

O T T A W A

February 12, 1946.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2004.

Metallurgical Examination of Cracked Manganese
Steel Swing Hammer Casting.

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Origin of Material and Object of Investigation:

On December 11, 1945, a cracked manganese steel swing hammer casting (see Figure 1) was submitted, for metallurgical examination, by Lynn MacLeod Metallurgy Limited, Thetford Mines, Quebec, per W. K. MacLeod, President.

The covering letter, dated December 10, 1945, stated that the crack had developed in the mould. This statement was confirmed by a following letter dated January 8, 1946. Additional information was provided to the effect that the casting had been "annealed", that is, heated and then quenched.

It was requested that an opinion be expressed as to the cause of the failure.

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

Figure 1.MANGANESE STEEL SWING HAMMER
CRACKED IN THE MOULD.

(Approximately 3/5 actual size).

PROCEDURE:1. Visual Examination.

Visual examination revealed a very coarse, crystalline fracture.

2. Chemical Analysis.

In the following table the chemical analysis obtained is compared with the A.S.T.M. specification for austenitic manganese steel:

	<u>As Found</u>	<u>A.S.T.M. Spec.</u>
	- Per Cent -	
Carbon	1.34	1.00-1.40
Manganese	13.50	10.0-14.0
Silicon	0.84	0.25-1.0
Sulphur	Trace.	0.05 max.
Phosphorus	0.054	0.10 max.
Chromium	0.71	--

3. Microscopic Examination.

Figure 2, taken at X50 magnification, shows the huge grain size of the steel, indicating high pouring temperature. Note, also, microporosity.

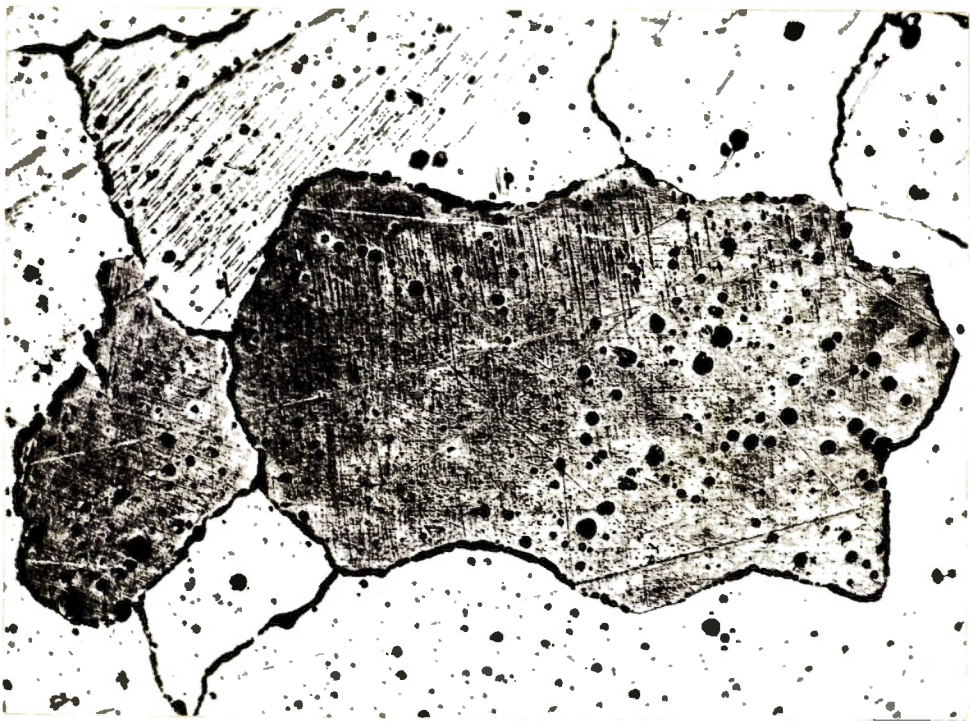
(Continued on next page)

(Procedure, cont'd) -

Figure 3, taken at X50 magnification, shows the intergranular nature of the cracks.

Figure 4, at X500 magnification, shows the presence of some carbides at the grain boundaries.

Figure 2.



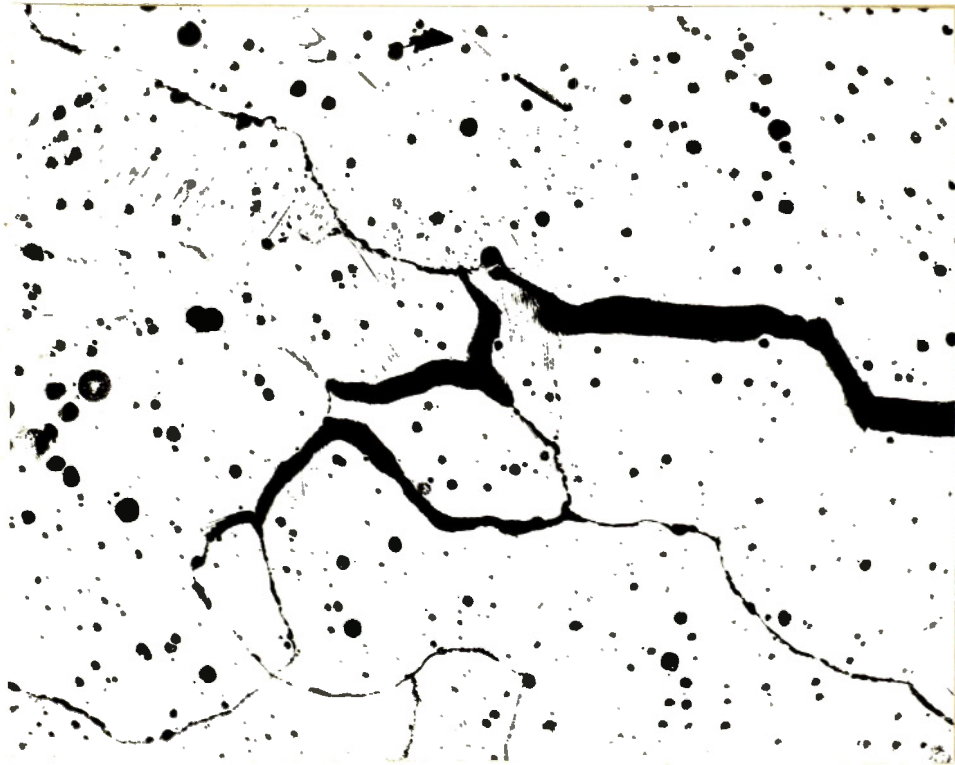
X50, nital etch.

Note large grain size, indicating excessively high pouring temperature. Note also microporosity.

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

(Procedure, cont'd) -

Figure 3.



X50, nital etch.

Note intergranular cracking.

Figure 4.



X500, nital etch.

Note presence of continuous carbides at the grain boundaries.

Discussion and Conclusions:

The results of the chemical examination indicate that the steel under examination falls within the normal limits (with the exception of the chromium content) of the A.S.T.M. specification for austenitic manganese steel.

According to some authorities the addition of chromium will have the effect of causing the steel to work-harden at lower loads. This would be an advantage in certain applications but would not necessarily result in improvement in services where heavy impact stresses are encountered.

The microscopic examination shows that the steel must have been poured at a very high temperature, as is evident from the very large grain size in Figures 2 and 3.

The temperature from which manganese steel is poured has a marked effect upon the strength of the castings. A high pouring temperature produces a coarse, crystalline structure (the casting under examination is a typical example), and this structure is not refined in the subsequent heat treatment because no phase change takes place.

According to the most reliable figures, manganese steel has a melting point of 2588° F. Small castings require considerable superheat and may be poured at temperatures up to 2800° or 2850° F. Heavier castings should be poured at temperatures slightly above the solidification point, to avoid the coarse structure and to prevent hot cracks and tears in the casting.

Because of the huge grain size, and because cracking was observed to have taken place in the mould, it may be safely concluded that cracking had resulted from the excessively high pouring temperature employed. The intergranular nature of the cracks is clearly shown in Figure 3.

The presence of the continuous carbide phase at the

(Discussion and Conclusions, cont'd) -

grain boundaries (see Figure 4) must have resulted from either of two conditions:

- (1) The quenching temperature was not high enough to permit complete solution of the carbides.
- (2) The quenching rate was not fast enough to retain the carbides in solution.

Whatever the reason, their presence would result in an embrittled steel and may have been a contributing cause of failure. This condition may be minimized by reducing the carbon content.

Recommendations:

In order to prevent a recurrence of this type of failure, it is recommended that the pouring temperature and heat treatment procedure be more carefully controlled.

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