O T T A W A July 26th, 1940.

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of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 872.

Experimental Work on Universal Machine Gun Carrier Steel Track Links.

BUREAU OF MINES
DIVISION OF METALLIC MINERALS
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CANADA
DEPARTMENT
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Nature of Work:

According to the British War Office specifications governing the manufacture of Universal machine gun carriers, the track links are to be made of white-heart malleable iron case-hardened by a cyanide heat

treatment. The finished links are required to withstand a load of 10,000 pounds when bent between 8-inch centres. In addition to this, they must have a file-hard surface and a bending angle of at least five degrees on the broken sample. The following report shows that the properties just mentioned can be obtained on a steel link following proper heat treatment.

Origin of Material:

The steel castings used in this work were sent by Mr. Charles V. Hacker, of the Hull Iron and Steel Foundries Limited, Hull, Quebec.

Macroscopic Examination:

The links cast by the Hull Iron and Steel Foundries Limited met the dimensional requirements of the War Office specifications. The castings were sound and their surfaces were fairly smooth.

Chemical Analysis:

A sample taken from one of the castings analysed as follows:

		Per cent
Carbon	-	0.32
Manganese	-	0.82
Silicon	-	0.29
Sulphur	-	0.020

Heat Treatment:

The following heat treatment was given to one of the castings and found to give excellent results:

(Heat Treatment, cont'd) -

The link was first heated for 40 minutes (total time) at 1750° F. in a cyaniding bath of the following composition:*

Sodium cyanide	-	50 per cent
Sodium carbonate	-	30 "
Sodium chloride	-	20 "

(* Approximately 1.5 per cent of NaCN was added every hour to keep the proper concentration.)

It was then cooled in air at room temperature, re-heated to 1485° F. in the cyanide bath (total time 30 minutes), and quenched in a pure mineral oil to prevent any saponification. The drawing was done at 400° F. for one hour.

Hardness Tests:

Hardness tests were run on the case and the core of the treated link, the Vickers method being used in all cases. For the core, a 30-kilogram load was used. Hardness determinations were made on the case with loads of 10 kilograms and 5 kilograms, both on the outside surface and on the inner bearing surface of the link. The following results were obtained and are compared with those of the British-made link. The small difference observed with a 10-kilogram load and a 5-kilogram load indicates a fairly thick case.

(Continued on next page)

(Hardness Tests, cont'd) -

	Hardness (Vickers)			
	Case, 5-Kg. load.	Case, 10-Kg. load.	Core, 30-Kg. load.	
Steel link	644	530	201	
Bearing surface of steel link	644	530		
British-made link	310		155(1)	245(2)

(1) At centre of bearing hole wall.
(2) At centre of thickest portion of casting.

Bend Tests:

The link which had been treated as mentioned above was bent between 8-inch centres in an Amsler Universal testing machine, the guide portions of the castings being in a vertical position during the test. The bending angle was calculated for different loads by measuring the permanent deformation at these loads. To measure this deformation the load had to be removed.

In reloading the link there was probably a certain amount of work hardening, which would probably tend to raise the ultimate breaking load slightly. The values observed are given in Column I together with the measured bend on the broken parts of the link. This bend is greater than the calculated bend at the ultimate breaking load due to subsequent deformation after this ultimate load is attained. For comparison, typical values obtained in earlier work on a British-made link are also given, in Column II:

(Continued on next page)

(Bend Tests, cont'd) -

Load, in pounds	BEND, IN DEGREES Treated Link.	British-made Link.
5,000	-	0.2
6,000	0.3	-
7,500	-	0.5
9,000	1.0	1.1
10,000	1.6	1.7
12,000	4.4	4.6
13,500	-	8.2
13,650	-	Break
14,000	9.9	-
14,400	13.2	-
	Break	-
Measured bend on broken parts	27 degrees.	12 degrees.

Microscopic Examination:

A section was cut from the treated steel link and subjected to microscopic examination. The structure of the core and case can be seen in Figure I (magnification X100) etched in 2 per cent solution of nitric acid in alcohol. The case shown at the right of Figure I reveals an outer zone of martensite, the hard form of steel. Immediately after is seen a troosto-sorbitic inner zone which is fairly visible and rests on a background

of fine-grained pearlitic iron which constitutes the core of the link. The presence of light unetched areas in the case is due to very hard iron nitride which is usually present when steel of low enough carbon content is cyanided.

DISCUSSION OF RESULTS:

Macroscopic Examination -

The links cast by the Hull Iron and Steel Foundries Limited met dimensional requirements, as could be determined by measuring the distance between the centres of the two sets of holes in the link and checking it against a standard British-made link. However, complete information on this ground could be had by an actual wrap test which would necessitate over twenty links.

Chemical Analysis and Physical Tests -

Analytical results showed the links to be made of a steel sufficiently low in carbon content. A slightly higher carbon content would make it stronger though more brittle but could still be used without endangering too much the necessary ductility, as the values obtained on the bend are far over those required. However, a much higher carbon steel is not to be recommended because, within certain limits, malleability in the finished products is more desirable than strength, as in actual use the links have to adjust themselves

to the required shape without breaking or causing a break in other parts of the machinery. It should therefore be emphasized that the complete bend test giving the permanent deformation under different loads is the main source of information on the actual usefulness of the finished link. In this particular case, the treated steel link gave a much better bend at the break than the typical British-made link, although the bend was actually less at 10,000 pounds.

The hardness of the case is rather on the high side, which condition could be improved by a slightly higher drawing temperature. However, this greater hardness should be regarded rather as a desirable advantage due to its higher wear resistance.

To ascertain that the inner bearing had come in contact with the cyanide and especially with the oil during the quenching process, hardness tests were made on small samples cut from the inner part of the bearing, and they gave results similar to those obtained on other portions of the surface.

Microscopic Examination -

The depth of the cyanided case can be measured on Figure I (magnification X100). It averages 0.015 inch, which is nearly 50 per cent deeper than in the British-made link. Its martensite structure reveals a hard and wear-resisting surface. This case thickness

could even be increased a few more thousandths of an inch by longer cyaniding time without changing too much the ductility of the finished link. The fine-grained pearlitic steel offers a high satisfactory base to the hard cyanided surface and reveals a soft malleable core.

Conclusions:

This work shows that a steel link can be made the physical properties of which are excellent. It has the required toughness and surface hardness. Due to the good case depth, its wearing properties in actual service will probably prove to be more than sufficient to recommend its use and make it, on an economical basis, comparable to (if not better than) the whiteheart malleable iron link specified by the British War Office.

It is suggested that a number of these links should be tried in the field.

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RP:PES.

Figure I.

X100.

Case and core of treated steel link,
etched in 2 per cent nitric acid
in alcohol.

RP:PES.