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OTTAWA June 1st, 1943.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1416.

Examination of Canadian Dry Pin Track Links.

(Copy No. 18)

Bureau of Mines
Division of Metallic Minerals
-
Ore Dressing and Metallurgical Laboratories

CANADA

DEPARTMENT OF MINES AND RESOURCES

Mines and Geology Branch

O T T A W A   June 1st, 1943.

R E P O R T

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Origin of Material and Object of Investigation:

Dr. C. W. Drury, Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario, requested verbally during May, 1943, that an examination be carried out on the Canadian Dry Pin Track links. It was thought that bend tests should be applied to a series of links obtained from the manufacturers and thus determine the limits to be expected in normal operation. Unfortunately, none of the manufacturers was in production. Hull Iron and Steel Foundries Limited, Hull, Quebec, however, were able to submit a number of shoes from experimental heats which they were casting. The regular production pattern was

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

used in the manufacture of these links. Two shoes made from experimental patterns were also obtained from Fahralloy Limited, Orillia, Ontario.

Mr. Beament General Manager of Fahralloy Limited, emphasized that these links were very experimental in nature and should not be considered as an indication of the quality of Fahralloy production links. This, of course, is also true of Hull Iron and Steel links.

Chemical Analysis:

The chemical analysis of the Fahralloy shoes was:

		Per cent
Carbon	-	0.96
Manganese	-	12.37
Silicon	-	0.77
Phosphorus	-	0.044
Sulphur	-	0.007

The chemical analysis of the heats from which the Hull shoes tested were taken were reported as follows:[@]

		Heat No. 5580	Heat No. 5590	Heat No. 5591	Heat No. 5592
Carbon	-	1.12	1.16	1.30	1.21
Manganese	-	12.37	11.15	12.0	12.17
Phosphorus	-	0.056	0.060	0.078	0.057
Sulphur	-	0.032	0.027	0.014	0.026
Silicon	-	0.42	0.43	0.35	0.49

@ Analysed at Hull Iron and Steel Foundries Limited.

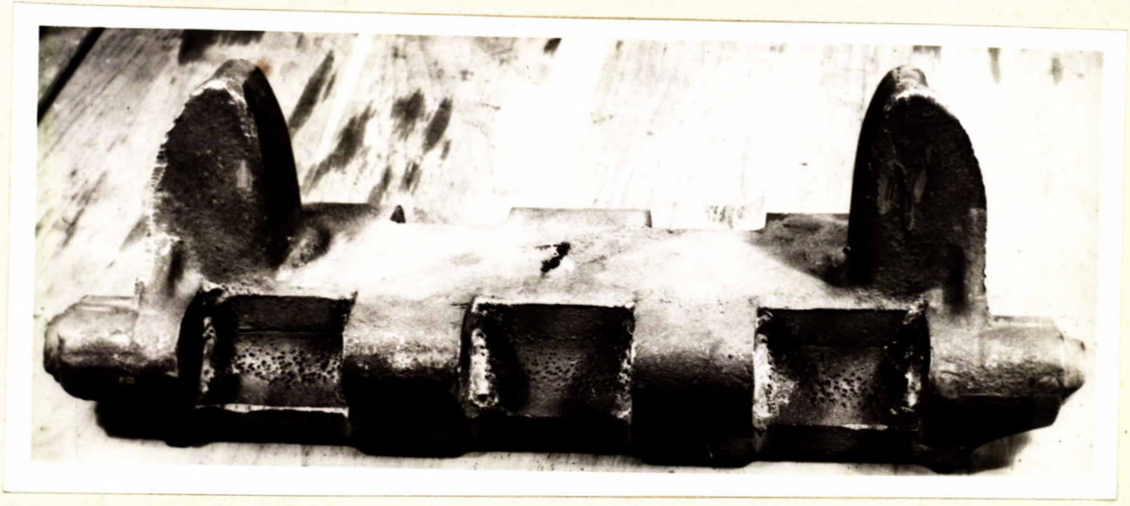
Macro-Examination:

The Fahralloy shoes indicated that they had been welded at the juncture of the eye-hole bearings and the main body of the shoe. Figure 1 illustrates this feature.

(Continued on next page)

(Macro-Examination, cont'd) -

Figure 1.



FAHRALLOY SHOE.

(Approximately ½ size).

X-Ray Examination:

X-ray photographs were taken at the National Research Council. The Hull shoes indicated that cavities were present in the main body of the shoes. The outside walls of the eye-holes were free from impurities or cavities of the size that would be detected by X-ray examination. The Fahralloy shoes had impurities and spongy metal in the eye-hole walls. Some shrinkage cavities were also noted towards the main body of the shoes.

Bend Tests:

Table I lists the results obtained on the bend tests. The Amsler Universal machine was used, along with 8-inch centres and a 2-inch-radius bending block.

Table I.

Service		Weight, in pounds	Load at first crack, pounds	Load at failure, pounds	Angle at failure	Brinell hardness
Fahralloy	-	18.3	55,000	76,000	40.5°	205
Hull	-	20.5	54,500	80,750	47°	
"	-	21	53,000	92,000	60°	
"	-	19.5	51,500	99,500	50°	
"	-	-	48,000	96,000	72°	
"	-	20	57,000	81,000	68°	
"	-	-	62,000	90,000	34°	223
"	-	21	60,000	86,000	59°	
"	-	20	48,500	64,000	44°	
"	-	20	50,000	82,000	60°	
Hull (As Cast)	-		36,000	42,500	4.5°	204
Hull, heat treated at O.D.M.L.*	-	20	48,500	79,000	53°	223
Hull, heat treated at O.D.M.L.**	-	20.75	42,500	72,500	49°	217

* Shoe was cast at Hull. The heat treatment was carried out in these Laboratories: 1900° F. for 2½ hours, cooled in air to about 1600° F., then water-quenched.

** Shoe was cast at Hull. The heat treatment was as follows: Heated at 1900° F. for 1 hour then water-quenched.

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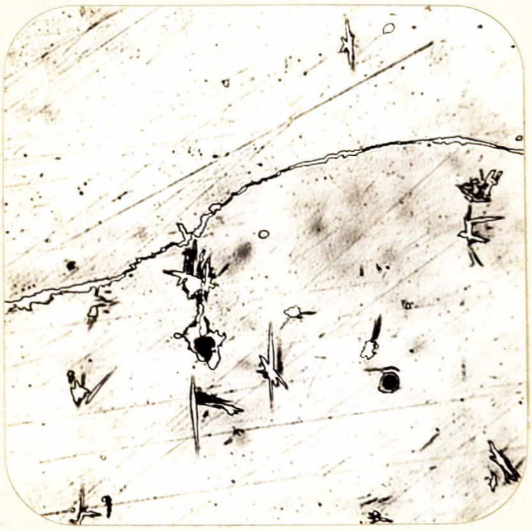
Microscopic Examination:

Samples taken from a number of links were polished and etched in nital. Figure 2 illustrates the 'as cast' structure. Figures 3 and 4 are the structures of Fahralloy and Hull heat-treated shoes, respectively. Figure 5 illustrates the carbide obtained by an insufficient soak at quenching temperature (1 hour at 1900° F). Figure 6 shows the structure of the weld metal with the austenitic manganese steel in the Fahralloy link. The intermediate structure was non-austenitic. Figure 7, taken at 500 diameters, illustrates carbides both at the grain

(Microscopic Examination, cont'd) -

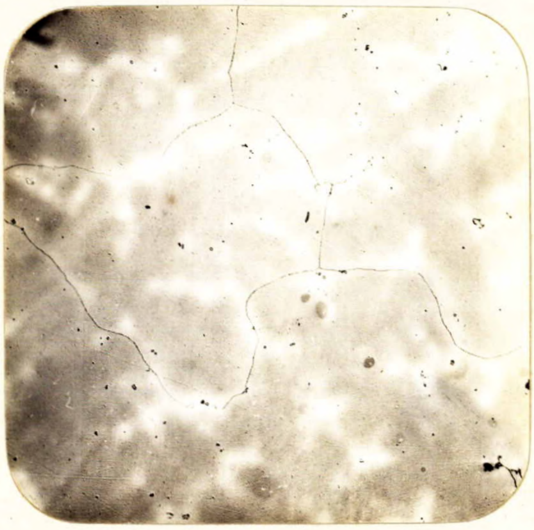
boundaries and in the austenite grains.

Figure 2.



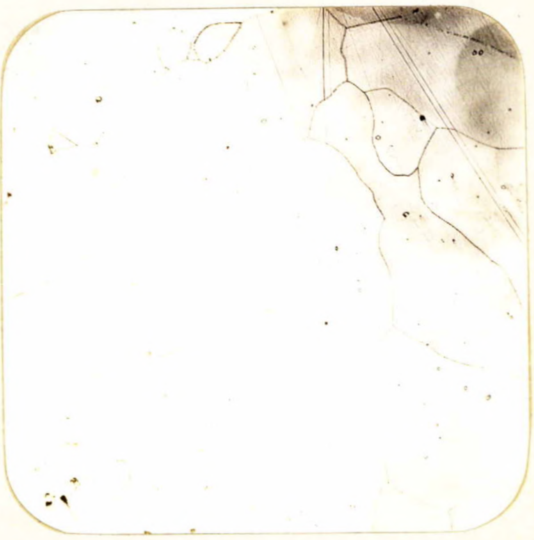
X250, nital etch.
"AS CAST" STRUCTURE.

Figure 3.



X100, nital etch.
STRUCTURE OF FAHRALLOY LINK.

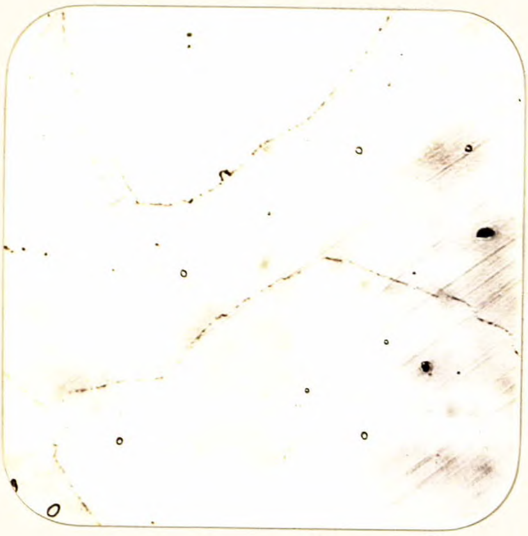
Figure 4.



X100, nital etch.
STRUCTURE OF HULL LINK.

(Microscopic Examination, cont'd) -

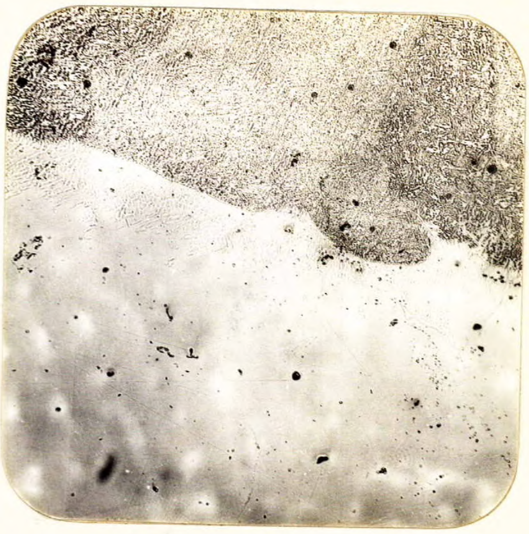
Figure 5.



X250, nital etch.

Note: Heated at 1900° F. for 1 hour and then water-quenched.

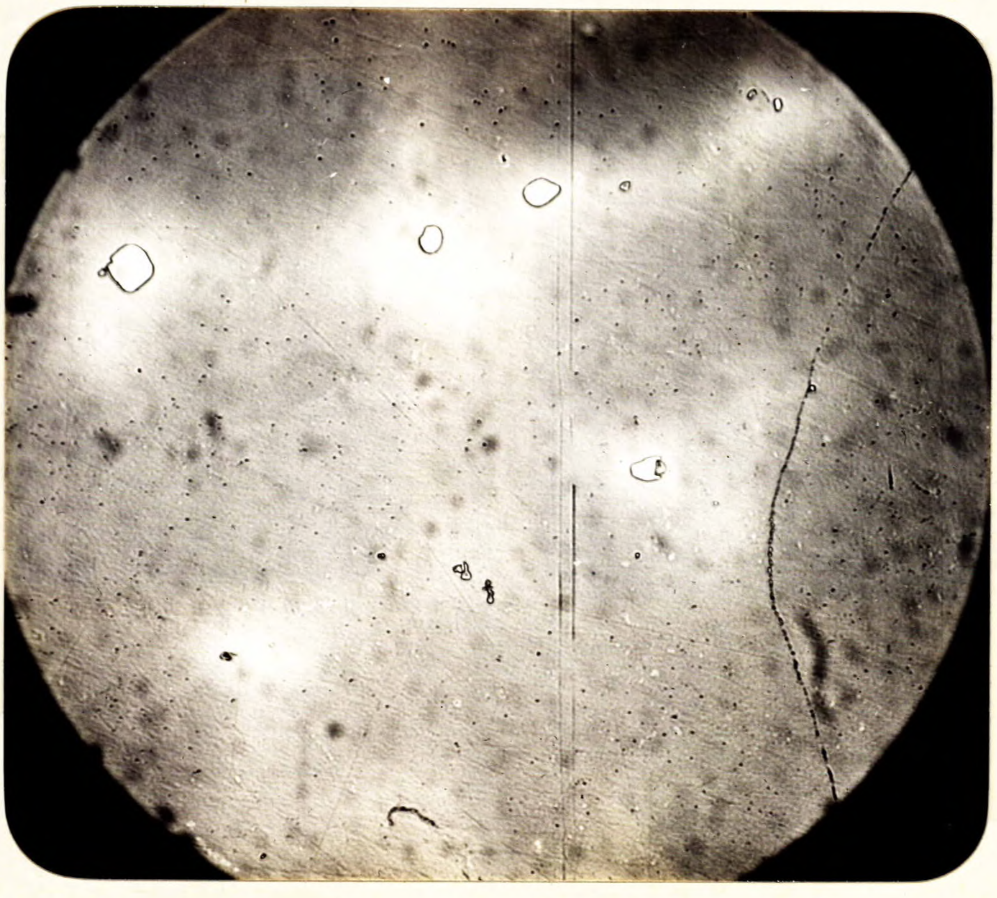
Figure 6.



X100, nital etch.

JUNCTURE OF WELD.

Figure 7.



X500, nital etch.

CARBIDES.

Note carbides both in the austenitic grains and at the grain boundaries.

DISCUSSION:

It must be remembered that the links obtained from both Hull and Fahralloy were experimental, merely preparatory links, poured mainly to develop casting technique, etc. The points brought out in this report should serve only as guides to assist further foundry trials.

At a meeting called by the Army Engineering Design Branch of the Department of Munitions and Supply, held in Ottawa on Friday, May 21st, it was decided that the carbon range accepted should be 1.0 to 1.4 per cent. This would fail an 0.96-carbon-content link. It is expected that in the near future figures will be obtained showing the effect of various carbon contents, both below and above 1.0 per cent. If no serious effect is created by carbons being below 1.0 per cent, the lower carbon limit specified should be extended.

At this meeting it was also decided to limit welding to the upper half-inch of the guide lugs. This is proper, since at the weld the strength is only 50 to 60 per cent of that of the unwelded austenitic manganese steel. Should welding be permitted at a highly stressed point in the link, it can be seen that failure might result. In welding the unstressed portion of the link steel, the type of welding rod used would not appear to be important, and the use of the 3 to 5 per cent nickel, 13-15 per cent manganese and 0.60 to 0.80 per cent carbon rod, which is generally recommended for welding austenitic manganese steel, would not appear to be necessary.

In the track link it is extremely important that the eye-hole walls be of solid metal. Defects in these sections would be dangerous. Consequently, foundry practice should be so designed as to avoid shrinks or dirty metal segregations in

(Discussion, cont'd) -

those very important sections. It is felt that once this has been achieved, the bend test is significant, as it is a measure of the strength and ductility of the centre of the casting--a section where the shrinks are now most likely to occur.

It is felt that the load at failure should be the significant feature in the bend test. The Hull heat-treated links vary from 64,000 to 99,500 pounds. A variation in the weight of the Hull links is also observed; the range is 19.5 to 21 pounds. Once production technique has been standardized the range should be narrowed down somewhat. The Fahralloy shoe is much lighter than any of the Hull shoes. The grouser and webbed sections of the Fahralloy shoes were of smaller dimensions than those from Hull. It would appear, from the results shown in Table I, that lower figures were obtained for the links that were purposely heat-treated to produce free carbides. The difference, however, is not large enough to be significant. The "as cast" shoe without heat treatment, however, does give a significantly low figure.

A representative sample should be taken from each producer and checked periodically for free carbide precipitation. This would act as a check on heat treatment. Free carbides in the grains are not so serious as those precipitating at the grain boundaries. These latter should be eliminated entirely.

The Fahralloy shoe was evidently welded with a ferritic rod.

CONCLUSIONS:

1. The Fahralloy shoes contain 0.96 per cent carbon. This is below the specified minimum but whether or not this deviation is of importance has not as yet been determined.

2. The strength of a weld on high-manganese steel is 50 to 60 per cent that of the unwelded metal; consequently, highly stressed sections of the shoe should not be welded.

3. The eye-hole walls should be free from shrinks or impurities.

4. Not enough results have been obtained to set a minimum load figure on the bend test.

5. The weight of the Hull shoes vary from 19.5 to 21 pounds. The two Fahralloy shoes weighed 18.5 and 18.3 pounds respectively.

6. Free carbides at the grain boundaries embrittle the steel. A check should be made microscopically to ensure satisfactory heat treatment from all the producers. This might be checked on periodically.

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SLG:GHB.