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O T T A W A February 21st, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1600.

Examination of Universal Carrier Track Links and Pins after 4,000 Miles of Field Test.

(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

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Abstract

This report deals with the metallurgical examination of Universal Carrier steel track links cast to New Zealand design and SAE 3115 cased pins which have been produced in the United States. The links and pins were taken from a carrier which had travelled 4,000 miles on field test at Camp Borden.

Origin of Material and Object of Investigation:

On September 15th, 1943, six (6) Universal Carrier track links and eleven (11) track pins (Requisition No. 712, A.E.D.B. Lots Nos. 657 and 658, Report No. 13, Test 43) were submitted by Dr. C. W. Drury, Director of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Toronto, Ontario. The links had been cast to New Zealand design by the Campbell, Wyant and Cannon Foundry Co. The pins were also produced in the United States. This material was

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

taken from a universal carrier which had completed 4,000 miles of field test at Camp Borden.

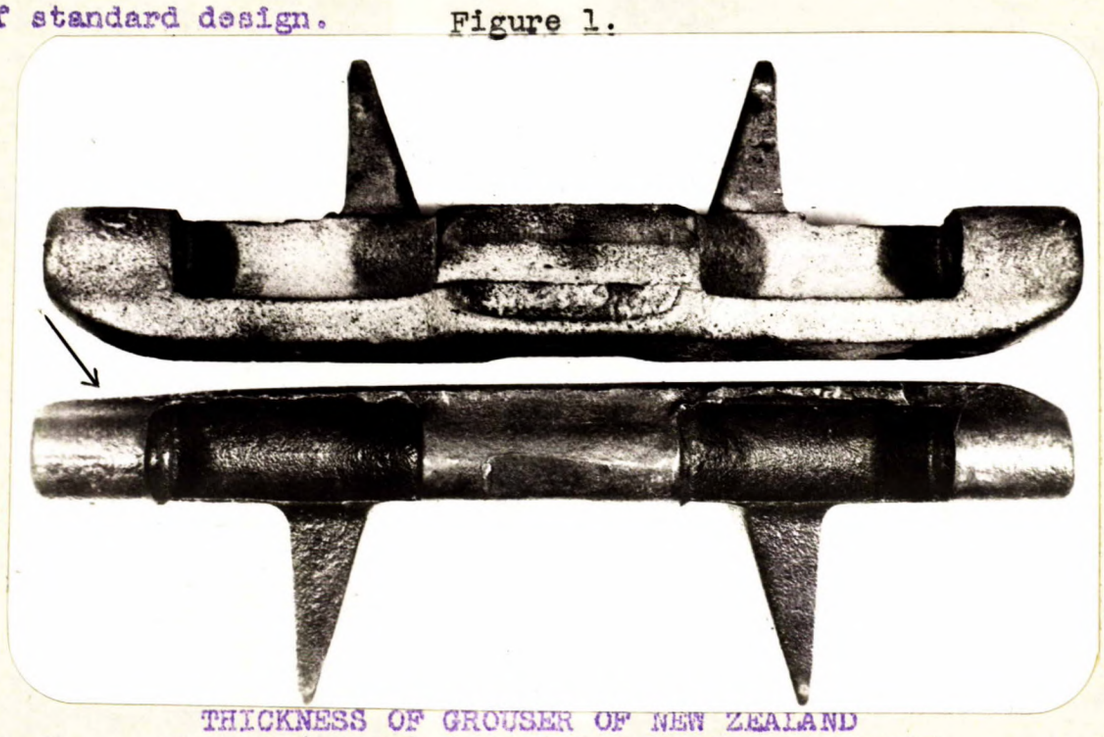
It was requested that the links and pins be examined to Universal Carrier specifications and also that the internal diameter of the link eye-holes, and the diameter of the pins, be measured.

LINKS.

Macroscopic Examination:

There were no broken links in the lot received nor were there any cracks which would suggest imminent failure. Figure 1 is a comparison of one of the links under consideration and an unused Campbell, Wyant and Cannon cast steel link of standard design.

Figure 1.



THICKNESS OF GROUSER OF NEW ZEALAND DESIGN (ARROW) COMPARED TO STANDARD LINK.

Since the original dimensions of the New Zealand links are not known it is impossible to state whether the difference in thickness of the grouser section is due to wear or whether the grouser of the New Zealand link was originally cast thinner. Inspection of the eye-hole walls showed that

(Macroscopic Examination, cont'd) -

the most extensive wear was at the ends (Figure 2), which have become bell-shaped.

Figure 2.

EYE-HOLES AT END OF LINK.

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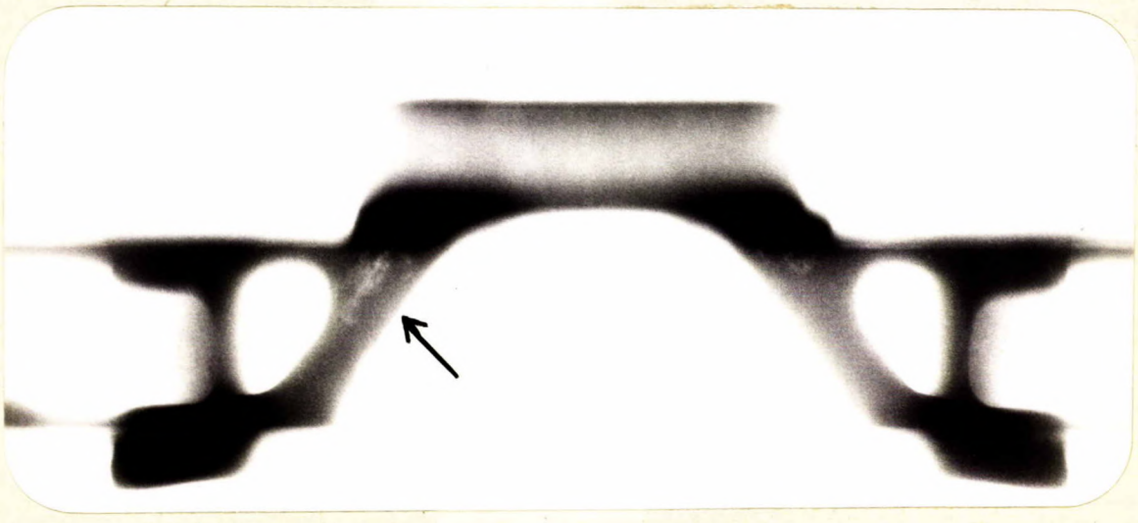
X-Ray Examination:

X-ray examination of three links was made at the National Research Council, Ottawa. Figure 3 (a positive of a radiograph of one link) shows the location of a shrink which is characteristic of the three links examined.

Figure 3.



RADIOGRAPH (POSITIVE).
Arrow indicates shrinkage area.

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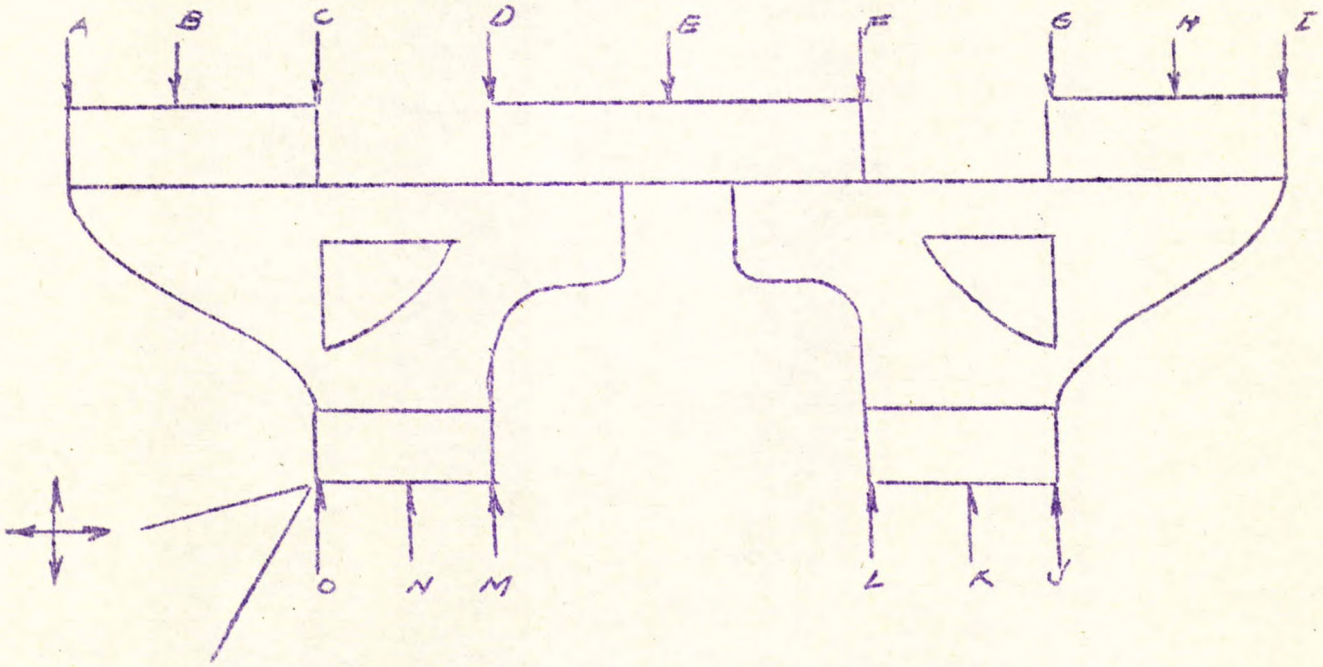
Wear Measurements:

The inside diameter of eye-holes was measured as shown in Figure 4. The results are tabulated in Table I.

Figure 4.



MEASUREMENTS GIVEN AT EACH POINT ARE THE AVERAGE OF VERTICAL AND HORIZONTAL MEASUREMENTS.

TABLE I. - EYE-HOLE DIAMETERS (INCHES).

No.	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	Average
1	0.50	.48	.51	.56	.49	.49	.55	.47	.49	.48	.48	.50	.47	.49	.52	0.49
2	0.51	.50	.50	.50	.49	.49	.51	.50	.50	.52	.49	.50	.51	.50	.51	0.50
3	0.50	.49	.51	.54	.50	.51	.53	.52	.50	.51	.48	.51	.52	.50	.52	0.51
4	0.52	.50	.51	.54	.50	.50	.52	.52	.50	.50	.51	.50	.51	.50	.52	0.51

Chemical Analysis:

		As Found	BTS #1 Specification
		- Per cent -	
Carbon	-	0.34	0.25-0.35
Manganese	-	0.93	1.25-1.65
Silicon	-	0.33	0.25-0.45
Phosphorus	-	0.030	0.06
Sulphur	-	0.050	0.06
Molybdenum	-	0.23	0.20-0.30
Copper	-	0.62	Optional, 0.30-0.50*

* The copper content varies. The range shown is the latest one of a number reported.

Bend Tests:

Standard bend tests were made, using the Amsler testing machine with 8-inch centres and 1-inch-radius block. Results are shown in Table II.

TABLE II.

No.	Breaking load, pounds	Angle after breaking
1	9,950	9°
2	10,250	5°
3	12,950	5°

Hardness:

Hardness readings taken on transverse sections from three links were 26 to 29 Rockwell 'C' (269-285 Brinell).

Impact Tests:

Impact tests on standard inspection testing machine gave the following results:

TABLE III.

		LUGS			BARREL		
No.		No. of blows	Foot-pounds	Remarks	No. of blows	Foot-pounds	Remarks
1	(a)	2	250	Passed.	1	250	Failed.
	(b)	2	250	"			
2	(a)	2	250	"	1	250	Passed.
	(b)	2	250	"			
3	(a)	2	250	"	1	250	Failed.
	(b)	2	250	"			

Microscopic Examination:

One link was sectioned transversely across the grouser and middle eye-hole wall. Microscopic examination at this location showed the metal structure to be uniform across the section. This structure is shown in Figure 5 (a photomicrograph at X500 magnification). The structure is tempered martensite.

(Continued on next page)

(Microscopic Examination, cont'd) -

Figure 5.

X500, etched in 2 per cent nital.

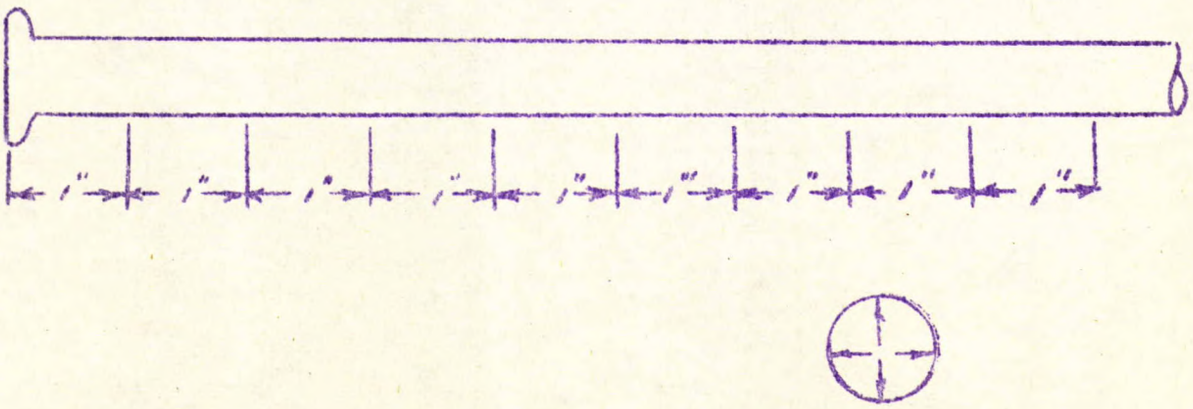
NEW ZEALAND DESIGN LINK, BTS #1 METAL.

PINS.

Diameter Measurements:

The average diameter of the pins was obtained by taking nine pairs of micrometer readings at right angles to each other at each 1-inch length of the pin (see Figure 6). Measurements are recorded in Table IV.

Figure 6.



METHOD OF MEASUREMENT OF AVERAGE DIAMETERS.

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Bend and Impact Tests:

Pins were tested for bend and impact properties, using standard inspection test machines. After these tests were completed, transverse sections were cut from each pin and the core hardness values were determined.

TABLE IV.

No.	Average diameter, inches	Bend Tests,* deflection, in inches	Impact Tests,* 45-ft-lb. blow	Core Hardness,* Rockwell 'C'
1		0.25		40-42
2	0.4163	0.32		30-32
3	0.4121	0.30		34-35
4	0.4141	0.32		29-32
5	0.4157	0.40		38-40
6	0.4198	-	Passed.	37-38
7	0.4147	-	"	34-37
8	0.4114	-	"	25-28
9	0.4139	-	"	40-42
10	0.4184	-	"	35-37
11	0.4197	-	"	26-27

* Universal Carrier Specification O.A. 214 requires that:

(1) Cased pins should bend 0.25 inch minimum, without audible or visible cracking of the case.

(2) Pins must withstand a blow of 45 foot-pounds.

(3) Core hardness limits are 24 to 32 Rockwell 'C'.

Chemical Analysis:

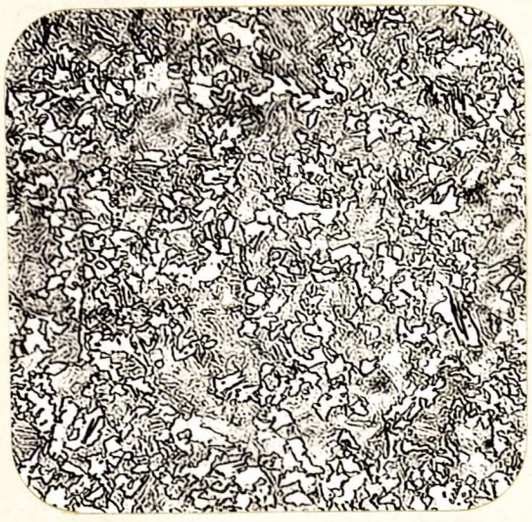
One pin was analysed, to check for conformity to SAE 3115 chemical specifications:

	As Found	SAE 3115 Chemical Specification
	- Per cent -	
Carbon -	0.16	0.10-0.20
Manganese -	0.56	0.30-0.60
Silicon -	0.21	0.15-0.30
Phosphorus -	0.006	0.05 max.
Sulphur -	0.012	0.05 max.
Nickel -	1.21	1.00-1.50
Chromium -	0.70	0.45-0.75

Microscopic Examination:

Microscopic examination of transverse sections of the pins showed that the case was largely worn away. The core structure shown in Figure 7, a photomicrograph at 250 diameters, is composed of low-carbon martensite and ferrite.

Figure 7.



X250, nital etch.
CORE STRUCTURE OF SAE 3115 PIN.
Low-carbon martensite and ferrite.

Discussion:

Track Links.

Shrinks in the body of the links cast to New Zealand design suggest the possibility that the casting was so gated that the shrink would be located in this area and not in the middle eye-hole wall. This may be considered an advantage, since shrinks in the middle eye-hole wall have been the cause of failure in numerous links of standard design (particularly

(Discussion, cont'd) -

malleable iron) which have been examined at these Laboratories.* The chemical composition of the links conforms to BTS #1 specifications.

Bend and impact properties are somewhat lower than those of cast steel links of standard design, which vary between 17,500 and 28,000 pounds, with 7-18° angle in bend tests, and which will resist a 380 to 400 foot-pound blow on the barrel of the link in impact tests. However, it must be considered that the New Zealand design links have completed a 4,000-mile field test and the metal at some of the sections has been worn away, therefore the links would not show the same bend and impact properties as if they had been tested in the unused condition. The microstructure of the links (drawn martensite) denotes a satisfactory quench-and-draw heat treatment.

Track Pins.

The chemical composition of the pins conforms to SAE 3115 specifications. Bend and impact properties are within specifications (O.A. 214) for Universal Carrier track pins. Core hardness values, however, vary from 29 to 42 Rockwell 'C'; seven of the eleven pins examined are above the specified hardness of 24 to 32 Rockwell 'C'. This high core hardness is due to the high chromium content. The large proportion of ferrite (white constituent) in the microstructure of the pin examined implies improper heat treatment. This pin has been either quenched from a temperature below the upper critical or quenched too slowly and optimum physical properties have not been obtained.

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* Report of Investigation No. 1490, September 2nd, 1943, illustrates one of these failures.

CONCLUSIONS:

Track Links.

1. A shrinkage area in the body of the link was characteristic of all the link castings examined. It is likely that the shrink was purposely located at this position to avoid porosity in the middle eye-hole wall.

2. Links conform to BTS #1 chemical specifications.

3. Bend and impact properties of the links are lower than those found in steel links of standard design.

Track Pins.

4. Pins conform to SAE 3115 chemical specifications.

5. Bend and impact properties of the track pins conform to Universal Carrier specifications for cased pins.

6. Pin core hardness varies between 29 and 42 Rockwell 'C'. The core hardness of seven of the pins is above that required by Specification C.A. 214. The high core hardness is usually due to a high chromium content.

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