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O T T A W A November 4th, 1942.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1320.

Examination of a High Manganese Steel
Valentine Tank Track Link.

(Copy No. 10.)

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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Examination of a High Manganese Steel Valentine Tank Track Link.

Origin of Material and Object of Investigation:

On October 19th, 1942, under requisition O.T. 3271, the Inspection Board of United Kingdom and Canada, Ottawa, Ontario, submitted a Valentine tank track link for examination. It was reported that the link was produced by a new source according to Specification DTD 9B. This specification demands that the casting be made out of a high manganese steel.

Macro-Examination:

Several parts of the link surface were in a pitted condition, the diameter of the pits being approximately 1/16 inch. Figure 1, showing the inner wall of the third eye-hole on the three-eye side of the link, illustrates the surface condition and also shows the presence of an exposed chill. This chill has evidently not been taken up by the metal.

Figure 1.

INNER WALL OF EYE-HOLE.
(Approximately to size).

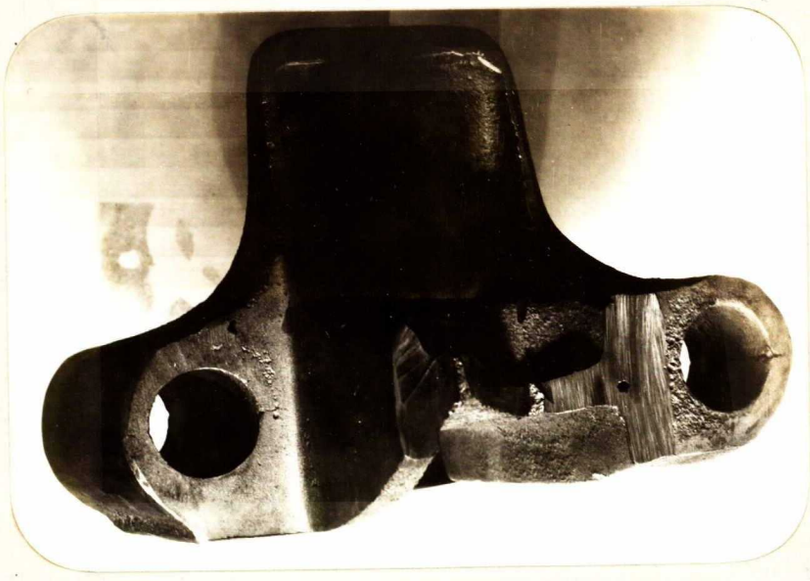
X-Ray Examination:

An X-ray examination of the link was made by Dr. G. C. Laurence, of the National Research Council, Ottawa. Cavities were found at the connections of the eye-holes to the main section of the link on the three-eye side of the link. Figures 2 and 3 show one of these cavities. The opening shown at the right in Figure 2 is 1/8 inch in diameter. Figure 3 shows the size of this cavity after some of the

(X-Ray Examination, cont'd) -

enclosing metal has been ground off.

Figure 2.



OPENING OF SHRINKAGE CAVITY.
(Approximately to size).

Figure 3.

"SHRINKAGE" CAVITY.
(Approximately to size).

Chemical Analysis:

		As Found	Specification DTD 9B
		- Per cent -	
Carbon	=	1.24	1.00 - 1.50
Manganese	=	12.89	11.00 minimum
Silicon	=	0.50	1.00 max.
Sulphur	=	0.008	0.06 max.
Phosphorus	=	0.061	0.10 max.

Hardness:

A cross-section was cut from the centre eye of the three-eye side of the link. Hardness readings were taken on the face of this section, about 0.10 inch apart. The Vickers hardness machine and a 10-kilogram load were used. The values obtained, translated into terms of Brinell hardness numbers (using the A.M.S. handbook), are shown below:

(Brinell Hardness)

191
175
197
206
225
185

Readings taken on the surface of the link, using the Brinell machine, gave an average of 185.

Magnetic Test:

A horseshoe magnet was used to test the magnetic properties of the link. It was only very slightly magnetic.

Microscopic Examination:

Several specimens were cut from the link, polished, etched in nital, and examined under the microscope. Figure 4, taken at X100 magnification, illustrates the structure of the link.

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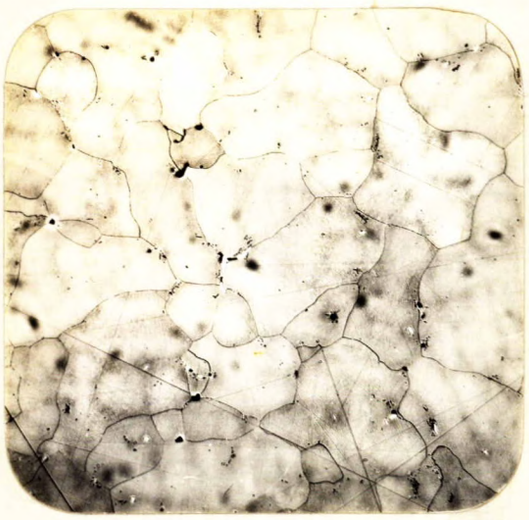
(Microscopic Examination, cont'd) -

Figure 4.



X100, nital etch.

STRUCTURE OF LINK.

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Discussion:

The pitted surface is probably due to gas. The gas may be caused by:

(1) A poorly baked core.
(2) A poorly vented core.
(3) The core wash.

Instruments are now available whereby the gas volume per c.c. of core can be measured. This volume should be kept to a minimum.

Cavities are present but at points where they should not seriously affect the strength of the link. The cavity shown in Figure 3 is of the "shrinkage" type. Elimination of this type of cavity can be effected, however, by a change in the technique, such as,

(1) Gating so as to supply hot liquid metal under pressure to the section while it is solidifying; or,

(2) Using metal chills in the mould so as to move the shrinkage to a point where Method (1) may be applied more easily.

(Continued on next page)

(Discussion, cont'd) -

The chemical analysis and hardness values are within the specification limits.

The austenitic grain size shown in Figure 4 indicates that the steel was poured close to the lower limit of the temperature range for high manganese steel. The absence of free carbides shows that the casting has been properly heat treated.

CONCLUSIONS:

1. Parts of the surface of the link are pitted.

2. Shrinkage cavities are present but should not seriously affect the strength of the shoe.

3. The chemical analysis is within the specification limits.

4. A satisfactory hardness has been obtained.

5. The link has been properly heat treated.

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SLG:GHB.

CONCLUSIONS:

A close examination of the D. F. & S. ballistic limit data, as shown on Charts Nos. 1 to 4, leads to the following conclusions:

1. Production ballistic limits have shifted upwards in the first half of 1942 to a higher quality level.

2. Accuracy of central values and control limits increases with the number of groups recorded. Considering the small amount of data, the differences in the control charts are not significant. All material, therefore, is from a common source.

3. The consistent quality of the armour plate may be due to -

characteristic of test piece,
ballistic testing technique,
projectile,
melting furnace,
heat treating technique,
hardenability,

one or more of which may be a constant controlling factor.

4. The experimental work done has not markedly affected quality. Wide variations in alloy content, therefore, seem to have little effect on armour quality. Hardenability of steel should be correlated with ballistic limit in order to see if it is an important factor.

5. Since ballistic limit is under statistical control, the risk of accepting defective plate is small. The policy of U. S. Ordnance could be adopted and considerable saving could be effected by the reduction in the number of plates destroyed by testing.

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HHF:GHB.