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R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1615.

Examination of Bronze (2B8) Gudgeon Pin Bushings.

(Copy No. 10.)

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Origin of Samples and Object of Investigation:

Cheetah engine gudgeon pin bushings from three different sources were submitted (with letter, File No. 935U1-15 (AMAE DAI)) on February 29th, 1944, by Air Commodore A.L. Johnson for Chief of Air Staff, Department of National Defence for Air, Ottawa, Ontario. Nine bushings (three from each source) were received.

These bushings, reported to be of B 8 bronze, were marked as follows:

Lot designated No. 1, tagged Ottawa Car and Aircraft Limited, CDTP 3292, Ottawa;

Lot designated No. 2, tagged Laurentian Metal Products Company Limited, Hull, Quebec, CDTP 6940;

Lot designated No. 3, tagged No. 201 Maintenance Unit Overseas, O.I.D. 431.

Request was made for a chemical analysis on each lot and for a metallurgical examination to determine the comparative quality of these components with respect to their application as bearings.

Chemical Analysis:

The compositions of these bushings, as found by chemical analysis, are recorded below:

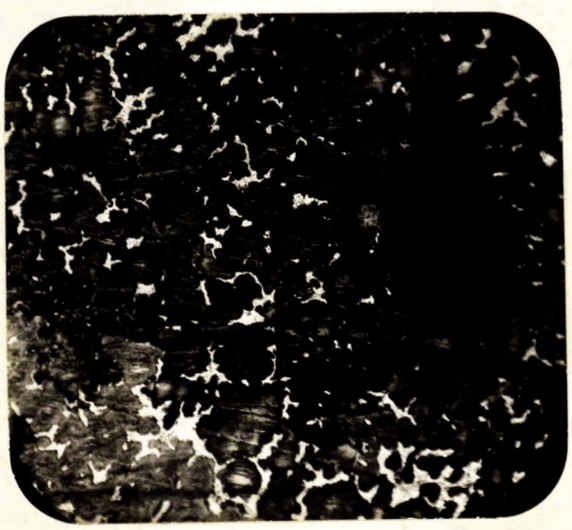
	OTTAWA CAR AND AIRCRAFT LIMITED	LAURENTIAN METAL PRODUCTS COMPANY LIMITED	No. 201 MAINTENANCE UNIT OVERSEAS	BRITISH STANDARD 2B8 SPECIFICATION
			- Per cent -	
Copper -	89.02	89.51	89.13	Remainder
Tin -	9.80	9.35	9.66	10.0 min.
Phosphorus-	0.82	0.65	0.65	0.5 min.
Lead -	0.07	0.25	0.25	0.25 max.
Iron -	0.02	0.03	0.01	
Zinc -	N.D.	N.D.	N.D.	(Other elements
Nickel -	"	"	"	0.5 max.,
Aluminium -	"	"	"	including
Manganese -	"	"	"	lead)
Silicon -	"	"	"	

N.D. = None detected.

Microscopic Examination:

Specimens for microscopic examination were taken from two bushings of each make. Considerable porosity was found in the bushings made by Ottawa Car and Aircraft and by Laurentian Metal Products. Those of the Overseas Maintenance Unit were quite sound. Also, the grain size was small and the comparatively hard constituents were much more finely distributed in the Overseas samples examined. The following photomicrographs, at 75 diameters, illustrate these points:

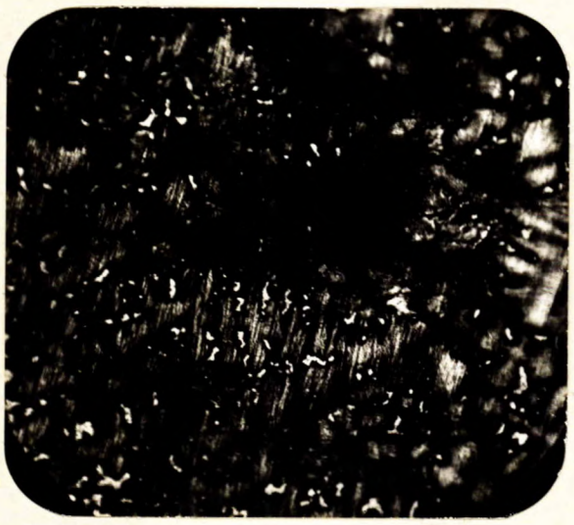
Figure 1.



X75, ferric chloride etch.
BUSHING TAGGED "OTTAWA CAR AND AIRCRAFT".
Note porosity (dark voids) and constituent distribution.
This photomicrograph is of one of the most porous areas discovered.

(Microscopic Examination, cont'd) -

Figure 2.



X75, ferric chloride etch.

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BUSHING TAGGED "LAURENTIAN METAL PRODUCTS, HULL, P.Q."

Note porosity (dark voids) and constituent distribution. This photomicrograph is of one of the most porous areas discovered.

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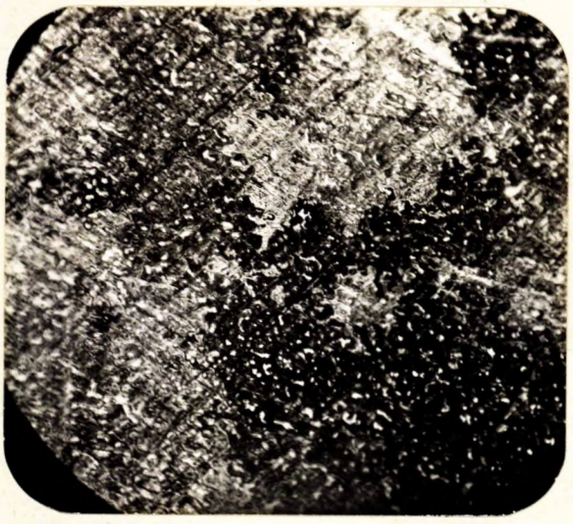
Figure 3.



X75, ferric chloride etch.

BUSHING TAGGED "NO. 201 MAINTENANCE UNIT OVERSEAS".

Note grain size and constituent distribution.

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Physical Examination:

Hardness tests were taken on two bushings from each source. Results were:

Source	Vickers hardness, (10-kg. load)	Rockwell 'B'
1. Ottawa Car and Aircraft -	58.5-108.0	18
2. Laurentian Metal Products -	58.9- 92.8	18-26
3. No. 201 Maintenance Unit Overseas -	110.0-117.0	59

Founding of Phosphor-Bronze:*

Porosity and grain size in phosphor-bronze castings are generally reduced by lowering the pouring temperature to the practical minimum. Accurate temperature control is, therefore, very important. Also, gas holes may be reduced or eliminated by rapid melting and lowering the casting temperature. Care should be taken to ensure that deliquescent accessories or alloying materials do not pick up moisture and that entrapped air, mould gas or steam be as low as possible. Included oxides are largely eliminated by casting evenly and steadily to prevent metal agitation in the mould and by using a flux which helps to prevent oxidation.

Discussion of Results:

The chemical analyses show that the composition of the material in the three makes of bushings corresponds fairly closely to the British 2B8 specification.

From the microstructures it is evident that the examined bushings from No. 201 Maintenance Unit Overseas are superior to examined components reported to be from Ottawa Car and Aircraft Limited and the Laurentian Metal Products Limited. The metallurgical quality of the bushings from the latter two sources appears to be approximately the same. A sound, fine-grained material with a relatively fine

* Taken from "Some Notes on Phosphor-Bronze" (by R. C. Stockton), in THE METAL INDUSTRY, Vol. 43, October 20, 1933, pages 301-392.

(Discussion of Results, cont'd) -

dispersion of the harder constituents, such as is found in the Overseas sample, would seem to be most favourable for the proposed application.

Hardness results vary greatly in the Ottawa Car and Aircraft and Laurentian Metal Products bushings because of porosity. The lower Vickers values and all Rockwell 'B' hardness numbers are absolutely unrepresentative of the metal hardness in these bushings because porosity present greatly decreased the resistance of the aggregate to deformation. The actual metal hardness throughout these samples is near the highest Vickers reading reported for them, i.e., about 95-115 Vickers. Hardnesses obtained on the sound Overseas sample are evidently more reliable.

Some notes on phosphor-bronze foundry practice are given in the hope that they may prove of interest.

It is understood that the inspection of the subject bushings presents certain problems, and some observations on this aspect of the matter were requested. To specify a small hardness range and reject castings that do not come within it would seem to be a mistake because different techniques and composition may result in varying hardnesses but produce satisfactory bushings. A hardness test, though, that produces considerable depth of plastic deformation and uses a relatively large load, such as the Rockwell 'B' test, should be valuable for the detection of non-uniformity (porosity, segregation, etc). For this use, a minimum of 4 or 5 hardnesses would be taken along the length of the bushing blank and if any of the readings fell below a hardness value lower than that which might be caused by normal metal variations, e.g., below Rockwell 'B' 40, it would be known that porosity was undermining the alloy's

(Discussion of Results, cont'd) -

resistance to penetration. The severity of the service will determine the amount of porosity to be allowed. For this particular use a hardness test (such as the Vickers) which does not produce a deep penetration is not desirable. There are, of course, other ways of detecting porosity, i.e., microscopic examination, radiography, etc., but equipment is often not available and they may be, in this case, more difficult to apply. A chemical analysis for the most important alloys, possibly tin and phosphorus, combined with this testing for porosity, would seem to be sufficient inspection because if the analysis is correct and the material is sound the microstructure very probably is satisfactory.

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LPT:GHB:MC.