O T T A W A August 30th, 1941.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1080.

Examination of a Mark III Tank Manganese Steel Track Link.

BUREAU OF MINES
DIVISION OF METALLIC MINERALS
ORE DRESSING AND
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CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

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Origin of Material and Object of Investigation:

On August 25th, 1941, Mr. R. Boult, of the Inspection Board of the United Kingdom and Canada, Ottawa, Ontario, sent in a Mark III Tank track link for examination. The link was cast in manganese steel by the Manitoba Steel Foundries, Selkirk, Manitoba, and was a sample of their first batch. A full report as to soundness of material

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

and casting was requested in order to know the quality of the product.

Macro-Examination and X-Ray Examination:

The link appeared sound on the surface but a close examination revealed flaws,

1st, on the inside part of one of the end bearing holes, and

2nd, on one end of the central bearing portion, as shown in Figure 1.

This was confirmed by an X-ray examination made by L. W. Ball, of the National Research Council, Ottawa, reproduction of which is included here. Figure 2 shows the shrinkage cavities (lighter areas) on the central bearing and Figure 3 shows the defect on the end bearing hole.

Chemical Analysis:

The steel analysed as follows:

		Per cent
Carbon	-	1.17
Manganese	-	11.55
Phosphorus	-	0.042
Silicon	-	0.53
Sulphur	-	0.006
Chromium	-	1.13

Physical Tests:

Hardness Test -

The hardness of the steel, using the Vickers method with a 10-kilogram load, averaged 198 on various core sections.

Hammer Test -

Hammer test, i.e., crack-free deformation of the

(Physical Tests, cont'd) -

bearing hole to two-thirds of its original diameter under hammer blow: - Excellent.

Bend Test -

The bend test was made between rollers at 12-inch centres, the guide portion of the link being on the under side. The following results were obtained:

Maximum Load	Bend on Broken Part
18,600 pounds.	28°.

The deformation of the link under a given load is given in Figure 4. The break occurred on the point of the bearing where the presence of a shrinkage cavity has been revealed by X-ray. Figure 5 shows the extent of the shrinkage defect, which occupies the larger part of the fractured surface on this particular side of the link.

Microscopic Examination:

Figure 6 (magnification, X40) shows the dendritic formation of the flaw in the central bearing portion at the point of fracture. A sample was also cut on one of the bearings, given a metallographic polish, and etched in a solution of 2 per cent nitric acid in alcohol. Figure 7 (magnification, X100) shows the steel structure. It consists of grains of austenite (a solid solution of iron and carbon). There is no indication in that section of the presence of iron carbide, which would appear as white particles. The small dark particles within the grain boundaries are inclusions.

Discussion of Results:

The composition of the steel is within the specified limits. The manganese content, however, is rather on the low side and it might be advisable to raise it to about 12.5 to 13 per cent. The addition of 1 per cent chromium might increase the wear resistance by increasing the work hardenability of the steel.

The hardness of the steel is in the middle of the desired range, 180 to 220 Vickers.

No specification for physical requirements on the bend test is available; a series of determinations in our laboratories showed, however, that a sound casting possessing good toughness and ductility could withstand a load of 12 tons between 12-inch centres if made of properly treated manganese steel. The average bend is between 20 to 30 degrees as measured on the broken parts. In this case, the bend was therefore excellent.

The flaw extending more than two-thirds of the section on one side of the middle bearing portion would obviously reduce the strength of the link and would explain the low maximum load observed.

The microphotograph in Figure 7 reveals a structure practically free from iron carbide as a consequence of an adequate solution heat-treatment. The moderately small grains of austenite indicate that the pouring temperature was properly controlled. The steel contains a fair amount of inclusions and microshrinkage cavities.

Summary and Conclusions:

1. The metal is a good grade of austenitic steel and was given an adequate heat treatment.

2. The casting reveals large flaws especially on each end of the central bearing portion. These flaws are mainly shrinkage cavities which could be avoided, -

(a) by increasing the pressure of the hot metal in the mould by the use of a proper gate and riser;

(b) by using metal chills (fillets) in the mould so as to displace the shrinkage cavities to a point where the hot metal would flow more easily (i.e., approximately $\frac{1}{2}$ inch from present shrinkage cavity on each end of the central bearing portion).

3. The hardness and the ductility of the material are good. The strength of the casting, however, is lowered by the flaws just mentioned above.

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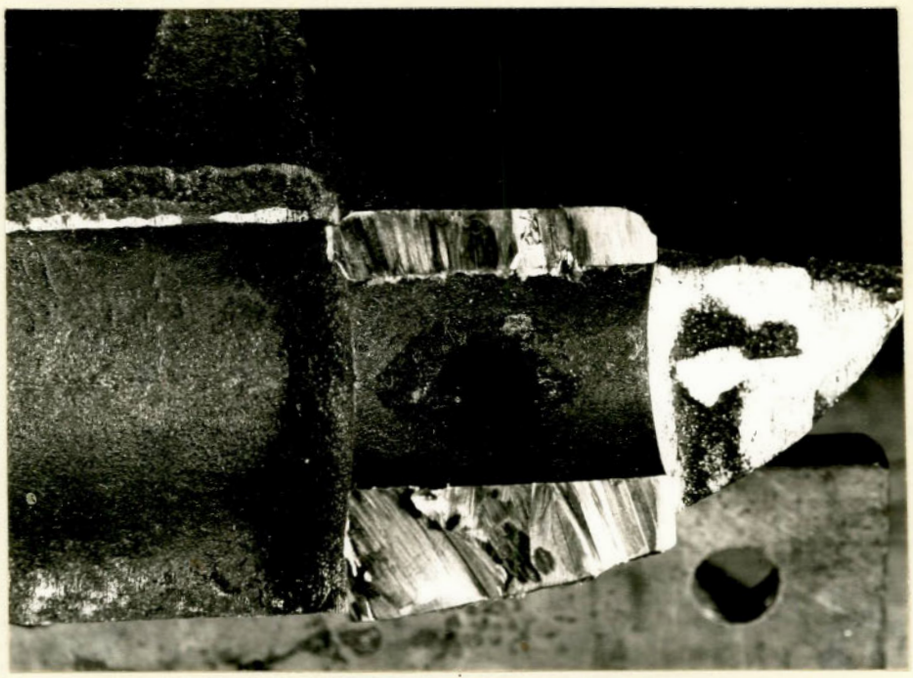
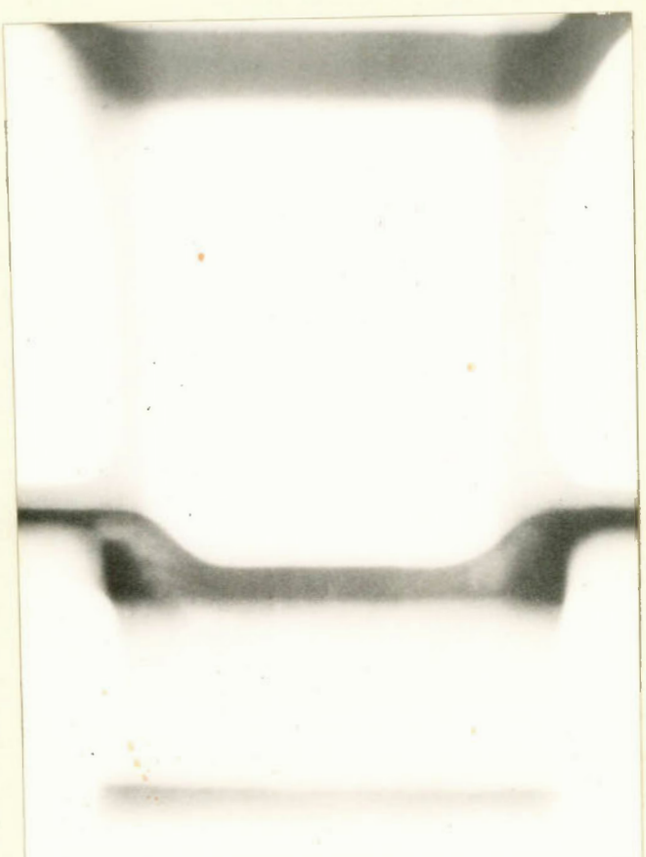
Figure 1.



Flaw on End of Bearing Hole.
(Approximately to size)

Figure 2.

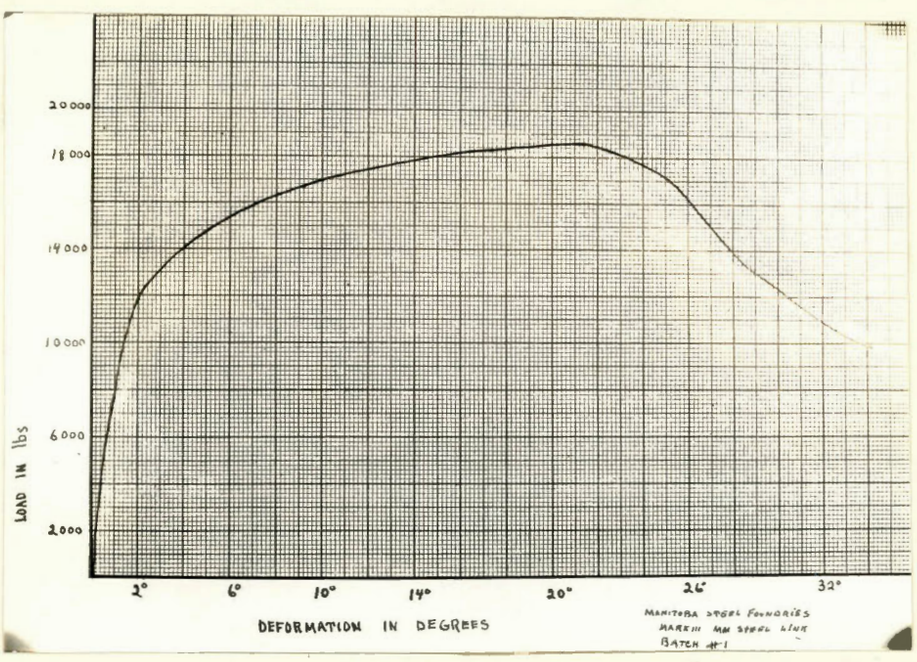


X-Ray of Middle Portion of Link.

Figure 3

X-ray of End Portion of Link.

Figure 4.

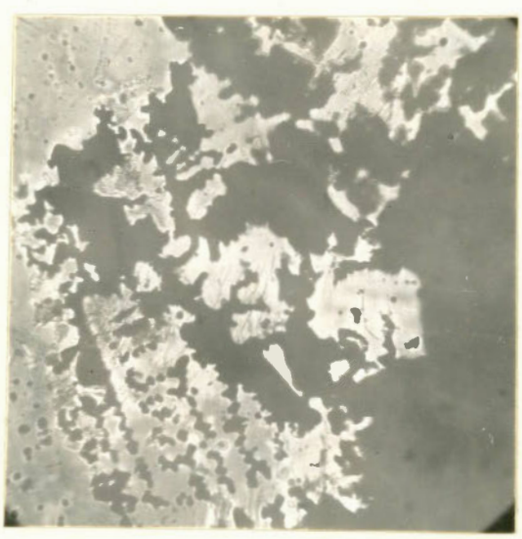


Deformation, Under a Given Load,
of Link Between 12-inch Centres.

Figure 5.

Shrinkage Cavity at Fracture.
(Approximately ½ size)

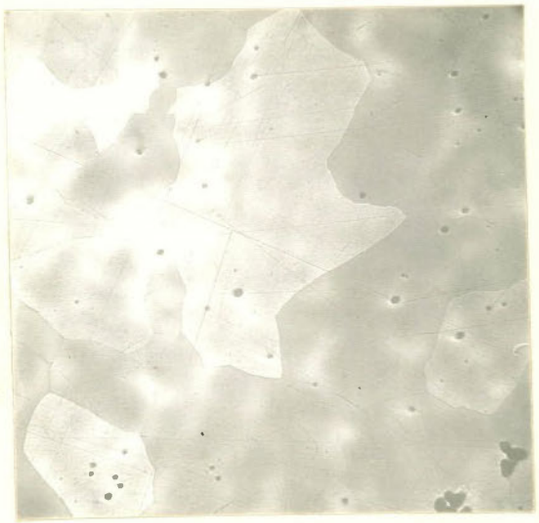
Figure 6.



X40.

Portion of Shrinkage Cavity,
Showing Dendritic Formation.

Figure 7.



X100, nital etch.

Steel Structure of Link.

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