OTTAWA April 10th, 1942.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1200.

Report on Malleable Iron Universal
Carrier Track Links.

(Copy No. 67.)

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   April 10th, 1942.

R E P O R T

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Preliminary:

In our Report of Investigation No. 1075, dated September 25th, 1941, on Malleable Iron Universal Carrier Track Links, various methods of heat treatment for malleable iron are described.

One of the methods outlined consists of an austempering treatment. The laboratory tests were considered sufficiently good to warrant a field trial. Four hundred

(Preliminary, cont'd) -

(400) Universal Carrier links, enough for a complete track, were therefore cast by the International Harvester Company Limited, Hamilton, Ontario, and on receipt at our Laboratories were given this austempering heat treatment. They were then returned to the International Harvester Company Limited, to be submitted to field tests.

On March 30th, 1942, a communication was received from Major C. W. Jones, Assistant Director of Inspection(d), for Inspector General, Inspection Board of the United Kingdom and Canada, 58 Lyon Street, Ottawa, Ontario, informing us that the track mentioned above had been tested at Kapuskasing, Ontario, and a preliminary report had been sent by telegram awaiting final report on completion of the trial. A copy of the telegram follows:

"KAPUSKASING ONT MAR 13, 1942.

MAJOR MAX EVANS
BLDG NO. 4
DEPARTMENT OF MUNITIONS AND SUPPLY
OTTAWA, ONT.

BLACKHEART TRACK ONE LINK BROKEN SIX HUNDRED FORTY NINE MILES STOP REMOVED ONE LINK FROM EACH TRACK SIX HUNDRED FIFTY SEVEN MILES TO TAKE UP STRETCH STOP LINKS BROKEN AT 4336 MILES TRACKS REMOVED LINKS WORN THROUGH TO PINS STOP TRACK VERY SATISFACTORY IN EVERY WAY STOP MORE MILEAGE WITH LESS BREAKAGE THAN OTHER TRACKS.

STEEL" (Capt.)

Data on Heat Treatment:

Since the performance of these links is considered "very satisfactory," all the following data on the heat treatment, including some discussion of the method, have been compiled from Report of Investigation No. 1075, in which various heat treatment methods were described:

(Data on Heat Treatment, cont'd) -

General Data:[@]

Since the major proportion of the tests were made by heating the casting in cyanide and cooling it in oil, data were obtained on the heating time in cyanide and cooling time in oil. The following was recorded, the Universal Carrier link being immersed in a bath of sufficient capacity to affect very little the temperature of the whole mass and the thermocouple being placed 1/16 in. below the surface of a clean malleable iron link:

- Heating in Cyanide -

Time, in seconds		Temperature, in degrees Fahr.
0	-	80
15	-	458
30	-	965
45	-	1330
60	-	1375
75	-	1410
90	-	1419
105	-	1421
120	-	1427
135	-	1433
150	-	1443
165(secs.)	-	--

Discussion:[@@]

The relative merits of each of these different methods cannot be discussed without first examining the relationship between wear and structural condition. Wear resistance is not always a direct function of hardness.

I. For straight abrasive wear, the highese possible hardness (as measured by the Vickers method) will give the longest life. In this case, a nitrided surface will give best service.

II. When, however, resistance to abrasion is needed under highly stressed conditions, a certain ductility is

@ From Report of Investigation No. 1075, p. 11.
@@ " " " " " " , p. 21.

(Discussion, cont'd) -

required, even at the expense of high hardness. In this latter case, as when, for instance, parts must withstand considerable battering (as would track links), the structural conditions of the surface will become the most important factor governing wear. The austenitic structure has proven to be an ideal wear-resisting structure. Graphite and temper carbon particles also are known to prolong the wear. This might be a point in favour of using a blackheart malleable link annealed in a neutral or slightly carburizing atmosphere and austempered from a cyaniding bath to harden and toughen the structure.

Austempering of Blackheart Malleable:*

The austempering treatment of properly annealed malleable iron produces remarkable toughness at the weakest points of the link, i.e., at the eye and guide portions. The tread portion, however, does not gain much by this treatment; its structure still has only average strength and ductility. The impact value is increased, however. The core hardness of the eye portion can be improved by the austempering treatment, to 300-325 Vickers, without loss of ductility. In fact, as shown in Figures 1 and 2, a considerable increase over the usual bend obtained was noticeable in the hammer test. The combination of toughness and hardness observed at the eye portion would result in decreasing the wear and the stretch of the link assembly.

As the increase in toughness at the eye portion of the link might not warrant the loss of ductility in the tread portion, it was felt that a trial in the field would give the real merit of the austempering treatment. Four hundred links were cast and annealed by the International

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* From Report of Investigation No. 1075, p. 23.

(Austempering of Blackheart Malleable, cont'd) -

Harvester Company of Canada Limited and sent for treatment to the Bureau of Mines, at Ottawa. Unfortunately, the links had been decarburized during the annealing operation, leaving a skin of low carbon content.

However, as much pearlite was visible under the microscope in the core of the links as received, the links were given a slow annealing in a carburizing atmosphere in order to free them of any excessive pearlite. The hardness on the core after this treatment averaged 115 to 120 Vickers.

The heat-treatment was as follows: 30 minutes in cyanide at 1400-1450° F.; quench in a salt mixture at 600-650° F. for 30 minutes. It was found that this treatment was very simple and could be made practicable on a large scale. Furthermore, this treatment is rapid and would probably mean a large heat-treating capacity with very little equipment. For typical results obtained, see Method V-2a (on Page 6).

A microphotograph at 3,000 magnification, Figure 3, reveals the bainite structure of a section from the eye portion, some darker areas of untransformed fine pearlite, and a portion of a temper carbon particle (large dark spot). It was noticed, however, that a fair amount of ferrite was still present between the austempered structures of the case and core. If the annealing process of blackheart malleable were done in a properly controlled atmosphere, a higher-carbon surface would likely be obtained (by decreasing the CO_2-to-CO ratio according to temperature or by using an atmosphere rich in hydrocarbons), which would result in a more homogeneous structure of the surface and core.

Method V. - Austempering of Blackheart Malleable.[⊕⊕]

A mixture of salt, consisting mainly of sodium hydroxide, potassium hydroxide and sodium carbonate, was used in order to obtain a medium the cooling rate of which would be intermediate between water and quenching oil at a temperature range of 1400° F. It was found that the quenching in the above medium was accomplished without any trouble. In fact, the operation was much easier than oil-quenching; with proper care, no splashing, no smoke, no foaming occurred. Even at 550° F., the bath is very fluid. The quenched articles come out of the bath clean and the mechanical losses are reduced to a minimum-- a loss of only about 3 pounds was experienced during the treatment of more than 350 links, i.e. nearly a thousand pounds of small castings. After the quench, the small amount of salt left on the casting is washed away in water.

A number of tests were made in order to find the austempering treatment which would give a tougher structure to the well annealed link and at the same time keep the surface at a sufficient hardness.

The following data were obtained: (The treatment comproses only a direct quench from cyanide into the salt bath. Hardness readings are given in Vickers, with a 30-kilogram load) -

2. a) 34 minutes in cyanide at 1400° F. Quenched into salt at 600° F. for 30 minutes.

Hammer test[⊕]: excellent.

Hardness:	Surface, on eye portion:	321-305.
	Core, on eye section:	295-325.
	" , on tread " :	270-295.
Maximum load, in pounds:	-- 13,700	13,100
Bend: --	-- 6 degrees	5 degrees

Impact test (no notch) on a 0.350 inch square bar = 21 ft.lb.

⊕ This test consists in flattening with a heavy hammer the bearing portion at the eye section until a certain deformation is obtained without cracking. A flattening reducing by at least one-third the distance between the inner surfaces at the top and bottom of the hole is considered satisfactory.

⊕⊕ From Report of Investigation No. 1075, p. 17.

SUMMARY:

Various methods of heat-treating malleable iron, used in connection with Universal Carrier track links, have been developed in order to combine strength, ductility, and wear resistance, required under highly abrasive and stressed conditions.

In the present report, one of these methods is described in which the casting, after being annealed in a neutral or carburizing atmosphere, is austempered. The various possibilities of this new method are discussed and the final preliminary report of field trial is given.

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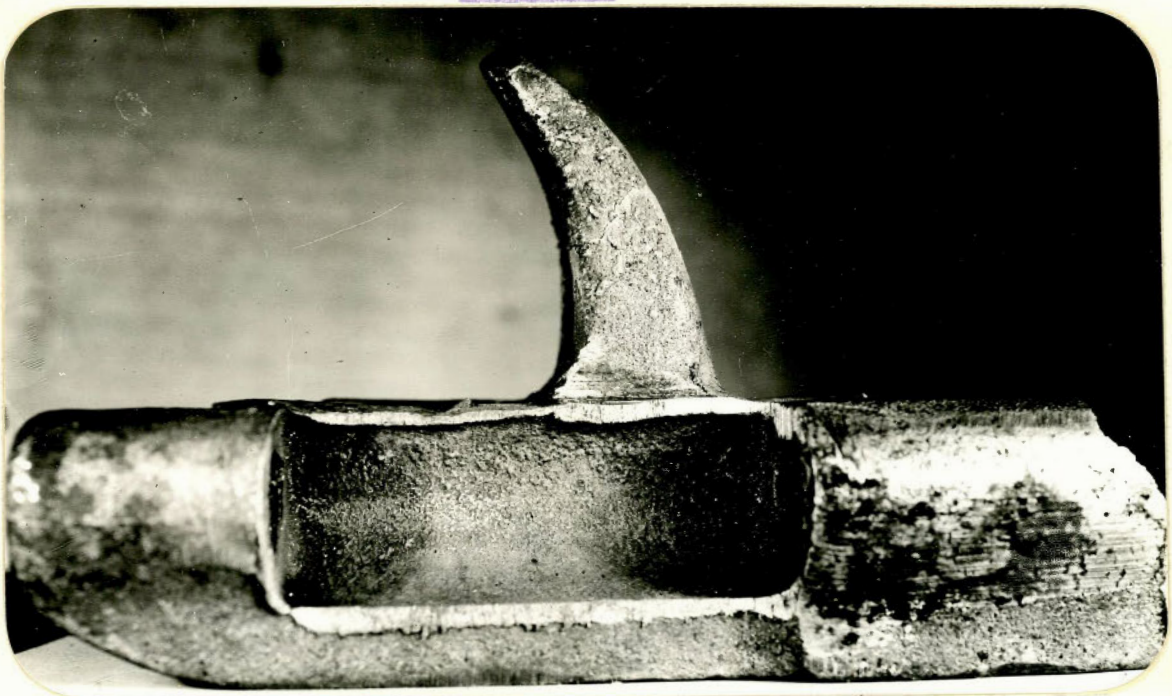
RP:PES.

Figure 1.



Deformation obtained on guide portion of link austempered from 1400°-1450° F. in salt at 600° F. for 30 minutes. (Natural size).

Figure 2.

Deformation obtained on eye portion on same link as shown in Figure 1.

Magnification: 1½ times natural size.

Figure 3.

X3000, nital etch.

Section of eye portion of link austempered from 1400°-1450° F. into salt at 600° F. for 30 minutes.

RP:GHB.