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OTTAWA January 20th, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1345.

Examination of a Fractured Piston.

(Copy No. 4.)

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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REPORT

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Source of Material and Object of Investigation:

On January 11th, 1943, Lieut. Commander (E) G. Taylor, R.N.V.R., of the British Admiralty Technical Mission, Section 2, 58 Lyon Street, Ottawa, Ontario, submitted the remains of a solid piston which had failed in service. This piston was reputed to have been made from a steel of SAE 1020 composition.

A complete range of physical tests, including izod, and also chemical analysis of the material, was requested.

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Chemical Analysis:

Sample drillings of the steel were analysed and the following results obtained:

		Per cent
Carbon	-	0.39
Manganese	-	0.58
Silicon	-	0.05
Phosphorus	-	0.019
Sulphur	-	0.041

Physical Tests:

A tensile specimen of micro dimensions was tested in the Hounsfield tensometer. The izod impact value was determined on a standard 0.45-inch-diameter bar. The hardness was determined by the Brinell method, using a 3,000-kilogram load for 30 seconds. The following results were obtained:

Ultimate stress, p.s.i.	-	64,700
Yield " , "	-	35,300
Reduction in area, per cent	-	40.0
Elongation, per cent in 1 inch	-	13.0
Brinell hardness	-	137.0
Izod impact value	-	13.0 foot pounds.

Macroscopic Examination:

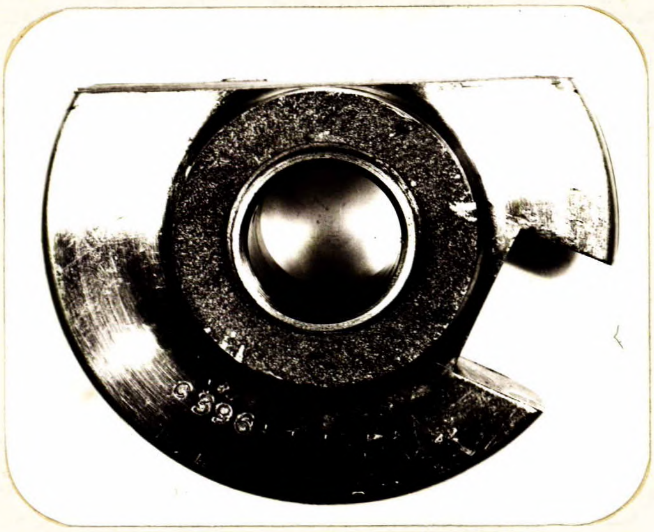

Figure 1.

PHOTOGRAPH OF PISTON FRACTURE.

(Approximately ¾ size).

Figure 1 shows the coarse nature of the fracture.

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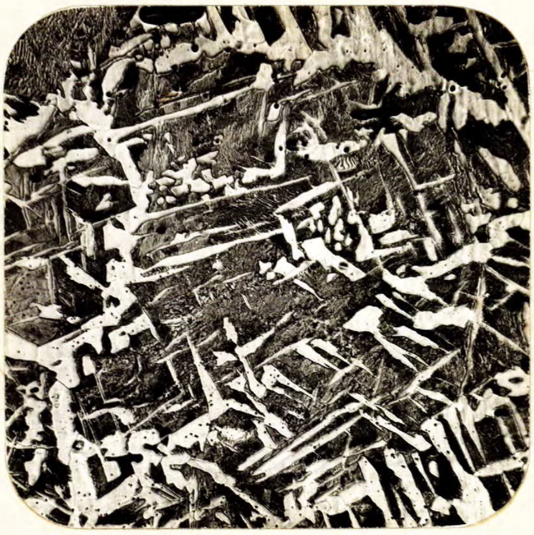
Microscopic Examination:

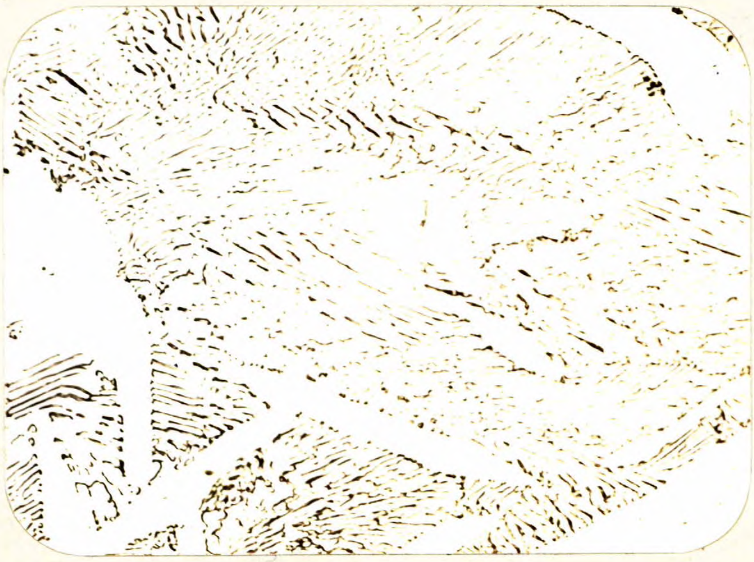
Specimens cut from the piston were polished and then examined under the microscope. The steel in the unetched condition was found to be fairly clean and free from any burning defects. The picral-etched specimen showed the structure illustrated in Figures 2 and 3, photomicrographs at X100 and X1000 magnification respectively. The grain size of the steel is large and the structure consists of ferrite (the white constituent) and fairly coarse pearlite (the dark etching material).

Figure 2.



X100, electro-polished, etched in 4 per cent picral.

Figure 3.



X1000, electro-polished, etched in 4 per cent picral.

Discussion of Results:

The composition of the steel was found to correspond to that of an SAE 1040 steel, and not to SAE 1020 steel as supposed. The coarseness of the fracture of the steel indicates that the part was not heat-treated subsequent to forging or was heated to an excessively high temperature in a post-forging operation. This was confirmed in the metallographic examination of the steel. Steel with this coarse structure would have lower physical properties than a similar steel which had been properly heat-treated to refine the grain. The reasonably coarse pearlitic structure shown in Figure 3 is that of a steel which has been cooled slowly through the critical stage.

The S.A.E. recommended heat-treatment (Revised 1938) for SAE 1035 and 1040 steels is given in the following table:

SAE	Treatment Number	Normalize	Quench	Draw
1035	I		1525-1575°F., oil or H_2O.	To desired hardness.
1040	II	1650-1750°F.	1525-1575°F., oil or H_2O.	To desired hardness.

Conclusions:

The steel in this failed piston did not have the composition (SAE 1020) mentioned in the request letter. Steel of the composition used, however, would certainly have proved most satisfactory had it been heat-treated after the forging operation.

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