O T T A W A February 14, 1946.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2005.

Metallurgical Examination of Austenitic Steel
Sample from Mantle of a Symons Cone Crusher.

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(Copy No. 3.)

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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Origin of Material and Object of Investigation:

On January 12, 1946, a piece of austenitic manganese steel casting (see Figure 1), cut from the mantle of a Symons $5\frac{1}{2}$-ft. Short Head Cone Crusher, was submitted by the Sorel Steel Foundries Limited, Sorel, Quebec, per H. M. Brownrigg, Metallurgist.

The covering letter, dated January 10, 1946, stated that the mantle had been removed, broken in three places, after 37 per cent normal service life. A complete metallurgical examination was requested in order to determine the cause of the failure.

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

Figure 1.

SAMPLE OF AUSTENITIC STEEL CUT FROM
MANTLE OF SYMONS CONE CRUSHER.

(Dimensions, 4 in. x 4 in. x 2 in.).

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PROCEDURE:

1. Chemical Examination.

The results of the chemical examination are compared in the following table, with A.S.T.M. specifications for austenitic manganese steel:

	As Found	A.S.T.M. Specification
	- Per	Cent -
Carbon -	1.59	1.00-1.40
Manganese -	11.84	10.0-14.0
Silicon -	1.33	0.25-1.0
Phosphorus -	0.025	0.10 max.
Sulphur -	0.010	0.05 "
Chromium -	1.25	--

2. Hardness Tests.

Hardness readings were taken on the sample submitted and it was found to average 22 Rockwell "C". No appreciable work hardness was evident.

3. Heat-treating Experiment.

A sample of the steel submitted was heated to 1900° F. for 1 hour and quenched in water.

(Procedure, cont'd) -

4. Microscopic Examination.

Figures 2 and 3, taken at X100 and X500 respectively, show the microstructure of the steel as submitted. Large quantities of brittle carbides are evident at the grain boundaries.

Figures 4 and 5, taken at X100 and X500 respectively, show the microstructure after the heat treatment described in (4). It will be noticed that the carbides are still evident, although in smaller quantities.

DISCUSSION AND CONCLUSIONS:

The results of the chemical analysis indicate that both the carbon and silicon contents of the steel are higher than called for by the A.S.T.M. specifications. In addition, the steel contains 1.25 per cent chromium.

It has been found that no appreciable effect is produced upon the physical properties by varying the silicon content from 0.3 to 1.0 per cent. If, however, the silicon is greater than 1 per cent (in this case it is 1.33 per cent), then the steel becomes embrittled.

The maximum carbon content specified for austenitic manganese steel is 1.40 per cent. If the carbon content is increased beyond this figure, a brittle carbide is formed which comes out at the grain boundaries and greatly decreases the toughness and strength of the steel.

Since the carbon content of the steel under examination was found to be 1.59 per cent, the presence of free carbides was to be expected. This is confirmed in Figures 2 and 3. It is quite certain, then, that the chief contributing factor to the premature failure of the steel is the high carbon content.

A small piece of the steel was reheated to 1900° F. and quenched in water, in an effort to dissolve the free

(Discussion and Conclusions, cont'd) -

carbides. It was found, however, that considerable quantities of free carbides persisted after this heat treatment (see Figures 4 and 5), thus indicating that the usual methods of heat treatment will not eliminate the carbides in austenitic manganese steels of this carbon content.

The presence of chromium in austenitic manganese steels is considered by some authorities to 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.

Summarizing, failure undoubtedly resulted from the presence of large quantities of free carbides caused by the high carbon content of the steel. Another contributing factor may have been the embrittling effect resulting from the high silicon content.

Recommendations:

In order to prevent similar failures it is recommended that the carbon content be kept within the range 1.00 to 1.40 per cent, and the silicon content 0.25 to 1.0 per cent.

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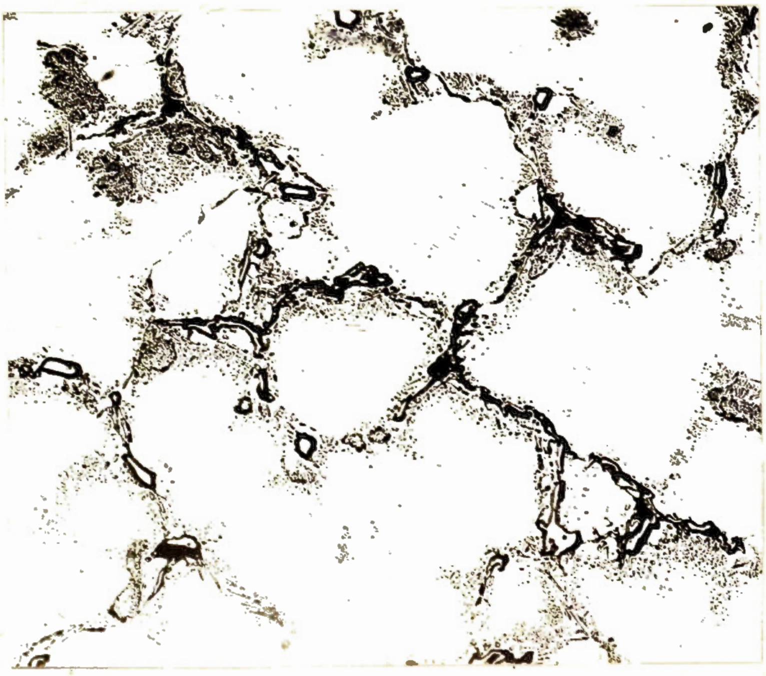
(Figures 2 to 5 follow,)
(on Pages 5 and 6.)

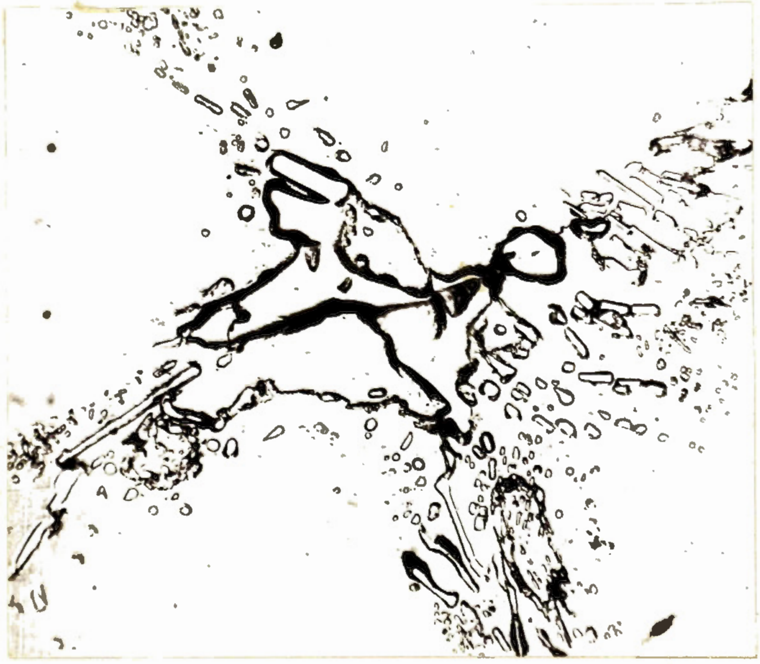
Figure 2.



X100, nital etch.

-

Figure 3.



X500, nital etch.

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STEEL AS RECEIVED, SHOWING FREE CARBIDES AT THE GRAIN BOUNDARIES.

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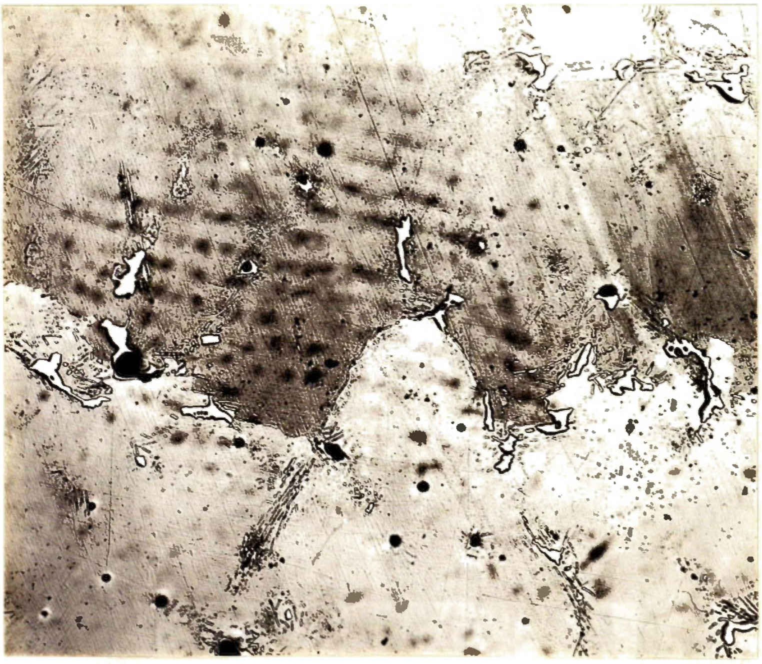
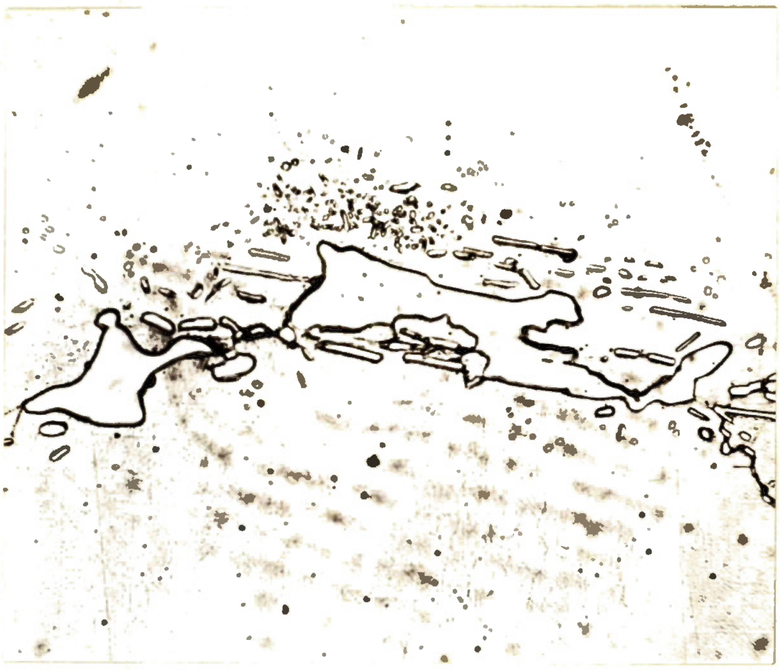
Figure 4.



X100, nital etch.

Figure 5.



X500, nital etch.

SMALL SECTION HEATED TO 1900° F.
AND QUENCHED IN WATER.

Note presence of large carbides still evident.

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