welded	2661±1	10359±50	113±10	10253±46	0.48	0.45
5	5	Standard	2656±2	10362±45	96±4	10278±47	0.43	0.46
5	5	Welded	2664±3	10344±45	104±4	10290±44	0.44	0.43
5	5	Standard	2657±3	10457±19	102±3	10364±22	0.18	0.21
5	5	Welded	2662±5	10303±43	106±6	10195±25	0.42	0.25

Range Table Range 10115 (W G RT)

TABLE IV

COMPARATIVE RANGING OF MK 33-O PROJECTILES WITH COPPER WELDED-OVERLAY ROTATING BANDS

Summary of Results of Ranging of Mk 33-O A. A. Projectiles with Copper Welded-Overlay Rotating Bands fired on 15 July 1952 and reported in detail on Naval Proving Ground Ranging Data Sheet No. 2674

Elevation: 15°
 Propellant: Powder Index SPDN-6192
 4.05 lbs.
 Projectiles: Mk 33-O Mullins Company
 Regular Projectiles
 Mk 33-O Ganary Brothers
 Welded-Overlay Rotating Bands

Gun Data: 3"/50 Mk 22 Mod 0 Serial
 No. 8889
 Rounds before test: 18
 ESR: 2820 Δ Do. 120 ESR: 2820

Rds. Fired	Rds. Ranged	Projectile Type	Missile Velocity (ft./sec.)	Uncorrected		Corrected		Uncorrected		Corrected	
				Range (yds.)	Drift (yds.)	Range (yds.)	D/R (%)	Range (yds.)	D/R (%)	Range (yds.)	D/R (%)
5	5	Standard	2635±2	10462±38	37±5	10394±42	0.37	10394±42	0.37	10394±42	0.40
5	5	Welded	2631±3	10273±70	35±6	10210±65	0.68	10210±65	0.68	10210±65	0.64
5	5	Standard	2638±7	10397±92	25±5	10330±87	0.88	10330±87	0.88	10330±87	0.84
5	4	Welded	2633±1	10254±65	25±3	10188±62	0.63	10188±62	0.63	10188±62	0.61
5	5	Standard	2631±2	10410±28	9±4	10356±30	0.27	10356±30	0.27	10356±30	0.29
5	5	Welded	2626±5	10297±69	29±6	10257±56	0.67	10257±56	0.67	10257±56	0.55
5	5	Standard	2628±5	10361±34	14±6	10315±22	0.33	10315±22	0.33	10315±22	0.21
5	5	Welded	2630±5	10298±33	22±2	10244±26	0.32	10244±26	0.32	10244±26	0.25

Range Table Range 10115 (NPG RT)

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APPENDIX A

TABLE V

BORE AND FLIGHT SAFETY TEST OF MK 33-0 PROJECTILES WITH COPPER WELDED-OVERLAY ROTATING BANDS

Results of Bore and Flight Safety Tests of Mk 33-0 AA Projectiles with
Copper welded-Overlay Rotating Bands fired on 6 September 1952

Projectiles: Mk 33 Mod 0 Comp. A-3
loaded with special
copper welded-overlay bands.
Propellant: SPDN 6191 (various charge weights
to maintain proof pressure)

Fuze: Dummy Nose Plug
Gun: 3"/50 Mk 21 Mod 0
No. 5546 Δ Do C/O 54
FSR 479

New Gun

Rd. No.	Gun Elevation	Bore Pressure	Time of Flight	Range of Impact	Action of Explosive
1	10°	21.0T	20.50	9495	Dud
2	"		20.83	9674	"
3	"		21.62	9827	"
4	"		22.06	9967	"
5	"		22.20	10052	"
6	"	21.4T	-	10124	"
7	"		22.70	9064	"
8	"		22.80	9198	"
9	"		22.74	9207	"
10	"		-	9108	"
11	"	21.3T	22.83	9293	"
12	"		19.52	9146	"
13	"		19.90	9308	"
14	"		19.72	9113	"
15	"		20.00	9273	"
16	"	20.6T	19.60	9191	"
17	"		19.72	9207	"
18	"		19.91	9303	"
19	"		19.50	9078	"
20	"	20.3T	20.00	9214	"

APPENDIX A

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TABLE V (Continued)

BORE AND FLIGHT SAFETY TEST OF MK 33-O PROJECTILES WITH COPPER WELDED-OVERLAY ROTATING BANDS

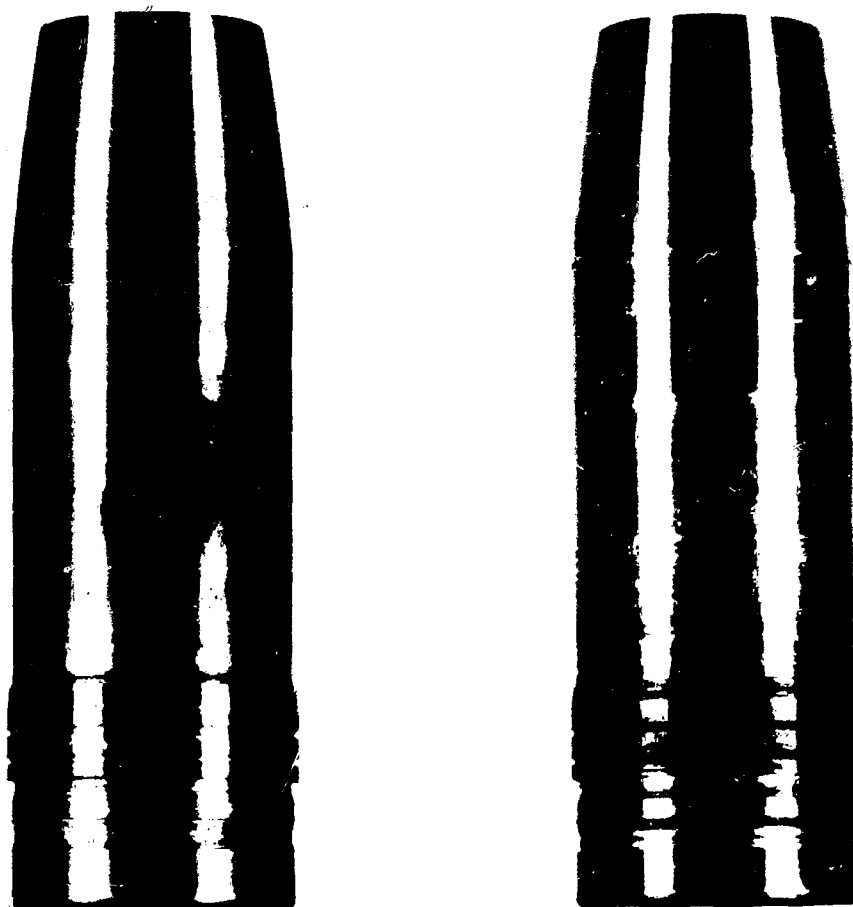
Results of Bore and Flight Safety Tests of Mk 33-O AA Projectiles with
Copper Welded-Overlay Rotating Bands fired on 6 September 1952

Projectiles: Mk 33 Mod 0 Comp. A-3
loaded with special
copper welded overlay bands.
Propellant: SPDN 6191 (various charge weights
to maintain proof pressure)

Fuze: Dummy Nose Plug
Gun: 3"/50 Mk 22 Mod 3
No. 16218 Δ Do OTC89
ESR 9263

Old Gun

Rd. No.	Gun Elevation	Bore Pressure	Time of Flight (Sec.)	Range of Impact	Action of Explosive
1	10°	20.1T	21.55	9634	Dud
2	"		21.25	9476	"
3	"		21.02	9458	"
4	"	20.3T	21.30	9711	"
5	"		20.92	9557	"
6	"		21.54	9862	"
7	"		21.40	9692	"
8	"		21.39	9749	"
9	"		21.09	9659	"
10	"	20.2T	21.00	9567	"
11	"		21.37	9852	"
12	"		21.11	9782	"
13	"		20.82	9431	"
14	"		21.79	10052	"
15	"		20.67	9295	"
16	"	21.1T	21.06	9654	"
17	"		21.05	9636	"
18	"		21.00	9616	"
19	"		21.37	9906	"
20	"	21.6T	21.25	9787	"



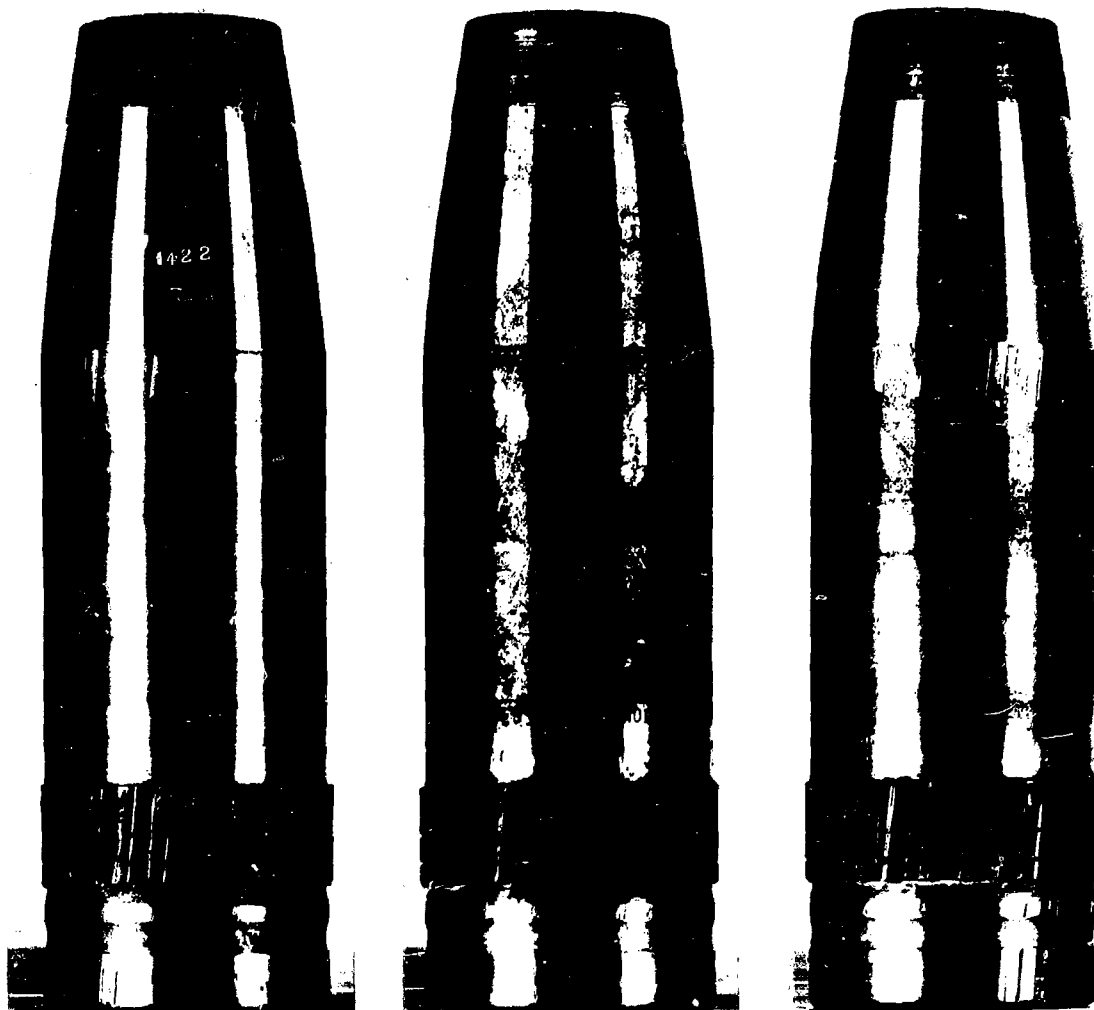
NP9-50962

20 June 1952

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Photograph of 3"/50 AA Mk 33 Mod 0 projectiles, with standard copper band (left) and copper welded overlay band (right), before firing.

Figure 1



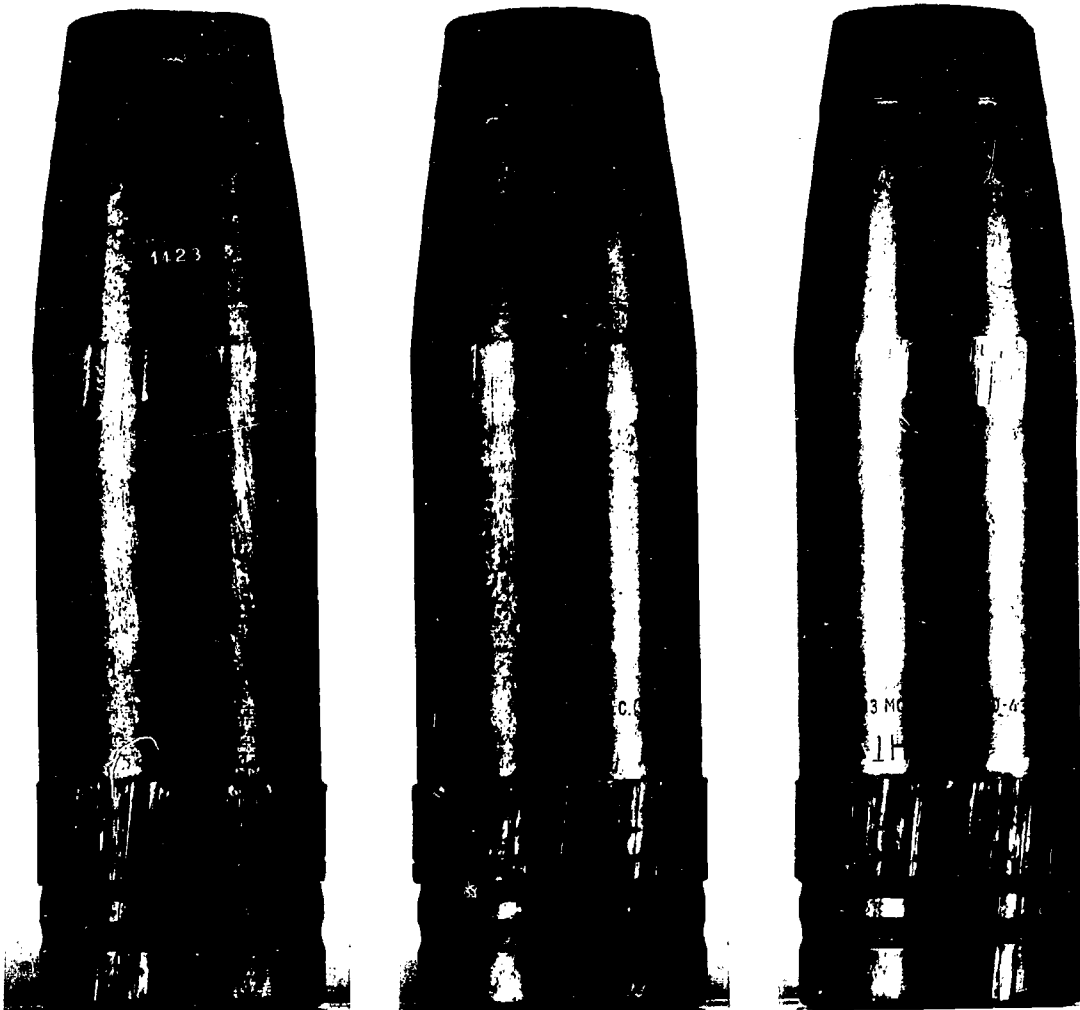
NP9-50963

27 June 1952

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Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0
projectile with standard band. Projectile No. 1422.

Figure 2

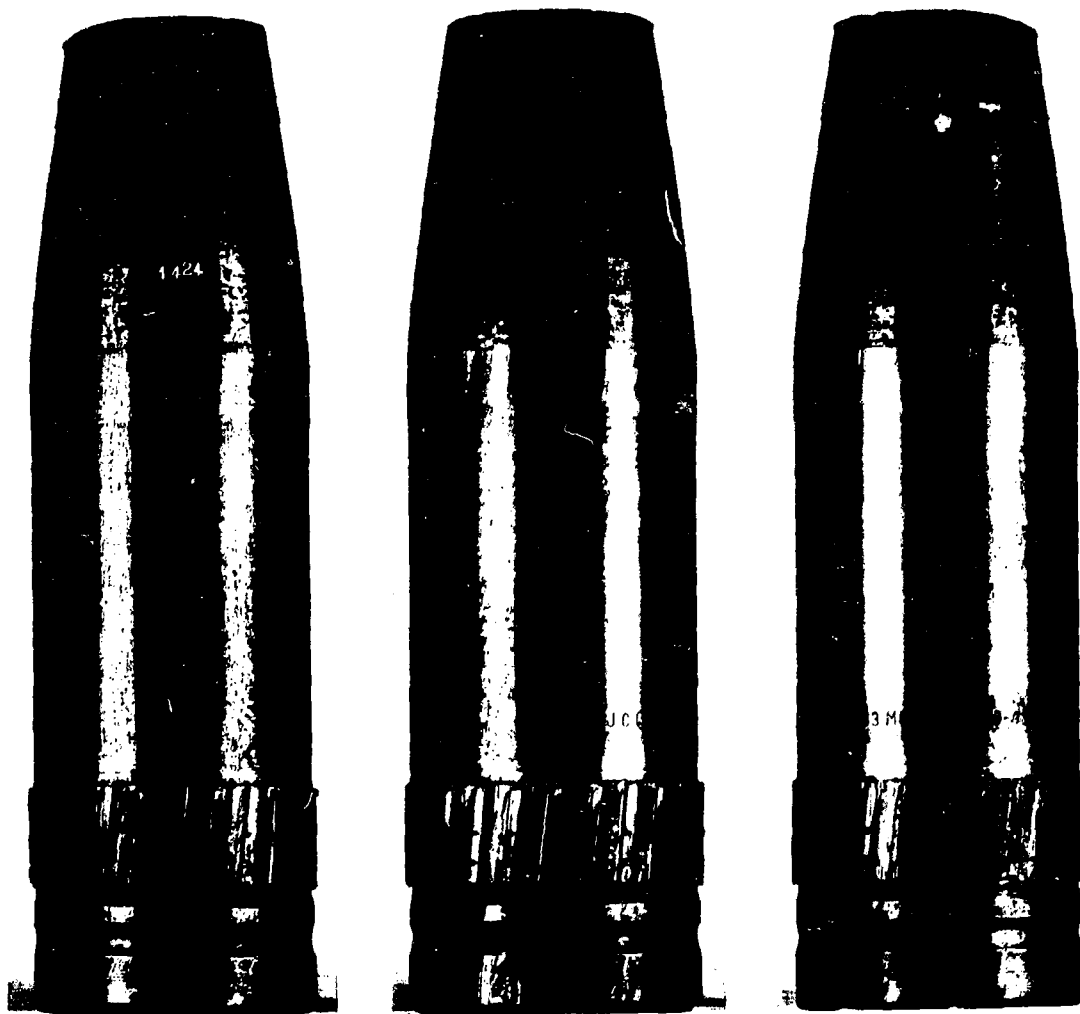


NP9-50964

27 June 1952

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Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0
projectile with standard band. Projectile No. 1423.
Figure 3



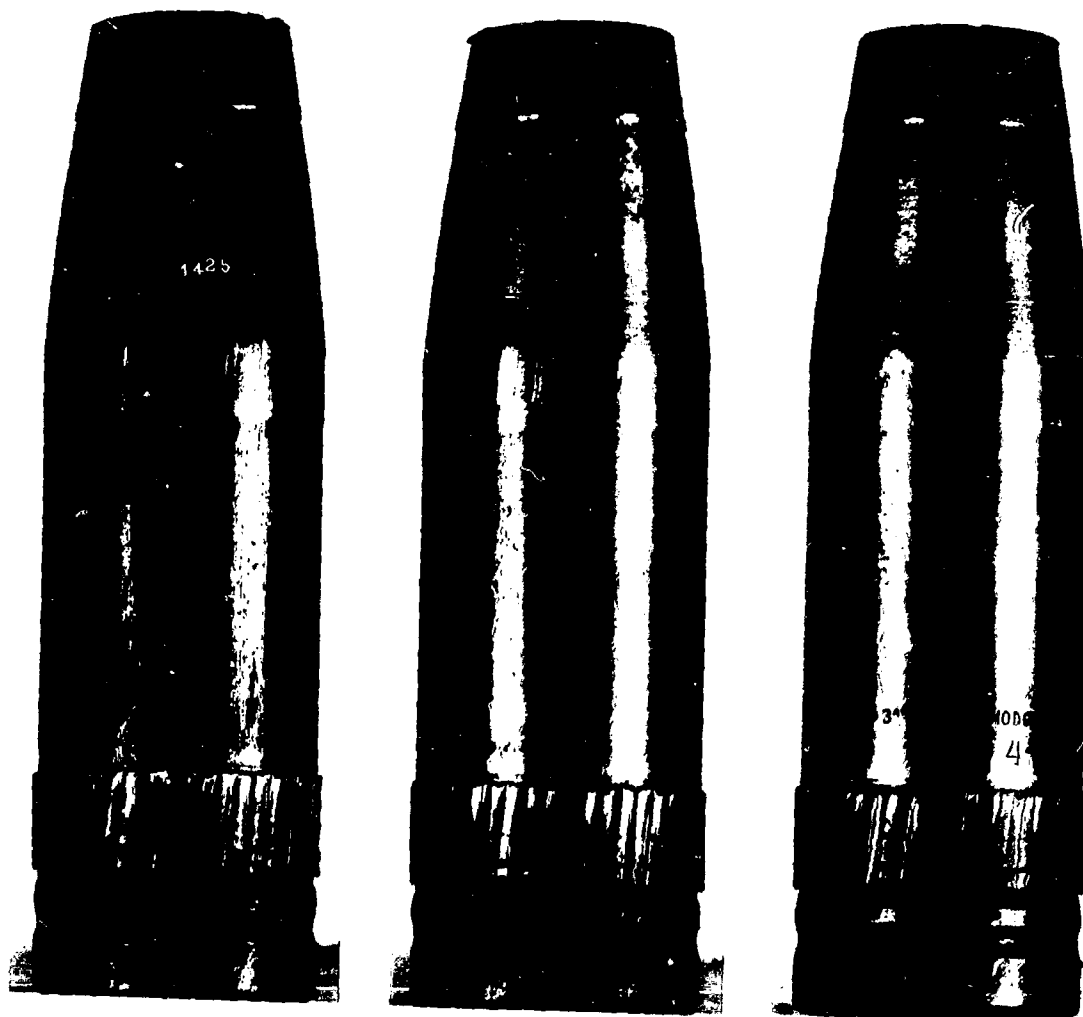
NP9-50965

27 June 1952

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Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0
projectile with standard band. Projectile No. 1424.

Figure 4



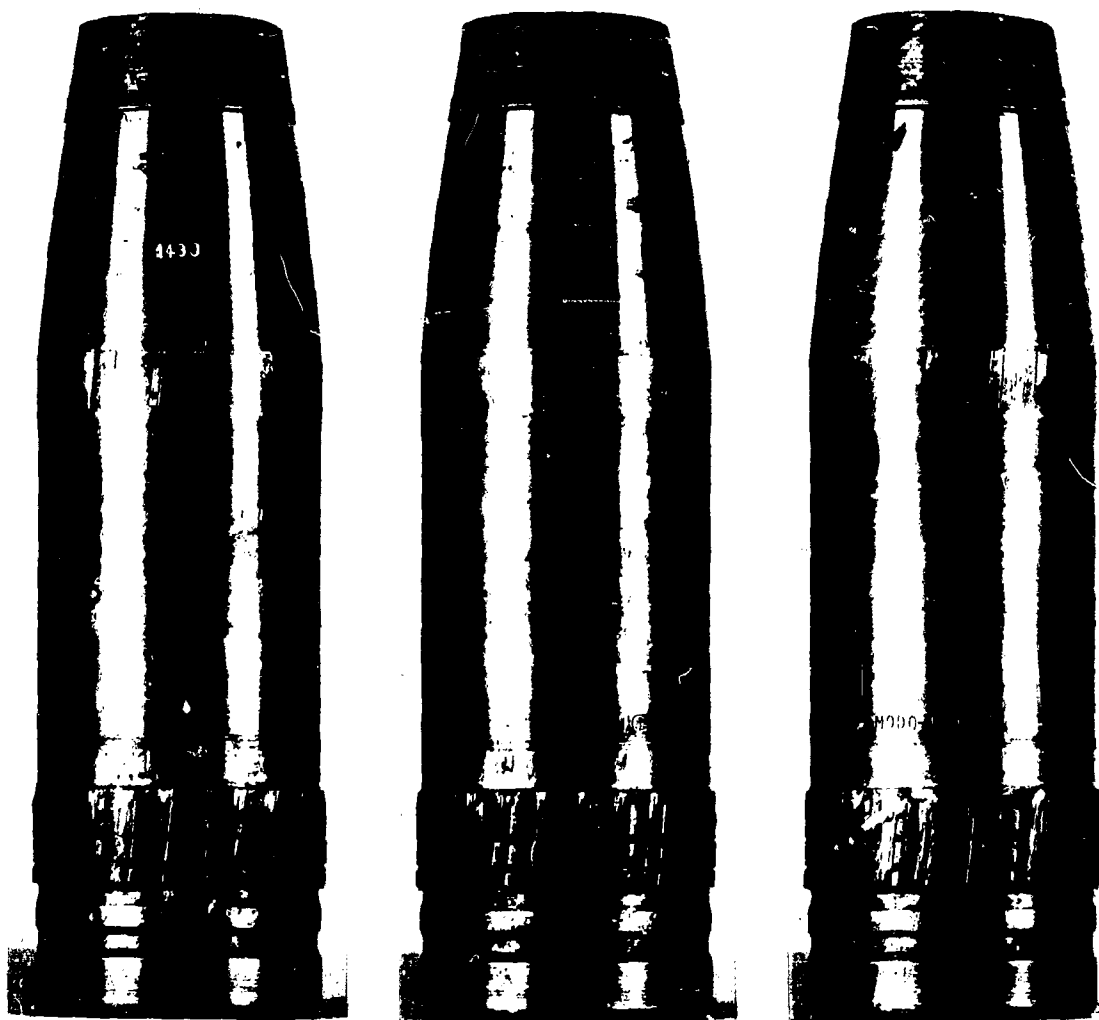
NP9-50966

27 June 1952

Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0 projectile with standard band. Projectile No. 1425.

Figure 5

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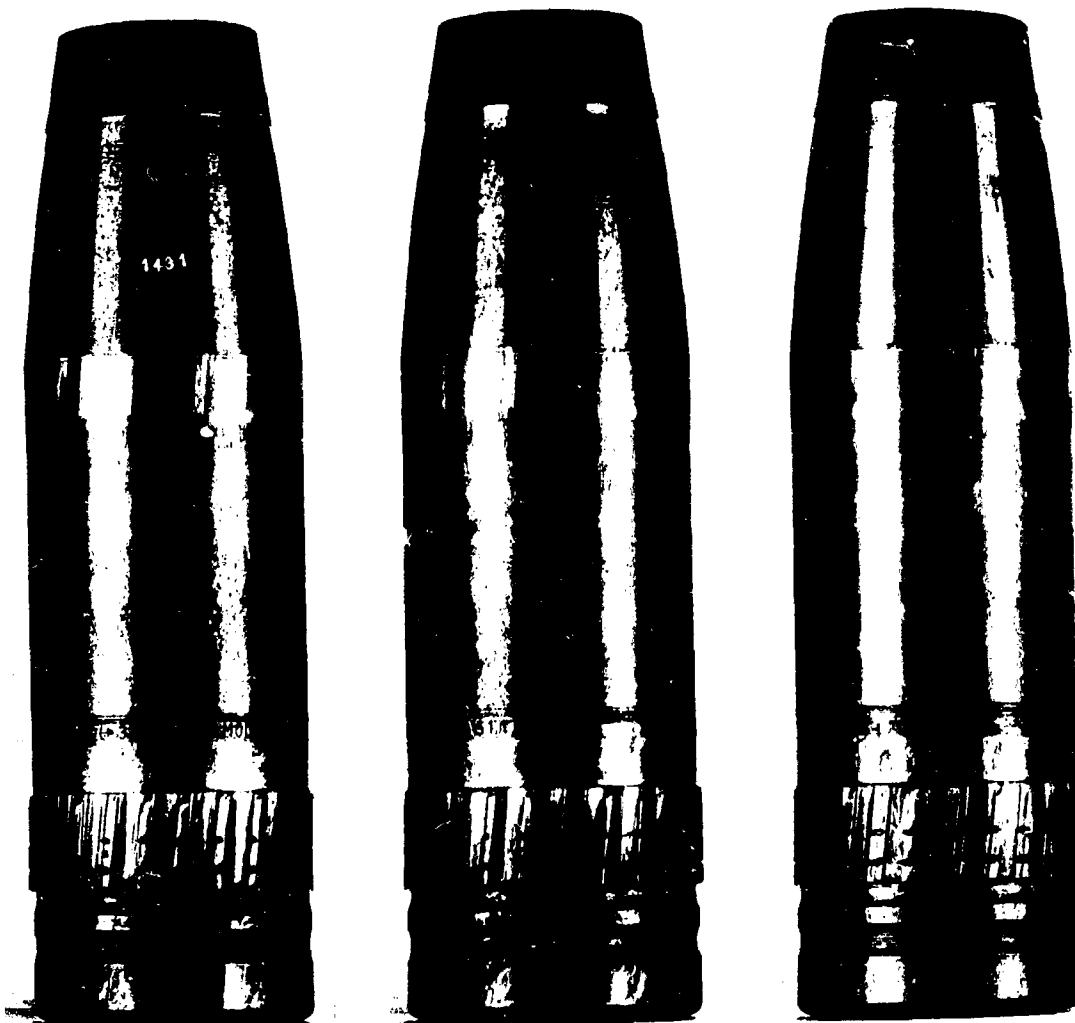
NP9-50967

27 June 1952

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Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0
projectile with welded overlay band. Projectile No. 1430.

Figure 6



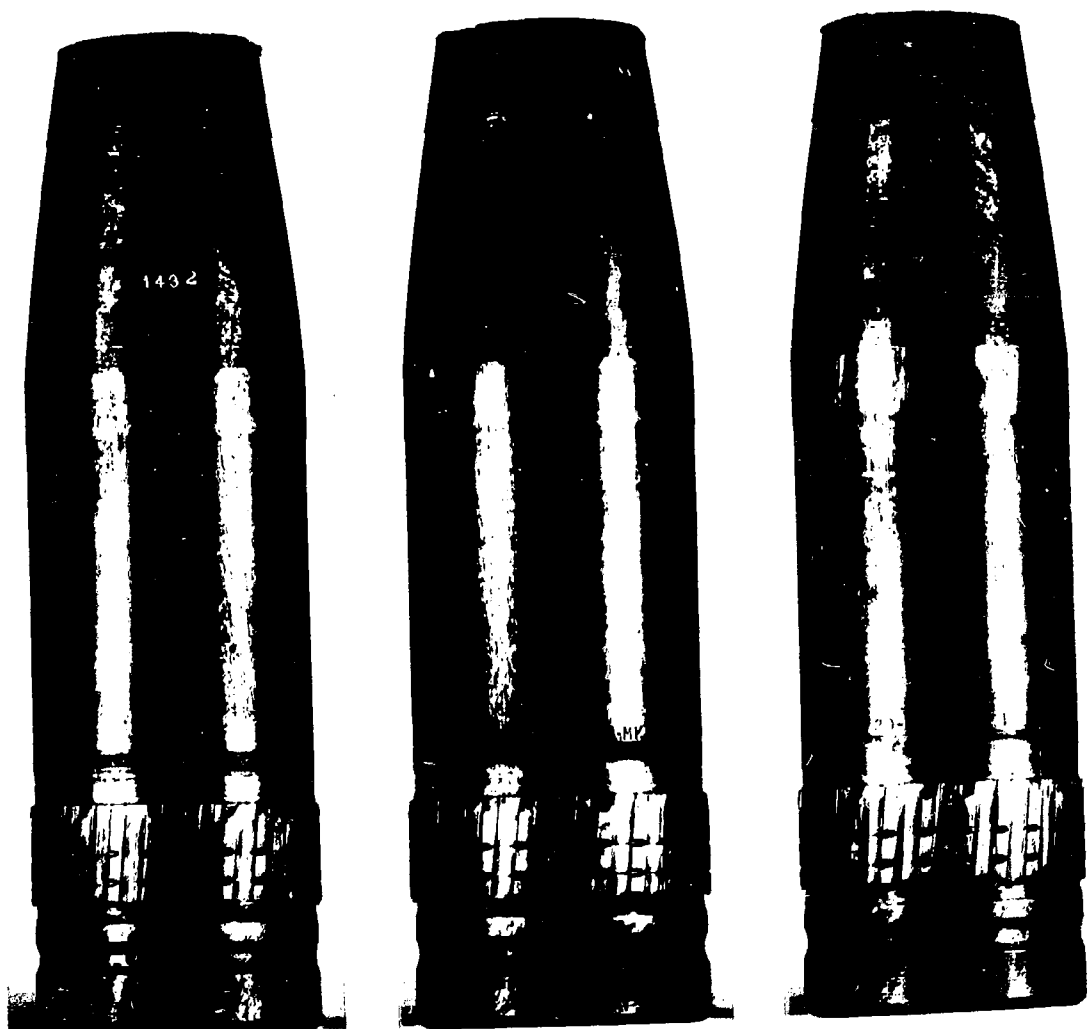
NP9-50968

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Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0
projectile with welded overlay band. Projectile No. 1431.

Figure 7



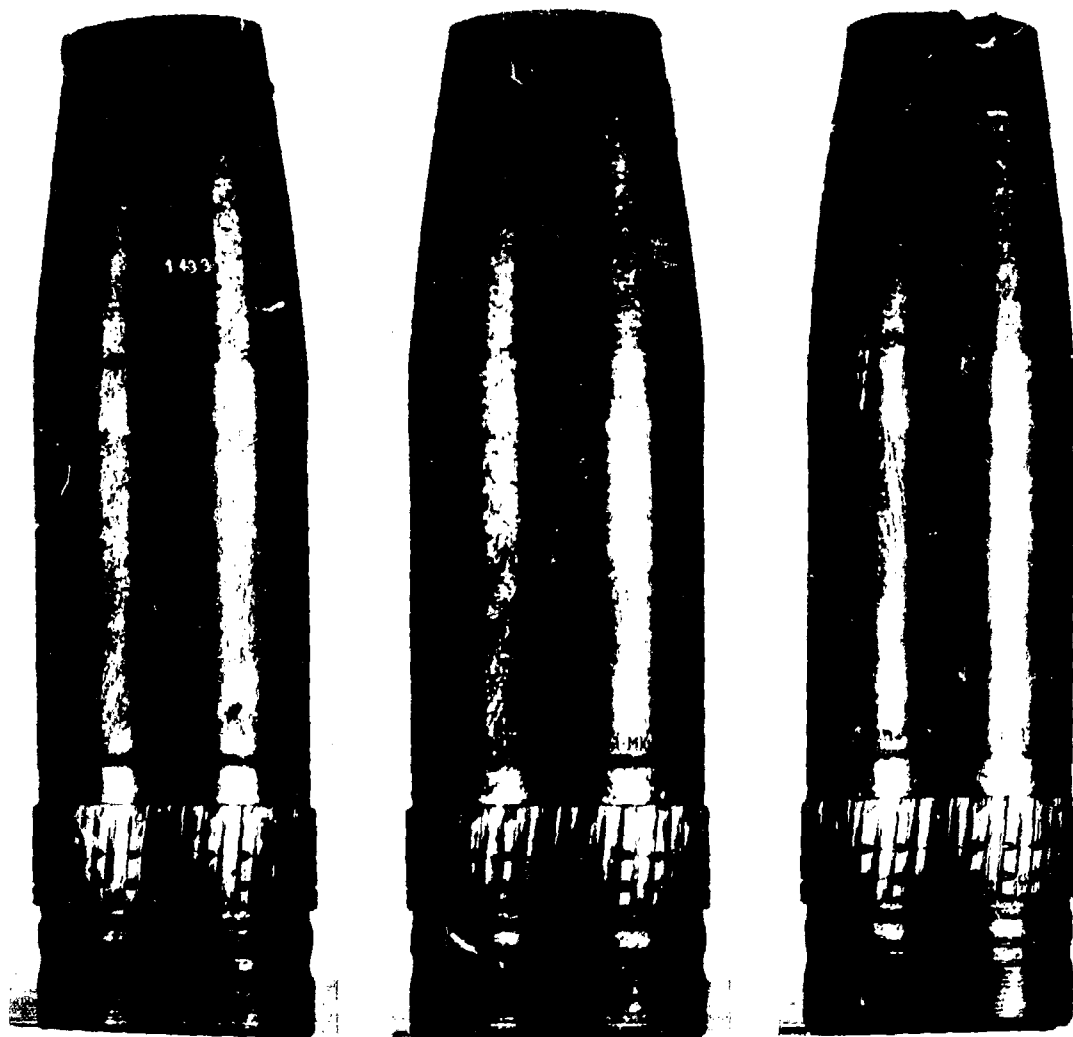
NP9-50969

27 June 1952

Three views (120° apart) of recovered
projectile with welded overlay band.

Figure 8

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3"/50 AA Mk 33 Mod 0
Projectile No. 1432.



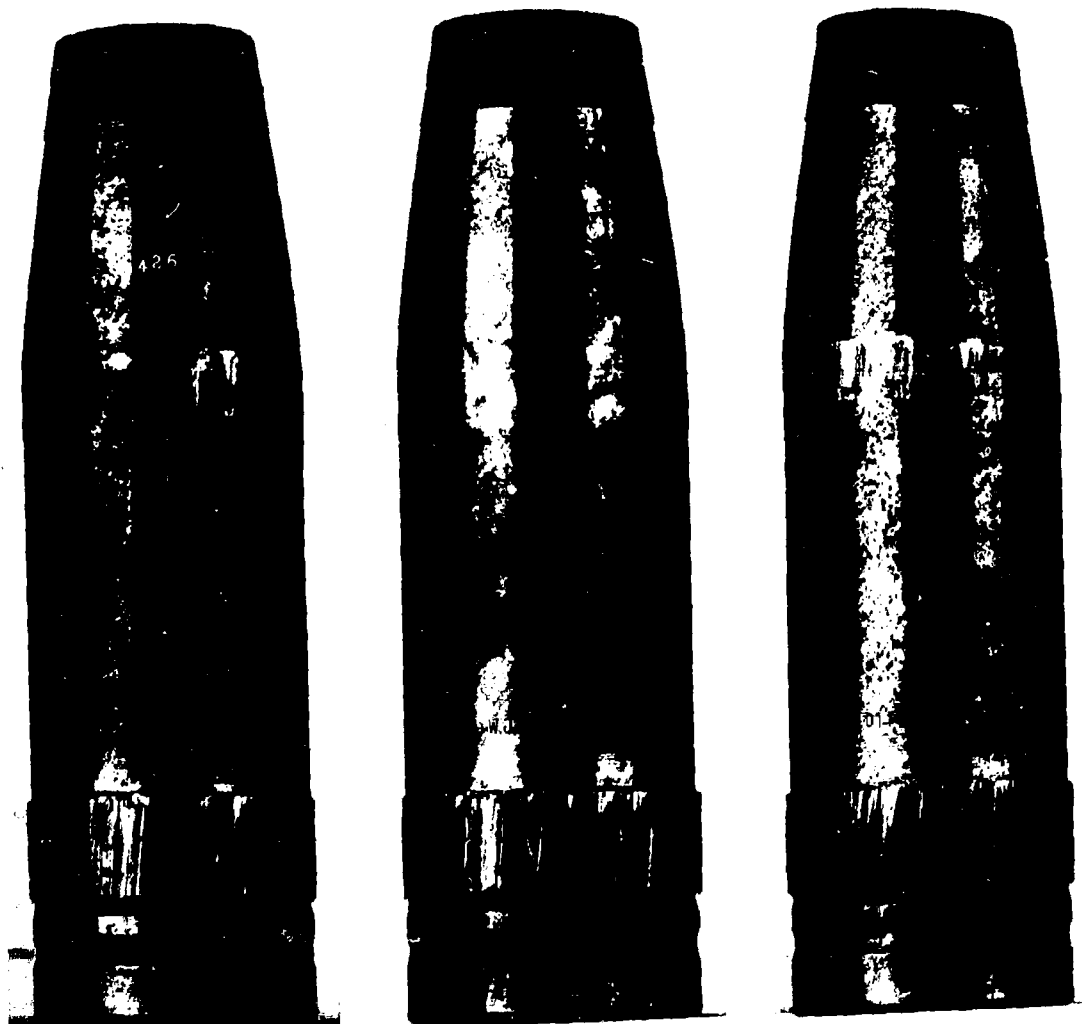
NP9-50970

27 June 1952

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Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0
proj. tile with welded overlay band. Projectile No. 1433.

Figure 9

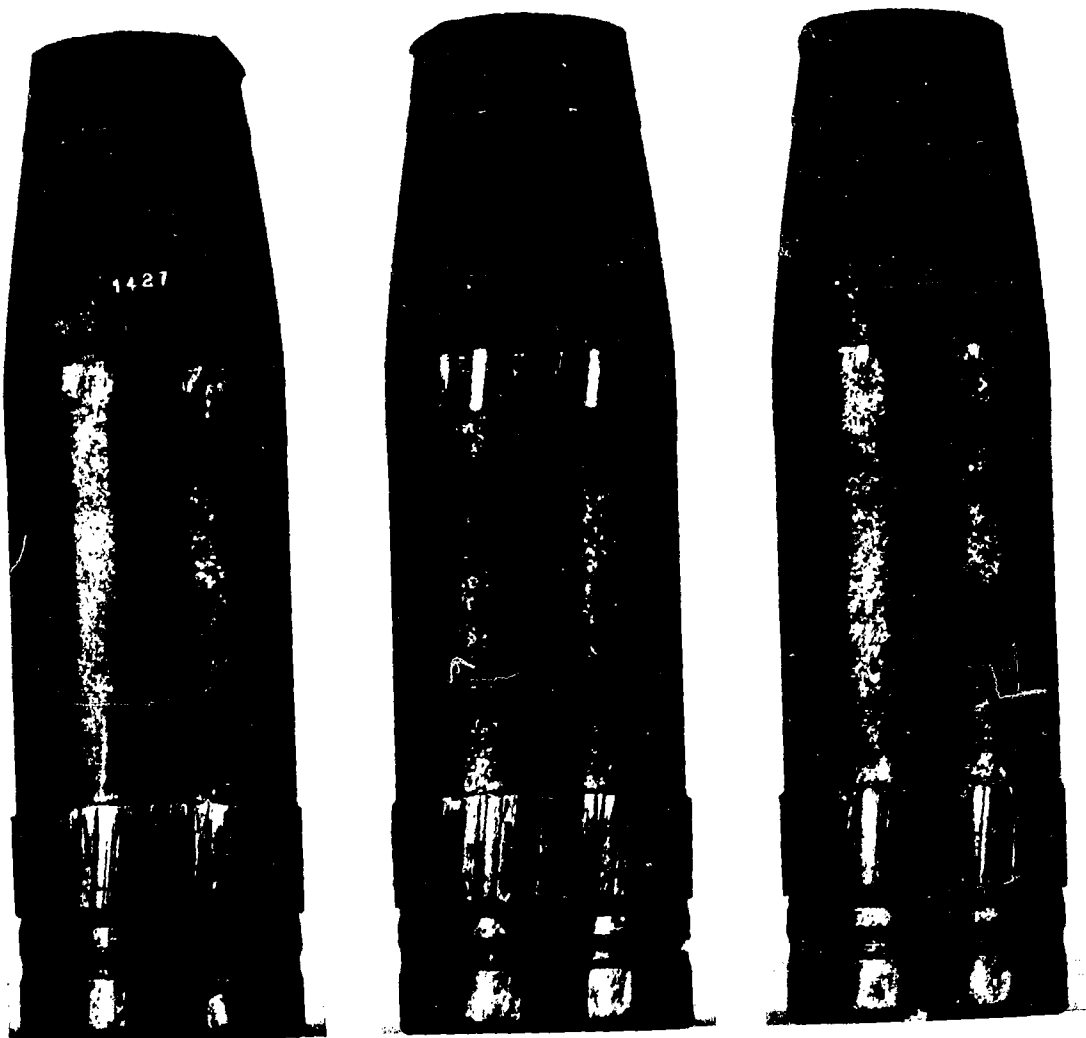


NP9-50971

6 August 1952

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Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0
projectile with standard band. Projectile No. 1426.
Figure 10



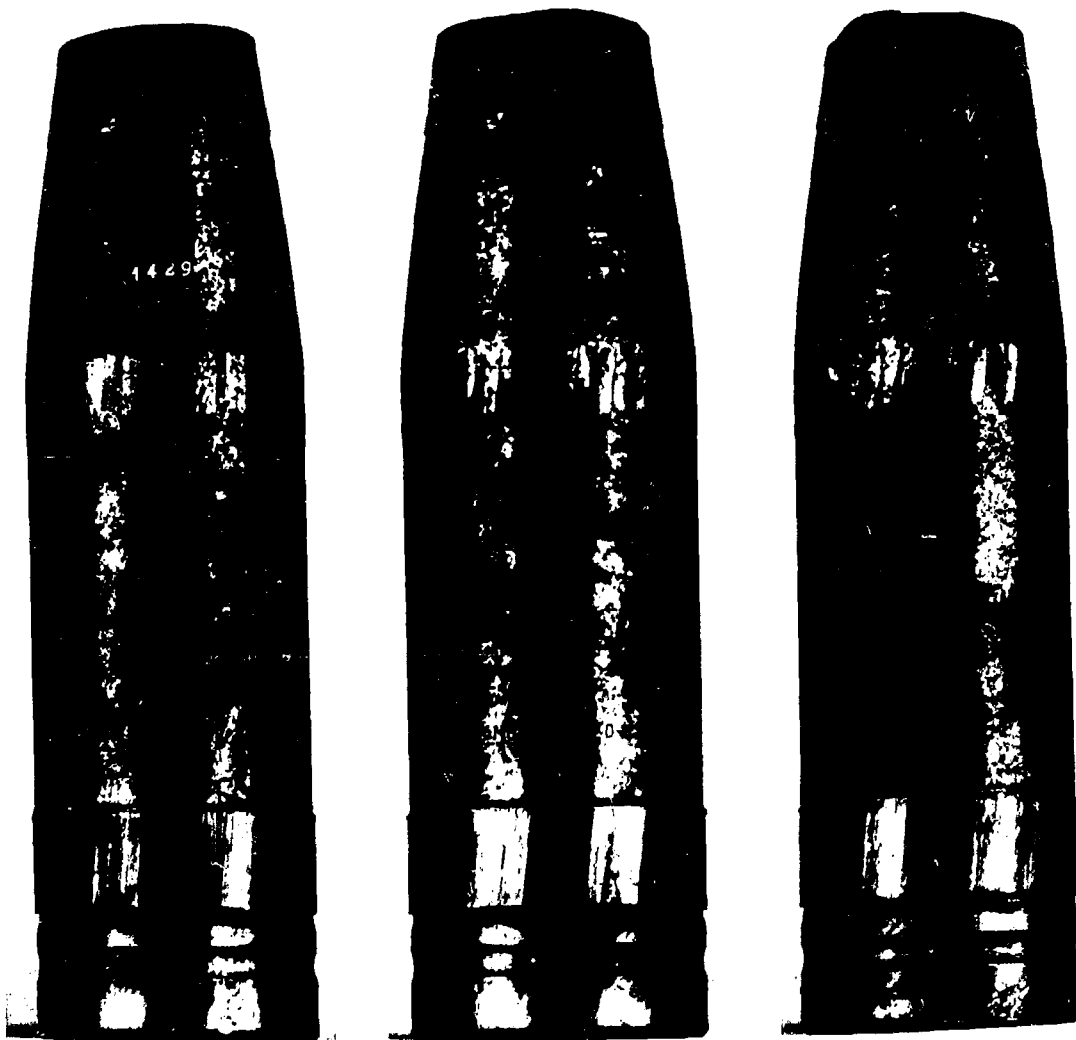
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Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0
projectile with standard band. Projectile No. 1427.

Figure 11



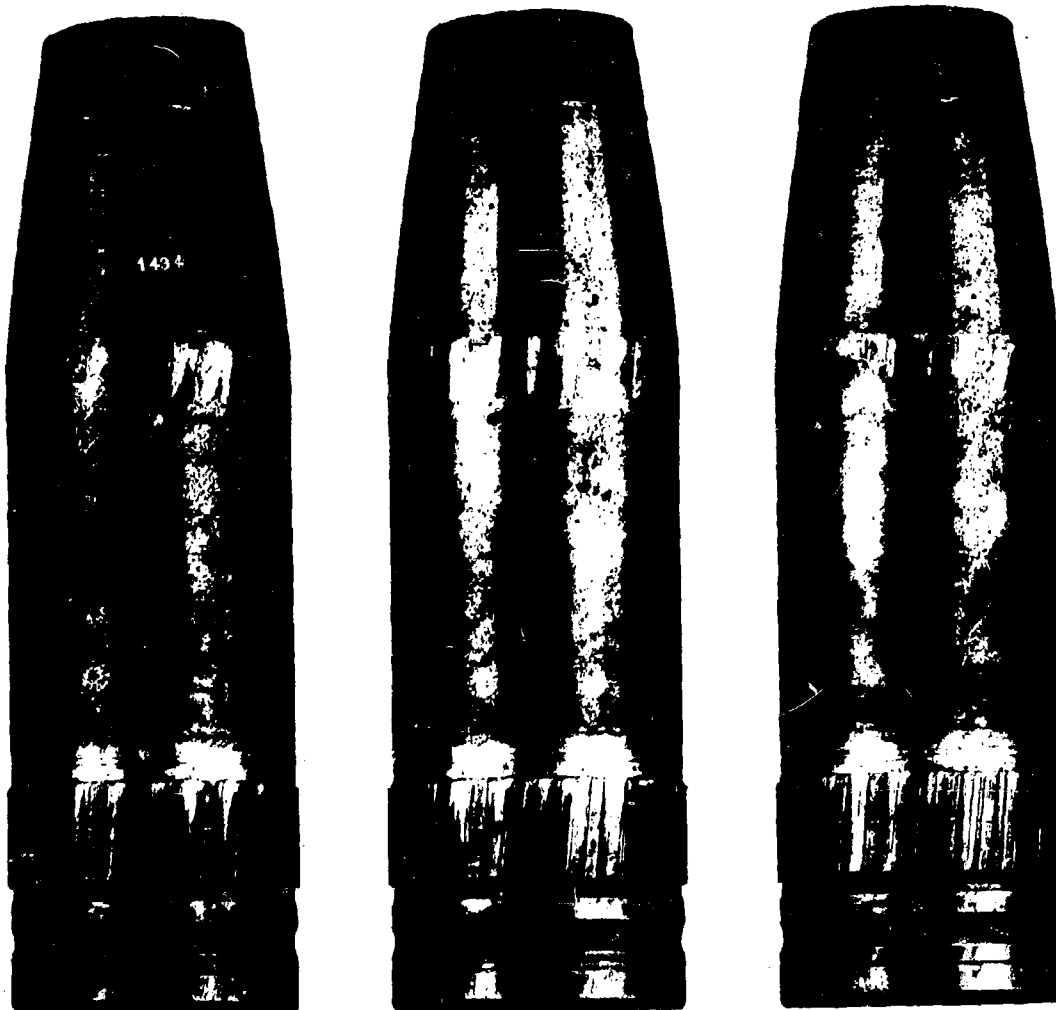
NP9-50973

6 August 1952

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Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0
proj. tile with standard band. Projectile No. 1429.

Figure 12



NP9-50974

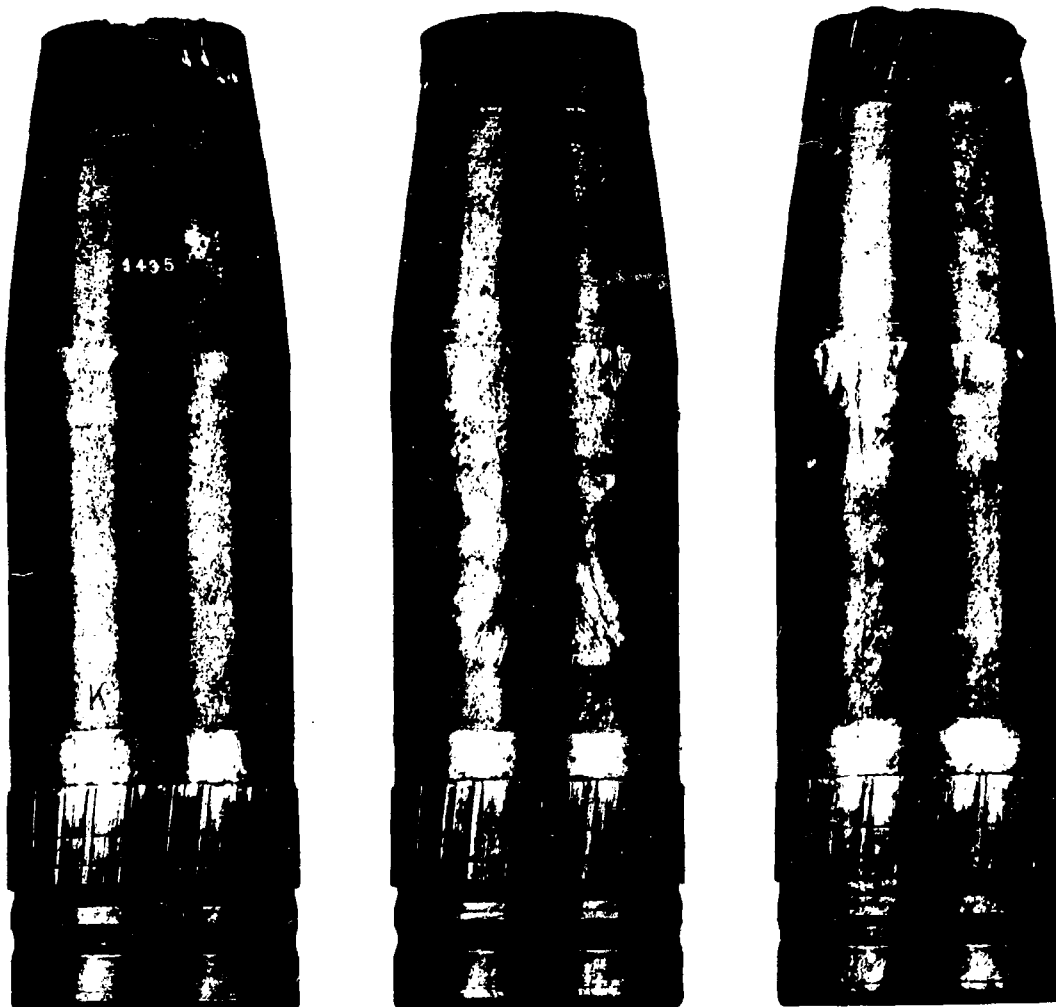
6 August 1952

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Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0
projectile with welded overlay band. Projectile No. 1434.

Figure 13



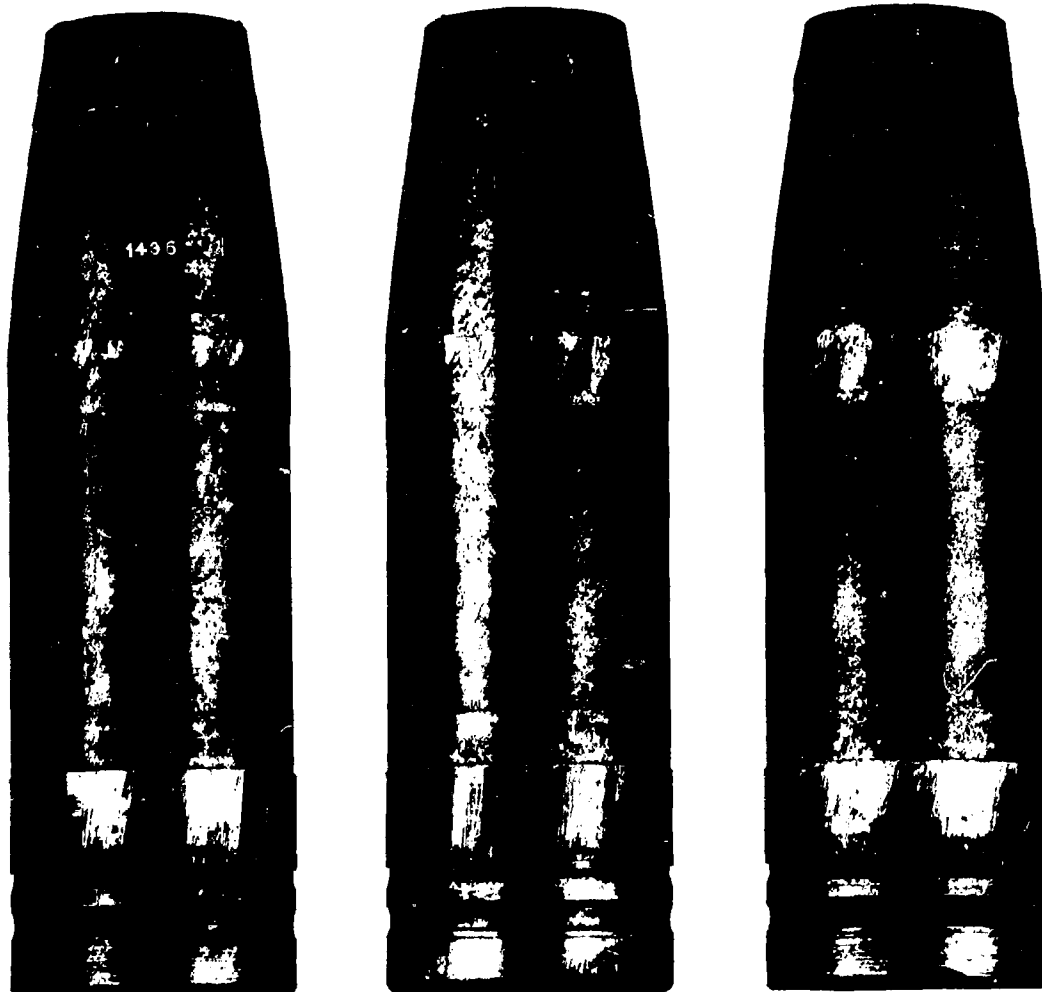
NP9-50975

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Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0
projectile with welded overlay band. Projectile No. 1435.

Figure 14



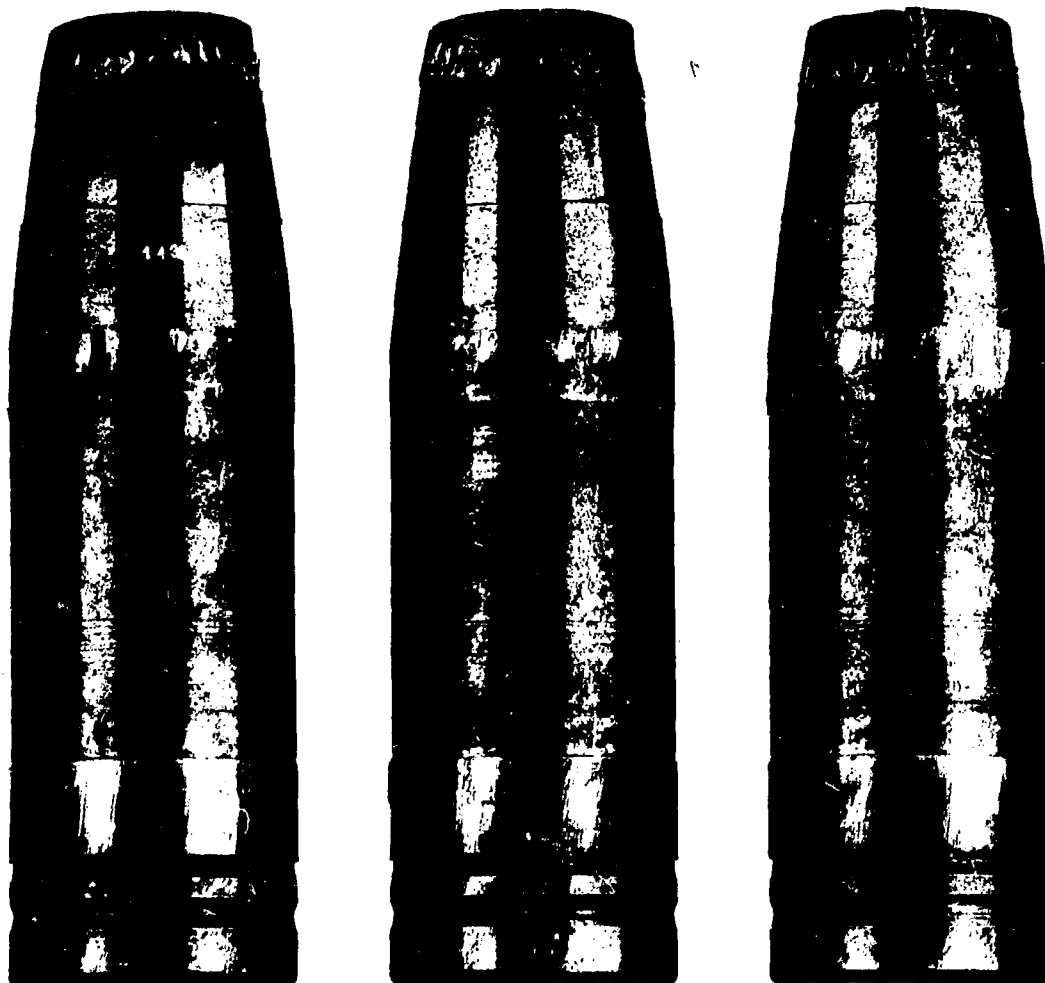
NP9-50976

6 August 1952

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Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0
projectile with welded overlay band. Projectile No. 1436.

Figure 15



NP9-50977

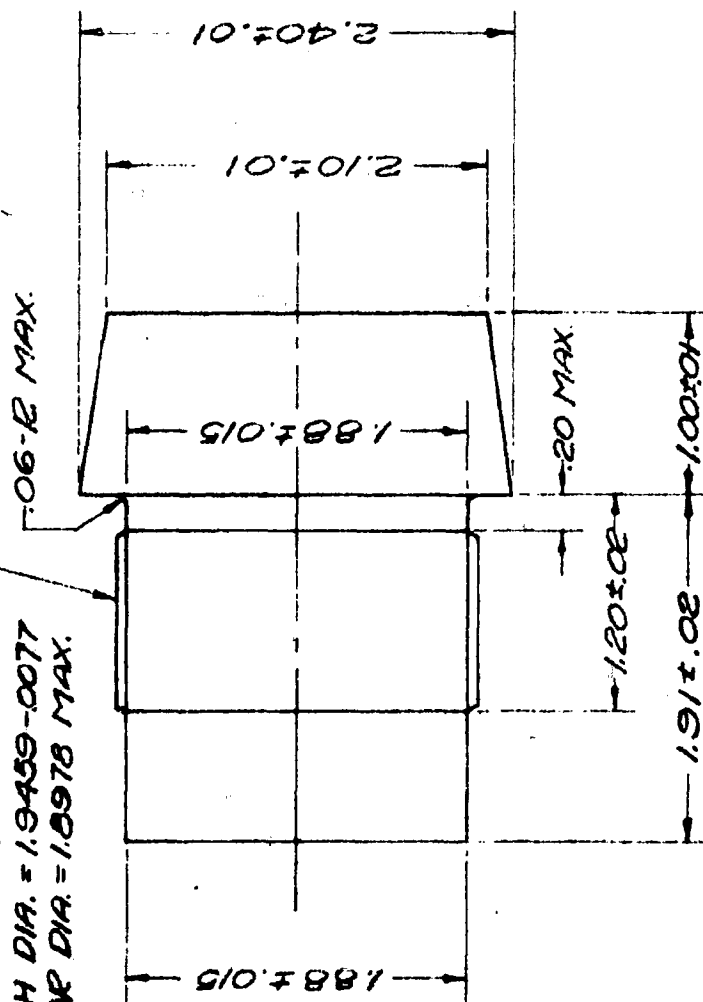
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Three views (120° apart) of recovered 3"/50 AA Mk 33 Mod 0
projectile with welded overlay band. Projectile No. 1437.

Figure 16

2.00 - 12 NS - 2 RH.
 MAJOR DIA. = 2.000 - 0.012
 PITCH DIA. = 1.9439 - 0.0077
 MINOR DIA. = 1.8978 MAX.



DUMMY NOSE PLUG

MATERIAL: STEEL, FORGED
 OR ROLLED STOCK.

WEIGHT: 2.68 $\pm$.05 LBS.

NOTE: BREAK SHARP EDGES

REF: SEE BUORD SK. NO. 239269

APR - 107

9/27/49

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FIGURE 17

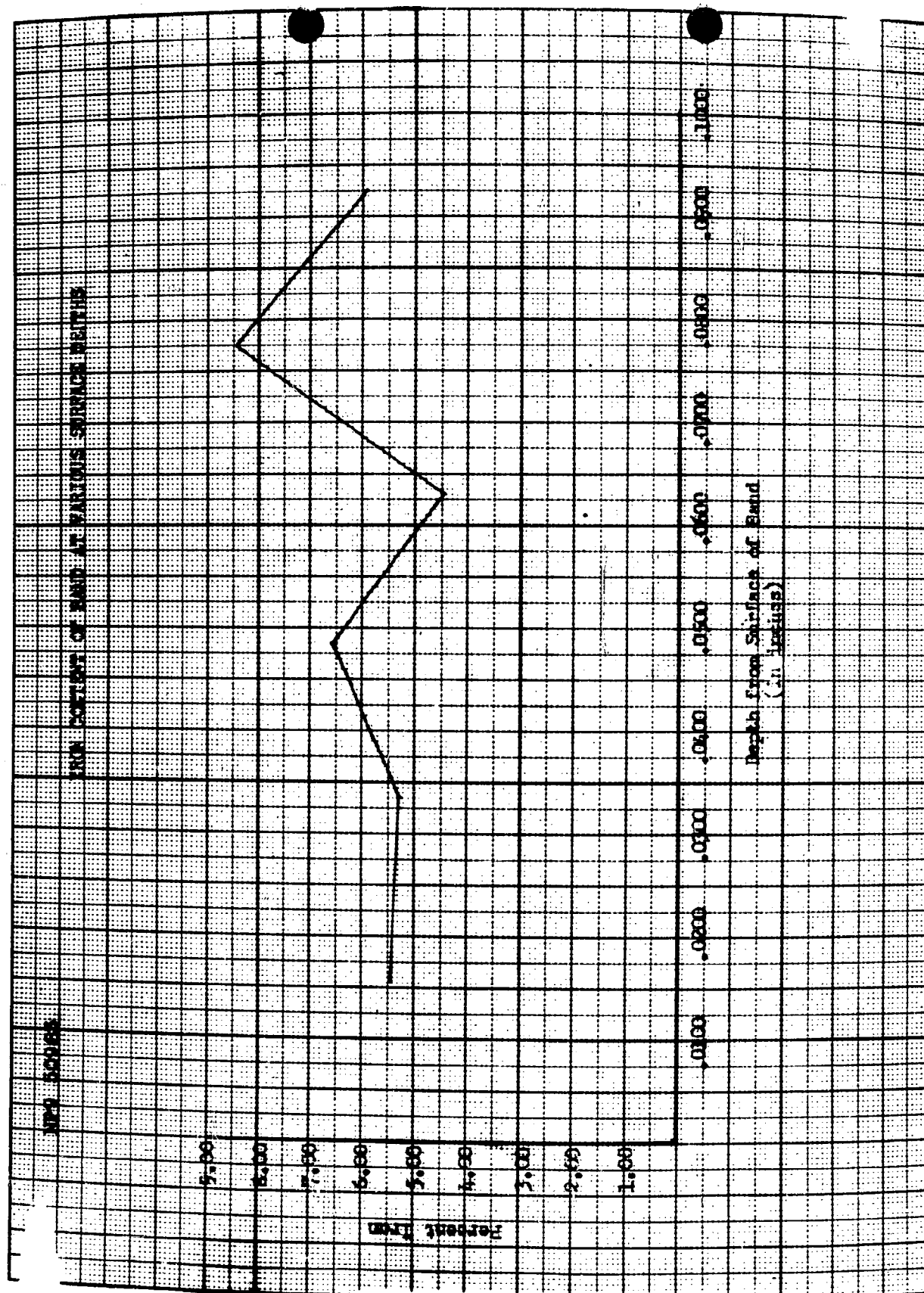
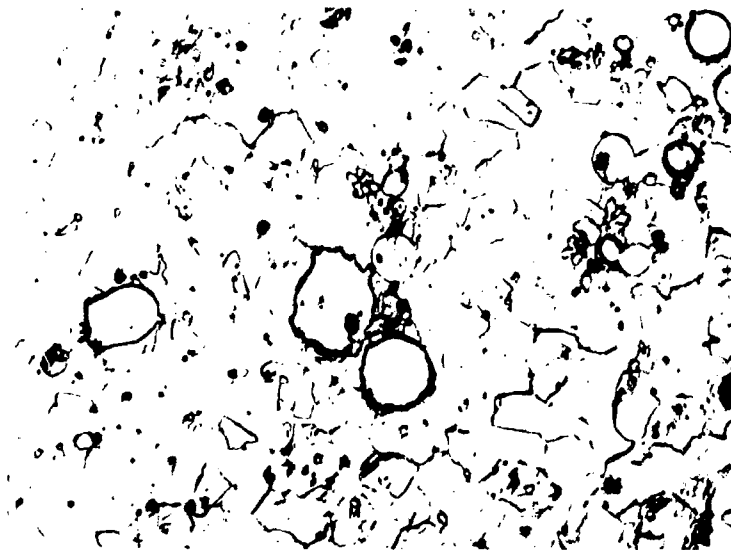


Figure 18

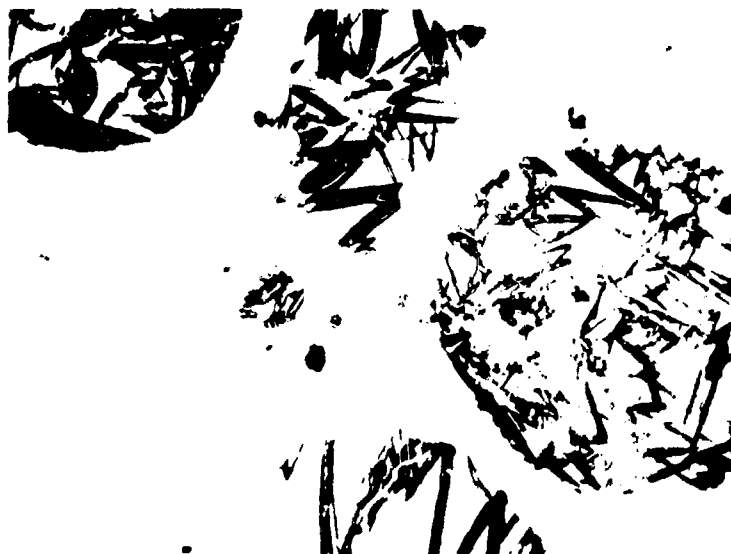
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NPG REPORT NO. 1077

Test of 3"/50 AA Projectiles with Copper
Welded-Overlay Rotating Bands



(A) Structure of deposited copper weld metal,
note globules of entrapped steel,
 $\text{NH}_4\text{OH} + \text{H}_2\text{O}_2$ etch - 500 X Mag.



(B) Hard martensitic structure of entrapped
steel. Nital Etch 1000 X Mag.

NP9-50985

Microstructure of deposited weld metal.

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Figure 19

APPENDIX C

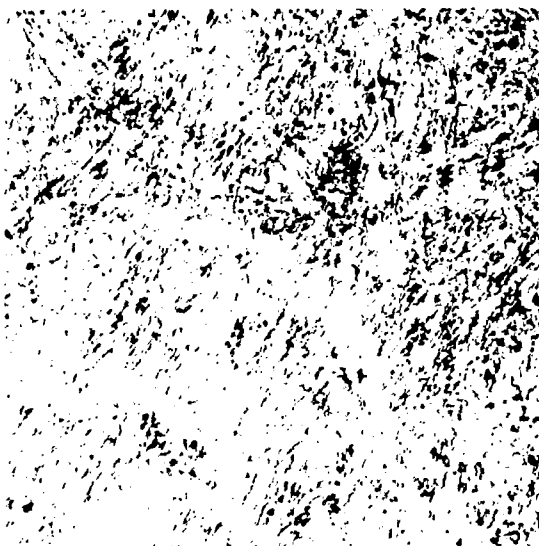
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NPG REPORT NO. 1077

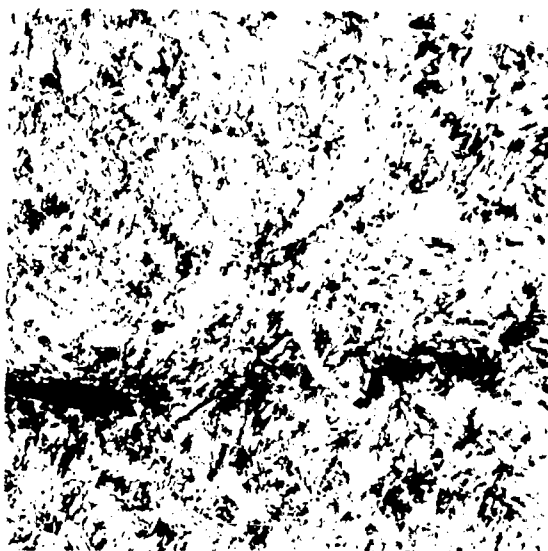
Test of 3"/50 AA Projectiles with Copper
Welded-Overlay Rotating Bands



(A) Weld Zone (47 R_c)



(B) Heat Affected Zone (37 R_c)



(C) Center of Shell (23 R_c)

NP9-50986

"As welded" copper overlay on
3"/50 AA Shell. Photomicrographs 1000X
Nital Etch.

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Figure 20

APPENDIX C

NP9 49080

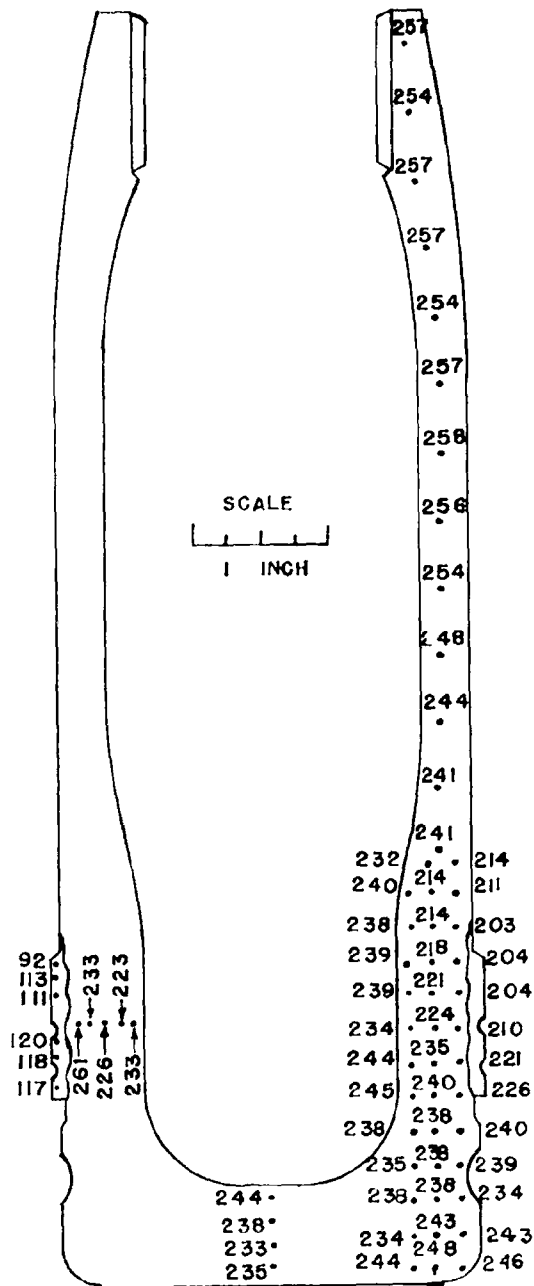
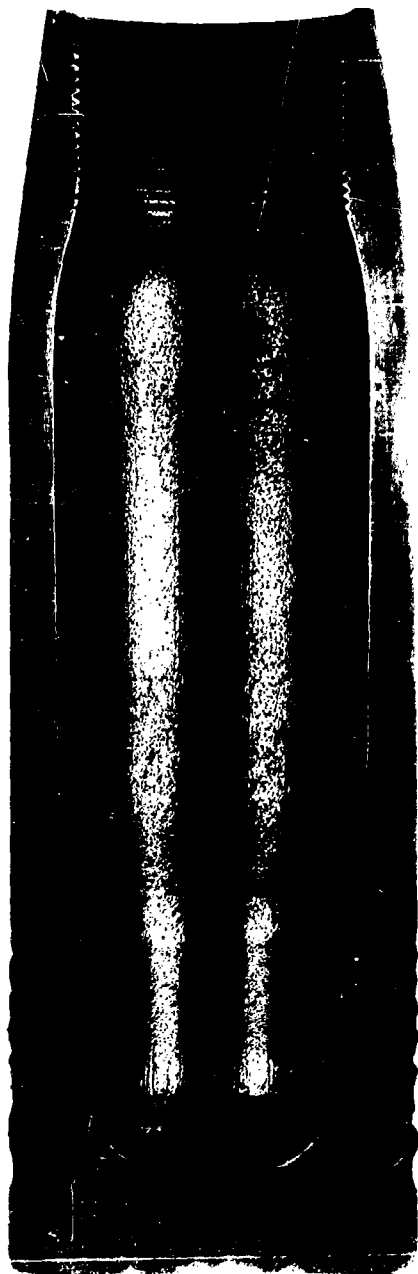
JUNE 1952

HARDNESS DISTRIBUTION AND MACROSECTION OF
3⁷/50 AA MK 33 MOD 0 PROJECTILE WITH
WELDED COPPER OVERLAY BAND

Hardness Values: Vickers Pyramid -- Body (20kg.) Band (10kg.)

Etch: Ammonium Persulfate

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NF9 49079

JUNE 1952

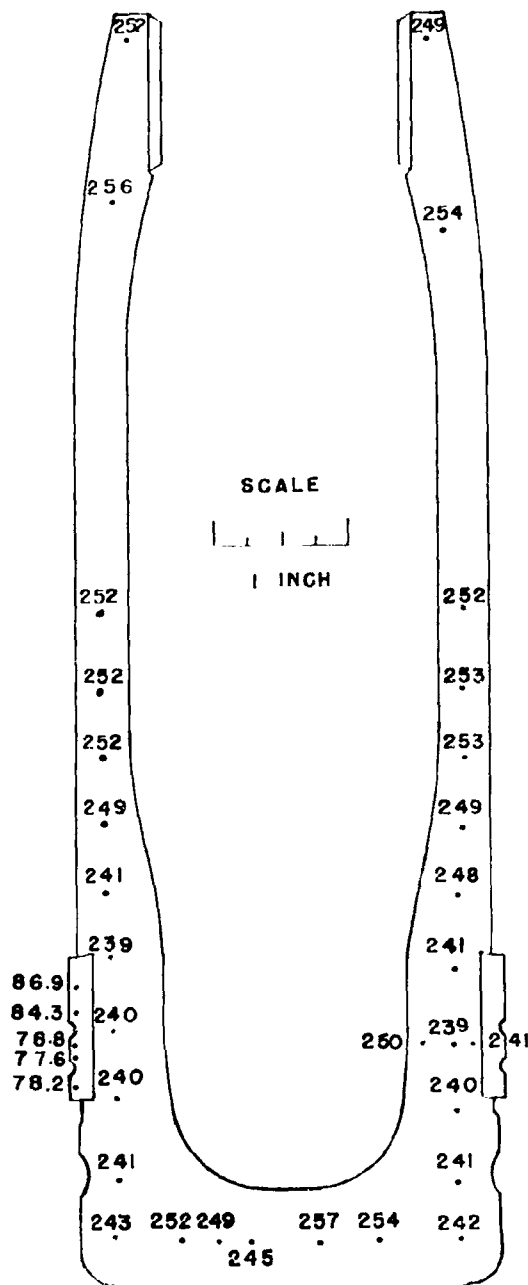
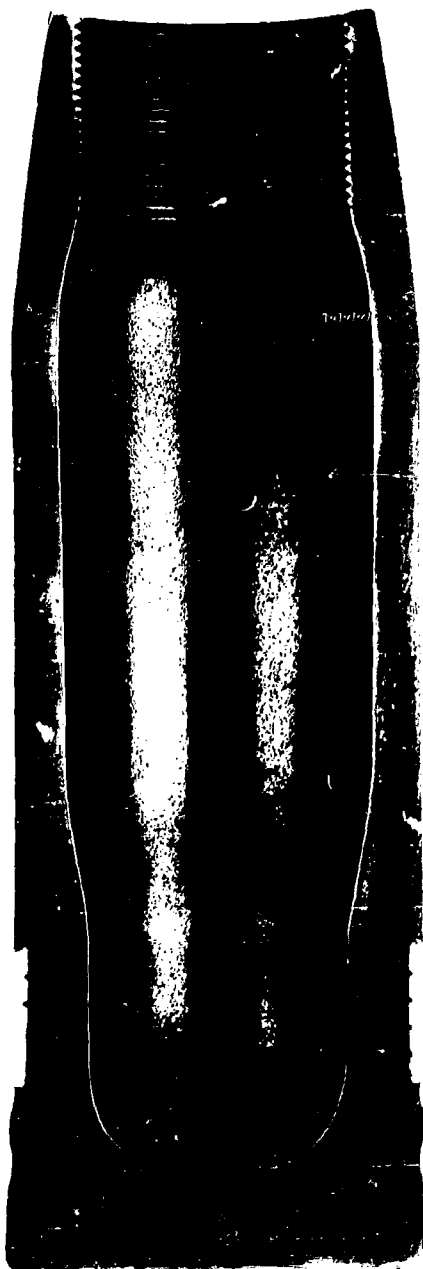
HARDNESS DISTRIBUTION AND MACROSECTION OF
3"/50 AA MK 33 MOD O PROJECTILE
WITH STANDARD COPPER BAND

Hardness Values: Vickers Pyramid — Body (20kg) Band (10kg)

Etch: Ammonium Persulfate

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Security Information



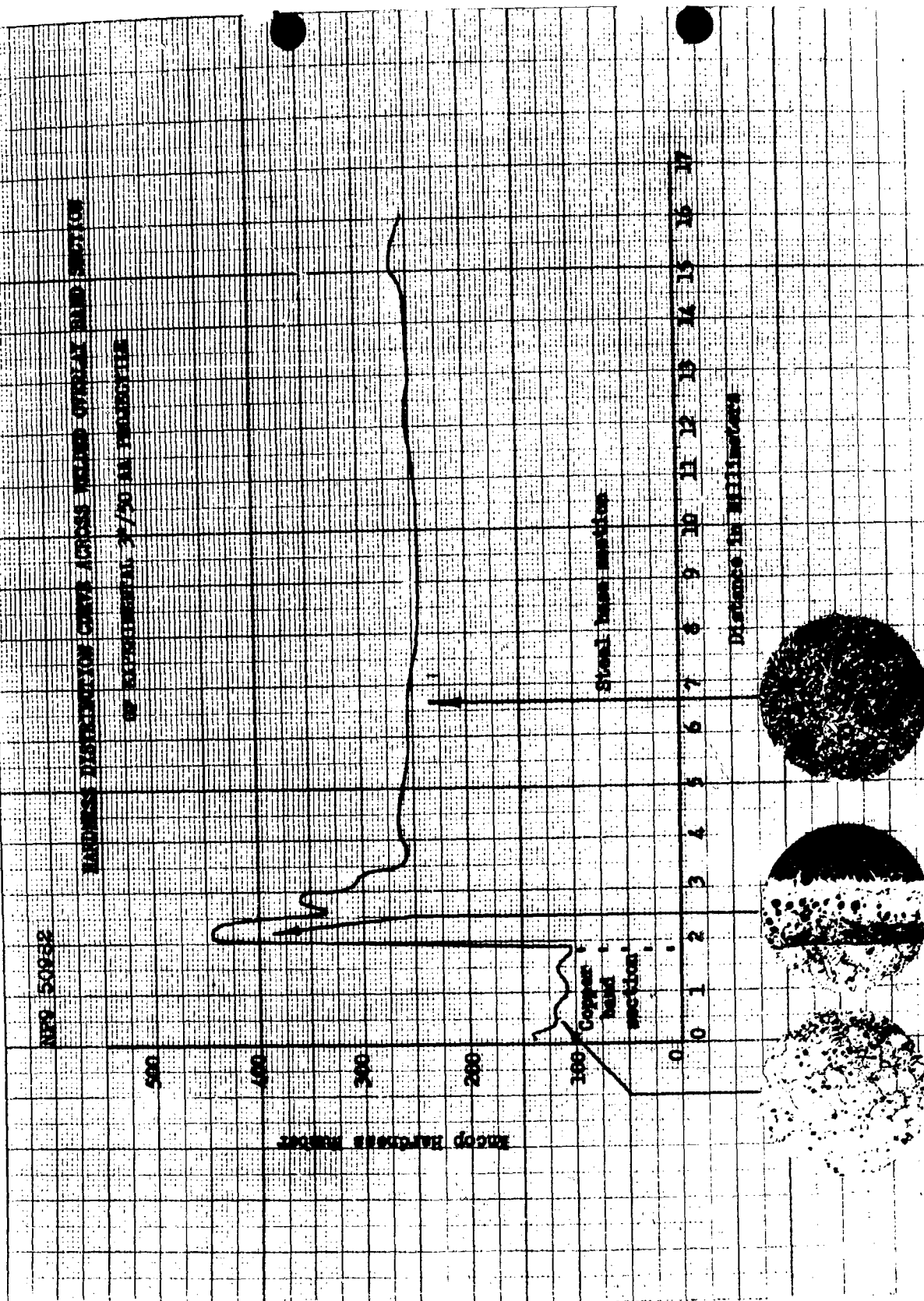
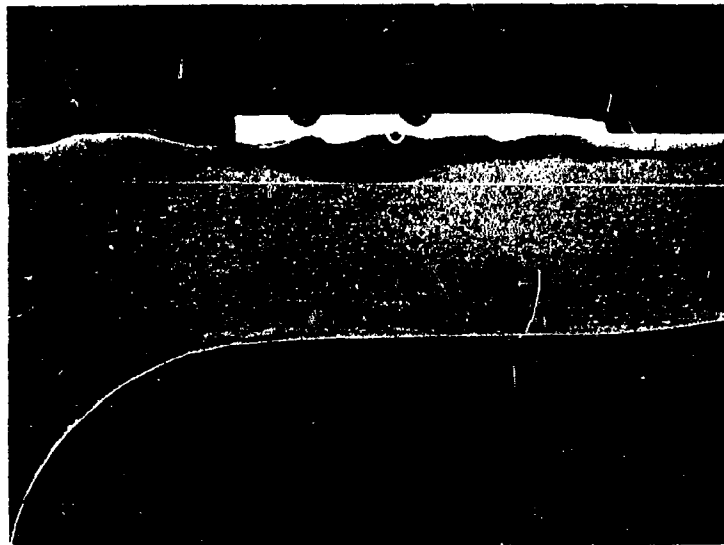


Figure 23

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Test of 3^{1/2}/50 AA Projectiles with Copper
Welded-Overlay Rotating Bands



- (A) Photomacrograph of cross section of shell in vicinity of the band. Magnification 2X Persulfate etch
(O) indicate the position of photomicrograph below.



- (B) Structures related to weld metal, weld zone and heat-affected zone. 100X Nital Etch.

NP9-50988 Photomacro and micrograph of cross section of welded overlay band.

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Figure 24

APPENDIX C

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NPG REPORT NO. 1077

Test of 3"/50 AA Projectiles with Copper
Welded-Overlay Rotating Bands

Wire Impression Method of Determining Spin

Two screens are set up 41/5 apart, each screen consisting of a metal frame with wood inserts, holding an array of parallel equidistant vertical copper wires. The spacing of the wires is 1/2" for the first screen and 3/4" for the second. The projectile is fitted with a flat-nosed dummy nose plug or the equivalent, so that after passing through the screens it bears two sets of impressions of the wires. The angle between the two sets of impressions is measured and from this measurement the rifling of the gun, the muzzle velocity, and the velocity at the spin screens, is computed the percentage of nominal spin. It is assumed that over the short distances involved the spin retardation is negligible.

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APPENDIX D

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NPG REPORT NO. 1077

Test of 3"/50 AA Projectiles with Copper
Welded-Overlay Rotating Bands

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APPENDIX E

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UNCLASSIFIED