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June 8th, 1943.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1425.

Examination of Three Broken Manganese
Steel Jaw Crusher Plates.

(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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Origin of Request and Object of Investigation:

On May 19th, 1943, three samples of manganese steel jaw crusher plates were submitted to these Laboratories for examination. Accompanying these samples was a letter, dated May 14th, 1943, in which Mr. J. R. Blais, of the Sorel Steel Foundries Limited, Sales Department, Sorel, Quebec, asked for chemical analysis and photomicrographic examination of the parts and also gave the following names for the users of the material.

Mark 1: Beattie Gold Mines.
Mark 2: Canadian Carborundum.
Mark 3: Bell Asbestos Mines.

Macro-Examination:

Sample marked 1, in the "as received" condition, was severely cracked and covered with rust (Figure 1).

The two other samples, though oxidized on surface, appeared sound.

Chemical Analysis:

The chemical analyses of the three pieces are given below as compared with the A.S.T.M. Specification A-128-33 for austenitic manganese steel:

	Marked 1	Marked 2	Marked 3	A.S.T.M. A-128-33
	- Per cent -			
Carbon	1.22	1.13	1.20	1.0- 1.4
Manganese	10.34	13.79	11.64	10.0-14.0
Silicon	0.19	0.950	0.61	-
Phosphorus	0.072	0.069	0.073	0.10 max.
Sulphur	0.007	0.010	0.015	0.05 max.

Hardness Determination:

The hardness of the samples was measured on the Vickers hardness tester, using a 10-kilogram load. The following results were obtained:

	Vickers Pyramidal Hardness Number
Marked 1	261
Marked 2	214
Marked 3	274

Micro-Examination:

One metallographic sample was cut from each of the pieces. All were electropolished and etched in 2 per cent nital.

Figure 2 (X500) shows the free carbides on the grain boundaries of the twinned austenite (sample marked 1).

Figure 3 (X500) shows an intercrystalline fracture

(Micro-Examination, cont'd) -

in the same sample.

Figure 4 (X100) shows the elongated carbides in the austenitic groundmass. Note the polishing streaks which fail to penetrate the carbides (sample marked 2).

Figures 5 (X100) and 6 (X500) show the lamellar distribution of carbides in austenite in the sample marked 3.

Discussion of Results; Conclusions:

According to the specifications of the American Society for Testing Materials, the chemical analyses of all three specimens conform with the given composition. However, according to Mr. John Howe Hall, in his paper, "Austenitic Manganese Steel Castings," published in SYMPOSIUM ON STEEL CASTINGS, June 21, 1932, pages 200-214, the silicon content should be 0.30 to 1.00 per cent. In this article, it is pointed out that the silicon, up to 1.00 per cent, promotes the fluidity of the steel, permitting intricate castings to be made without 'cold shuts' when pouring at low temperatures. Moreover, it is accepted that silicon has no harmful effect on the steel.

The hardness of the material is higher than would be expected in normal austenitic manganese steel. However, the presence of carbides and work-hardening might be the explanation of this condition.

The photomicrographic examination of the three samples has revealed that all three of them contained free carbides. The latter are especially objectionable when they are present at the grain boundaries of the steel. Their presence might be caused either by a too low quenching temperature or by a too short soaking period at this temperature. The temperature of quenching should be 1950° F. to 2000° F. The

(Discussion of Results; Conclusions, cont'd) -

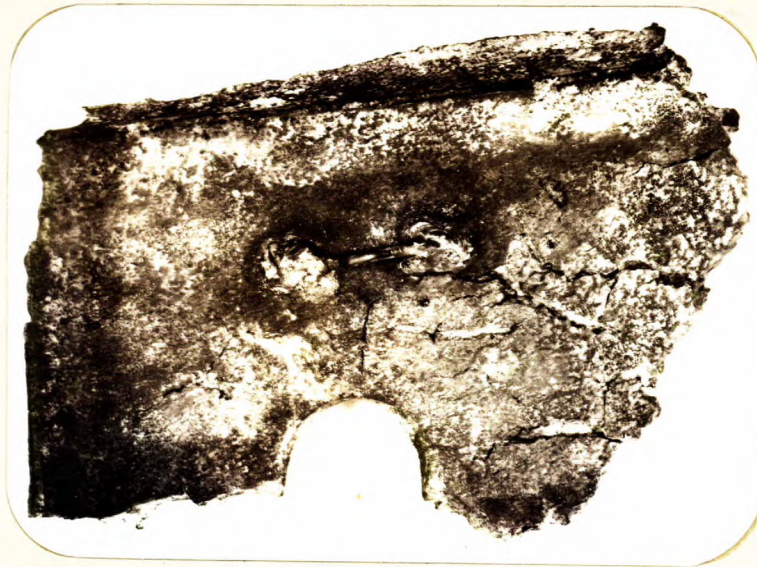
soaking time should be long enough to allow all the carbides to go into solution.

The detrimental influence of these carbides might have been the cause of failure of the material.

The relatively coarse grain size of the metal is an indication of a high pouring temperature. In order to refine the grain, it is recommended that the steel be poured at a temperature close to the melting point. It must be noted that an austenitic manganese steel cannot be grain-refined by heat treatment, because this steel has its first transformation point A_{c1} at temperatures much below 60° F. The transformation from γ to α , iron which is the basis of grain refining is absent in this case.

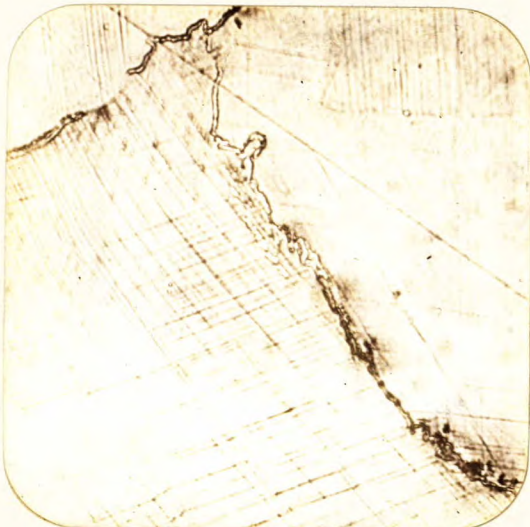
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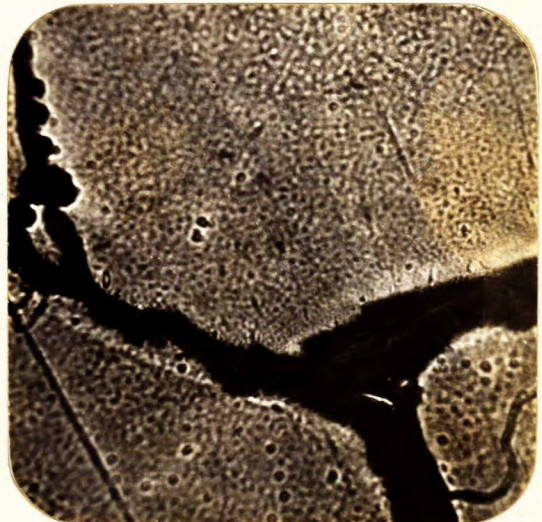
SAMPLE MARKED 1, IN THE 'AS RECEIVED' CONDITION.

Figure 2.



X500, nital etch.
FREE CARBIDES ON GRAIN
BOUNDARIES OF TWINNED AUSTENITE
IN SAMPLE MARKED 1.

Figure 3.



X500, nital etch.
INTERCRYSTALLINE FRACTURE OF
SAMPLE MARKED 1.

Figure 4.



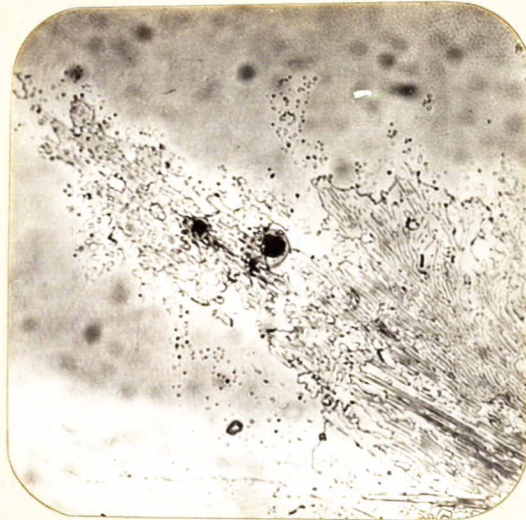
X100, nital etch.
ELONGATED CARBIDES IN
AUSTENITIC GROUNDMASS.
Note the absence of penetration of the
streaks on carbides. SAMPLE MARKED 2.

Figure 5.



X100, nital etch.
GENERAL STRUCTURE OF
SAMPLE MARKED 3.

Figure 6.



X500, nital etch.

SHOWING DISTRIBUTION OF CARBIDES
IN AUSTENITE (IN SAMPLE MARKED 3).

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