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DEPARTMENT OF MINES AND RESOURCES

BUREAU OF MINES

CANADA

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Ottawa, October 16, 1946.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2121.

Examination of a 17 Pdr. Pot Sabot Projectile.

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Introduction:

On September 21, 1946, a letter received from Capt. E. S. Guy, for the Superintendent, Canadian Armament Research and Development Establishment, P.O. Box 1427, Quebec, Quebec, requested the assistance of these Laboratories with regard to the 17 pdr. pot sabot projectile. With the letter were submitted drawings of the base of the projectile showing two proposed welds, and also chemical specifications of the materials to be welded. Subsequently, five (5) bases were submitted in the welded condition for examination and experiment.

The letter gives the following additional information regarding the projectile base:

> "The whole base may be expected to come under an instantaneous pressure of 45,000 p.s.i. from the rear, thus brittleness of the driving band would not be acceptable. The driving band and base plate are pressed together and required to transmit torque, so that any shrinkage tending to loosen this union would not be acceptable, whereas shrinkage tending to tighten the union would."

Object of Investigation:

(1) To determine the suitability of welding this type of projectile base as proposed in the specification.

(2) To suggest alternative methods of joining the components if welding, as proposed, is considered inadvisable.

PROCEDURE:

(1) A typical base was photographed 'as received'. (See Figure 1.)

(2) One base was prepared for welding as follows. A chamfer 1/8" deep, 45° included angle, was machined on the forward lip of the driving band. The angle-ring was not machined prior to welding. All welding was done with a 3/32"-diam. Fleetweld No. 7 electrode operated at 90 amps. straight polarity. The angle-ring-to-driving-band weld was made first after a furnace preheat of 500° F. When this weld was finished there was a noticeable slackness between the driving band and the base plate. Figure 2 shows the appearance of this weld compared with an unwelded specimen.

(3) The preheat temperature was maintained and the base-plate-to-driving-band weld made using the same welding conditions. When this weld was completed the assembly was stress-relieved at 1100° F. for 20 minutes and furnace-cooled. Figure 3 shows the appearance of this weld compared with an unwelded specimen.

(4) Since the welding experiments indicated that welding would not be satisfactory, a silver-brazing method was considered to be a possible alternative. This method is limited in its application to materials not requiring subsequent heat treatment or to materials which can be brazed in the heat-treated condition without undue loss of mechanical properties. For convenience, the specifications of the

(Procedure, cont'd) -

driving band and base plate as given in the letter are reproduced below:

SPECIFICATION

		Driving Band	Base Plate
		- Per Cent -	
Carbon	-	0.20 max.	0.35/0.45
Phosphorus	-	0.07 max.	0.05 max.
Sulphur	-	0.07 max.	0.05 max.
Manganese	-	0.40/1.00	0.45/0.70
Silicon	-	0.10/0.35	0.10/0.35
Chromium	-		0.90/1.40
Nickel	-		1.30/1.80
Molybdenum	-		0.20/0.35
		To give Brinell 110-150	Hardened in oil from 830/850° C., tempered from 550/650° C. to Brinell 352/429.

The driving band and angle rings were machined to give a 0.003" clearance and rings of 3/32" diam. Easy-Flo silver brazing alloy were placed as shown in Sketch No. 1. The assembly was then placed, driving band up, in a furnace operated at 1175-1200° F. for 20 minutes, then taken out and cooled to room temperature.

(5) After brazing, the base was sectioned through the centre. One half was polished, etched and photographed (Figure 4), to show the complete penetration of the brazing alloy. From the second half a complete section of the brazed joints was machined, polished, etched and photographed (Figure 5) to show in greater detail the penetration of the brazing alloy.

(6) The latter section was used for hardness tests of base plate and driving band. The table below lists the 'as received' hardnesses and the after-brazing hardnesses of these components. All readings were made with a Rockwell

(Procedure, cont'd) -

Hardness Tester and the results converted to Brinell numbers.

	As Received	After Brazing	Specified Hardness
Driving Band -		125-132	110-115
Base Plate -	426	285-289	352-429

DISCUSSION:

The bases as received were assembled with press fits. After welding, it was noted that the contraction of the weld metal on cooling had loosened the union between the driving band and the base plate. This, in itself, would not be serious, were it not for the possibility of improper alignment of parts when the driving-band-to-base-plate weld was made. Such misalignment could not be tolerated in a projectile.

It is noted, from the stated chemical composition, that the driving bands may have maximum phosphorus and sulphur contents of 0.07 per cent. These elements can cause serious difficulties in welding when 0.05 per cent is exceeded with resultant porous welds. In addition, the base plate is of high hardenability, which necessitates special welding techniques such as preheat, stress relief, and special-type welding rods. Even using the utmost care may not eliminate brittle structures adjacent to the weld in the base plate material, and these structures have poor impact resistance. In such cases complete heat treatment after welding is the only safe procedure. In addition, welded assembly would necessitate considerable machining after welding, to clean up and to attain the desired dimensions. Such machining would be difficult where welds on high hardenability material

(Discussion, cont'd) -

become hard as a result of alloy pick-up during welding.

In brief, the possible misalignment of parts, porous welds and sensitive steels indicate the desirability of using an alternate method of assembly which will avoid these difficulties. It was noted that the specified drawing temperature for the base plate is 1022-1202° F. (500° - 650° C.) Silver brazing alloys with melting points ranging from 1175° F. (Easy-Flo[1]) down to 1145° F. (Easy-Flo No. 45[2]) are available. This being the case, silver brazing is a possible process for assembling the base components. One base was prepared, brazed and sectioned as described above, and will be submitted with this report.

Hardness readings before and after the brazing operation show a considerable drop in hardness of the base plate as a result of the thermal cycle of brazing. This would indicate that the base plate was drawn at the low side of the drawing range and this is confirmed by the 'as received' hardness of 426 Brinell as compared with the specified maximum of 429 Brinell. It is believed that the use of Easy-Flo No. 45 on material nearer the center of the specified hardness range would not produce an 'as brazed' hardness outside of the specified hardness range.

The advantages of silver brazing are highly desirable in this application. No structural changes are produced by the thermal cycle of brazing, so no subsequent heat treatment is necessary. Since heating and cooling is uniform, no distortion is encountered. The strength of silver-brazed joints where clearances of 0.003" are used is approximately 115,000 p.s.i., and their impact resistance is good. No

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(1) Handy & Harman, Toronto, Ont.: Ag, 50%; Au, 15.5%; Zn, 16.5%; Cd, 18.0%.

(2) Handy & Harman, Toronto, Ont.: Ag, 45%; balance not available.

(Discussion, cont'd) -

post-brazing machining would be required. There is every reason to believe that the silver-brazing assembly method would prove to be satisfactory.

Conclusions:

1. Welding of the base assemblies cannot be recommended.

2. Silver brazing of the base assemblies appears to be a satisfactory alternative.

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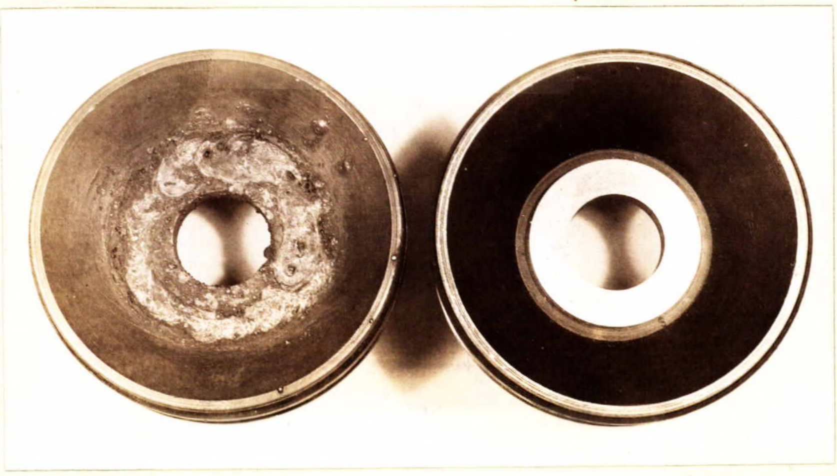
(Figures 1 to 3, Sketch No.1)
(and Figures 4 and 5 follow,)
(on Pages 7 to 9.)

Figure 1.

PROJECTILE BASE AS RECEIVED. ANGLE RING UP.

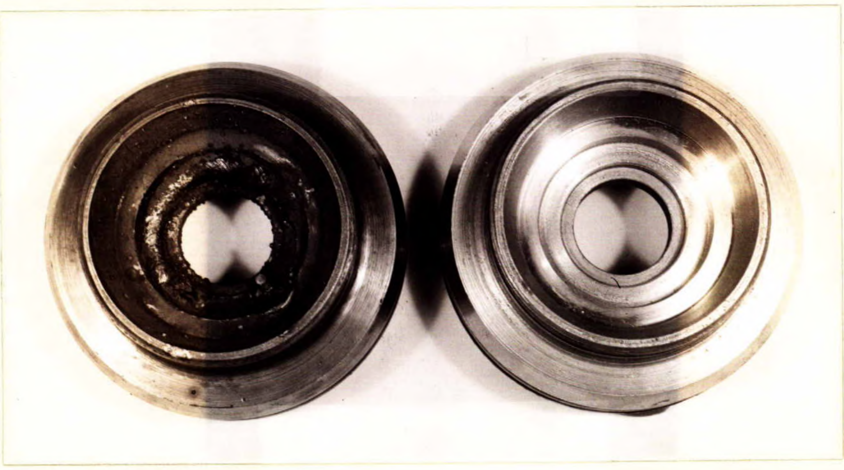
Figure 2.



ANGLE-RING-TO-DRIVING-BAND WELD.

Note porosity in weld. Compare with unwelded assembly.

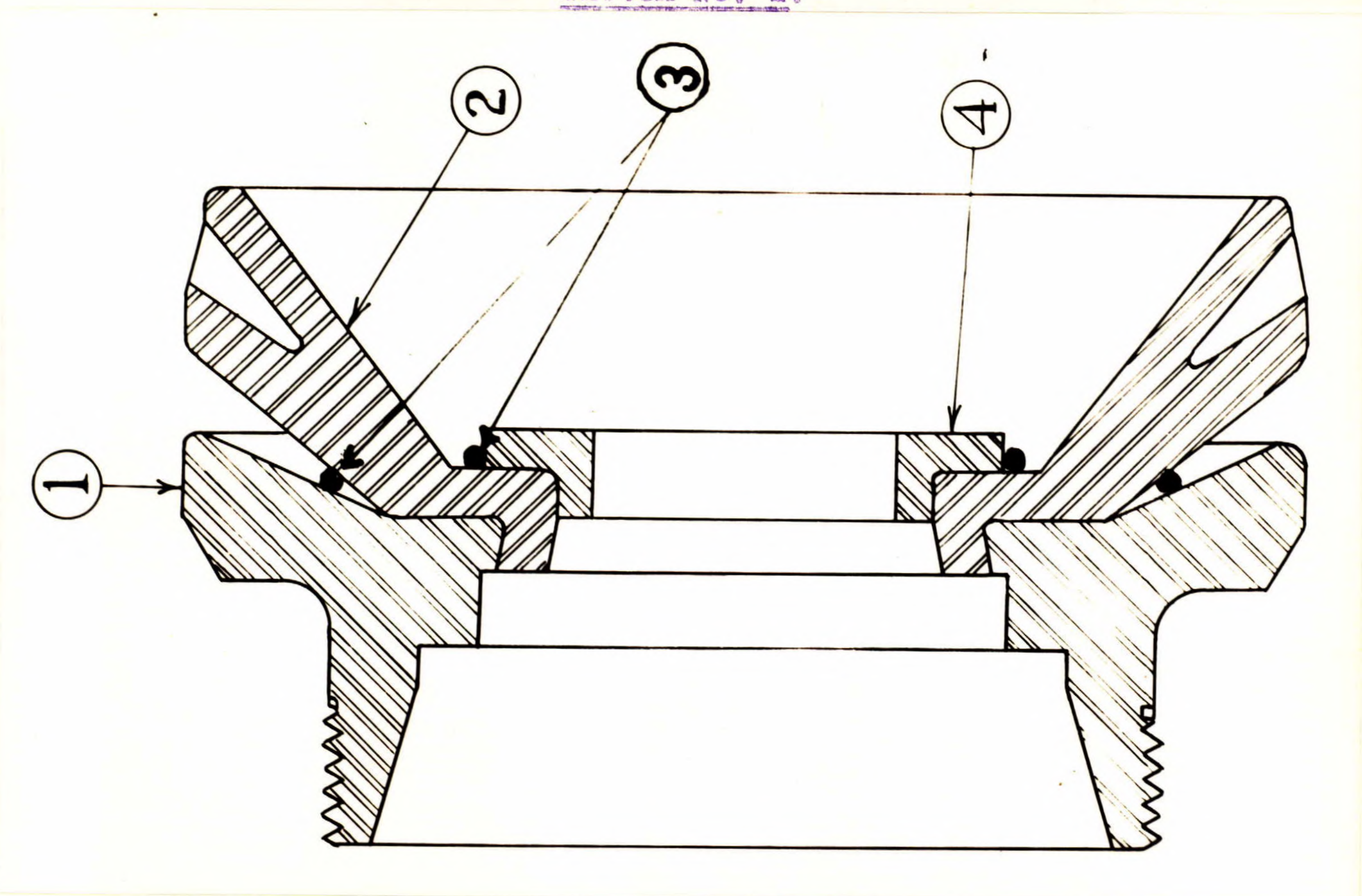
Figure 3.



BASE-PLATE-TO-DRIVING-BAND WELD.

Note unavoidable weld spatter. Compare with unwelded assembly.

Sketch No. 1.

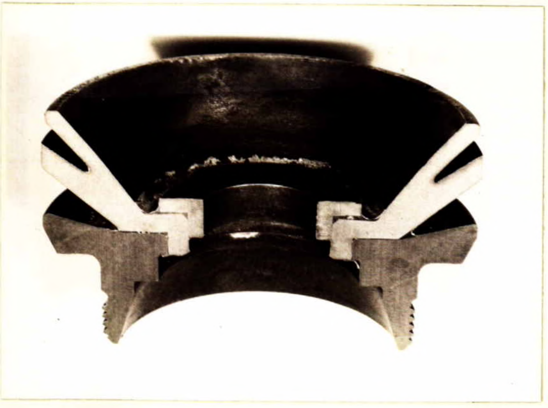


SKETCH OF ASSEMBLY, SHOWING LOCATION OF PRE-PLACED BRAZING ALLOY RINGS.

(1) Base plate.
(2) Driving band.
(3) 3/32" diam. Easy-Flo silver brazing alloy rings.
(4) Angle ring.

Assembly placed in furnace in this position.

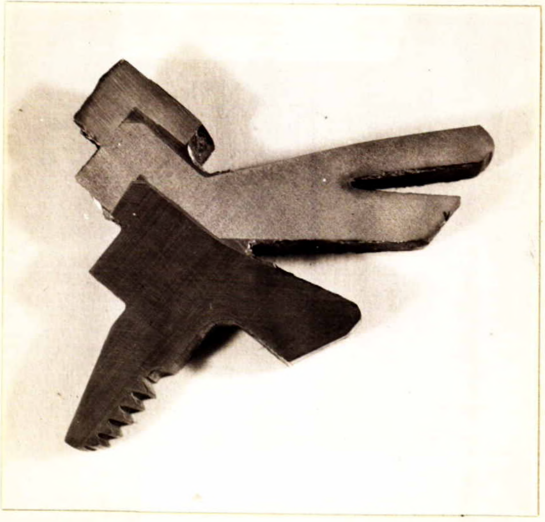
Figure 4.



ONE HALF OF SILVER-BRAZED BASE ASSEMBLY.

Note penetration of brazing alloy completely through the joints.

Figure 5.



CLOSE-UP OF SILVER-BRAZED JOINTS.

Note complete penetration of the brazing alloy.

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