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OTTAWA March 1st, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1605.

Examination of Failed Copper-Lead
Connecting Rod Bearings.

(Copy No. 13.)

Bureau of Mines
Division of Metallic
Minerals
-
Ore Dressing
and Metallurgical
Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

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Origin of Samples and Object of Investigation:

Failed connecting rod bearings, reportedly from two Ford vehicles which had been under heavy duty oil tests in Texas, were submitted for examination on February 14th, 1944, by Mr. N. C. MacPhee, Division of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario. This material, covered by Requisition No. 630 (AEDB Lot No. 521 - Connecting Rod Bearings from Vehicle No. C-121; AEDB Lot No. 522 - Connecting Rod Bearings from Vehicle No. C-122), Report No. 13, Test No. 57, was obtained from Mr. P. B. MacEwen for Director of Automotive Design, A.E.D.B. (File No. 73-1-16). Bearings from Vehicle C-121 were marked as having gone 8,433 miles.

Request was made for an examination to determine whether the bearing failure was due to corrosive action of the oils or to poor bonding of the bearing.

Chemical Analysis:

Some areas undermined by cracking were removed from one of the bearing surfaces in Vehicle No. C-122 for chemical analysis. The results were:

		Per cent
Copper	-	85.27
Lead	-	10.71
Phosphorus	-	0.07
Tin	-	0.15
Silicon	-	0.06(?)
Iron	-	Present in small amount.
Zinc	-	Nil.
Nickel	-	Nil.

Note: Failure to total 100 per cent is probably due to presence of organic matter, oil, etc.

Macro-Examination:

A photograph of two of the half bearings, as received, is given in Figure 1.

Figure 1.

BEARINGS AS RECEIVED.
(Approximately ¾ size).

(Macro-Examination, cont'd) -

These bearings are evidently of the floating type, being coated with copper-lead on both sides.

On the inner, concave surface of the bearing there was, in general, much more of what appeared to be a pitting-type corrosion than on the convex surface. On the outer, convex surface there were some glazed or shiny circumferential paths containing networks of fine cracks which were not noticeable in other parts of the bearing. These paths were frequently through the oil seepage holes but were sometimes in other locations. The most important point in this connection, however, is that areas of severest pitting on the inside of the bearing corresponded to areas of distress on the convex side.

In all flaked-out areas, some of the copper-lead alloy was still adhering to the steel back.

The mode or modes of failure in both vehicles appeared to be the same.

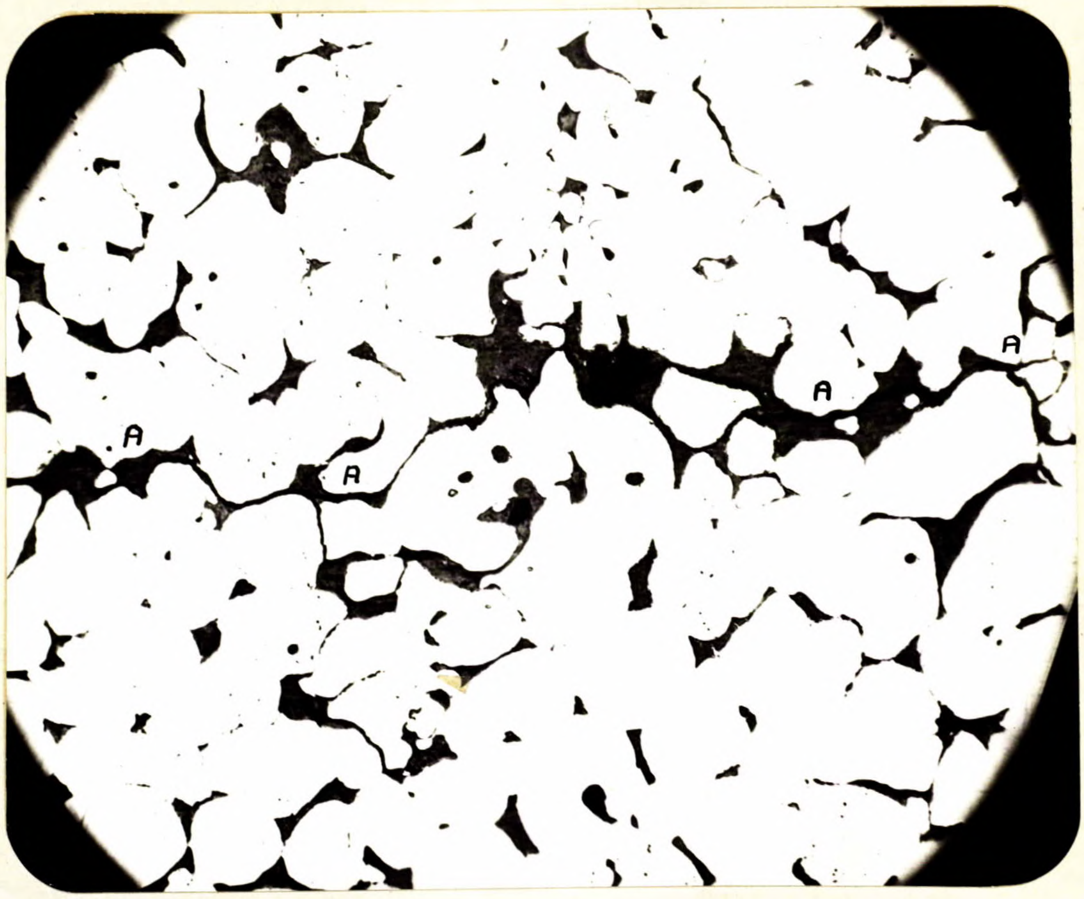
Micro-Examination:

On examination of sections through several flaked-out areas it was found that the bearing-to-steel bond exhibited no defects and was intact in all cases (see Figure 3).

Examination of some developing cracks in the glazed paths on the convex side of the bearings did not reveal any selective lead loss (see Figures 2 and 3).

(Continued on next page)

Figure 2.



X250, unetched.
TANGENTIAL SECTION FROM CONVEX BEARING SURFACE, IMMEDIATELY BELOW SURFACE. VEHICLE NO. C-122.
Note fine crack proceeding through lead areas of the alloy.

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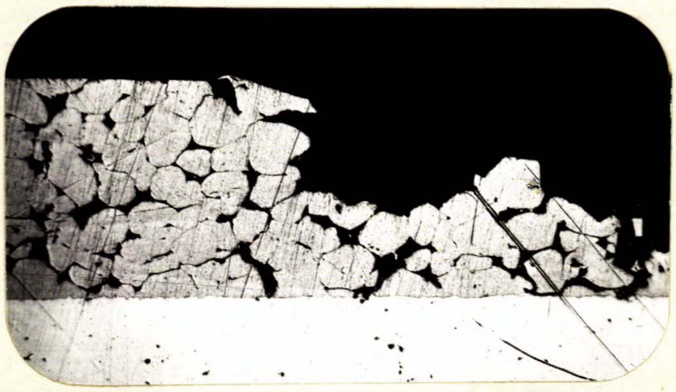
Figure 3.



X100, unetched.
RADIAL SECTION FROM CONVEX BEARING SURFACE, WITH LEAD PRESENT TO THE OUTER EDGE.
Note partially flaked-out location showing bond intact.

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(Micro-Examination, cont'd) -

The examination of flaked-out areas for lead loss was not conclusive because of the number of factors which could produce similar results.

The lead was distributed intergranularly, with the lead areas frequently connected by fine stringers of lead (see Figures 2 and 3).

No defects were noticed in the steel backing.

Discussion of Results:

The chemical analysis results are not conclusive, because (1) the sample was taken from a cracked portion of the bearing, (2) lead removed while obtaining the sample is not known, and (3) lead content determinations in such alloys are none too reliable. However, if the original analysis is known the results may be of interest.

Macro- and micro-examinations, which showed that the bearing alloy was still adhering to the steel back in flaked-out areas, indicated that the bonding was satisfactory and was not the cause of this failure.

It is known that in copper-lead alloys the lead distribution and the initial porosity greatly influence the life of bearing service. Since the lead areas in the bearings examined were frequently connected by stringers of lead, its distribution is not the most advantageous. However, it is emphasized that the lead distribution in this case appears satisfactory and is not believed to have been the direct cause of these early failures.

The shiny circumferential paths on the convex surfaces of the bearings may have been caused by metal-to-metal contact or possibly some slight corrosion.

Cracks and flaked-out areas similar to those found

(Discussion of Results, cont'd) -

in these bearings may result from one or more of the following:

(a) Selective lead loss by corrosion.

(b) Sweating out of the lead by heat generated by friction, etc.

(c) Fatigue of the metal.

In the present case, at least some of the cracks appear to have been caused by fatigue. Generally, fatigue cracks develop radially inward from the outer surface of the bearing metal and turn at right angles when the bond is neared but not reached. These cracks develop until another similar one is reached and the section, thus undermined, falls out. Factors (a) and (b) result in failures that appear similar because the selective lead loss leaves the metal porous and prone to failure.

The presence of fatigue cracking does not mean, of course, that the bearing used has not the strength required for the application, because the fatigue limit in service is reduced by heat and other variables which may, in turn, result from mechanical or oil factors such as insufficient oil flow or oil film strength, inadequate clearance, etc. The endurance limit and the loads applied, in this case, are not known but, if conditions were normal, it is most unlikely that the bearings would fail from fatigue in such a short time. Also, since areas of cracking on one face of the bearing correspond to areas of severest corrosion on the other, it would seem that secondary factors, rather than the normal fatigue limit of the bearing and the corrosiveness of the oil, were of major importance.

CONCLUSIONS:

1. The failure of the bearings examined was not caused by poor bonding.

2. Areas of apparent fatigue cracking on the convex surfaces of the bearings corresponded in location to areas of deepest pitting (evidently corrosion) on the concave surface. Because of this, secondary mechanical or oil characteristics (i.e., not the normal bearing fatigue limit or the normal corrosiveness of the oil) are believed to have been of major importance in the failures.

References:

(1) "Bearings for Heavy-Duty Automotive Engines," by A.B. Willi, S.A.E. Journal (Transactions), Vol. 50, No. 2, Feb. 1942, pp. 62-72.

(2) "Bearings and Bearing Corrosion," by L. Raymond, S.A.E. Journal (Transactions), Vol. 50, No. 12, December 1942, pp. 532-537.

(3) "Bearings for Diesel Engines," by A.B. Willi, Mechanical Engineering, Vol. 64, June 1942, pp. 439-448.

(4) "Bearings and Lubrication," by R.J.S. Pigot, Mechanical Engineering, Vol. 64, April 1942, pp. 259-269.

(5) "Bearing Trouble," by Herman S. Eberts, Bus Transportation, Vol. 20, No. 7, July 1941, pp. 324-325.

(6) "Aus der Praxis der Bleibronzen als Lagermetall," by A. Blankenfeld, Z.f.METALLKUNDE, Vol. 31, February 1939, pp. 31-45.

(7) "Untersuchungen von Bleibronze-Ausgüssen in der DVL-Lagerprüfmaschinen," by J. Fischer, LUFTFAHRTFORSCHUNG, Vol. 16, No. 7, July 20, 1939, pp. 370-383.

(8) Report of O.D.M.L. Investigation No. 1487 (Aug. 30, 1943), Bureau of Mines, Department of Mines and Resources, Ottawa, Canada.

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