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U. S. NAVAL PROVING GROUND

Dahlgren, Virginia.

REPORT NO. 9-43.

EXAMINATION OF A JAPANESE 140mm (5.5-INCH) BOMBARDMENT PROJECTILE.

[redacted] April 26, 1943

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NAVAL PROVING GROUND CAPTURED ENEMY EQUIPMENT REPORT NO. 67.

APPROVED:

DAVID F. HEDRICK
CAPTAIN, USN,
INSPECTOR OF ORDNANCE IN CHARGE.

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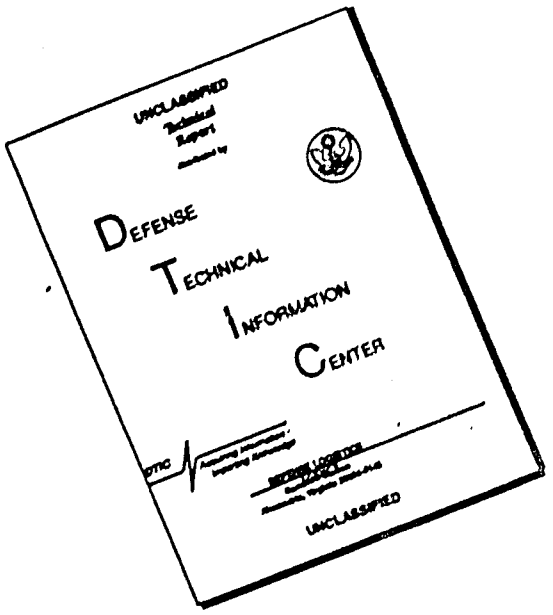

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P R E F A C E

AUTHORIZATION

Specific directives for this investigation were issued in Bureau of Ordnance ltr. EF74 (Relb) Serial 62535 dated January 28, 1943.

OBJECT

To make a complete physical, chemical and metallurgical study of a Japanese 140mm (5.5 inch) Bombardment Projectile. (CEE527).

SUMMARY

This report covers a complete examination of the subject projectile and a reconstruction of the gun from which it was fired. Drawings of the projectile and profile of the rifling are included.

The projectile is of bombardment type, having a single nose fuze of slight delay. It has a total unfuzed weight of 82.7 lbs. and carries a charge of approximately 8 lbs. (10%). The single copper rotating band used showed considerable fringing.

The projectile body is a nickel steel, heat treated to a tensile strength of approximately 110,000 p.s.i. It was manufactured by a single piercing operation. The base plug is of an analysis similar to the body but was not heat treated; it has an approximate tensile strength of 100,000 p.s.i. The fuze is an alloyed high strength brass made by hot forging and machining.

A study of the engravings on the rotating band and the design of the projectile indicates that the gun was of 5.541-inch caliber using either bag or semi-fixed ammunition, and having uniform right-hand twist hook-rifling. The angle of twist is 6°-15' corresponding to one revolution in 28.5 calibers. There are 38 grooves and lands of unequal width.

Tables are included which compare this projectile and gun with some U. S. Naval projectiles and guns of five and six-inch caliber.

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NPG Photo No. 62[illegible] (APL) - Examination of Enemy Weapons. Report No. 67.
Japanese 140 mm. (5.5 inch) Bombardment Projectile; as received (CBE527)
March 20, 194[illegible].
Figure 1
- CONFIDENTIAL -

NPG Photo No. 624 (APL) - Examination of Enemy Weapons. Report No. 67.
Base of Japanese 140 mm. (5.5 inch) Bombardment Projectile; as received.
(CEE 527)
March 20, 1943. Figure 2 - CONFIDENTIAL -

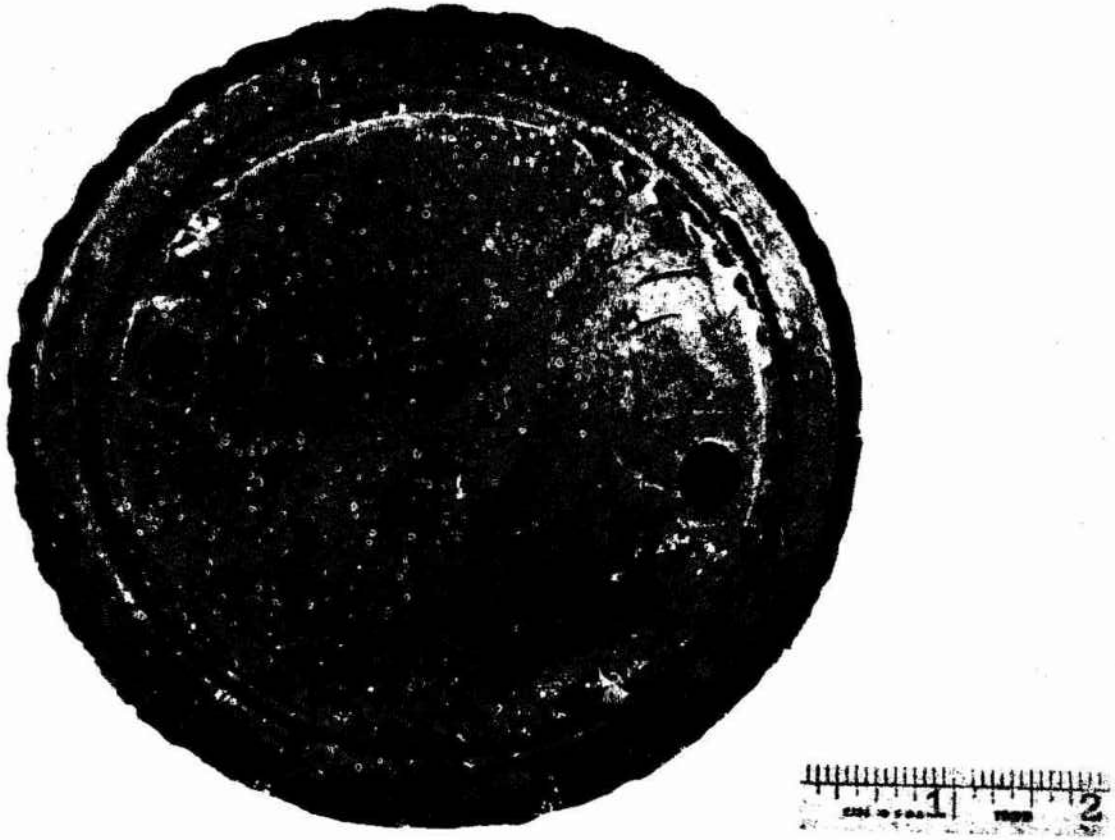


TABLE A

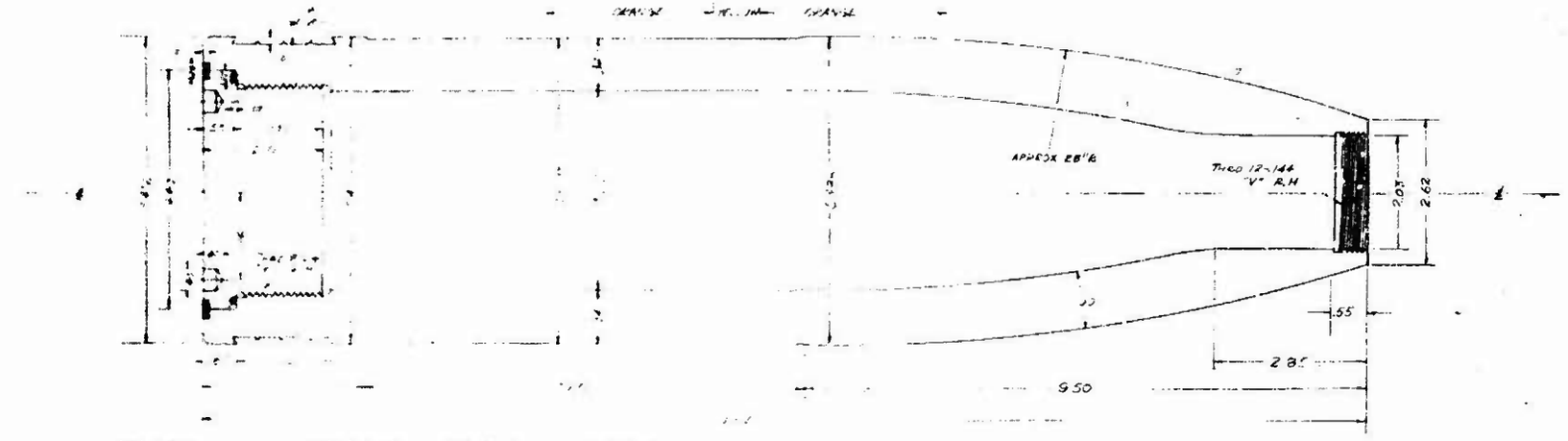
COMPARISON OF SOME U. S. NAVAL PROJECTILES OF 5 AND 6-INCH CALIBER WITH A JAPANESE 5.5-INCH BOMBARDMENT PROJECTILE

Projectile	Weight Unfuzed (lbs)	Weight Charge (lbs.)	Length	Wall Thickness at Center	Fuzes	Base Plug
5" Mk. 33-1 Bombardment - 1942.	57.5	6.55	17"	0".85	1 Nose 1 Base	None
5" Mk. 36 A.A. Common 1942	48.0	6.95	21"	0".52	1 Nose 1 Base	None
6" Mk. 34 H. C. 1942	99.0	13.2	27"	0".74	1 Nose 1 Base	None
Japanese	82	7.9	20"	0".94	1 Nose	Yes

I INTRODUCTION.

One Japanese 140mm Bombardment Projectile was received on March 15, 1943, by the Armor and Projectile Laboratory of the Naval Proving Ground, Dahlgren, Virginia, for physical, chemical and metallurgical examination. This projectile was unloaded, but otherwise complete with the exception of certain parts of the nose fuze.

This projectile was one of a number fired from Japanese submarines against the Hawaiian islands of Kauai and Maui in December, 1941; two of these projectiles were recovered in January, 1942.



JAPANESE 140 MM (5.51 INCH) BOMBARDMENT PROJECTILE

RECONSTRUCTED BY THE ARMOR & PROJECTILE LABORATORY
NAVAL PROVING GROUND DAHLGREN, VA.
MARCH 24 1943

CONFIDENTIAL

N.P.G. DWG 104 ADL

II INVESTIGATION.

(A) PHYSICAL.

The projectile as received but without the nose fuze is shown in Figs. 1 and 2. It is seen to be a nose fuzed bombardment type projectile having three bourrelet surfaces; one at the usual position where the ogival surface blends into the body and the other two immediately fore and aft of the single rotating band. The apparent discontinuity in the rotating band was due to the presence of a cannelure which filled with copper during firing. The presence of this single cannelure was evidently insufficient to prevent fringing which is quite marked on this band.

The exterior of the projectile, with exception of the bourrelet surfaces, was protected by an orange colored paint; for identification a yellow band 3/4" wide was painted at midbody. The surface of the cavity was coated with a tightly adherent and acid resistant lacquer, which had evidently been sprayed and baked on.

The following code marks were found:

Midbody ✕ S8A

Rear Bourrelet (front of band) 水 ㊧ 主

Base Ring ~~2208~~ C763 S8A 山

Base Plug ~~2208~~ S № 3 ㊧ 主 C763

A complete dimensional drawing of this projectile is given in NTG Drawing 104 APL. A comparison of this projectile with some U. S. 5 and 6-inch Naval projectiles is made in Table A.

The fuze was found to be incomplete, hence no drawing was made. Fig. 3 shows a cross section of this fuze. In a report* of a similar fuze the action is described as follows:

> "The nose fuze contained two firing pins and two impact detonators which apparently worked together to give a slight delay action. From the three unfired fuses

* Letter from the Office of the Commandant, Fourteenth Naval District, ltr. C-S81/S76/ND14 0188 of January 15, 1942.

TABLE E

CHEMICAL ANALYSES OF JAPANESE 140mm (5.5-INCH) BOMBARDMENT PROJECTILE.

Component	Analyses													
	C	P	S	Mn	Si	Cr	Ni	Mo	V	Ti	Zr	W	Cu	B
Projectile	.43	.018	.019	.65	.25	.11	1.60	.05	NT	NT	NT	NT	T	NT
Base Plug	.42	.017	.026	.58	.22	.17	1.42	NT	NT	NT	NT	NT	T	NT

	Cu	Zn	Sn	Mn	Ni	Pb	Fe	Al
Fuze	56.7	34.7	.75	1.95	1.82	1.13	2.91	.11
Booster Cup	57.9	37.6	1.17	1.28	.02	.25	1.19	.42
Gaskets	100 ~							
Rotating Band	100 ~							

NPG Photo No. 741 (APL) - Examination of Enemy Weapons. Report No. 67.
Acid etched cross section of Japanese 140 mm. (5.5 inch) Bombardment Projectile. (CPE527).
April 1, 1943. Figure 3 - CONFIDENTIAL -

examined, it appears that the forward firing pin never reached the forward detonator. This might possibly have been caused by neglecting to consider creep in the design, and also the fact that the shells were fired at extreme ranges may have introduced more creep than usually expected. The sleeve containing the forward detonator and the second firing pin possibly crept forward and thus on impact was unable to sheer the sheer pins, driving the forward detonator onto the forward firing pin. The resulting detonation was apparently intended to drive the second firing pin onto the second detonator and thus detonate the main charge through the booster train. From the three fuses observed, the forward firing pin will not quite strike the detonator."

(B) CHEMICAL.

Chemical analyses of all components are given in Table B. Steel analyses are spectrochemical excepting carbon, phosphorus and sulphur which were obtained by standard wet chemical procedures. Non-ferrous analyses were obtained by standard procedures.

The silicon, phosphorus and sulphur contents are seen to be fairly typical of steels made by our present basic open hearth practice.

(C) METALLURGICAL

MACRO ETCHING. Hot acid etching showed these steels to be exceptionally sound and free from segregation of non-metallics. The flow figures of the macrostructure, Fig. 3, indicate the projectile body has been forged by piercing. The base plug was forged slightly by upsetting.

MICROSTRUCTURE AND HARDNESS. The projectile body has a uniform hardness of 21 R_C, corresponding to a tensile strength of approdimately 110,000 p.s.i.; the microstructure, shown in Fig. 4A, indicates that the steel has been cooled fairly rapidly from above the critical, but not sufficiently rapidly to affect complete hardening. Following this treatment a complete spheroidization was attained by a high temperature draw estimated to be between

MICROSTRUCTURES OF JAPANESE

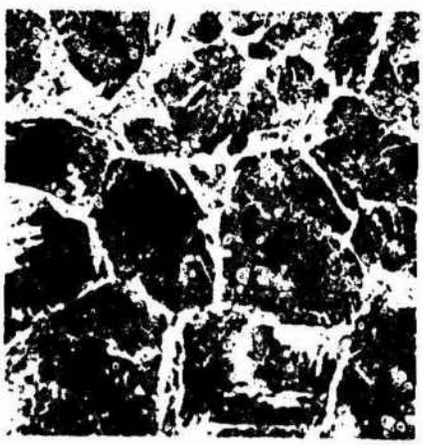
140MM (5.5INCH) PROJECTILE

4A

PROJECTILE BODY Spheroidized carbides and acicular ferrite.

MAGNIFICATION 1200X

ETCHED PICRAL



4b

BASE PLUG Normalized structure; pro-eutectoid ferrite and pearlite.

MAGNIFICATION 1000X

ETCHED PICRAL

4C

FUZE BODY Beta in an Alpha matrix; small inclusion-like particles are Epsilon a copper-rich iron phase.

MAGNIFICATION 100X

ETCHED FERRIDE

FIGURE 4

1150 and 1250°F.

The base plug has a uniform hardness of 17 R_C, corresponding to a tensile strength of approximately 100,000 p.s.i.; the microstructure, shown in Fig. 4B, indicates that the steel has been cooled slowly from above the critical to give a normalized structure.

FABRICATION OF PROJECTILE. The simple design of this projectile having rather heavy parallel walls of uniform thickness and an open end with a base plug allows the use of the simplest possible method of shell forging. A study of the metal flow of the projectile body (see macroetching) indicates that such a method was actually used. By this method a cylindrical steel block, preheated to forging temperature, is placed in a die shaped to the exterior surface of the projectile and pierced by a punch having the contour of the cavity. Such a forging requires but little machining to make the finished projectile.

FUZE. The various components of the fuze are made from alloyed high strength brass. The physical properties of such brasses are inherent and unlike non-alloyed, cold-worked, high strength brasses, will withstand heating without loss of mechanical strength, either during fabrication, e. g., hot pressing, or as required in service.

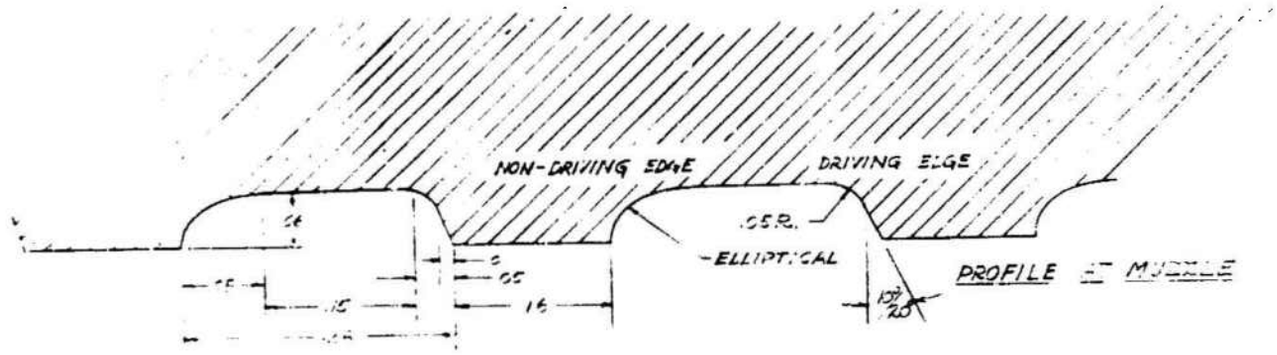
This composition is roughly similar to the analysis called for by the United States Navy Department specification 46B15C covering manganese bronze bars, plates, rods and shapes.

The hardness of the fuze components was uniformly 70 R_B, the microstructure shown in Fig. 4C indicates a slowly cooled, hot worked Muntz metal. The individual parts were evidently hot forged and final-machined to size.

TABLE C

COMPARISON OF SOME U. S. NAVAL GUNS OF 5 AND 6-INCH CALIBER WITH JAPANESE 5.5-INCH NAVAL GUN.

Caliber Mark - Mod. Year	Rifling	Twist Rev/cal	Grooves	Width Groove	Width Land	Depth Groove	Radius Driving Edge	Radius on Land
5"-51, Mk.9-1, 1943	Rib Uniform R.H.	1-30	45	0".209	0".14	0".05	0".03	0".01
6"-53, Mk.12-1, 1921	Rib Uniform R.H.	1-35	48	0".242	0".15	0".06	0".03	0".01
6"-47, Mk. B, 1934	Rib Uniform R.H.	1-30	48	0".242	0".15	0".06	0".03	0".01
6"-47, Mk. 14, 1936	Rib Uniform R.H.	1-25	48	0".242	0".15	0".06	0".03	45° Chamfer.
Japanese 5".5	Hook Uniform R.H.	1-28.5	38	0".28	0".16	0".06	0".05	None



Diameter Across Lands	.554
Rifling	Hook, Uniform Twist
Depth of Groove	.008" or Caliber
Twist Per Cal.	1-28.5
Angle of Twist	6° 15'
Grooves per Inch of Caliber	6.85
Number of Grooves	38

* Reconstructed from Engravings on Rotating Band

MUZZLE CHARACTERISTICS OF JAPANESE 140MM (5.5 INCH) GUN

Reconstructed* By The Armor & Protectile Laboratory
Naval Proving Ground - Dahlgren, Va.

March 29 1943

Dimensions in Inches

CONFIDENTIAL

N.P.G. DWG. 105 APL

III CHARACTERISTICS OF GUN.

The rotating band on this projectile carried sharply defined engravings from which various characteristics of the gun have been deduced. NPG Drawing 105 APL gives a complete reconstruction of the muzzle profile and characteristics of this gun.

The caliber, obtained by measuring across the grooves on the engravings is 5.541 inches. There are 38 grooves and lands of hook-rifling, having right-hand twist; the angle of twist is 6°15' corresponding to one revolution in 28.5 calibers. The clean cut nature of the rifling engravings indicate that the twist is uniform.

The gun was apparently in new condition for the bottom corners of the engraved grooves were cut sharply, being made by a land having no chamfer or radius.

The design of the projectile with the rotating band far back on the body indicates that the gun was either a bag gun or used semi-fixed ammunition.

For comparison Table C lists some characteristics of 5 and 6-inch U. S. Naval guns currently in service.