File

FILE COPY

O T T A W A August 5th, 1944.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1695.

Metallurgical Examination of C.D.P. Track Shoe and Pin Which Had Been Field-Tested in England.

(Copy No. 14.)

Division of Metallic Minerals

Physical Metallurgy Research Laboratories

CANADA

DEPARTMENT OF MINES AND RESOURCES

Mines and Geology Branch

O T T A W A   August 5th, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1695.

Metallurgical Examination of C.D.P. Track Shoe and Pin Which Had Been Field-Tested in England.

=============

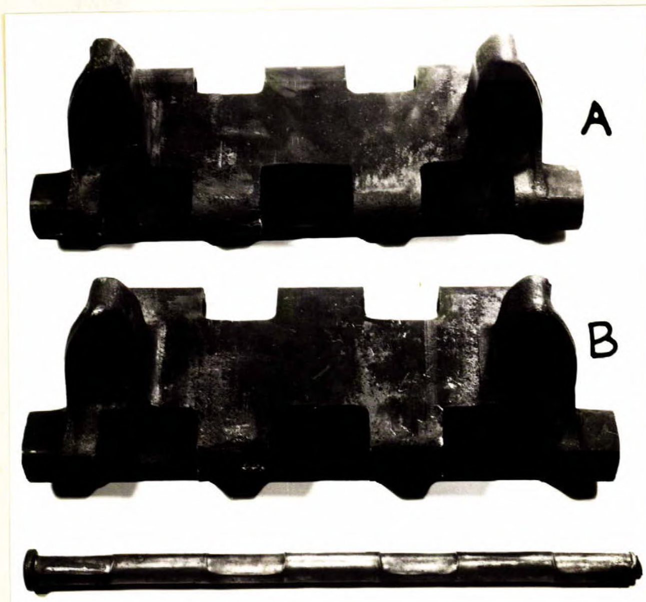
Origin of Material and Object of Investigation:

On July 11th, 1944, Prof. J. U. MacEwan, of the Division of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario, submitted two Canadian Dry Pin track shoes and one pin taken from a vehicle that had been field-tested in England. The covering requisition, No. 655, A.E.D.B. Lot No. 548 (Report No. 23, Sec. 5c/D2), requested a complete metallurgical examination of the pin and one shoe and an analysis of the soil adhering to the shoe.

Macro-Examination:

Photographs of the track shoes and the pin were taken and the less severely worn shoe (B) was immediately returned. Figure 1 shows the two shoes and the pin.

Figure 1.



TRACK SHOE.

Figures 2, 3, 4 and 5 show two views of each of the two shoes. It can be seen that Track Shoe A was the more severely worn.

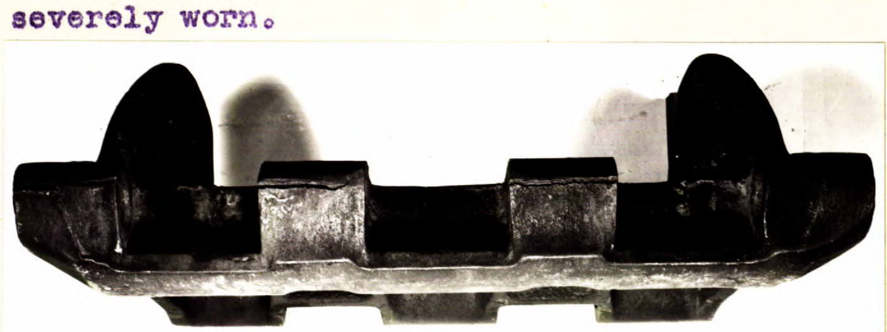


Figure 2.
TRACK SHOE A.
Note cracks in eye-hole walls.

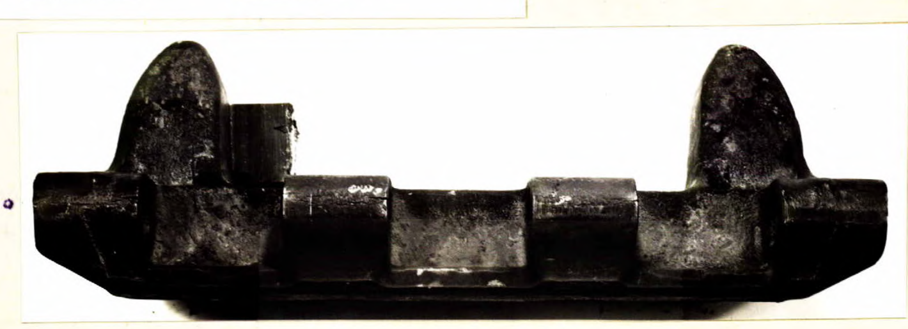
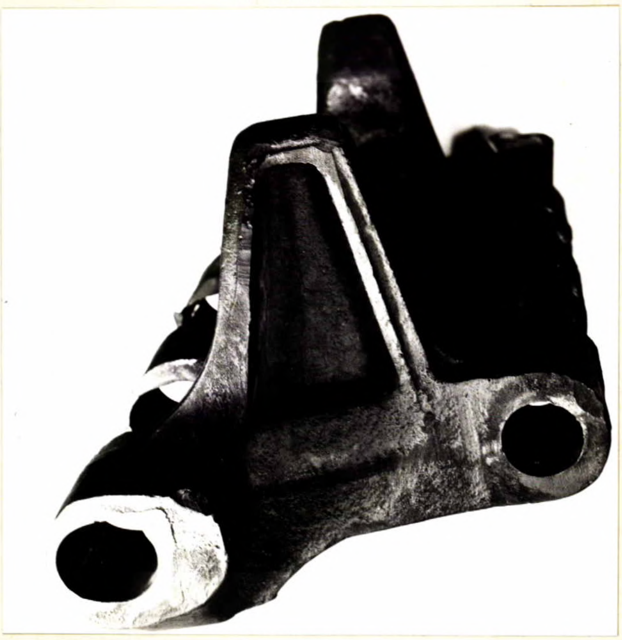


Figure 3.
TRACK SHOE B.

(Continued on next page)

(Track Shoe, cont'd) -

Figure 4.

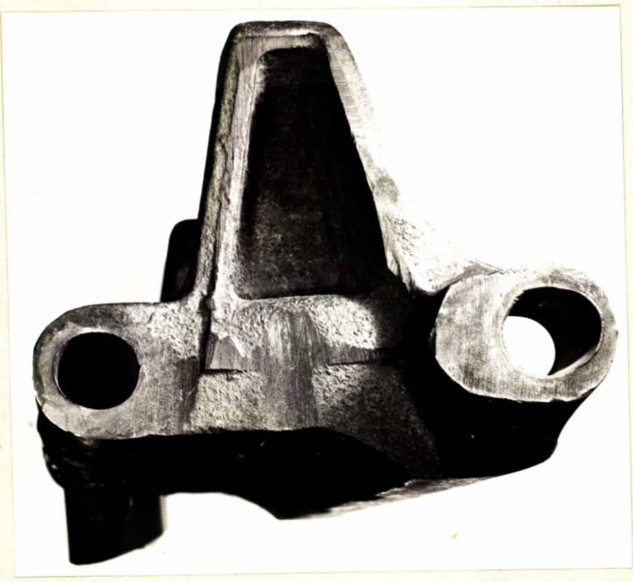


END VIEW OF TRACK SHOE A.

Note elliptical shape of eye-hole, due to wear.

-

Figure 5.



END VIEW OF TRACK SHOE B.

-

(Continued on next page)

(Track Shoe, cont'd) -

The dimensions of the eye-holes, as submitted by Prof. J. U. MacEwan, are shown in Table I. Measurements were made as shown in Figure 6.

Figure 6.

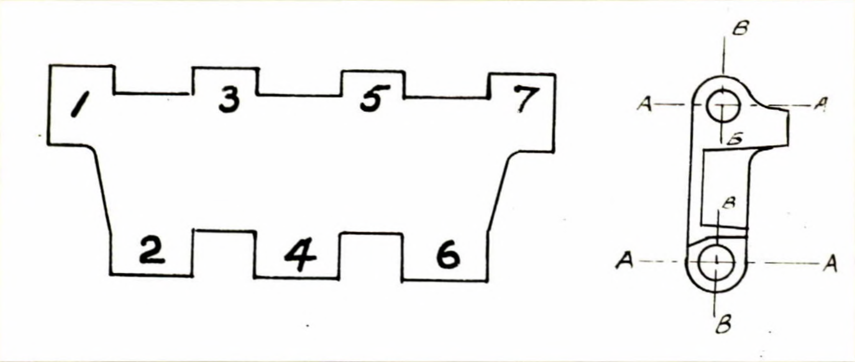


TABLE I.

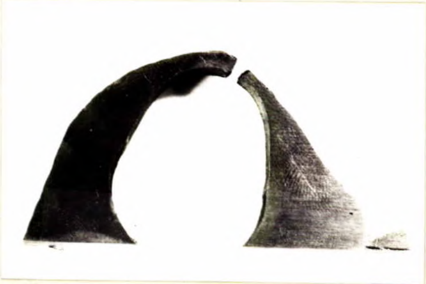
	Section	A-A	B-B	Wall Thickness
		- Inches -		
SHOE A:	1	0.866	0.946-0.995	0.201
	3	0.850	1.027-1.081	0.150
	5	0.850	1.007-1.072	0.142
	7	0.851	0.998-1.015	0.190
	2	0.835	0.902	0.252-0.300
	4	0.833	0.892	0.300
	6	0.849	0.902	0.324
SHOE B:	1	0.853	1.045-1.062	0.143
	3	0.853	1.130; Broken.	0.114
	5	0.850	1.162-1.174;Broken.)	0.123
	7	0.858	1.078-1.122	0.132
	2	0.875	0.918-0.969	0.295
	4	0.846	0.892	0.320
	6	0.856	0.910-0.924	0.272

(Continued on next page)

(Track Shoe, cont'd) -

A section was cut from the eye-hole wall as shown in Figure 7. A transverse section was also taken from the grouser.

Figure 7.



SECTION FROM EYE-HOLE WALL.

-

Chemical Analysis:

Results of chemical analysis of the shoe are shown in Table II.

TABLE II.

		As Received	Specification O.A. 219
		- Per Cent -	
Carbon	-	1.00	1.1-1.4
Manganese	-	11.87	11.0-14.0
Silicon	-	0.78	1.00 max.
Sulphur	--	0.010	0.05 max.
Phosphorus	-	0.074	0.10 max.
Chromium	-	0.22	Not specified.

Hardness Surveys:

A hardness survey was run on the transverse section from the grouser, on two lines perpendicular to the wearing surface. The Vickers hardness tester, with a 10-kg. load, was used. Results are shown in Table III. There was little evidence of work-hardening near the surface of the grouser.

(Continued on next page)

(Track Shoe)
(Hardness Surveys, cont'd) -

TABLE III. - Hardness Surveys on Transverse Section from Grouser.

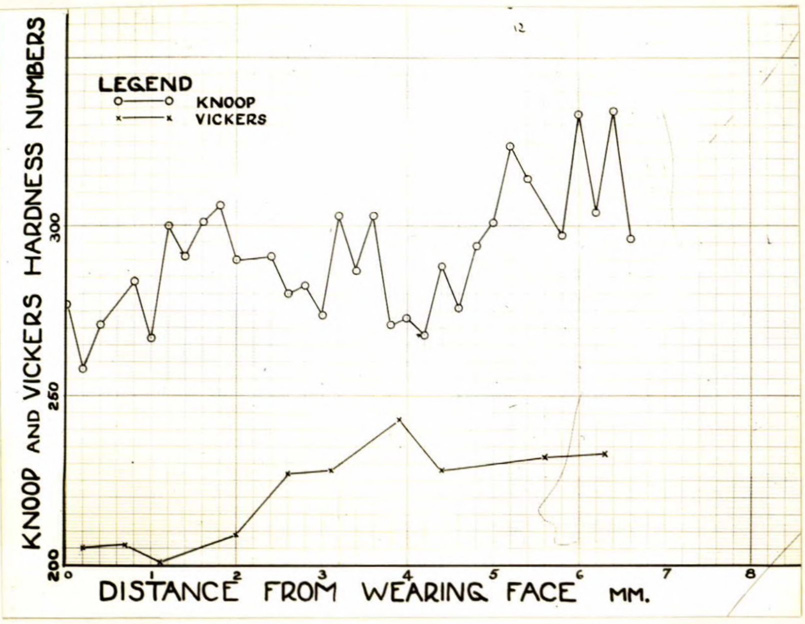
	Distance from edge, millimetres	Hardness Numbers Rockwell 'C'	Vickers (10-kg. load)
1st Survey:	0.00	28.0	285
	0.01	22.5	249
	0.02	21.5	243
	0.03	21.5	243
	0.045	21.0	242
	0.07	24.5	262
	0.09	22.0	247
	0.12	26.5	274
	0.13	26.5	274
	0.15	25.5	268
	0.17	27.0	276
	0.20	24.0	258
	0.25	26.5	274
	0.36	24.5	260
	0.41	25.0	264
	0.46	22.5	249
2nd Survey:	0.035	29.0	219
	0.06	23.0	251
	0.10	25.5	266
	0.16	21.0	240
	0.23	20.5	238
	0.34	<20	233
	0.45	<20	219

The transverse section from the eye-hole wall was also subjected to hardness surveys with both Vickers and Tukon hardness testers, using 10-kilogram and ½-kilogram loads respectively. The wall was not work-hardened (indeed, it appeared softer near the worn surface, as may be seen in Figure 8), although slip bands showed up in the micro-examination.

(Continued on next page)

(Track Shoe)
(Hardness Surveys, cont'd) -

Figure 8.



-

Microstructure:

The transverse section of the eye-hole wall was etched and the grain size estimated according to A.S.T.M. standards. A photomicrograph of the area is shown in Figure 9.

Figure 9.

X100, nital etch.
STRUCTURE OF EYE-HOLE WALL.
A.S.T.M. Grain Size, 3.
Note strain lines.

-

(Continued on next page)

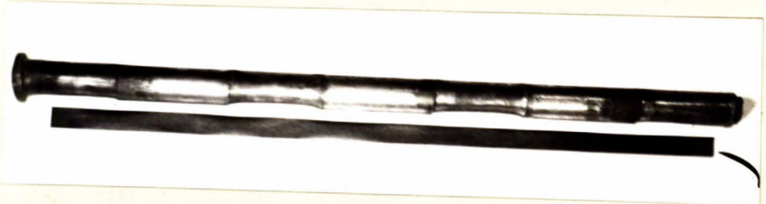
(Track Shoe)
(Microstructure, cont'd) -

A microscopic study of a transverse section of the grouser showed the microstructure to be almost identical with that of the eye-hole wall, with fewer indications of work hardening.

TRACK PIN.

Figure 10 shows the track pin as it was received.

Figure 10.



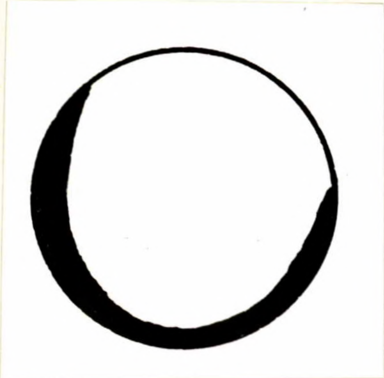
TRACK PIN AS RECEIVED.

Note worn contours of pin.

-

Transverse sections were cut from one worn and one unworn portion of the pin. Figure 11 gives a comparison of the two sections. The shaded area represents approximately the amount of metal worn from the smaller section.

Figure 11.



(Approximately twice normal size).

-

(Track Pin, cont'd) -

Chemical Analysis:

Chemical analysis showed the pin to be NE 9260 steel although NE 9255 was specified. Results are shown in Table IV.

TABLE IV.

		As Determined	Specification NE 9260
		- Per Cent -	
Carbon	-	0.63	0.55-0.65
Manganese	-	0.86	0.75-1.00
Silicon	-	1.94	1.80-2.20
Sulphur	-	0.023	0.040 max.
Phosphorus	-	0.011	0.040 max.
Chromium	-	0.04	-
Nickel	-	Trace.	-
Molybdenum	-	Nil.	-

Hardness Measurements:

Hardness surveys, with a 10-kg. load on the Vickers hardness tester, across two diameters of the worn section and across one diameter of the unworn section showed no essential variation in hardness across either section. Maximum, minimum and average values of these surveys, converted to Rockwell 'C' values, are shown in Table V.

TABLE V. - (Rockwell 'C').

		Worn Section		Unworn
		Long. diam.	Short diam.	Section
Average	-	43.5	44	43.5
Maximum	-	44.0	45	46.5
Minimum	-	43.0	43	40.0

The diameter of the pin was measured by the Army Engineering Design Branch. For purposes of identification the sections of the pin were numbered as illustrated in Figure 12. The diameter measurement results are shown in Table VI. It will

(Track Pin)
(Hardness Measurements, cont'd) -

be noted that three measurements were made on each section.

Figure 12.

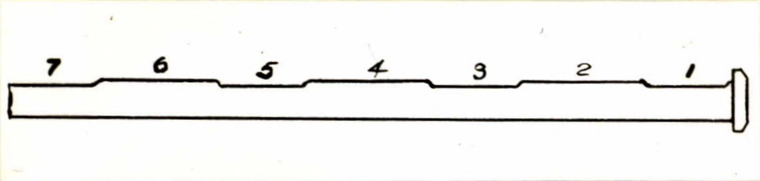


TABLE VI.

Section		Diameter, inches
1.	-	0.770
		.759
		.770
2.	-	0.799
		.794
		.807
3.	-	0.747
		.726
		.739
4.	-	0.807
		.809
		.816
5.	-	0.733
		.714
		.726
6.	-	0.796
		.802
		.812
7.	-	0.750
		.748
		.770

The surface hardness was taken in these sections with the Rockwell hardness tester, with the results shown in

(Track Pin)
(Hardness Measurements, cont'd) -

Table VII.

TABLE VII.

Section		Rockwell 'C' Hardness
1.	-	42, 42.5
2.	-	44, 44.5
3.	-	42.5, 41
4.	-	43.5, 42.5
5.	-	41, 42.
6.	-	43, 41
7.	-	42.5, 40.5

Core hardnesses were taken on the two transverse sections cut from the pin. These samples were cut from Sections 4 and 5 as shown in Figure 12. Results are shown below:

Section 4 (unworn)	Section 5 (worn)
44, 44.5	44, 44.5
44.5, 43.5	45.5, 44.5
46	45

Specifications called for Rockwell 'C' values of 45 ±3 for both surface and core hardness.

Microstructure:

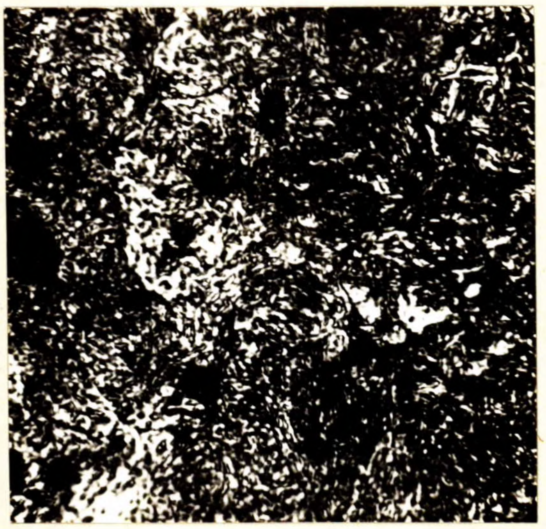
The pin was first examined unetched and appeared quite clean.

A photomicrograph of one transverse section etched in 2 per cent nital was then made. It is shown in Figure 13. The structure is entirely drawn martensite. The structure shown is typical, there being no banding of the steel.

(Continued on next page)

(Track Pin)
(Microstructure, cont'd) -

Figure 13.



X1000, nital etch.

TRANSVERSE SECTION OF PIN.

-

A section of the pin was broken and the fracture compared with prepared standards to determine the grain size. The grain size was A.S.T.M. 7½.

EXAMINATION OF SOIL ADHERING TO SHOE.

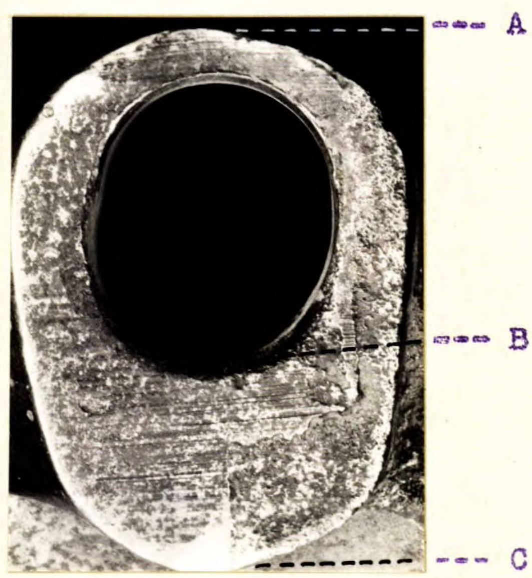
Chemical analysis showed the soil adhering to the shoe to be almost entirely silica. Under the microscope most of it proved to be angular quartz. A great proportion of this was under 200 mesh. There was little or no flint present.

DISCUSSION:

The low carbon content of the shoe would, according to some, lower the yield point of the steel. However this may be, it has no bearing on this investigation, as failure was due to pure abrasion. The additional chromium in the shoe would have little or no effect on the properties of the steel.

The metallurgical examination indicated that the shoe had been subjected to abrasion only, since there was no appreciable work-hardening in the eye-hole wall. Also, any stretching of the eye-hole wall by the pounding of the track pin would result in an increase in length between A and B and between A and C (as shown in Figure 14), and no change in

Figure 14.



either dimension was observed. The presence of slip bands, as outlined by decomposition products (see Figure 9), indicates that work-hardening had commenced but had not reached a sufficiently advanced stage to produce a measurable increase in hardness.

The results of the soil examination corroborate the conclusions reached from the metallurgical examination, i.e.

(Discussion, cont'd) -

service conditions were such that abrasion was very severe.

Quartz has a hardness of 7 in Moh's scale of hardness. This, according to O'Neill's "Hardness of Metals and its Measurement", page 138, is equivalent to 685 Brinell or 885 Vickers, or 64 on the Rockwell 'C' scale. As can be seen from Figure 8, the eye-hole wall had a Vickers pyramid number of about 225. The pin was about 45 Rockwell 'C'. The fineness and great hardness of the quartz give it excellent abrasive qualities. The presence of moisture, due to either climatic or surface conditions, is essential, however, as the tests on both the American and African deserts prove.

CONCLUSIONS:

1. Both pin and shoe are satisfactory metallurgically and chemically.

2. Excessive wear is due to the abrasive qualities of the soil on which the test was run, probably with attendant moist climatic or surface conditions.

0000000000000
0000000
0

TCH:GHB.