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**NPG Report No. 1263**

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**THE DEVELOPMENT OF  
INGOT-IRON ROTATING BANDS FOR  
3"/70 AA PROJECTILES**



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

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U. S. Naval Proving Ground  
Dahlgren, Virginia

The Development of  
Ingot-Iron Rotating Bands for  
3<sup>rd</sup>/70 AA Projectiles

by

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and  
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Terminal Ballistics Department

NPG REPORT NO. 1263

Task Assignment No.  
NPG-B-3b-225-1-54

16 April 1954

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



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Ordnance Officer  
By direction

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ABSTRACT

This report covers work on the development of a swaged-on ingot-iron rotating band design for 3<sup>n</sup>/70 AA Projectiles. The final design evolved was satisfactory in velocity, gun pressure, and yaw at short range, and not only produced full spin but also showed no perceptible band wear. In addition, it produced negligible body deformation under the band of the fired projectile, and permitted a strong joint between projectile and case. The design is somewhat novel, incorporating a series of high ribs canted to the rear which fold down during run-up and engraving. The band is lubricated with molybdenum disulfide.

Ranging and rapid-fire tests of this design are in progress, and will be the subject of a later report.

FOREWORD

This is the 12th partial report on Projectile Rotating Bands and Components. The work was authorized by BUORD Conf ltr Re3b-RS:mt NP9 Ser 24422 of 15 Aug 1951 (reference (a)) under Task Assignment NPG-Re3b-225-1-52.

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

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INTRODUCTION

Reference (b) reported the first work done on iron rotating bands for the 3"/70 projectile. Two designs of 3"/70 band (Figures 5 and 6), as well as a small-diameter design (Figure 4) not adaptable to service use in the 3"/70 gun, were investigated, and the results indicated that it was possible to fit a 3"/70 projectile with a soft iron (Armco ingot iron) rotating band by using precisely the same method of manufacture as for a copper band, that iron bands caused little if any more barrel strain than copper or copper alloy bands of the same contour, and that projectiles with iron bands of the standard 3"/70 Ex 24 Mod 2 contour, fired from a G-3 gun, showed no evidence of band wear and gave range performance far better than projectiles with gilding-metal bands of the same contour.

This report covers further development of swaged-on ingot-iron band designs for the 3"/70 gun.

PROCEDURE AND RESULTS

All rounds in this program were fired from 3"/70 barrel Type G Mod 3 Serial No. 24493, which had approximately 400 ESR and an origin enlargement of 0.009. This gun has a short run-up, a uniform twist of 1 in 25, rifling with a constant groove depth of 0.035, and is chromium plated (0.006). All rounds were inert-loaded with Epsom salts and fitted with flat dummy nose plugs (Figure 11) to a total weight of 15 pounds. All projectiles were rubber-crimped in the case, except for Type 23 Mod 1, which could not be crimped. All rounds fired were recovered in sawdust and examined. Measurements were made of velocity, pressure, and spin (by the wire impression method, Appendix (C)). In some cases, deformation under the band was obtained from measurements of projectile inside diameter before and after firing.

All the iron bands, with exceptions noted below, were liberally coated before firing with powdered molybdenum disulfide suspended in a plastic paint. It was hoped that this material, which is a well-known high-pressure lubricant, would reduce the friction of the band on the barrel and consequently reduce gun wear.

#### TYPE 23 MOD 1

The Type 23 Mod 1 band, shown in Figures 1 and 7, was designed to investigate to what extent the length of the iron band could be reduced without detriment to the performance previously observed (reference (b)). This was not an actual design for a 3"/70 band, since it was not possible to crimp it in the case, but only a test device. Only two of these bands were ever fired; the results are shown in Table 1, and photographs of the recovered projectiles in Figures 12 and 13. The results were quite satisfactory, except for an indication of fringing, which pointed out the need for more canneluring.

#### TYPE 23 MOD 2

During the time in which the Type 23 Mod 1 bands were in process of fabrication, the idea was hit upon of designing a band with several high lips (so as to fit the case properly) with all the lips undercut from the rear. The intention was to produce a design in which the lips on passing through the run-up would be folded down rather than swaged down, with a consequent reduction in band pressure and body deformation of the projectile. A somewhat similar design in gilding metal had been tried much earlier in the 3"/50 Type C (Probert) gun, but this band had failed and was abandoned. Since earlier results had indicated clearly that iron was less susceptible to band wear than gilding metal, it was believed that in the present instance this type of design had a good chance of success. The Type 23 Mod 2 band (Figures 1 and 8) was the first design on this principle. Two rounds were fired along with the Type 23 Mod 1 bands, and the results are shown in Table 1 and Figures 14 and 15. (Two projectiles with the standard Ex 24 Mod 7 gilding-metal band were also fired in the same program

for comparison; see Table 1 and Figures 16 and 17,) The results were highly encouraging. The velocities, pressures, yaws and spins for the projectiles with Type 23 Mod 2 bands were all satisfactory, the recovered bands showed no signs of wear, and the considerable body deformation observed with the standard bands was reduced to negligible proportions (as was also the case for the Type 23 Mod 1 bands; see Table 1).

Five more of the Type 23 Mod 2 bands were made and tested. Three of these were coated with molybdenum disulfide as before, and two had no coating (Figure 2). The results are shown in Table 2 and Figures 18-22. These confirmed the previous results, with the additional observation that the uncoated bands exhibited considerably more temper color than the coated ones. This was taken as evidence that the molybdenum disulfide was providing some effective lubrication, and preventing the bands from reaching as high a surface temperature as they otherwise would. It was therefore decided that molybdenum disulfide coating would be adopted as standard for these bands.

#### TYPE 23 MOD 3

The Type 23 Mod 3 band was similar to the Type 23 Mod 2, but was shorter and had a somewhat larger effective diameter (Figures 2 and 9). The results for the three rounds fired are given in Table 2 and Figures 23-25. The reduction in length led to no reduction in performance, but the increase in diameter caused an increased amount of temper color, and this band was therefore not considered as acceptable as Type 23 Mod 2.

#### TYPE 23 MOD 4

The next step was to design the Type 23 Mod 4 band, with the reduced length of the Type 23 Mod 3 and the smaller diameter of the Type 23 Mod 2 band (Figures 3 and 10). The results for the five rounds fired are shown in Table 3 and Figures 26-30. Again the results were satisfactory.

Two of the rounds rubber crimped in cases for this test were pulled apart to determine the debulleting load. Both rounds separated at over 15,000 pounds load. These rounds were then reassembled and fired (Table 3).

#### DISCUSSION

Fifteen rounds of the basic Type 23 design had now been fired, and each round had shown good performance of the band. Bullet pull strength had been shown to be superior to that obtained with the standard gilding-metal band, and body deformation (and therefore band pressure) was much reduced. In addition, iron bands which did not fail in the gun had been shown (reference (b)) capable of excellent range performance in the G-3 gun, whereas standard gilding-metal bands gave very poor range uniformity when fired for comparison. The remaining important question about the performance of this band was therefore its effect on gun

The Naval Proving Ground therefore recommended that the Bureau of Ordnance procure a substantial number of 3"/70 projectiles with the Type 23 Mod 4 band design, together with a new G-3 barrel, for the purpose of conducting ranging tests and, if these should prove successful, eventual rapid-fire tests. This was done, and the ranging and rapid-fire tests, now in progress, will be covered by a subsequent report.

#### REFERENCES

- (a) BUORD Conf ltr Re3b-RS:mt NP9 Ser 24422 of 15 Aug 1951
- (b) NPG Report No. 896 of 29 Nov 1951

APPENDIX A

TABLE 1  
COMPLETE RANGE AND FIRING DATA

Test of 3"/70 AA Projectiles with Amnic Iron Sights in Gun Type G Mod 3 No. 24493

Proj. No.	Firing Order	Type 23 Mod	Powder Charge (lbs.)	Average Pressure (psi)	Muzzle Velocity (ft/sec)	% Nominal Spd.	Deflection (in.)	
							High	Length
855	4	1	10.01	20.5	3343	100.0	-.030	-.001
856	5	1	10.01	20.0	3371	100.8	-.011	-.005
857	6	2	10.01	20.9	3420	100.6	-.001	-.006
858	7	2	10.01	20.7	3427	99.6	-.001	-.003
859	10	*	10.01	20.6	3427	99.6	-.054	+.022
860	11	*	10.01	21.4	3432	101.4	+.053	+.018

Type 23 Mod 1 Projectiles according to API, Drawing 268 (Figure 7).  
 Type 23 Mod 2 Projectiles according to API, Drawing 269 (Figure 8).  
 Gun Type G Mod 3 No. 24493 had 387 ESR ballers 2558 firing.  
 \*Standard Projectiles Type Ex 24 Mod 7.

TABLE 2  
COMPLETE RECORD AND SUMMARY FIRING DATA

Test of 3 1/2 AA Projectiles with Arms of Non-Bands in Gun Type 0 (Mod 3 No. 24493)

Proj. No.	Firing Order 11/15/51	Type 23 Mod	Powder Charge (lbs.) HPS: 1	Average Pressure (psi)	Muzzle Velocity (ft./sec.)	% Nominal Spin
912	2	2	10.01	20.0	3419	99.6
913	3	2	10.01	20.7	3404	99.6
914	6	2*	10.01	20.2	3407	99.6
915	7	2*	10.01	20.7	3409	99.6
916	8	2*	10.01	20.6	3418	99.6
917	9	3*	10.01	18.8	3409	100.3
918	10	3*	10.01	20.4	3431	100.1
919	11	3*	10.01	20.2	3414	100.3

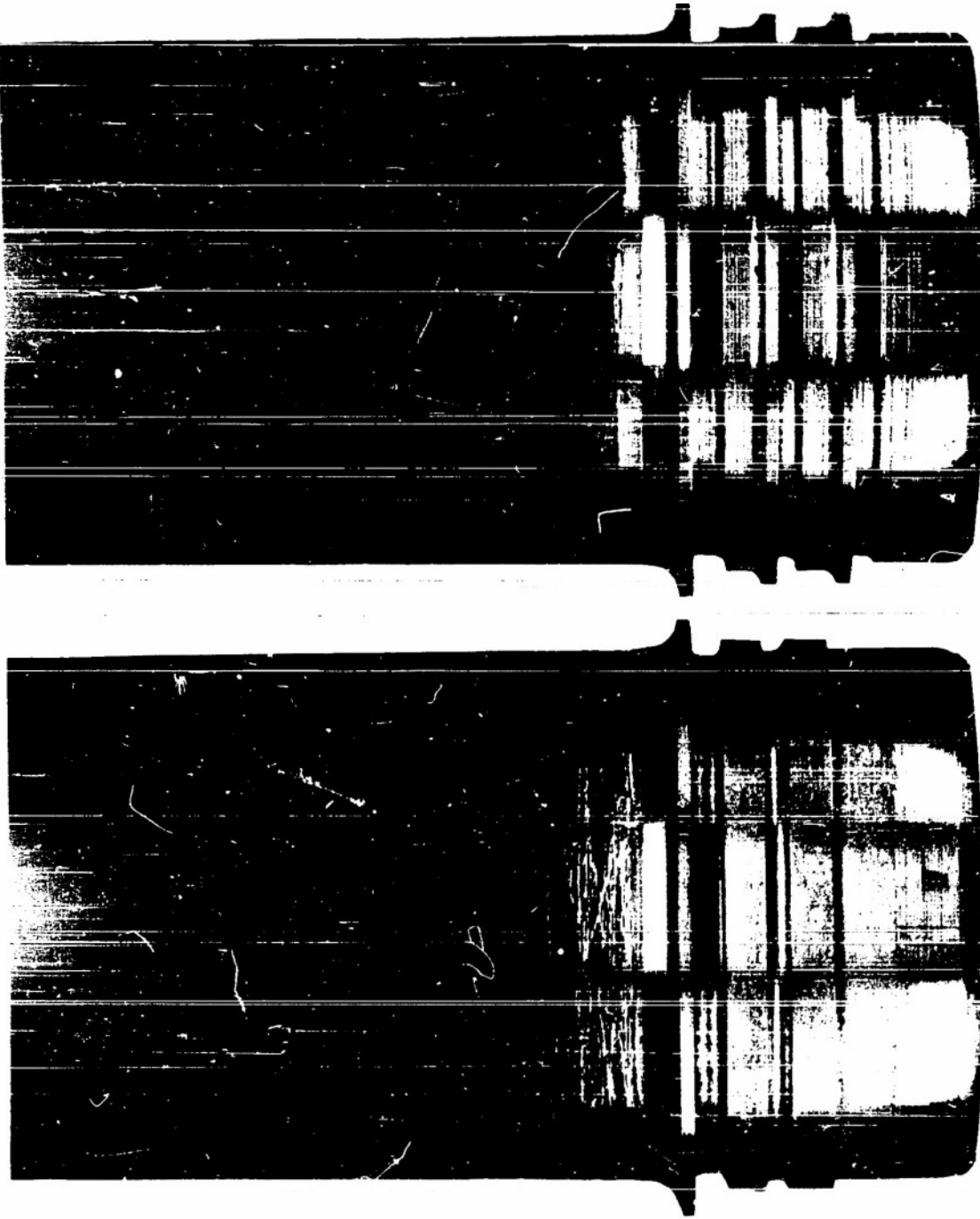
Type 23 Mod 2 Projectiles according to API Drawing 269 (Figure 8).  
 Type 23 Mod 3 Projectiles according to API Drawing 276 (Figure 9).  
 Gun Type 0 Mod 3 No. 24493 had 398 3500 psi test results during firing.  
 One warning round was fired prior to this test.  
 \*Bands coated with molybdenum disulfide.

TABLE 2  
COMPLETE BEFORE AND AFTER FIRING DATA  
 Test of 3<sup>n</sup>/70 AA Projectiles with Armco Iron Bands in Gun Type G Mod 3 No. 24493

<u>Proj. No.</u>	<u>Firing Order</u> <u>12/27/51</u>	<u>Type</u> <u>Mod</u>	<u>Powder Charge</u> <u>(lbs.)</u> <u>HKPC-1</u>	<u>Average Pressure</u> <u>(psi)</u>	<u>Muzzle Velocity</u> <u>(ft./sec.)</u>	<u>% Nominal Spin</u>	<u>Debulleting Load</u> <u>(lbs.)</u>
943	1	4	9.86	19.5	3374	98.6	15,320
944	2	4	9.86	20.0	3377	99.1	15,760
945	3	4	9.86	20.0	3332	100.1	
946	4	4	9.86	19.6	3383	99.1	
947	5	4	9.86	19.6	3399	99.1	

Type 23 Mod 4 projectiles according to APL Drawing 2E1 (Figure 1C).  
 Gun Type G Mod 3 No. 24493 had 409 ESR before this firing.

APPENDIX B



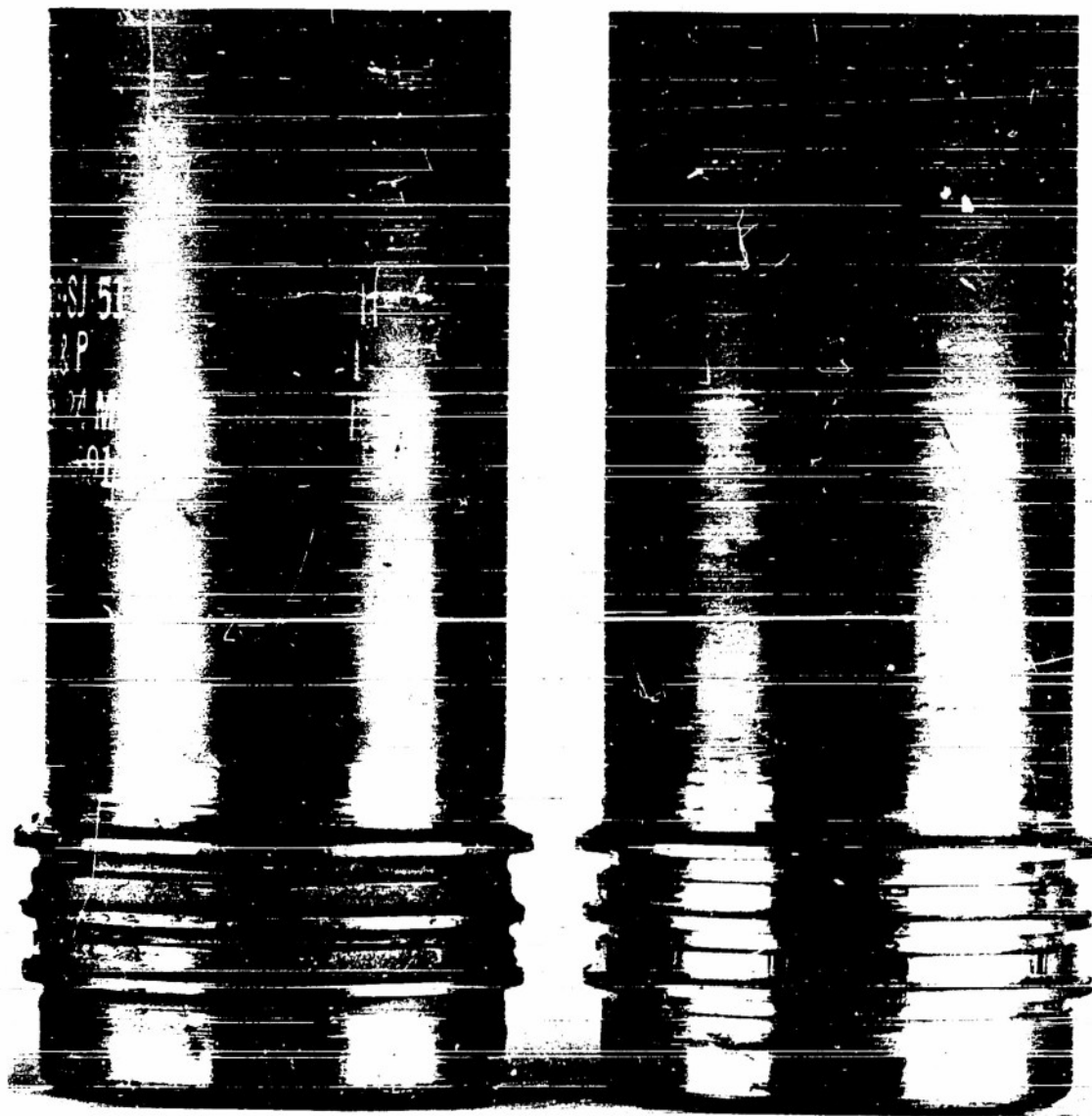
Type 23 Mod 1

Type 23 Mod 2

NF9-65149

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3"/70 AA Projectile Band Designs  
Figure 1



Type 23 Mod 3

Type 23 Mod 2

NF9-64809

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3"/70 AA Projectile Band Designs with and without  
molybdenum disulfide coating.

Figure 2

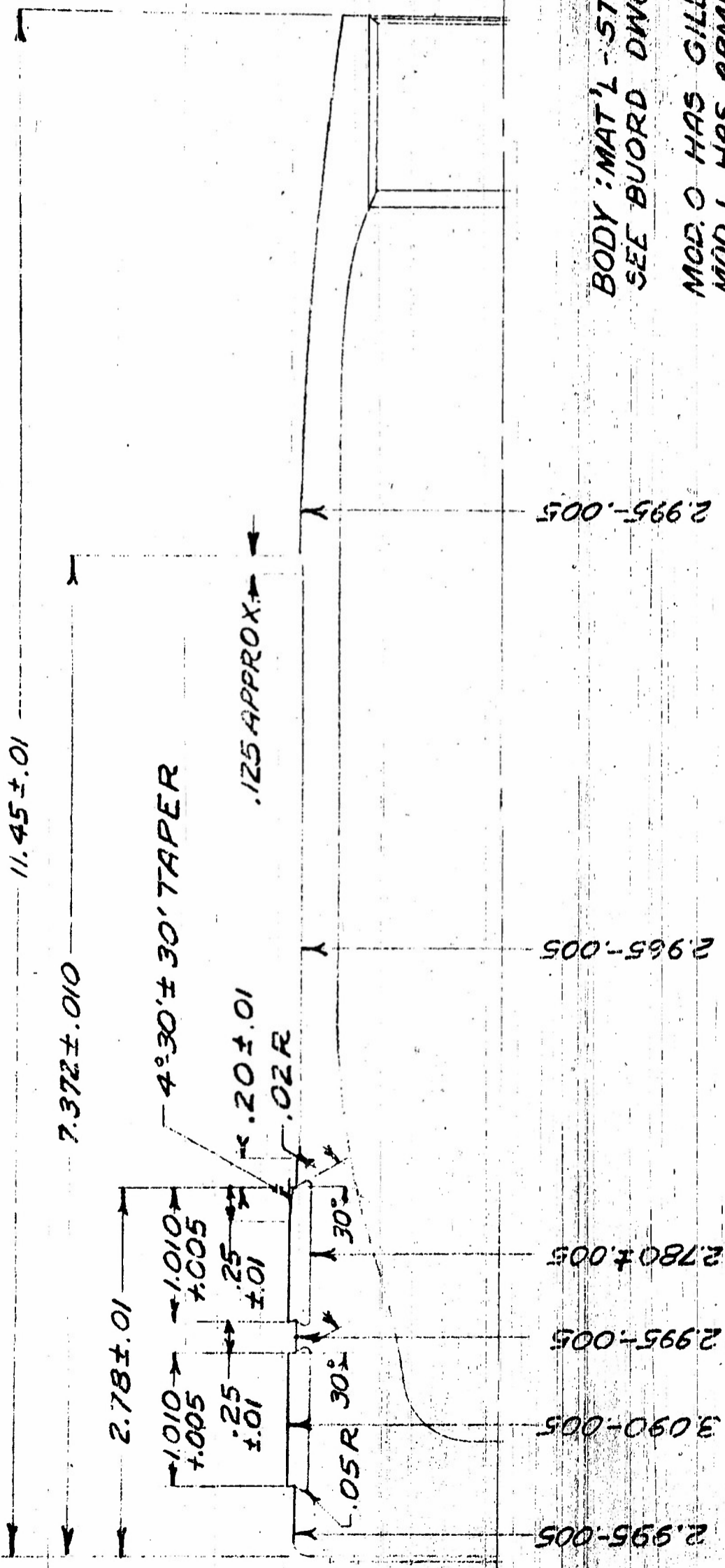


Type 23 Mod 4

NP9-64810

3"/70 AA Projectile Band Design  
Figure 3

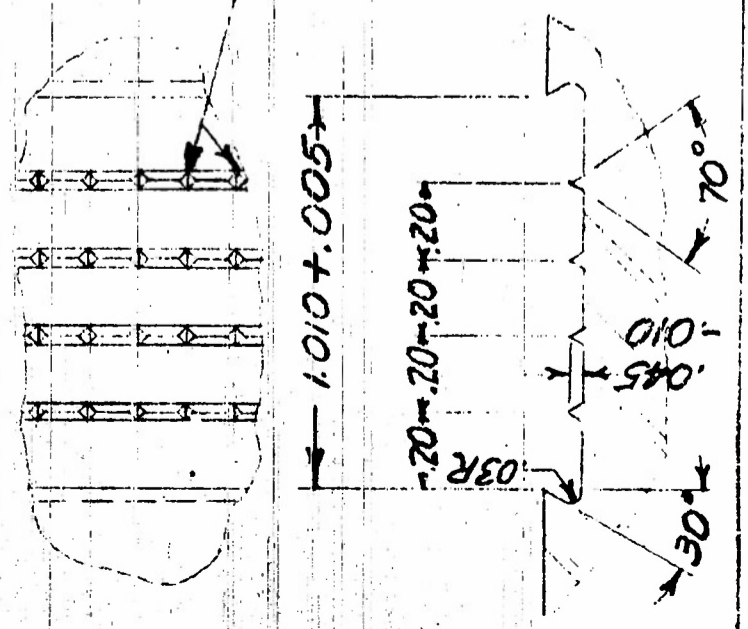
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BODY: MAT'L - STEEL  
 SEE BUORD DWG. NO 239075  
 MOD. 0 HAS GILDING METAL BANDS  
 MOD. 1 HAS ARMCO IRON BANDS

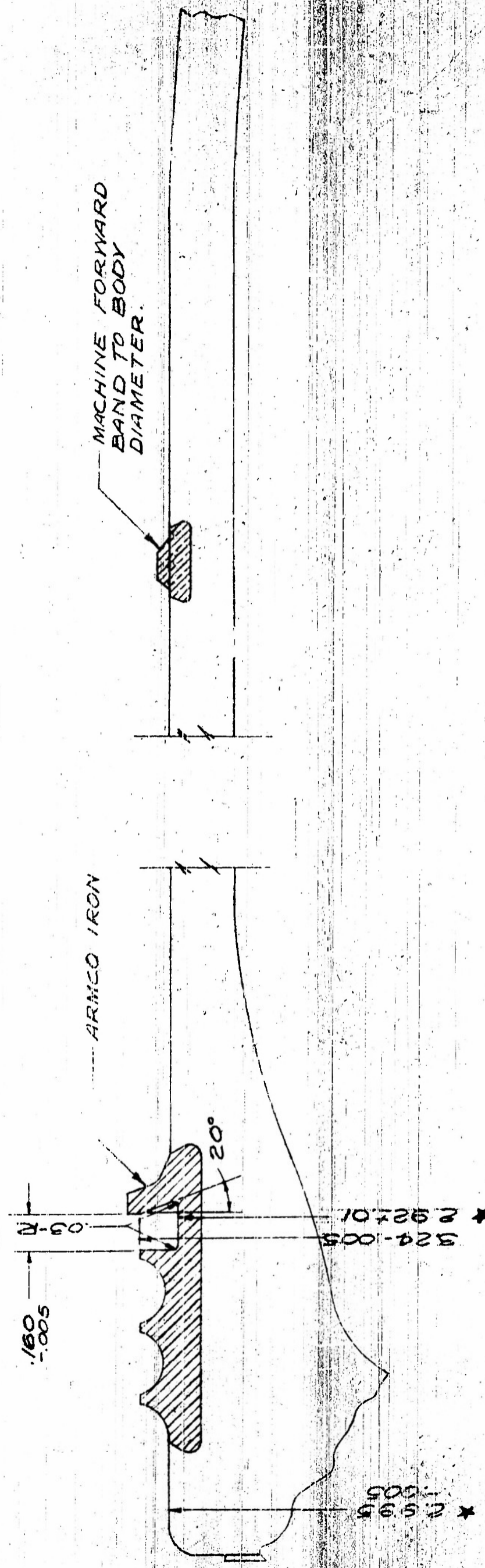
BAND SEAT DETAIL

APPROX 8 SCORES PER INCH



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U.S. NAVAL PROVING GROUND ARMED AND PROJECTILE LABORATORY QUANTICO, VIRGINIA	3"/70 AA PROJECTILE EX 24 MOD 2 MODIFIED TYPE 22 MOD 0 & MOD 1	TEST NO. 3203-1.33	APL-202
APPROVED	2.27.51.890	1/1 8/1:2	



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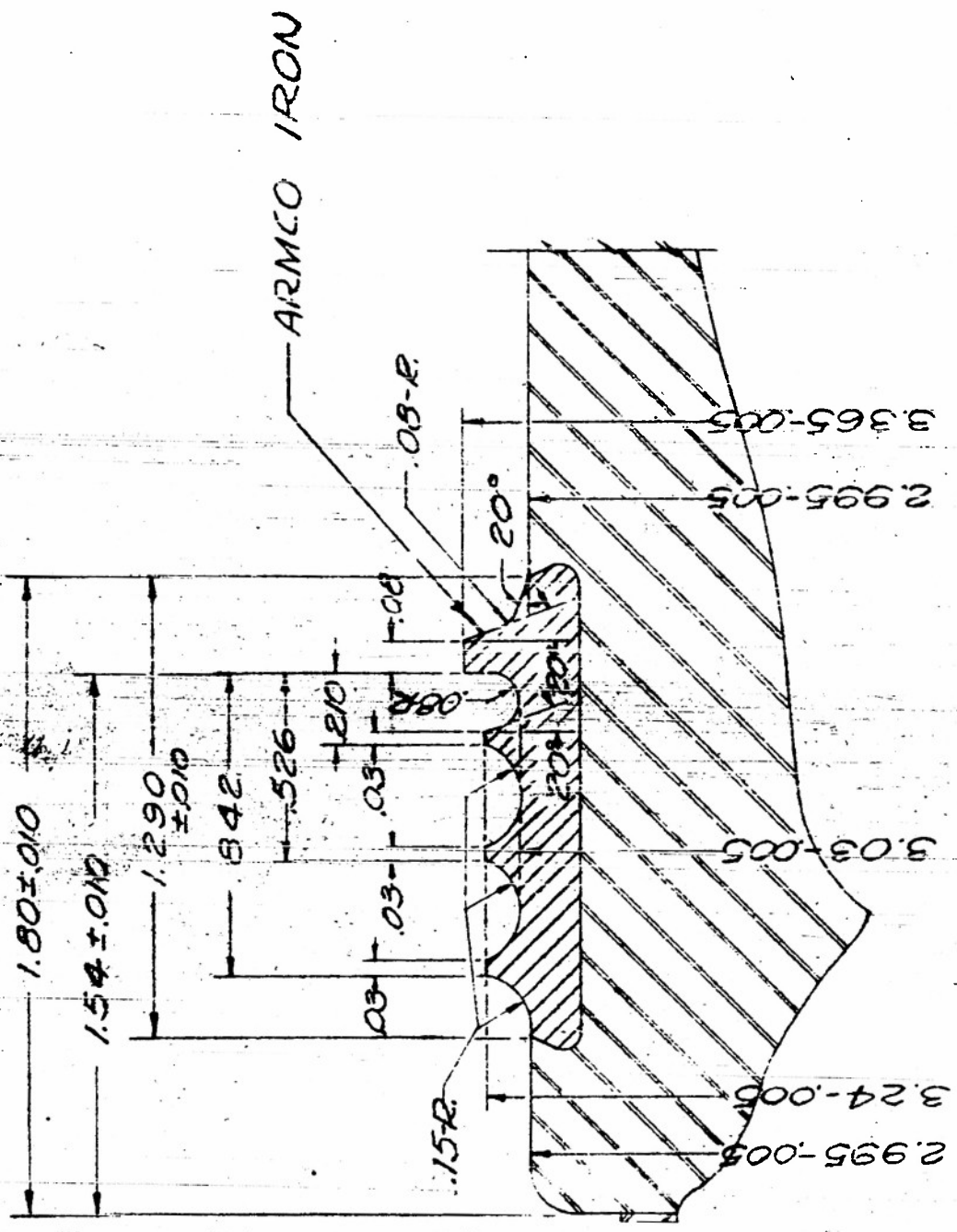
NOTE: STARRED DIAMETERS TO BE CONCENTRIC WITHIN .005"

REF: BUORD SK. NO. 239075 FOR UNMODIFIED BAND AND BODY DIMENSIONS.

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ON FRACTIONS: DECIMALS: ANGLES	APPROVED	19	ORDNANCE OFFICER		
DO NOT SCALE THIS DRAWING MATERIAL	CHECKED DEANN	7/16/51 3/17/51	DESIGNED WAG	TEST NO. T3203-135	U.S. ARMY PROVING GROUND ARMSTRONG PROJECTILE LABORATORY DAKOTA
				SCALE 2:1	DRAWING NO. APL-206

7

4



3"/70 A.A. PROJECTILE TYPE 23 MOD 0  
 (TYPE EX 24 MOD 2 BAND CONTOUR)  
 SCALE - 2:1

NOTE: MACHINE FORWARD BAND TO BODY DIAMETER.

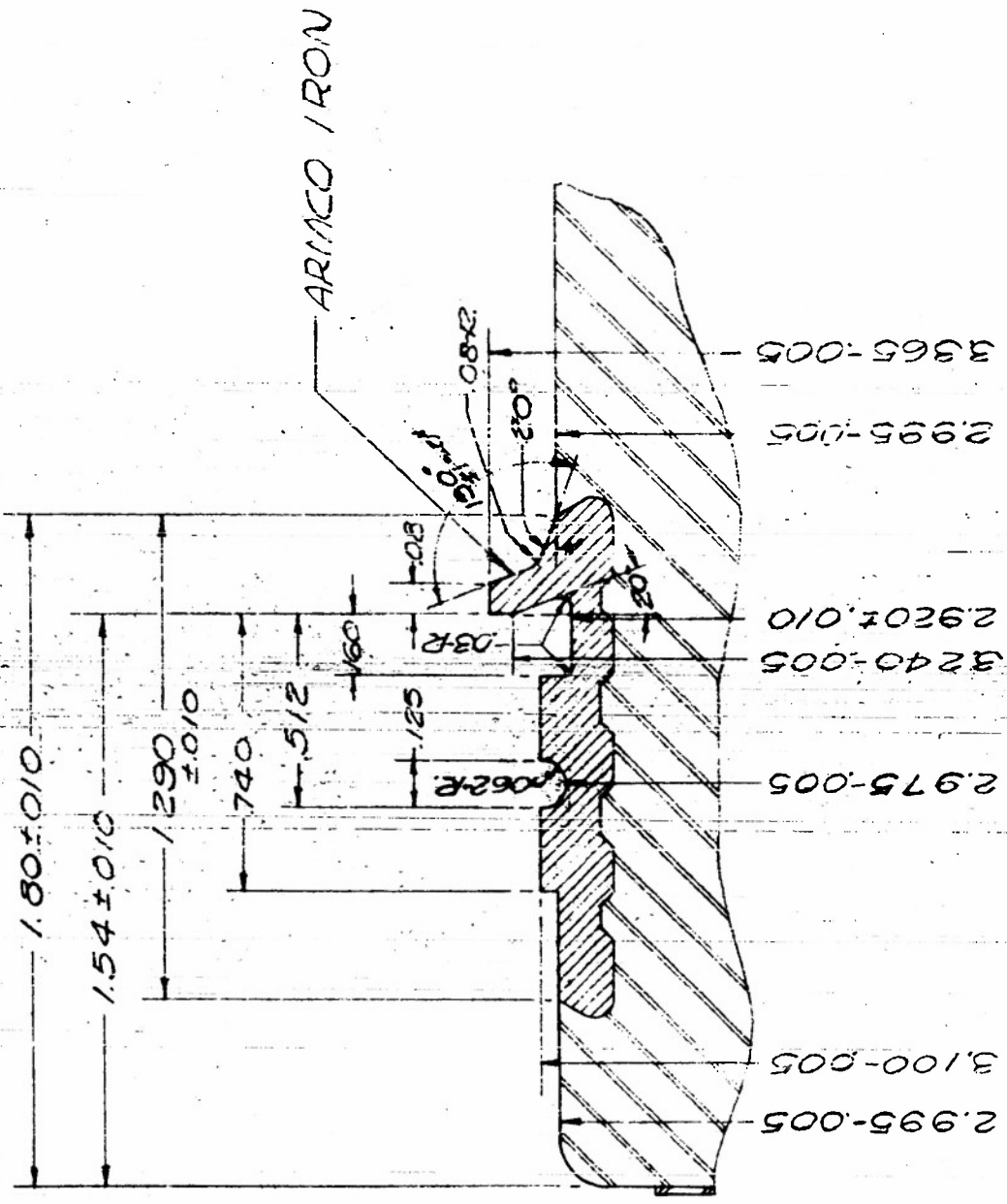
3/22/51 W.M.T.  
 APL-210

REF: BUORD SK. NO 249075

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FIGURE 6

19/17/51 WAT.  
APL-268



3"70 A.A. PROJECTILE TYPE 23 MOD 1

SCALE = 2:1

FIGURE 7

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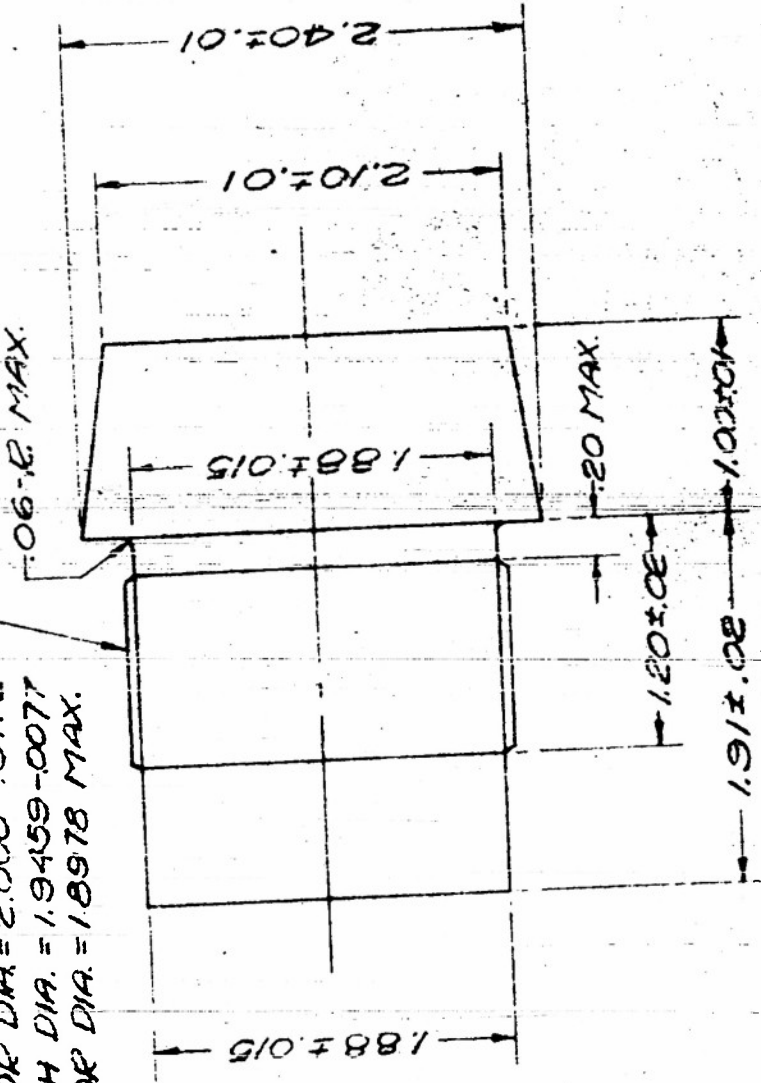
REF: HUKARD SK. NO. 239075







2.00 - 18 NS - 2 RH.  
 MAJOR DIA. = 2.000 ± .0112  
 PITCH DIA. = 1.9459 - .0071  
 MINOR DIA. = 1.8978 MAX.



# DUMMY NOSE PLUG

MATERIAL: STEEL FORGED  
 OR ROLLED STOCK.

WEIGHT: 2.68 ± .05 LBS.

NOTE: BREAK SHARP EDGES

REF: SEE BUOED SK. NO. 239269

APL-107  
 9/27/49 wmf

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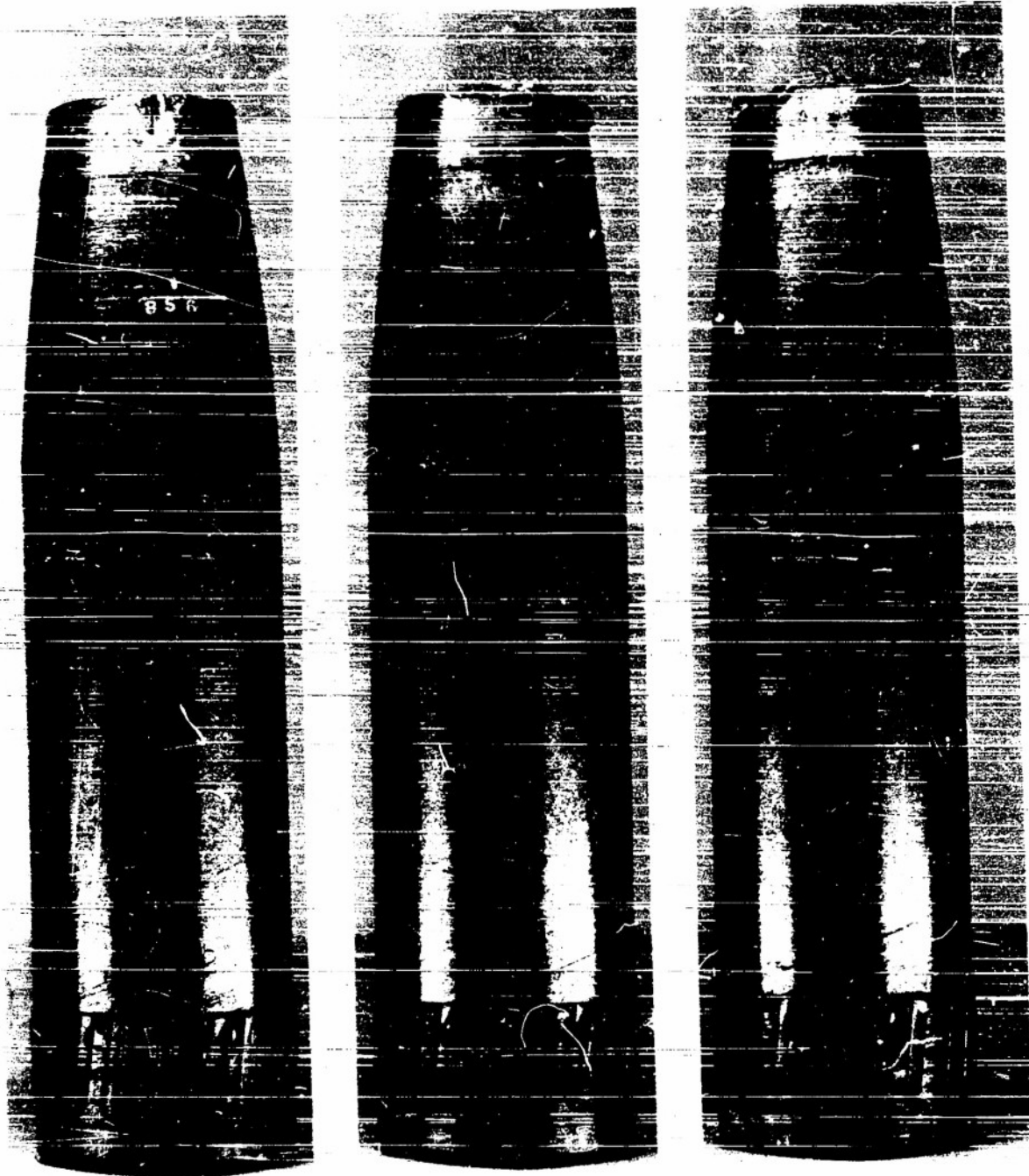
FIGURE 11



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Three views (120° apart) of recovered 3"/70 AA Projectile  
Type 23 Mod 1 No. 855.  
Figure 12



NP9-64812

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Three views (120° apart) of recovered 3"/70 AA Projectile  
Tyne 23 Mod 1 No. 856.  
Figure 13



NP9-64813

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Three views (120° apart) of recovered 3"/70 AA Projectile  
Tyne 23 Mod 1 No. 857  
Figure 14



NP9-64814  
Three views (120° apart) of recovered 3"/70 AA Projectile  
Type 23 Mod 1 No. 858  
Figure 15

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Three views (120° apart) of recovered 3"/70 AA Projectile  
Type EX 24 Mod 7 No. 859.  
Figure 16



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Three views (120° apart) of recovered 3"/70 AA Projectile  
Type EX 24 Mod 7 No. 860.  
Figure 17



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Three views (120° apart) of recovered 3"/70 AA Projectile  
Type 23 Mod 2 No. 912.  
Figure 18



NP9-64818

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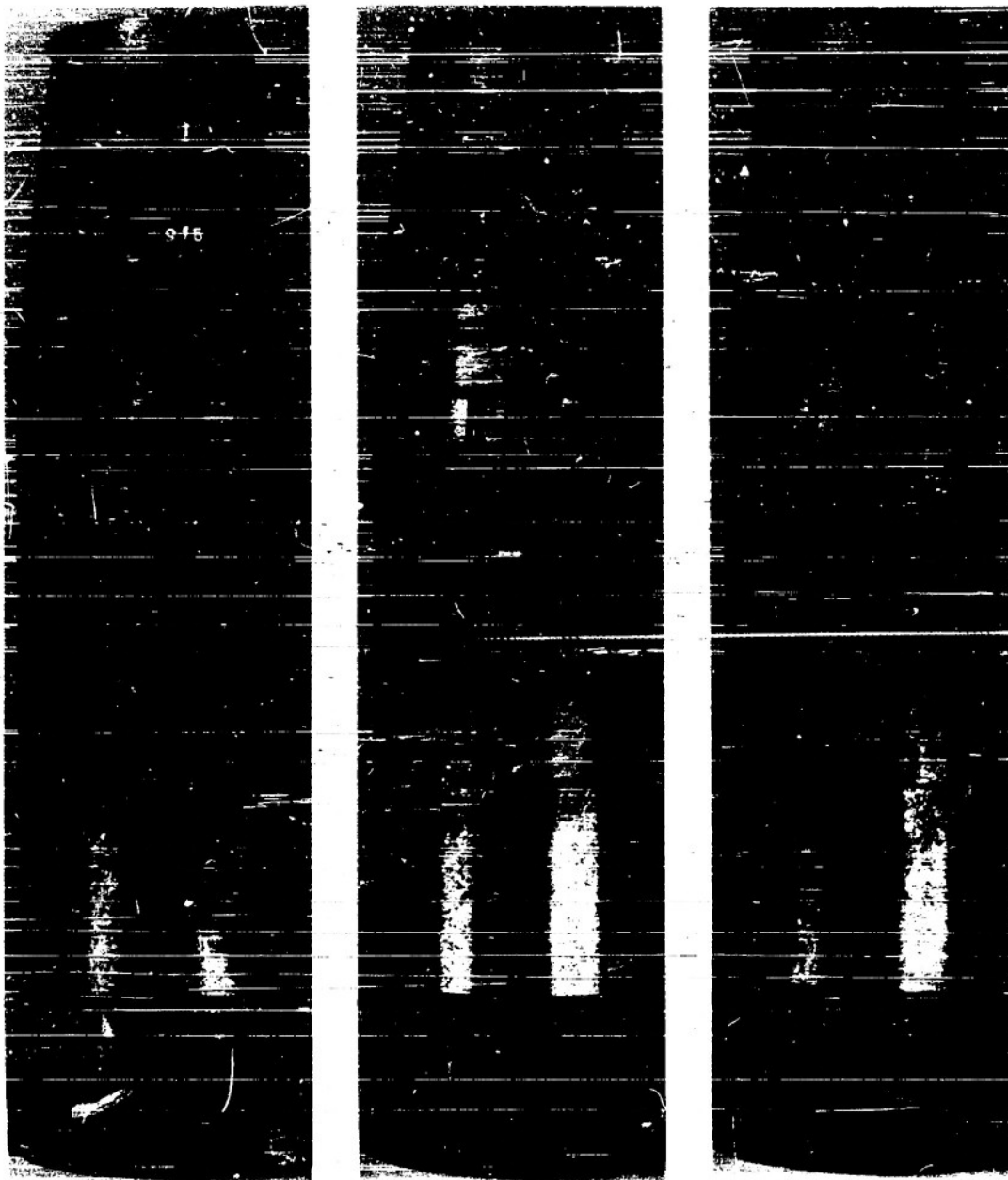
Three views (120° apart) of recovered 3"/70 AA Projectile  
Type 23 Mod 2 No. 913.  
Figure 19



NP9-64819

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Three views (120° apart) of recovered 3"/70 AA Projectile  
Type 23 Mod 2 No. 914.  
Figure 20



NP9-64820

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Three views (120° apart) of recovered 3"/70 AA Projectile  
Type 23 Mod 2 No. 915.

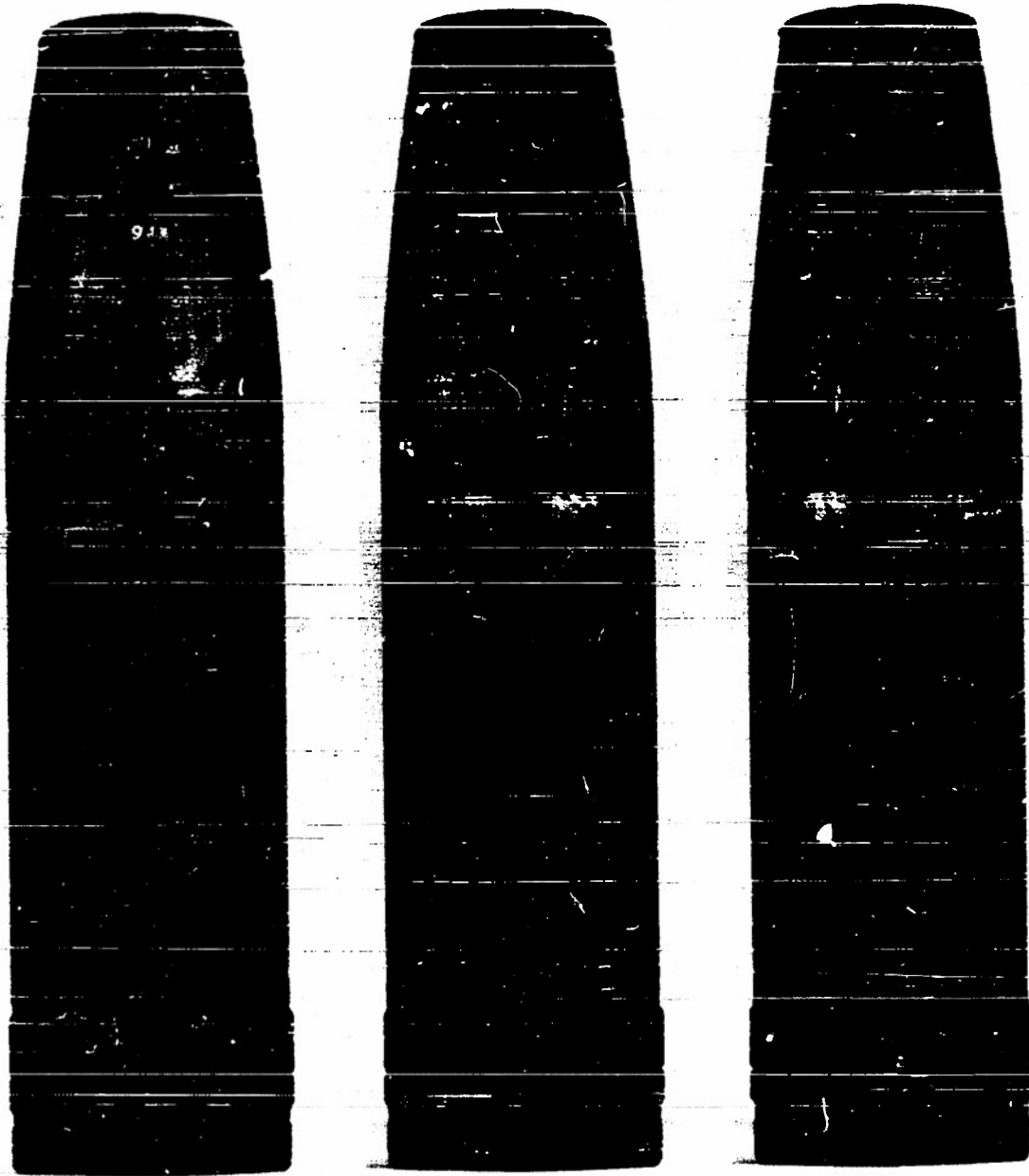
Figure 21



NP9-64821

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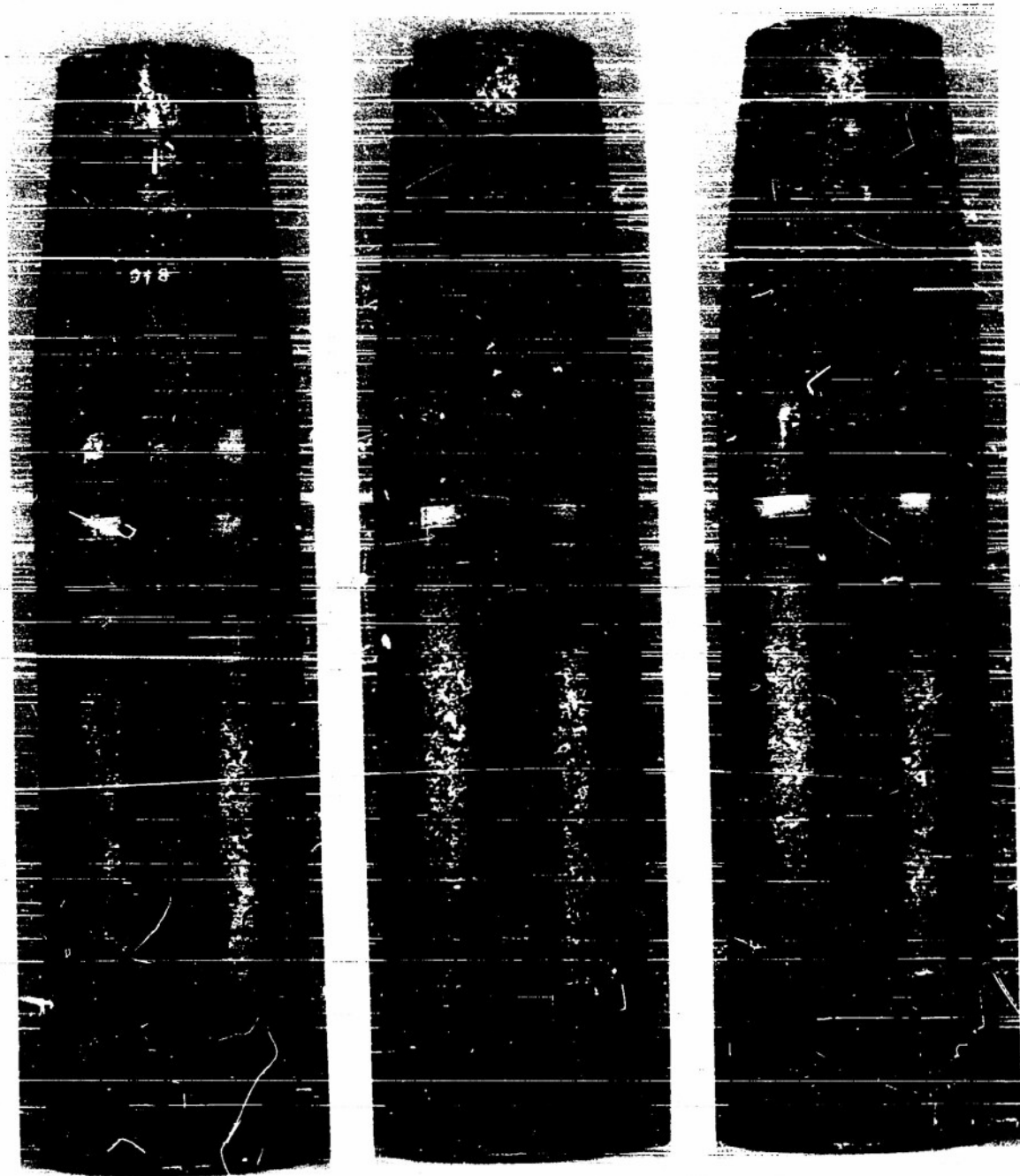
Three views (120° apart) of recovered 3"/70 AA Projectile  
Tyre 23 Mod 2 No. 916.  
Figure 22



NP9-64822

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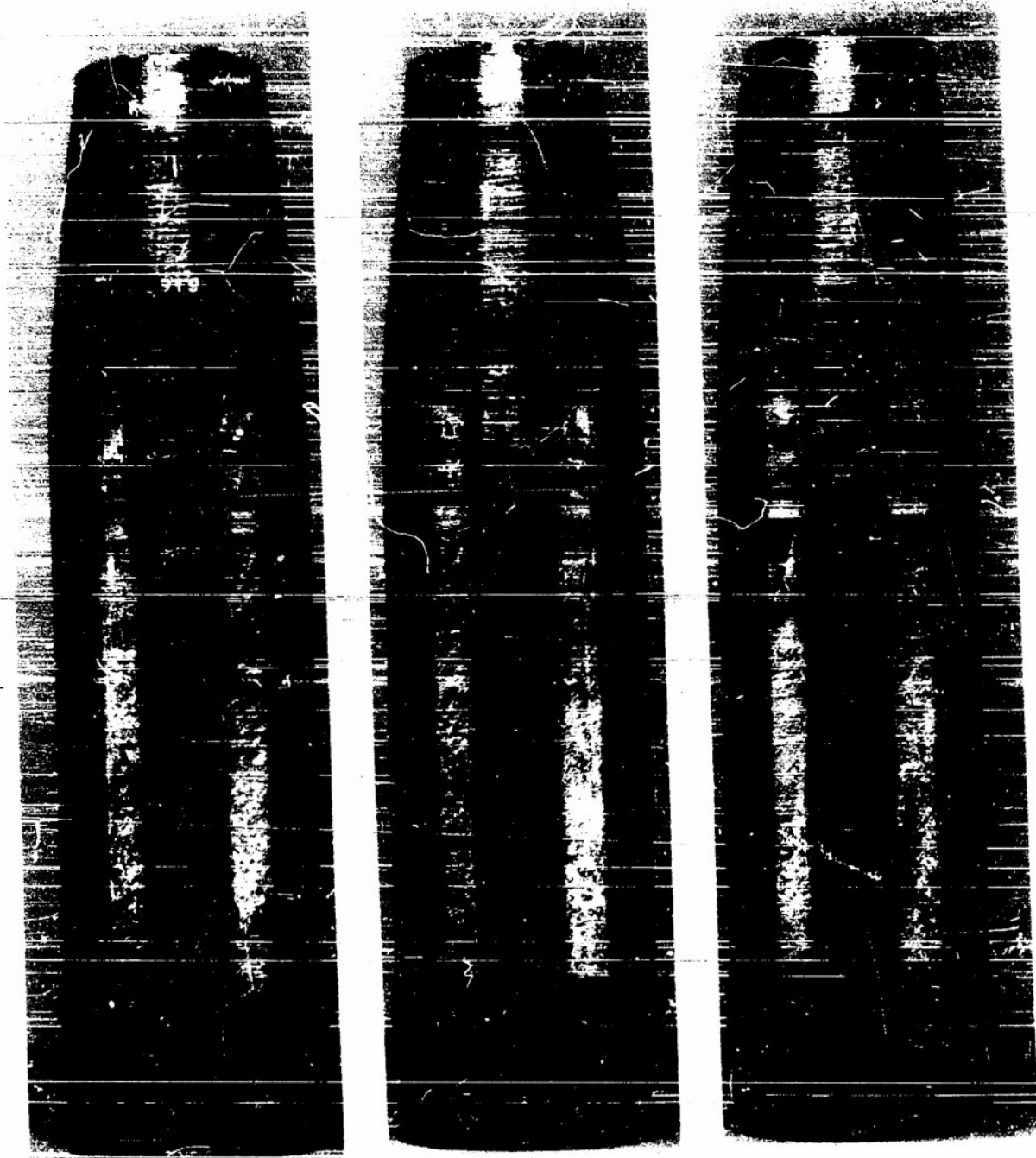
Three views (120° apart) of recovered 3"/70 AA Projectile  
Type 23 Mod 3 No. 917.  
Figure 23



NP9-64823

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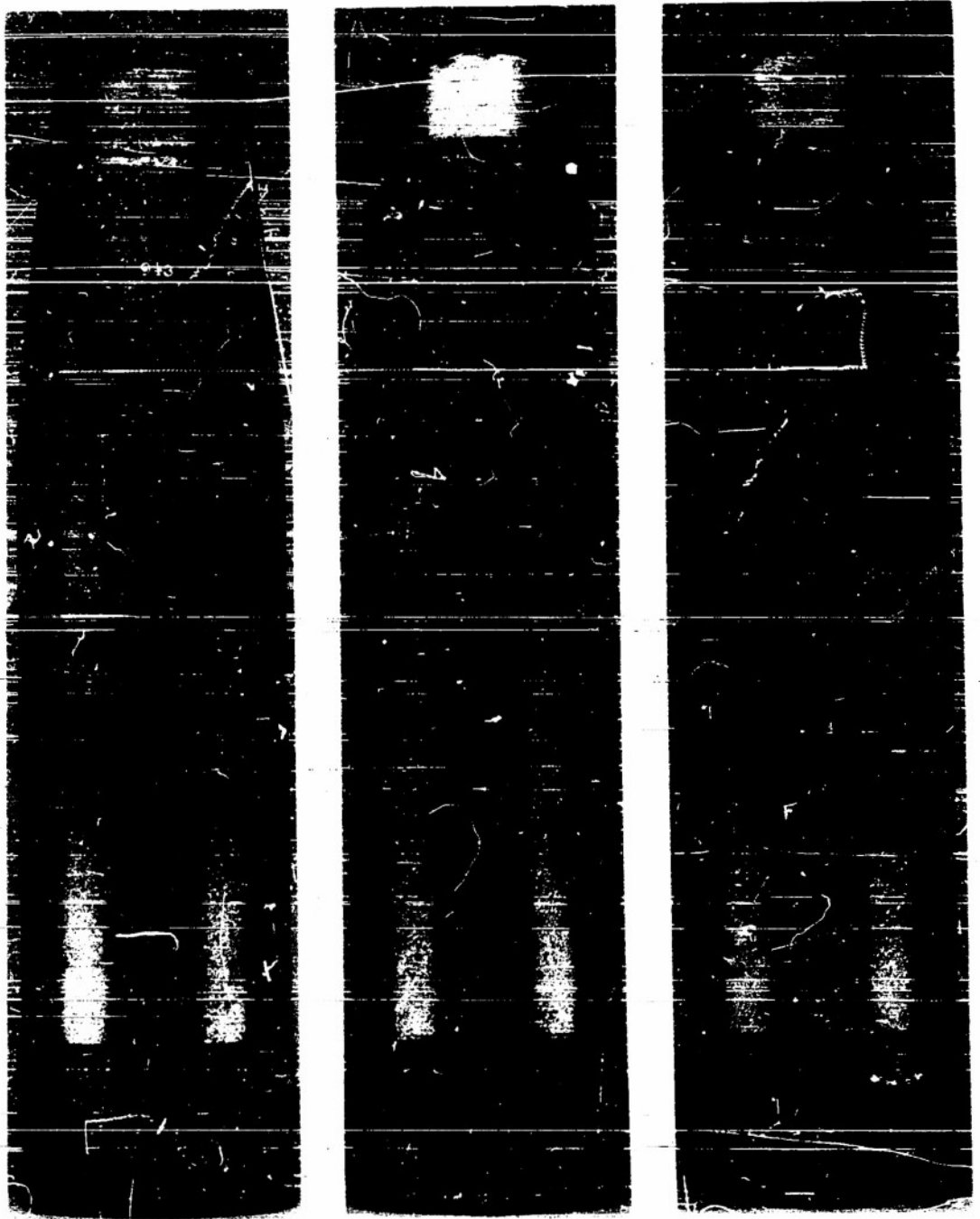
Three views (120° apart) of recovered 3"/70 AA Projectile  
Type 23 Mod 3 No. 918.  
Figure 24



NP9-64824

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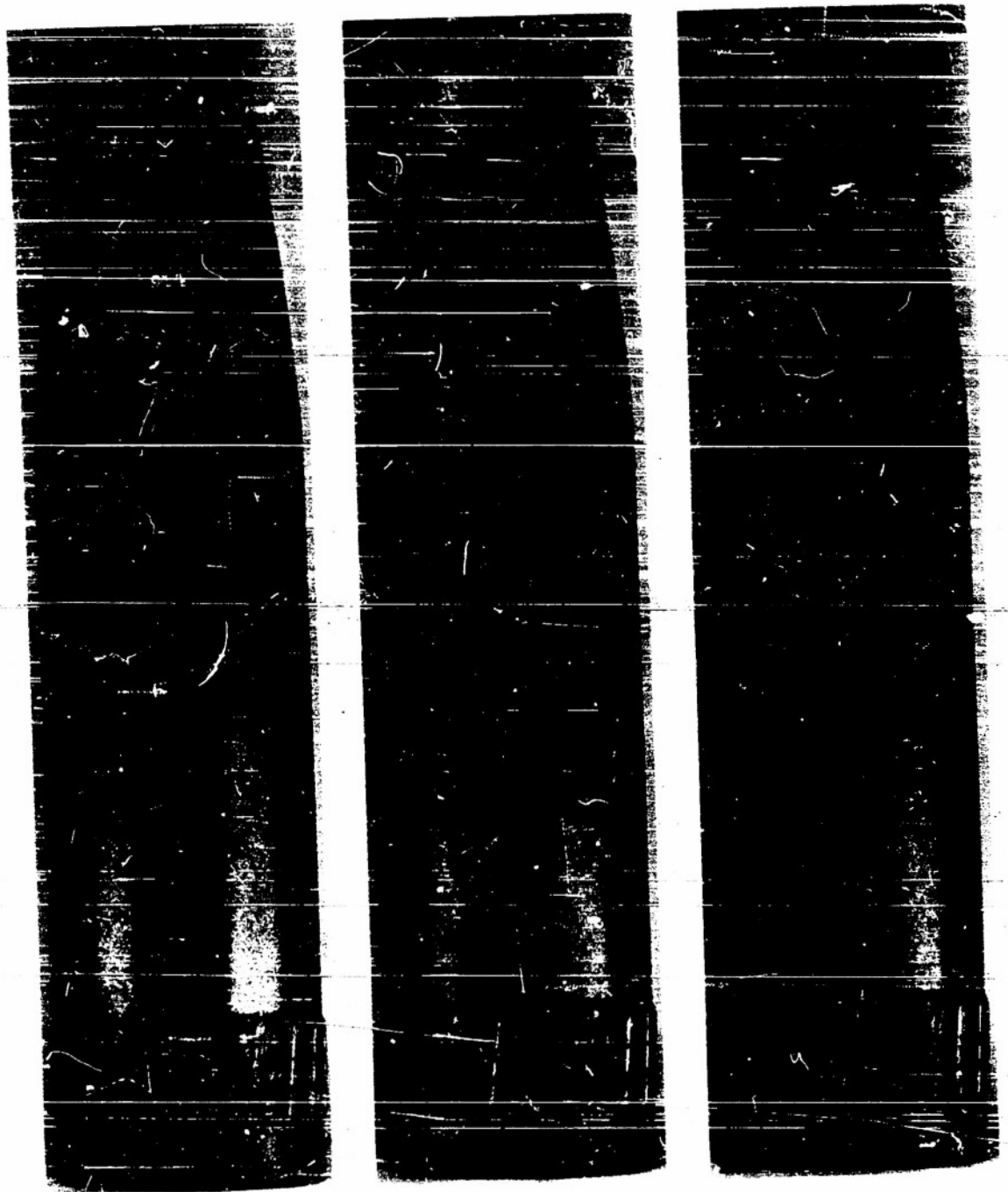
Three views (120° apart) of recovered 3"/70 AA Projectile  
Type 23 Mod 3 No. 919.  
Figure 25



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Three views (120° apart) of recovered 3"/70 AA Projectile  
Type 23 Mod 4 No. 943.  
Figure 26



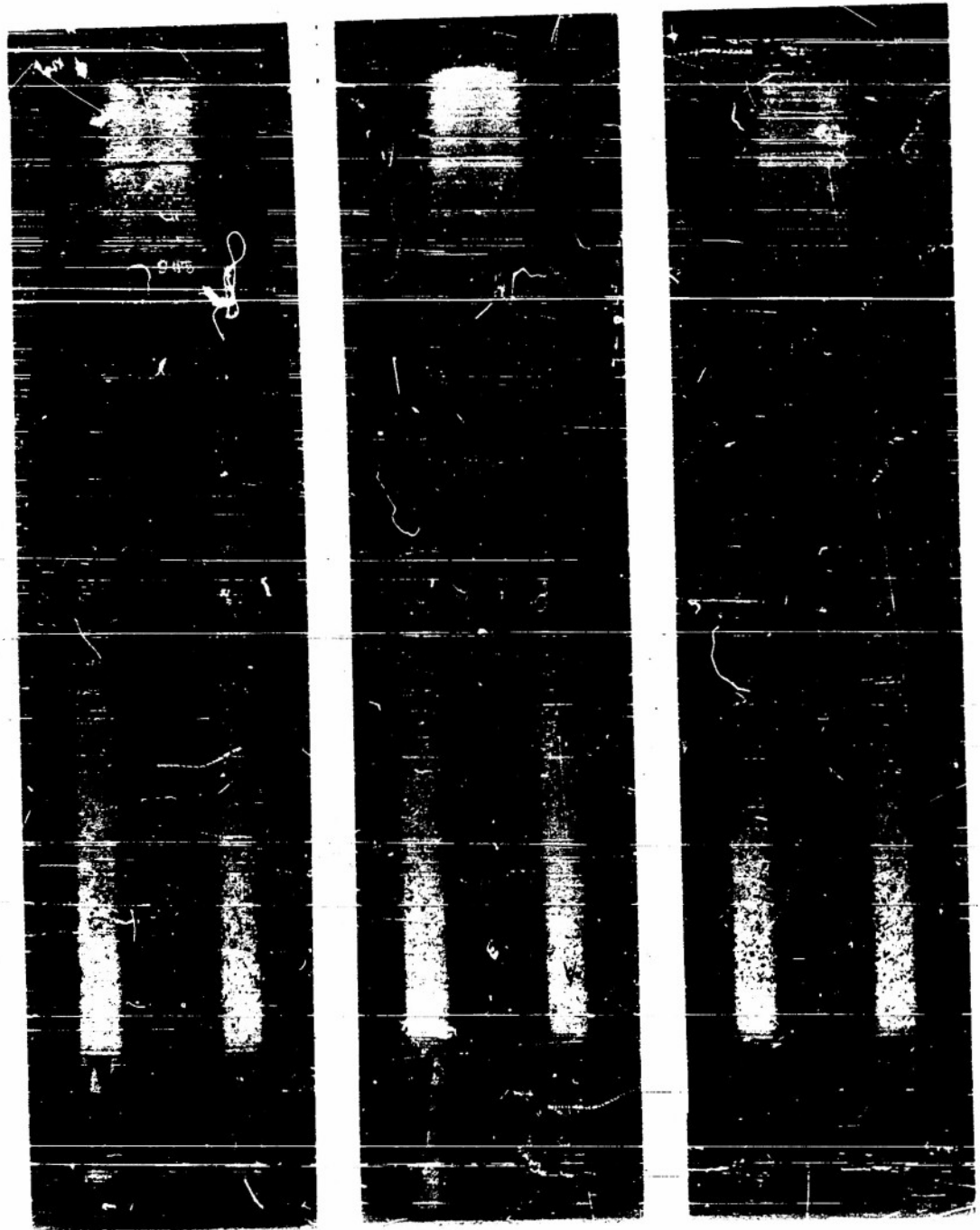
NP9-64826

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Three views (120° apart) of recovered 3"/70 AA Projectile  
Type 23 Mod 4 No. 944.  
Figure 27

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Three views (120° apart) of recovered 3"/70 AA Projectile  
Type 23 Mod 4 No. 945.  
Figure 28



NP9-65134

Three views (120° apart) of recovered 3"/70 AA Projectile  
Type 23 Mod 4 No. 946.  
Figure 29

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Three views (120° apart) of recovered 3"/70 AA Projectile  
Type 23 Mod 4 No. 947.  
Figure 30 .

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APPENDIX C

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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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NPG REPORT NO. 1263

Subject: The Development of Ingot-Iron Rotating Bands  
for 3<sup>1/2</sup>"/70 AA Projectiles by R. H. Lyddane and  
R. B. Butler, Terminal Ballistics Department,  
U. S. Naval Proving Ground, Dahlgren, Virginia  
16 April 1954

ABSTRACT

This report covers work on the development of a swaged-on ingot-iron rotating band design for 3<sup>1/2</sup>"/70 AA Projectiles. The final design evolved was satisfactory in velocity, gun pressure, and yaw at short range, and not only produced full spin but also showed no perceptible band wear. In addition, it produced negligible body deformation under the band of the fired projectile, and permitted a strong joint between projectile and case. The design is somewhat novel, incorporating a series of high ribs canted to the rear which fold down during run-up and engraving. The band is lubricated with molybdenum disulfide.

Ranging and rapid-fire tests of this design are in progress, and will be the subject of a later report.

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TEAR SHEET

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NFC 263

Subject: The Development of Ingot-Iron Rotating Band Design for 3"/70 AA Projectiles. By R. H. Lytle, R. B. Butler, Terminal Ballistics Dept., U. S. Naval Proving Ground, Dahlgren, Virginia  
21 Dec 1954

ABSTRACT

This report covers work on the development of swaged-on ingot-iron rotating band design for 3"/70 AA projectiles. The final design evolved was satisfactory in velocity, gun pressure, and yaw at short range, and not only produced full spin but also showed no perceptible band wear. In addition, it produced negligible body deformation under the band of the fired projectile, and permitted a strong joint between projectile and case. The design is somewhat novel, incorporating a series of high ribs canted to the rear which fold down during run-up and engraving. The band is lubricated with molybdenum disulfide.

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