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DEPARTMENT OF MINES AND RESOURCES

BUREAU OF MINES

CANADA

Ottawa, July 9, 1946.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2074.

Metallurgical Examination of Flour Mill Beater Plates and Two Steel Bars from an Anderson Expeller Mill.

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(Copy No. 5.)

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

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Mines and Geology Branch

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Origin of Samples and Object of Investigation:

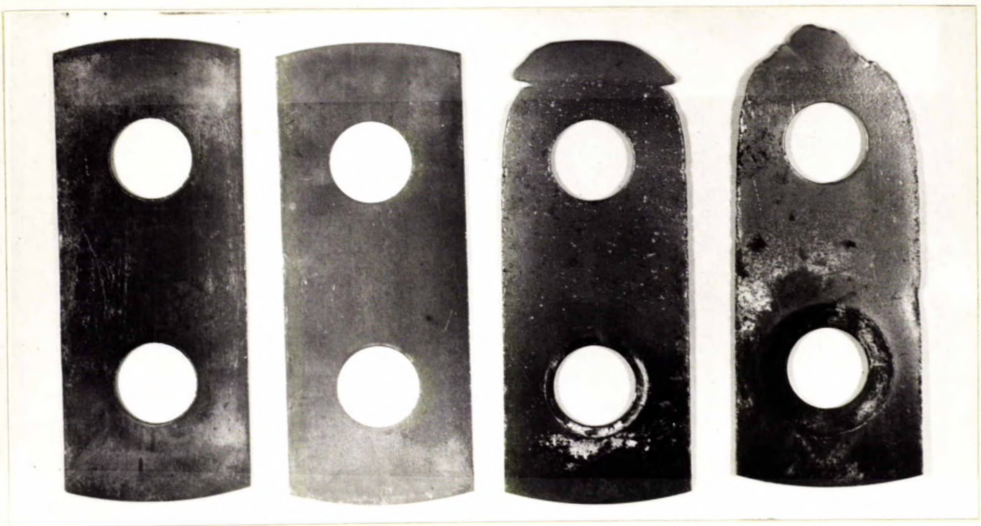
On June 8, 1946, Dr. G. S. Farnham, metallurgist of the Development and Research Division, The International Nickel Company Limited, 25 King St. West, Toronto 1, Ontario, submitted for examination two new and two used beater plates and also two steel bars from an Anderson Expeller Mill. One of the bars had worn, while the other had given satisfactory service. These parts, which are shown in Figures 1 and 2, were taken from flour mill equipment of Toronto Elevators Limited, Queen's Quay, Toronto, Ontario.

A metallurgical examination was requested in order to determine, if possible, the cause of poor service life of these parts.

Macro-Examination:

The new and used beater plates are shown in Figure 1.

Figure 1.



BEATER PLATES.

(Approximately 1/2 actual size.)

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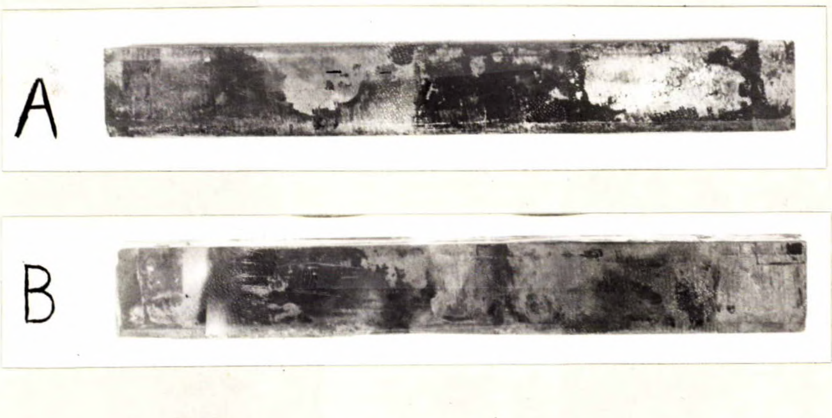
The bar from the Anderson Expeller Mill which gave poor service is shown in Figure 2-A, while the good bar is shown in Figure 2-B.

Figure 2.



EXPELLER MILL BARS.

(Approximately 1/2 actual size.)

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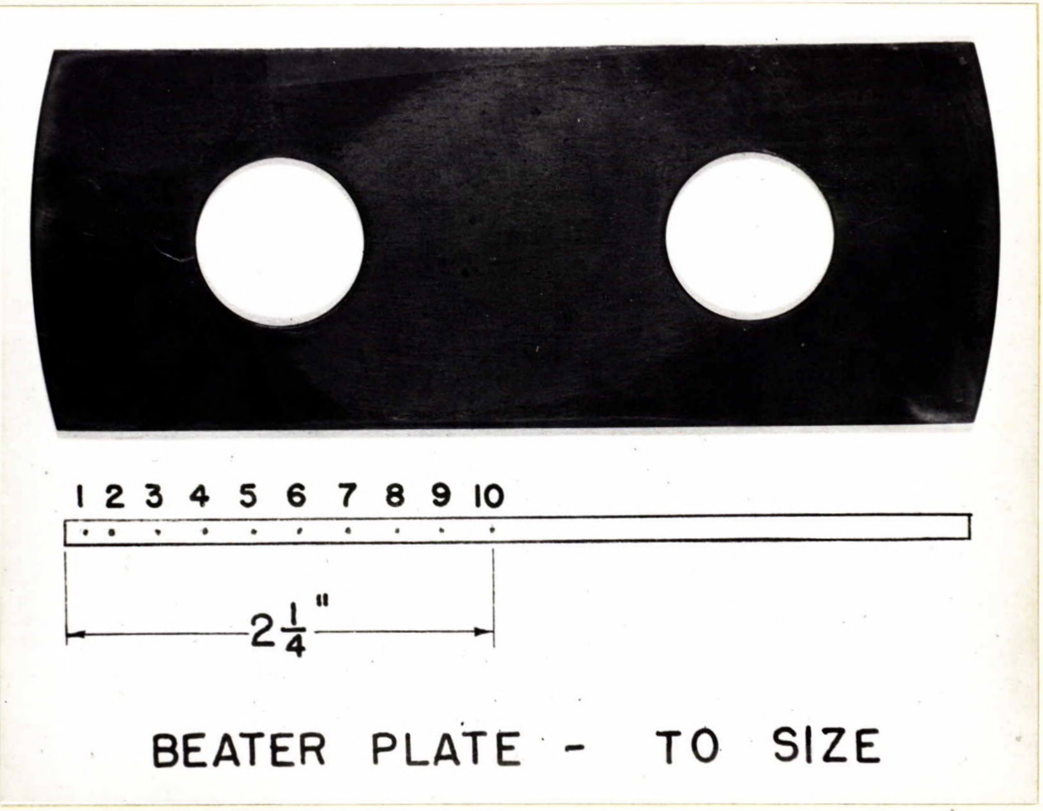
Hardness Tests:

The results of hardness tests on the parts submitted are shown in the following tables. For the beater plates, (Hardness Tests, cont'd) -

Figure 3, below, shows locations at which hardness readings were taken.

Beater Bars -

Figure 3.



BEATER PLATE, TO SIZE, SHOWING LOCATIONS OF HARDNESS READINGS.

No. of Test	Distance from end, in inches	Vickers Hardness Number	Rockwell "C" Scale, Converted
1	1/16	828	65
2	1/4	244	23½
3	1/2	221	20
4	3/4	223	20
5	1	205	16*
6	1¼	205	"
7	1½	205	"
8	1¾	205	"
9	2	205	"
10	2¼	201	15*

* Approximate.

(Hardness Tests, cont'd) -

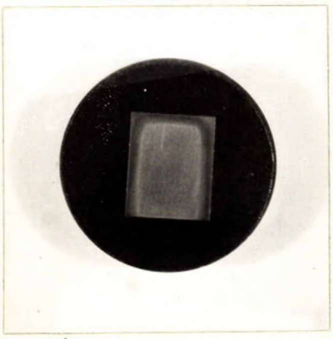
Steel Bars -

	Vickers Hardness Number		Rockwell "C" Scale (Converted)	
	Core	Case	Core	Case
Good Bar "B"	197	757	93B	62½
Worn Bar "A"	232	666	20	58½

Measurement of Case:

The thickness of the case on the two bars ranged from 0.060 to 0.070 inch.

Figure 4.



SHOWING CROSS SECTION OF CASED STEEL BAR FROM ANDERSON EXPELLER MILL.

(Approximately to size.)

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Chemical Analysis:

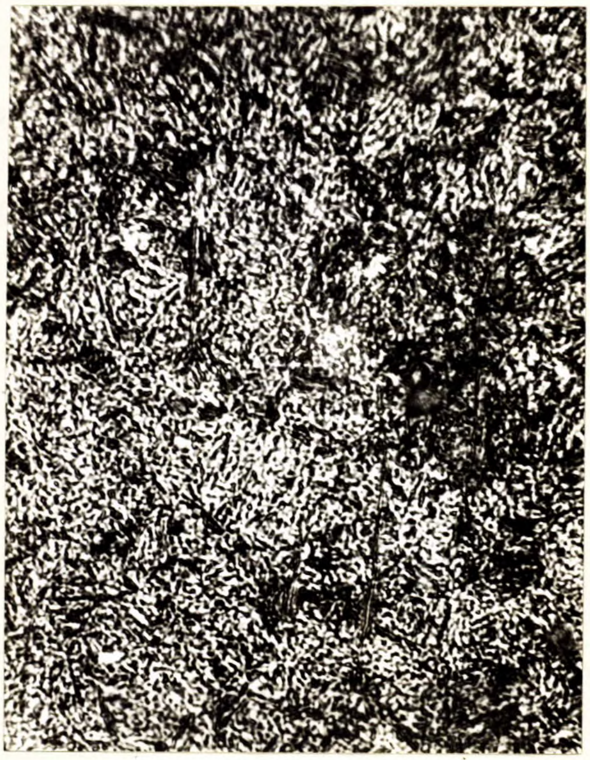
The steels were found to have the following chemical composition:

		Beater Plates	Steel Bars Bar A	Steel Bars Bar B
		- Per	Cent -	
Carbon	-	0.57	0.31	0.20
Manganese	-	0.87	1.38	0.77
Silicon	-	0.19	0.11	0.10
Sulphur	-	0.035	0.108	0.026
Phosphorus	-	0.014	0.015	0.014
Chromium	-	0.04	0.05	Nil.
Nickel	-	Nil.	Nil.	Nil.
Molybdenum	-	Trace.	Trace.	Trace.

Microscopic Examination:

Samples cut from the used and new beater plates, and also the two cased steel bars, were mounted in bakelite, polished, and examined under the microscope. The beater plate steels and the steel bar "B" were all fairly clean. However, a large number of sulphide inclusions were observed in the cased steel bar "A". The samples were then etched in a 2 per cent solution of nitric acid in alcohol and re-examined. The hardened and unhardened sections of the new and used beater plates are shown in Figures 5 and 6 respectively. The structure of the hardened section is typical of quenched and tempered high carbon steel. The structure of the unhardened section consists of pearlite, the dark etching iron-iron carbide constituent, and ferrite, the light etching iron constituent.

Figure 5.

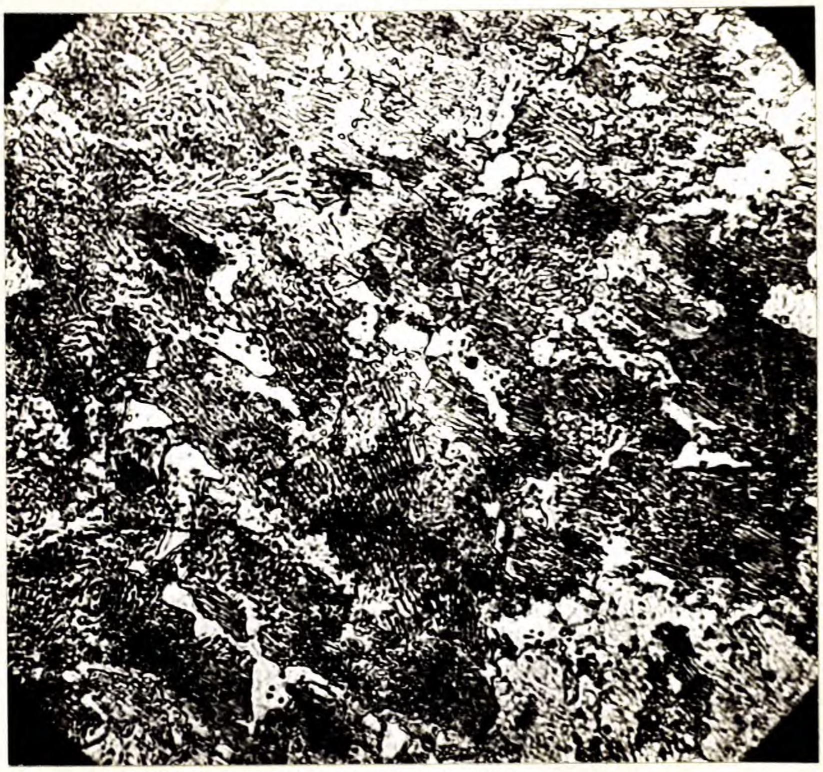


X1000, etched in 2
per cent nital.

HARDENED SECTION.

(Microscopic Examination, cont'd) -

Figure 6.



X1000, etched in 2 per cent nital.

UNHARDENED SECTION.

-

The core structures of the cased bars "A" and "B" are shown in Figures 7 and 8 respectively.

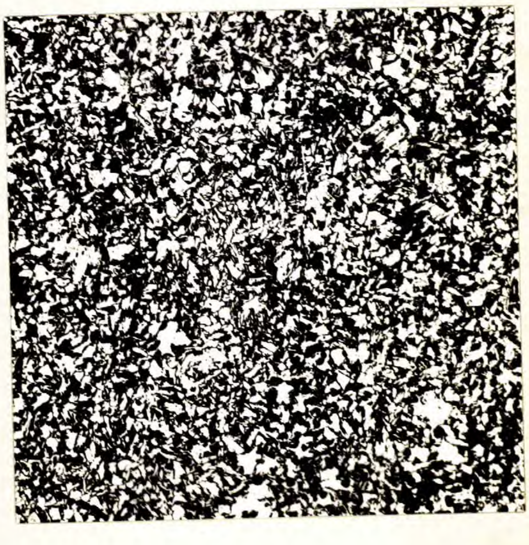
Figure 7.

X100, etched in 2 per cent nital.

CORE, "A" BAR.

-

Figure 8.



X100, etched in 2 per cent nital.

CORE, "B" BAR.

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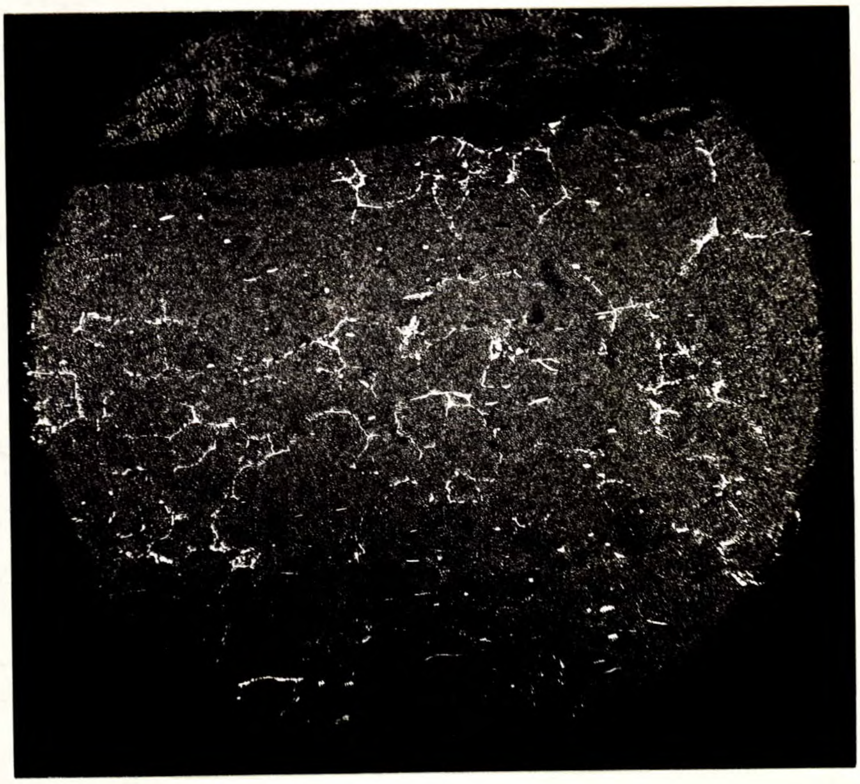
(Microscopic Examination, cont'd) -

The case of the good-wearing bar "B" was free from carbides. However, free carbides were observed in the case of the bar "A" which gave poor service. Figure 9 is a photomicrograph, at X100 magnification, showing a white network of cementite at the grain boundaries in the cased bar "A".

Figure 9.



X100, etched in 2 per cent nital.

SHOWING CARBIDE NETWORK IN THE CASE OF BAR "A".

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Heat Treatment:

One of the beater plates was homogeneously hardened by quenching in oil from 1500° F. and then drawn at 350° and 550° F. A Rockwell hardness, "C" scale, of 61 and 56 was obtained at these respective draw temperatures.

Discussion of Results:

The beater plates had a chemical composition similar to that of an SAE 1060 steel. A hardness survey

(Discussion of Results, cont'd) -

showed that the plates had been hardened on the outer edge only. The service life of these plates could be greatly improved by quenching and tempering the whole plate after machining. A quench in oil from 1500° F. and a draw at 350° F. to 550° F. are recommended. Experimental heat treatment tests showed that these plates could be homogeneously hardened to a hardness of 56 to 61 Rockwell "C" scale, the plates being free from distortion.

The poor-wearing bar "A" from the Anderson Expeller Mill had a chemical composition similar to that of an SAE X1330 steel, a free-cutting high sulphur and high manganese steel. The bar "B" which gave good service had a chemical composition similar to that of an SAE 1020 steel. The depth of the case appeared to be quite ample in these bars. However, free carbides were observed in the case of the poor-wearing bar "A". This brittle constituent has poor impact properties and would chip off readily under heavy impact stresses. A diffusion heat treatment (1500° F. approximately, followed by a rapid quench) would overcome this trouble. It is difficult to evaluate the importance of the manganese and sulphur content of bar "A". The size and distribution of the manganese sulphide inclusions, while contributing to better machinability properties, may possibly contribute to lower impact and wear resistance properties.

Hardness tests showed that the case of the poor-wearing bar was softer than that of the bar which gave good service. This lower hardness would also account for the poor service life of bar "A". The service life of a part subject to abrasion, i.e., grinding away of the metal surface, can best be improved by heat-treating the part to a higher hardness value.

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