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R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2001.

Metallurgical Examination of Hadfield Manganese Steel Containing Boride Crystals.

(Copy No. 4.)

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Origin of Material and Object of Investigation:

On September 20, 1945, two pieces of 13 per cent manganese steel containing boride crystals (see Figure 1) were submitted by Mr. M. E. Nixon, Joliette Steel Limited, Montreal, Quebec, for metallurgical examination.

The covering letter, dated September 18, 1945, stated that the bar had been cast from metal containing 0.3 per cent of Wall Colmonoy Sweat-on Paste, which is a mixture of boride crystals and an organic binder. The bar had been heated for 18 hours and quenched. It was also stated that the boron had been added for the purpose of giving the metal "a harder wearing surface."

The letter requested that the effect of the boride crystals on the manganese steel be determined and that an opinion be expressed regarding the possibility of increasing the wear life of the steel by the addition of boride crystals.

(Origin of Material and Object of Investigation, cont'd) -

Figure 1.

13 PER CENT MANGANESE STEEL BAR
CONTAINING BORIDE CRYSTALS.

Size of bar, 3 in. x 2 in. x 1 in.

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PROCEDURE:

1. Chemical Examination.

A chemical analysis was made on one of the pieces submitted. The results are compared, in the following table, with the normal limits for austenitic manganese steel:

		As Found	A.S.T.M. Spec. A128-33
		- Per Cent -	
Carbon	-	1.15	1.00-1.40
Manganese	-	12.29	10.0-14.0
Silicon	-	0.37	0.25-1.0
Sulphur	-	0.004	0.05 max.
Phosphorus	-	0.043	0.10 max.
Nickel	-	Nil.	--
Chromium	-	0.49	--
Boron	-	0.09	--

2. Hardness Test.

Hardness readings were made on the sample, using a Vickers hardness tester and a 20-kg. load. Results are as follows:

Hardness = 215-218 Vickers.

(Procedure, cont'd) -

3. Heat Treat Experiment.

Samples were heated at 1900° F. for periods of 1 hour and 3 hours, respectively, in an effort to eliminate the excess boron carbides at the grain boundaries.

4. Microscopic Examination.

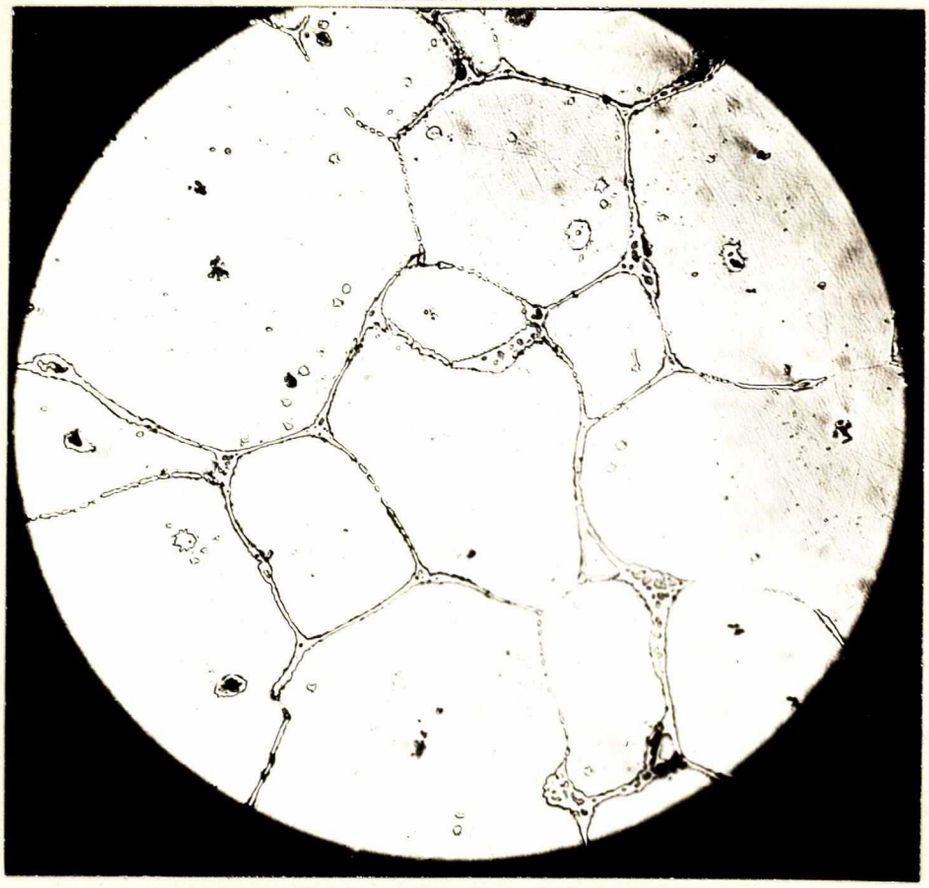
Figures 2 and 3, taken at X100 and X500 magnifications respectively, show the microstructure of the steel "as received." The presence of a constituent (probably boron carbide) around the grain boundaries is clearly evident.

Figure 4, taken at X100 magnification, shows the intercrystalline cracking observed in the steel "as received," indicating the brittle nature of the constituent at the grain boundaries.

(Figures 2 and 3 follow,
on Page 4.)

(Procedure, cont'd) -

Figure 2.



X100, nital etch.

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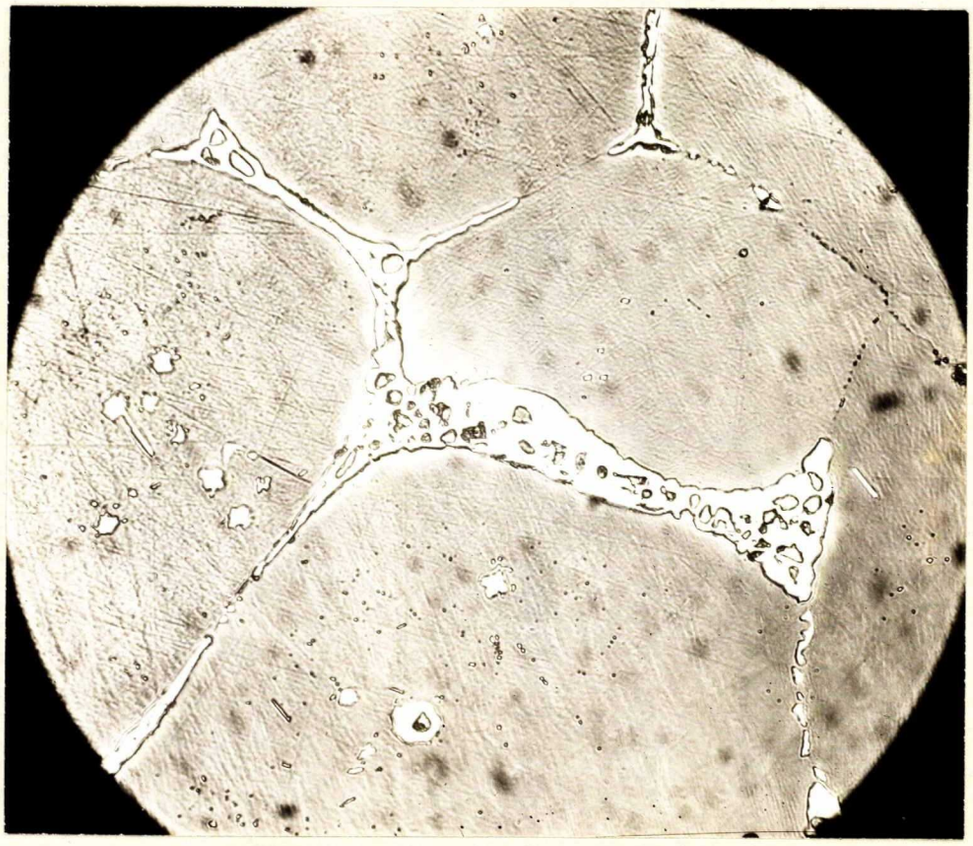
Figure 3.



X500, nital etch.

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BORON MANGANESE STEEL, "AS RECEIVED".

Showing continuous boron constituent at the grain boundaries.

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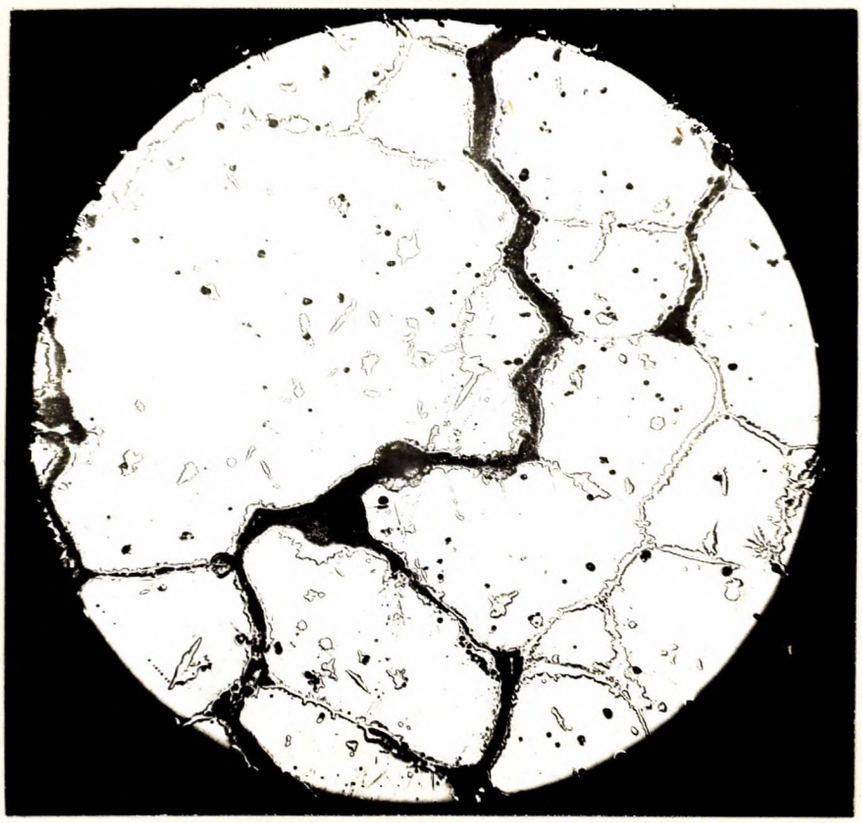
(Procedure, cont'd) -

Figure 4.



X100, nital etch.

BORON MANGANESE STEEL, "AS RECEIVED".

Showing intergranular cracking.

Discussion and Conclusions:

Microscopic examination has shown that the addition of boron to the Hadfield manganese steel has resulted in the formation of a brittle boron constituent at the grain boundaries. This constituent, which may be a carbide of boron, appears to be rather continuous in nature (see Figure 2) and is undoubtedly responsible for intergranular cracking (see Figure 4). Such a steel would be useless for wear resistance because of the brittleness.

An attempt was made to eliminate this constituent by reheating at 1900° F. for periods of 1 hour and 3 hours respectively, but without success.

Boron has been frequently used in steels for the purpose of increasing the hardenability, but the quantities

involved are very small (usually in the neighbourhood of 0.0025 per cent). The only instance of which we have a record wherein boron was employed for improving wear resistance is given in Reference (1). Cast iron cylinder liners containing 0.7 per 1.2 per cent boron were used in mud pumps in connection with the drilling of oil wells. Boron was added in the form of ferroboron, containing 10 to 75 per cent boron. The resultant alloy had a hardness of 67 to 70 Rockwell "C" and was claimed to have given a service life equal to nine plain steel liners. No record, however, of the use of boron in Hadfield manganese steel has been noted.

Since there is practically no information available in the literature regarding the effect of boron on the wear resistance of manganese steels, it would be necessary to conduct practical field tests in order to obtain any reliable information. However, it is considered very unlikely that any beneficial effects would result from such treatment.

Microscopic examination indicates rather conclusively that the quantity of boron added would have to be kept below a certain maximum in order to prevent the formation of a brittle boron constituent at the grain boundaries. This figure can be determined only by the microscopic examination of heats of varying boron contents.

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AF:LB.

Reference

(1) "Boron-bearing Cylinder Liners" (Abstract from the Russian). MATERIALS AND METHODS, Nov. 1945, p. 1498.

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