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OTTAWA May 22, 1945.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1875.

Metallurgical Examination of a Broken
Camshaft from a 3-Ton Dodge Truck.

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(Copy No. 14.)

Bureau of Mines
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

CANADA

DEPARTMENT
OF
MINES AND RESOURCES

Mines and Geology Branch

OTTAWA May 22, 1945.

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Source of Material and Object of Investigation:

On May 7, 1945, the Division of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario, submitted two broken camshafts for metallurgical examination. The request for this work was covered by Requisition No. 698, A.E.D.B. Lot No. 591, Report No. 13, Test No. 75. This requisition contained the following information:

Material -

Two Dodge camshafts from 3-ton 4 x 2 vehicle, Chrysler Part No. 1067201 made by C.W.C. (Pattern

(Source of Material and Object of Investigation, cont'd) - Symbol No. 855471).

Material Obtained -

Mr. C. G. Menendez, Service Engineering Section, A.E.D.B. (File No. 73-E-1).

Drawing Specifications -

Material: High Test Cast Iron to Analysis M.S. 891. Hardness on gear blank and bearings: 269-302 Brinell. Hardness on chilled portion of cam and eccentric: minimum 65 scleroscope.

Relevant Data -

Material is probably made from C.W.C. Proferral P x 1A of approximately the following analysis:

		Per Cent
Carbon	-	3.10 to 3.25
Silicon	-	2.00 to 2.25
Manganese	-	0.60 to 0.90
Chromium	-	0.70 to 1.00
Nickel	-	0.30 to 0.45
Molybdenum	-	0.25 to 0.35

Sulphur and phosphorus contents should be low and presence of other elements, especially copper, should be checked. Hardness on the nose of cam may have been obtained by either (a) use of chills in the mould or (b) flame hardening followed by a water-spray quench.

Additional Information -

These two camshafts have been returned from vehicles in service in the Middle East due to the shaft breaking adjacent to the timing gear. Failure may have been due to mechanical causes.

Information Desired -

Metallurgical investigation to determine quality of material.

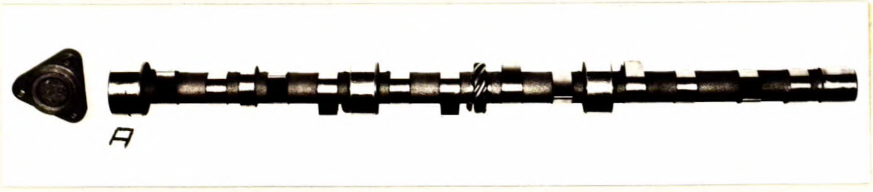
Macro-Examination:

Figure 1 is a photograph illustrating the location of the failure of these camshafts.

(Continued on next page)

(Macro-Examination, cont'd) -

Figure 1.



(Approximately 1/8 actual size).

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Figures 2 and 3 are photographs of cross-sections of the cam and bearing respectively. A slight shrinkage cavity was observed in the centre of the bearing section, (at A in Figure 1) of the shaft. This is shown at B in Figure 3. No defects were noted in the cam section, and the hardened portion appeared uniform.

Figure 2.

Scleroscope hardness of cam, 66.

(Approximately to size).

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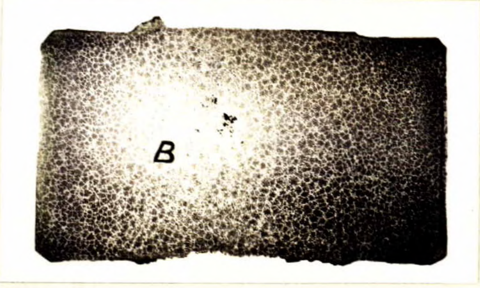
Figure 3.



Brinell hardness of bearing surface (3,000-kilogram load), 255.

(Approximately to size).

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X-Ray Examination:

An X-ray examination was carried out at the National Research Council laboratories, Ottawa, on the camshaft marked "5-C-A-θ-29", and several small centre-line shrinkage cavities were observed.

Chemical Analysis:

Drillings taken from the camshaft marked "7-C-B-θ-12" were found to have the following chemical composition:

		Per Cent
Total carbon	-	3.27
Graphitic carbon	-	2.40
Combined carbon	-	0.87
Manganese	-	0.65
Silicon	-	2.25
Phosphorus	-	0.079
Sulphur	-	0.114
Chromium	-	0.82
Nickel	-	0.41
Molybdenum	-	0.50
Copper	-	0.11

Mechanical Tests:

The results of tensile and fatigue tests obtained on test specimens machined from the camshaft marked 7-C-B-θ-12 are listed in the following tables.

TABLE I. - Tensile Test.

Diameter of test bar, p.s.i.	Ultimate stress, p.s.i.	Brinell hardness (3,000-Kg. load)
0.505	48,500	229

TABLE II. - Fatigue Test.

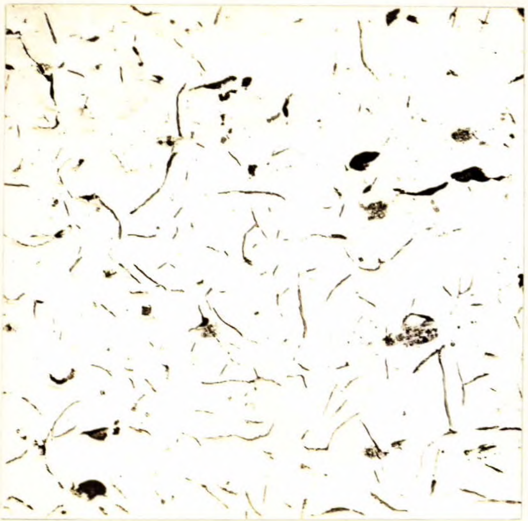
Diameter of test bar, inch	Fatigue stress, p.s.i.	Number of cycles	Remarks
0.300	25,000	99,000	Broke.
0.300	20,000	332,000	"
0.301	15,000	11,000,000	No break.

(Continued on next page)

Microscopic Examination:

Figures 4 and 5 are photomicrographs, at X100 magnification, showing the unetched and nital-etched structures, respectively, of the iron. The graphite flakes are quite fine and uniformly distributed throughout the pearlitic matrix. Considerable free cementite, however, was found to be present throughout the iron. One of these areas, in which Tukon hardness readings were taken of the cementite and the pearlite, is shown in Figure 6, a photomicrograph at X500 magnification. The matrix material is fine pearlite. Figure 7 is a photomicrograph, at X500 magnification, showing the martensitic background structure of the chilled section of the cam. Massive carbides are also present.

Figure 4.



X100, unetched.

Figure 5.

X100, etched in 2 per cent nital.

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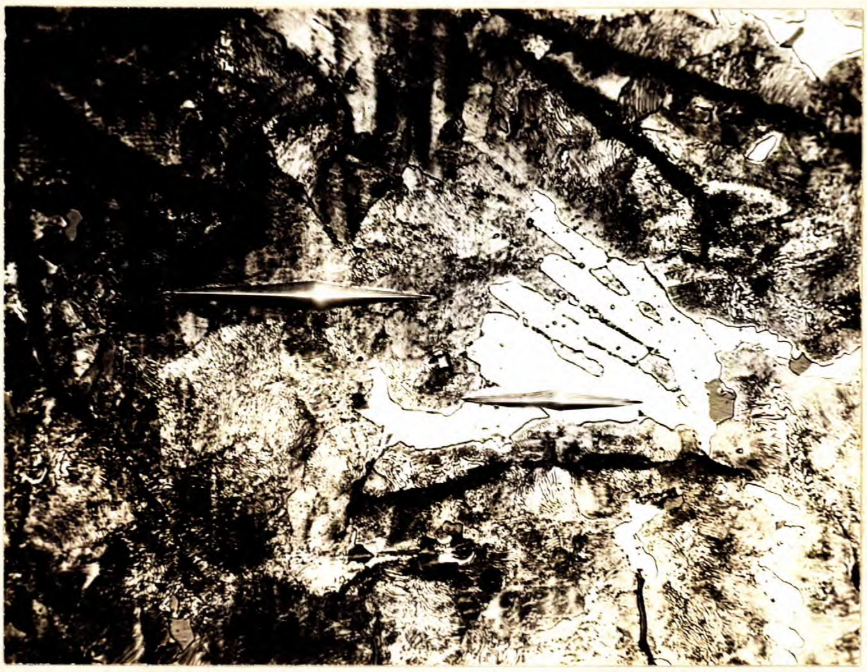
(Microscopic Examination, cont'd) -

Figure 6.



X500, etched in
2 per cent nital.

A. Cementite; Tukon hardness number, 707.
B. Pearlite; Tukon hardness number, 240.

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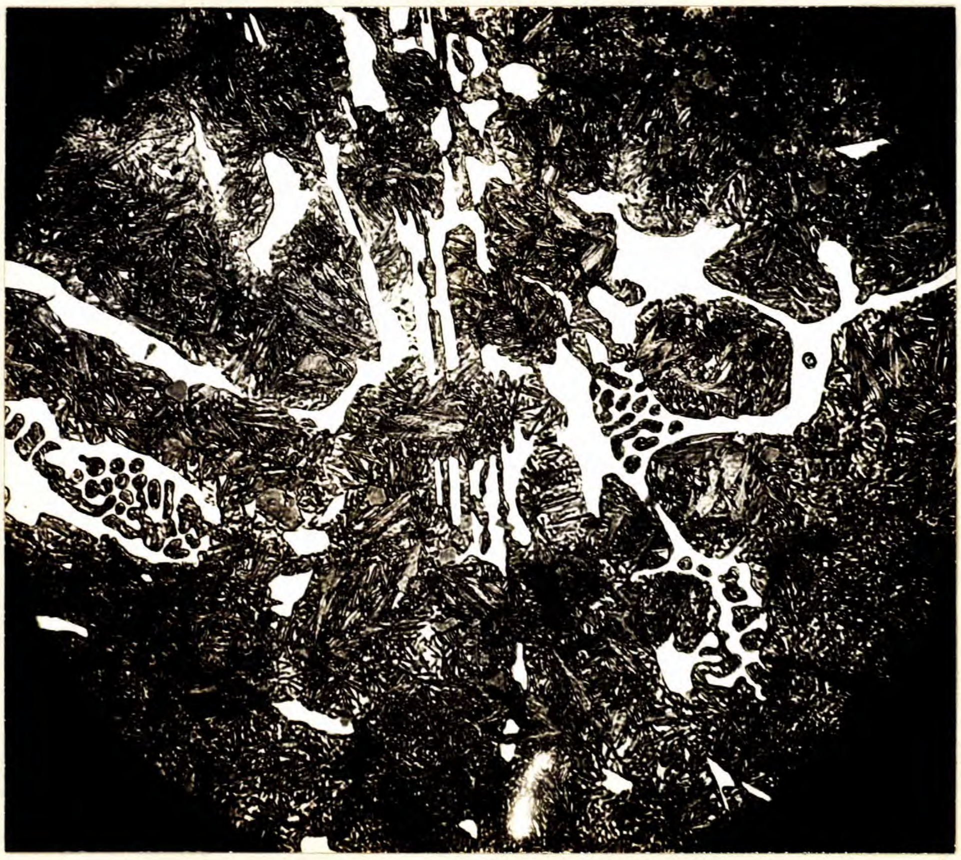
Figure 7.



X500, etched in
2 per cent nital.

SHOWING THE STRUCTURE OF THE CHILLED PORTION OF THE CAMSHAFT.

Discussion of Results:

The chemical composition of the camshaft examined is within the range generally used by C.W.C. Crankshaft Co., Muskegon, Michigan, for this application. The several small centre-line shrinkage cavities shown to be present by macro and X-ray examinations are not considered to be serious defects. The tensile and fatigue properties of the iron are regarded as satisfactory. The Brinell hardness of the bearing surface of the camshaft was slightly less than the value specified. However, the scleroscope hardness of the chilled portion of the cam met the requirements specified by Chrysler. A microscopic examination showed massive carbides to be present in the chilled and unchilled portions of the shaft. These carbides can be reduced by increasing the silicon and nickel additions. An increase in the nickel content would probably be preferred as it would improve the chilling and tensile properties of the iron. The presence of these carbides would probably lower the impact strength of the iron. The martensitic structure observed in the chilled section of the camshaft indicates that the cams were hardened by a water quench in the flame-hardening operation.

Cast iron, on account of its relatively low impact strength as compared with steel, is seldom used where the part is subjected to heavy impact stresses. Therefore the presence of these carbides in the metal under normal operating conditions probably would not be a cause of failure. If, however, any change were made in the design or in the operating conditions which would increase these stresses on the camshaft, then one would expect the shaft to break sooner than if the metal were free from carbides. The evidence in the present case, however, would seem to indicate that failure was due to some external factor, such as the imposing of stresses

(Discussion of Results, cont'd) -

greater than allowed for, rather than to the presence of massive carbides or to the small shrinkage cavities observed in this casting. It therefore is quite probable that failure was due to some mechanical rather than metallurgical cause.

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