OTTAWA April 2, 1945.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1829.

Metallurgical Examination of Two Broken Steel Studs from a Snowmobile Rebound Chain Assembly.

(Copy No. 10.)

Bureau of Mines
Division of Metallic Minerals

Physical Metallurgy Research Laboratories

CANADA

DEPARTMENT OF MINES AND RESOURCES

Mines and Geology Branch

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Source of Material and Object of Investigation:

On March 19, 1945, Mr. W. J. Washburn, of the Army Engineering Design Branch, Department of Munitions and Supply, 1872 Notre Dame Street W., Montreal, Quebec, submitted for examination two broken steel studs, part No. 39227 N.D., from a rebound chain assembly No. B-38487 of a snowmobile bogie arrangement.

In a letter accompanying the material it was requested that the broken pieces be checked in order to determine, if possible, the cause of failure, and, also, what might be done to eliminate future breakages. Copies of the prints B-38487 and F-307551, giving the details of the assembly and also the material specified, namely SAE 1020 steel, were also enclosed.

For purposes of identification the broken studs will be referred to as Samples Nos. 1 and 2.

Macro-Examination:

Figure 1 is a photograph showing the fractured surface of the two steel studs. The surface of Sample No. 1 was rusted, so that no special significance could be attached to the fracture. Sample No. 2 had a duplex fracture, and the failure appeared to have originated at the base of the thread (at "A" in Figure 1).

Figure 1.

SAMPLE NO. 1.

"A"

SAMPLE NO. 2.

(Approximately 4/5 actual size).

Izod Impact Tests:

A single-notch Izod specimen was machined from each sample and tested in the Tinius Olsen 120-foot-pound impact testing machine. The following values were obtained:

Sample No.		Ft-lb.
1	-	3
2	-	40

Figure 2 is a photograph showing the fracture of the Izod specimens. The fracture of Sample No. 1 was fairly coarse. However, Sample No. 2 appeared to be fine-grained at the outer surface and coarse-grained towards the centre. A seam was observed in the centre of Sample No. 2.

(Continued on next page)

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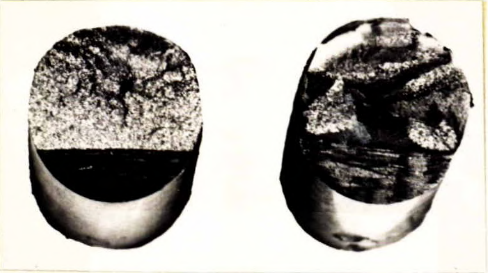
(Izod Impact Tests, cont'd) -

Figure 2.

SAMPLE NO. 1.



SAMPLE NO. 2.

(Approximately twice actual size).

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Hardness Tests:

The hardness of the steel studs was determined by the Brinell method, using a 3,000-kilogram load. The following values were obtained:

Sample No.		Brinell Hardness Number
1	-	201
2	-	187

Chemical Analysis:

A chemical analysis was made on the two samples submitted. The results obtained and the composition specified for the steel are given in the following table:

		SAE 1020 Specification	Sample No. 1	Sample No. 2
		- Per Cent -		
Carbon	-	0.15-0.25	0.14	0.16
Manganese	-	0.30-0.60	0.95	0.59
Silicon	-	0.15-0.30	0.02	0.14
Sulphur	-	0.055 max.	0.229	0.062
Phosphorus	-	0.045 "	0.299	0.194
Chromium	-	-	N.d.	0.13
Nickel	-	-	N.d.	N.d.
Molybdenum	-	-	N.d.	N.d.

N.d. = None detected.

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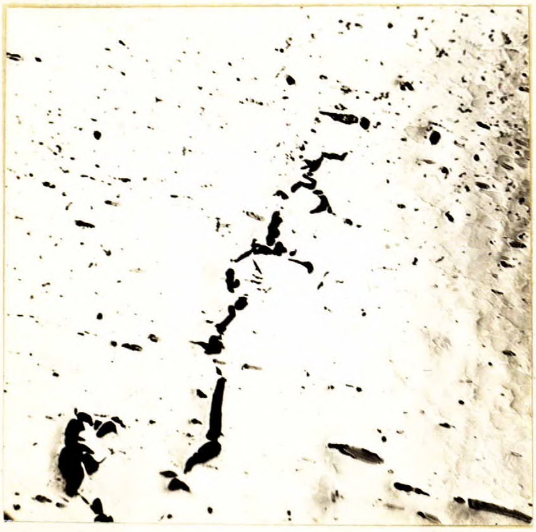
Microscopic Examination:

Specimens of the steels adjacent to the fracture were mounted in bakelite, polished, and examined under the microscope in the unetched condition. The inclusion content of these steels was quite high. Sample No. 1 was found to contain shrinkage cavities, while slag was observed in Sample No. 2. These defects are illustrated in Figures 3, 4 and 5. Figure 6 illustrates a crack typical of several found at the base of the thread in Sample No. 2.

Figure 3.



X100, unetched.

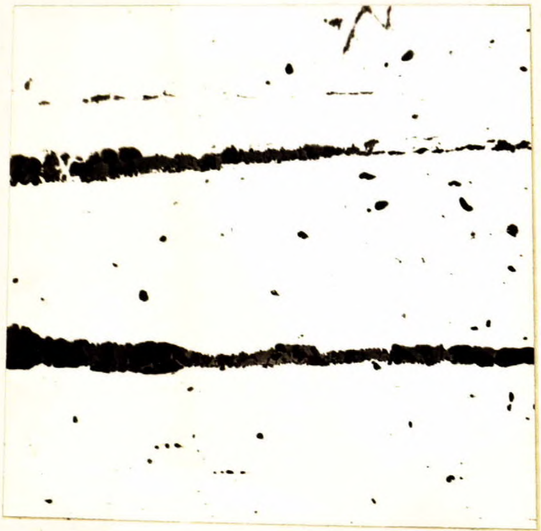
SHRINKAGE CAVITIES, SAMPLE NO. 1.

Figure 4.

X100, unetched.

SULPHIDE INCLUSION, SAMPLE NO. 1.

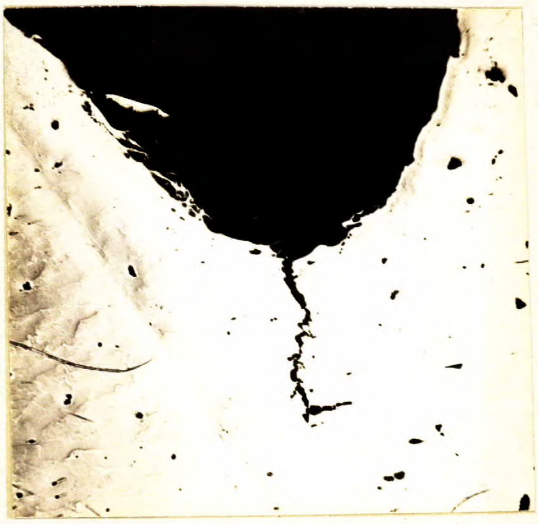
Figure 5.



X100, unetched.

SLAG INCLUSION, SAMPLE NO. 2.

Figure 6.



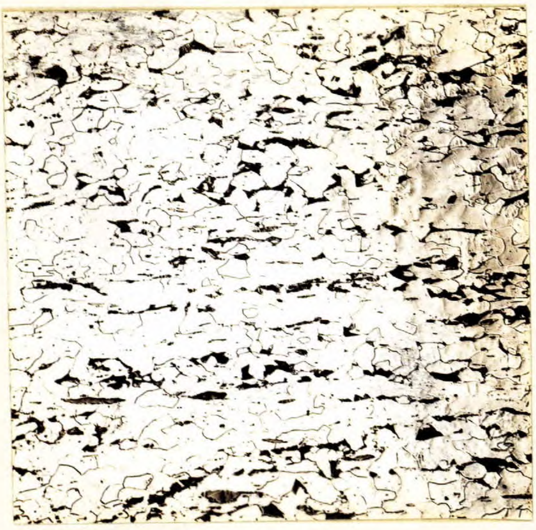
X100, unetched.

CRACK AT BASE OF THREAD, SAMPLE NO. 2.

(Microscopic Examination, cont'd) -

The nital-etched structures of Samples Nos. 1 and 2 are shown in Figures 7 and 8 respectively. The steels are fine grained. The structure consists of pearlite, the iron-iron carbide constituent (the dark etching material), and ferrite, the iron constituent (the light etching material).

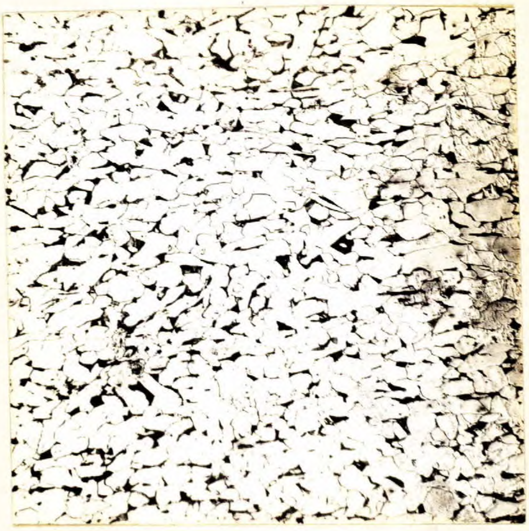
Figure 7.



X100, etched in
2 per cent nital.

SAMPLE NO. 1.

Figure 8.



X100, etched in
2 per cent nital.

SAMPLE NO. 2.

Discussion of Results:

The chemical composition of the two broken steel studs submitted did not conform to that of the SAE 1020 steel specified. Sample No. 1 had a chemical composition similar to that of an SAE X1112 steel, a free-cutting steel, except for the phosphorus content which was much higher than is normally present in high sulphur free-cutting steels. Sample No. 2 had a chemical composition similar to that of an SAE 1020 steel, except for the phosphorus content which is exceedingly high. The sulphur is also above the upper limit. The composition would indicate that this steel might have been made by an acid process from high-

(Discussion of Results, cont'd) -

phosphorus scrap. In the acid process the sulphur and phosphorus cannot be substantially removed from the steel. The microscopic examination showed that the phosphorus was all in solution and, from the high impact test result obtained, it would seem that the high phosphorus content had not greatly affected the steel's toughness. As a rule, however, phosphorus lowers the impact properties and should be kept down to the lowest limit commercially possible for any given class of steel.

The photomicrographs show that steel Sample No. 1 had a high sulphide inclusion content, as would be expected in a high-sulphur, free-cutting steel. In addition, Sample No. 1 was found to contain shrinkage cavities. Sample No. 2 was made from seamy stock in which slag inclusions have been entrapped in the rolling operation.

The use of free-cutting steels for the manufacture of parts subject to high impact stresses is not recommended, on account of their low impact properties. The poor impact strength of Sample No. 1, therefore, would account for its premature failure in service. The duplex nature of the fracture of Sample No. 2 indicates that it failed by fatigue. The use of higher strength steel and a reduction of the amount of thread to just enough to take the threaded bushing and two lock nuts would probably overcome similar failures.

A nickel steel of SAE 2320 composition, quenched in oil from 1450° F. to 1500° F. and tempered at 1100° F., or a chromium-molybdenum steel of SAE 4130 composition, quenched in water from 1575° F. to 1625° F. and tempered at 1100° F., is recommended and should give improved service. The lower-carbon steel would be preferable as it is more easily welded. Both steels have high impact properties at room and sub-zero

(Discussion of Results, cont'd) -

temperatures and can be readily welded. If the alloy steels are unavailable it is thought that a normalized SAE 1020 steel should prove satisfactory for these studs, provided the steel is properly made and the thread on the steel is reduced to the minimum requirements as suggested above.

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