OTTAWA March 2nd, 1942.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1170.

Examination of English Valentine
Tank Track Pin.

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(Copy No. 10.)

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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Origin of Material and Object of Investigation:

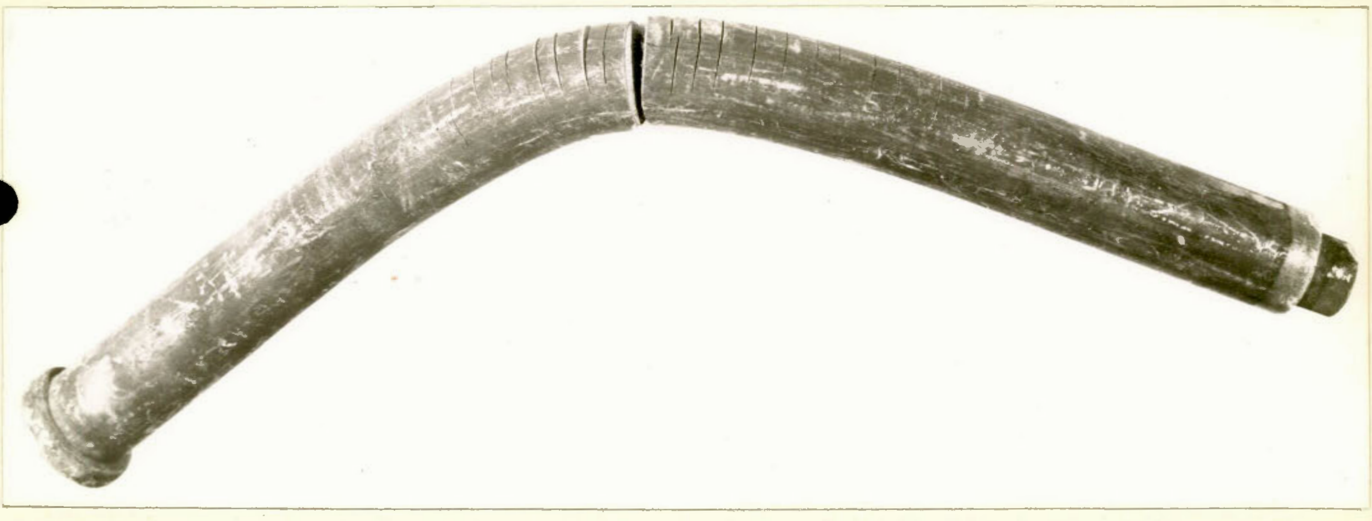
On February 14th, 1942, Major A. V. Golding of the Inspection Board of the United Kingdom and Canada, 58 Lyon Street, Ottawa, Ontario, submitted a Valentine tank track pin for examination. This pin had been produced in England and had been bent to destruction prior to this investigation.

Macroscopic Examination:

Figure 1 illustrates the pin as received. It will be noted that the pin failed on the bend test after first cracking at a number of points.

Examination of the fracture revealed the presence of a crystalline core. A fresh fractured surface was obtained by striking a part of the pin with a heavy hammer until it broke. Figure 2 shows the crystalline appearance of this fresh fracture as compared to the silky fractures obtained by bending a pack-carburized (C.P.R.) and a Tocco pin to destruction.

Figure 1.

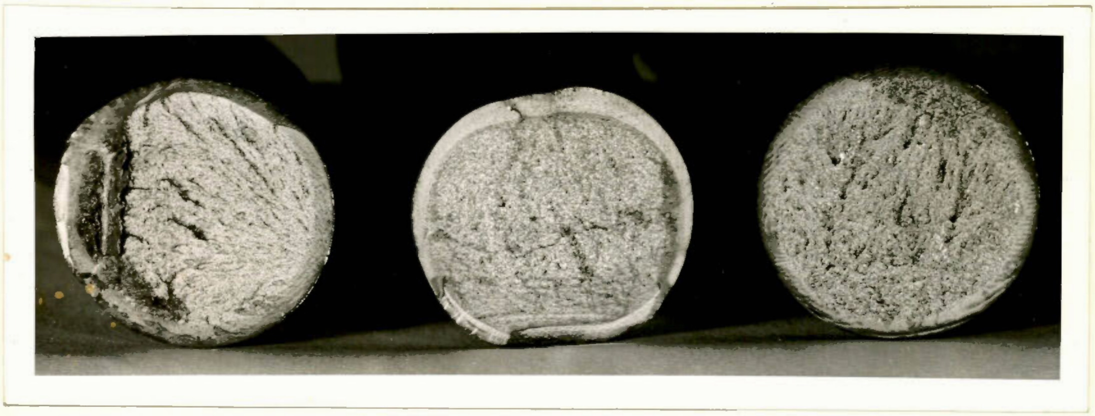


PIN AS RECEIVED.

(Continued on next page)

(Macroscopic Examination, cont'd) -

Figure 2.



C.P.R. Pack-Carburized Pin.	English Pin.	Tocco-Hardened Pin.

Chemical Analysis:

		Per cent
Carbon	-	0.12
Manganese	-	0.49
Silicon	-	0.24
Phosphorus	-	0.039
Sulphur	-	0.025
Nickel	-	1.63
Chromium	-	Trace
Molybdenum	-	0.098
Vanadium	-	Not detected.

Hardness Tests:

Using the Vickers method and a 10-kilogram load, hardnesses were taken of the etched microscopic specimen at varying distances from the surface. The depth-to-hardness relationships are shown in Table I and Figure 3.

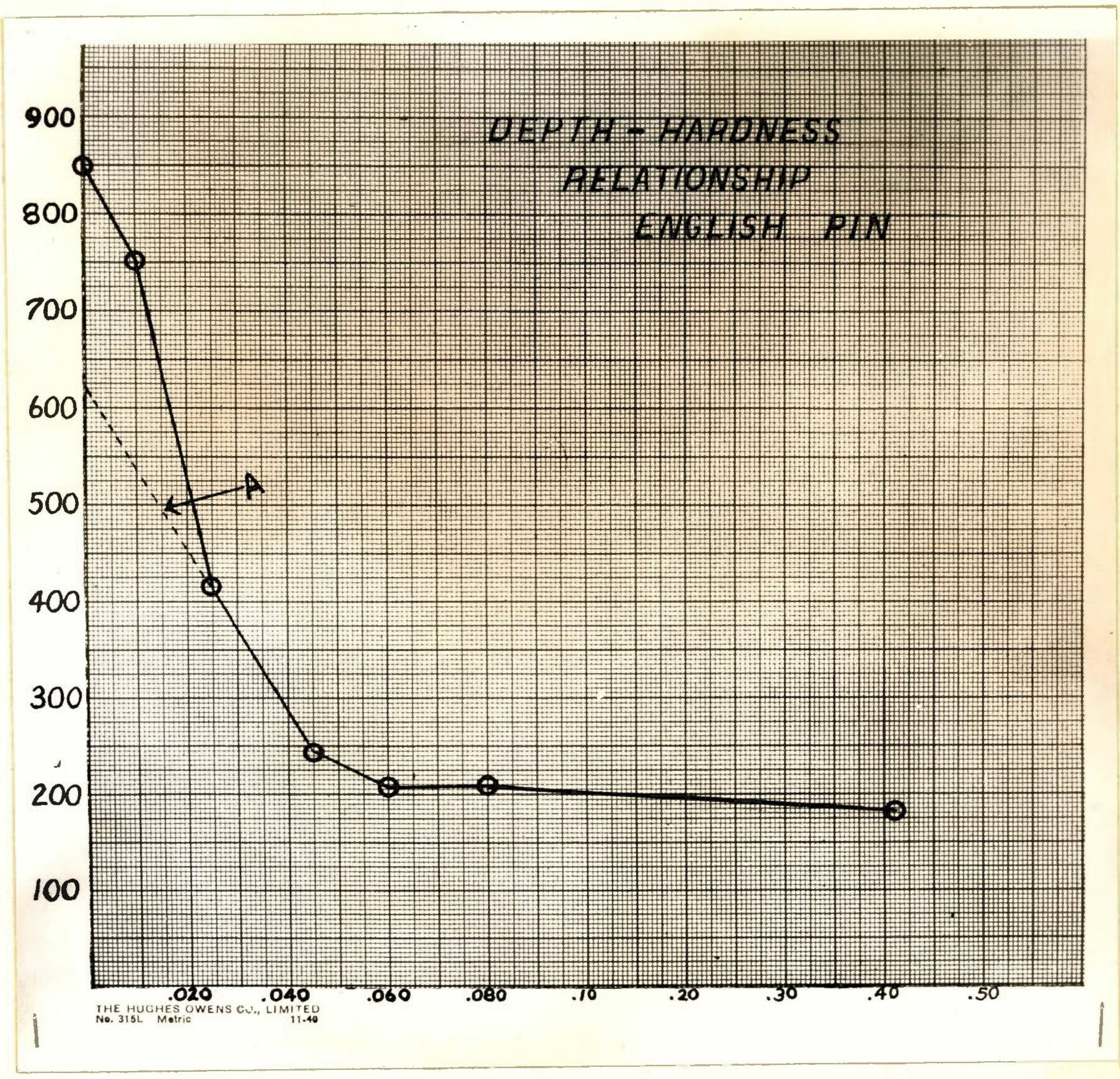
Table I.

Distance from the Surface.		Hardness.
At the surface	-	647
0.010 inch	-	752
0.025 "	-	417
0.045 "	-	245
0.060 "	-	210
0.080 "	-	210
0.410 "	-	183

(Figure 3 appears on next page)

(Hardness Tests, cont'd) -

Figure 3.



Depth of Case:

A sample of the pin was polished and etched and the depth of case was measured microscopically to an accuracy of thousandths of an inch. The case depth was taken from the outside edge to the middle of the transition zone.

Case depth = 0.024 inch.

Microscopic Examination:

All photomicrographs were taken at X1000 magnification.

Figure 4 is the core structure of the pin as received. Note the large amount of ferrite with the faint showing of the carbide phase.

Figure 5 shows the more uniform and tough core structure that it is possible to obtain by heating the pin to 1650° F. for ½ hour, quenching in water, and drawing to the desired hardness.

Figure 6 reveals the structure of the case. Note the presence of free carbides (white spots).

Figure 7 is a photomicrograph of the case after it has been subjected to a diffusion treatment, namely, held at 1600° F. for three hours in a lead bath, cooled to 1450° F. in the bath, and then quenched. The carbides have now been absorbed.

(NOTE: The photomicrographs (Figures 4)
(to 7) are placed at end of this report.)

Discussion of Results:

Figure 1 shows a series of cracks in the pin. These were created by the continued application of the load on the bend test.

In these laboratories it is the practice to discontinue application of the load at the first appearance of a crack and then to measure the bend angle. This simulates actual conditions in the field, where the first crack on a pin of a tank in motion will grow and pin failure will result from it probably before any other crack has a chance to appear.

(Discussion of Results, cont'd) -

A crystalline pin structure is undesirable, as it indicates pin brittleness. Crystalline structure can be removed by proper heat treatment.

The chemical analysis of the core shows that the steel conforms to Specification B.S.S. (British Standard Specification) 5005/102. There is, however, 0.098 per cent molybdenum present. This is probably residual.

The curve in Figure 3 shows the depth-to-hardness relationship. A curve following the broken line indicated by the arrow would give tougher characteristics.

The depth of case is satisfactory. We feel that any greater depth of such a hard case would greatly reduce pin toughness.

The microstructural appearance of the core shows that the pin was quenched from approximately 1400° F. Whether a quench from a higher temperature was first employed it is difficult to say.

Elimination of ferrite is desirable if the best combination of strength and toughness is to be obtained. This investigation shows that a quench from 1650° F. and a subsequent draw to the required case hardness gives satisfactory results.

A diffusion treatment to absorb the carbides in the case should be applied, as the presence of free carbides lowers the fatigue strength of the pin. The experience of the John Inglis Company with the Bren Gun breech blocks has shown that this diffusion treatment markedly improves the fatigue strength of a part which has been given a high carbon case. This diffusion treatment should also make the

(Discussion of Results, cont'd) -

pin tougher.

The mechanism of failure has not as yet been definitely established. Improvement in impact strength by the diffusion treatment, then, may very well be at least as important as improvement in the fatigue properties.

Conclusions:

1. A bend test should be considered as completed with the first appearance of a crack.

2. The chemical analysis shows that a satisfactory grade of bar stock has been employed. U. S. A. practice, however, shows that the use of some chromium may aid in pin fabrication, as the chromium-containing pin may be oil-quenched.

3. The depth of case is satisfactory.

4. Quenching from a higher temperature gives the best combination of strength and toughness in the core.

5. A diffusion treatment to eliminate free carbides would increase the fatigue strength of the pin.

6. A lower surface hardness is preferable. A change in specification to a surface hardness of 500 to 550 V.P.N. has already been recommended by the Track Pin Committee.

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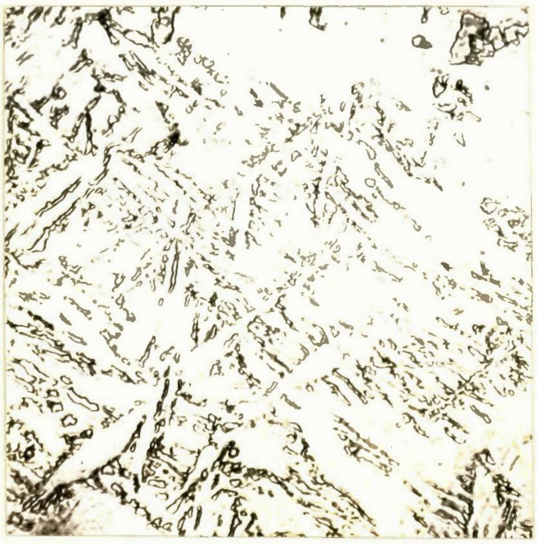
SLG:GSF:PES.

Figure 4.

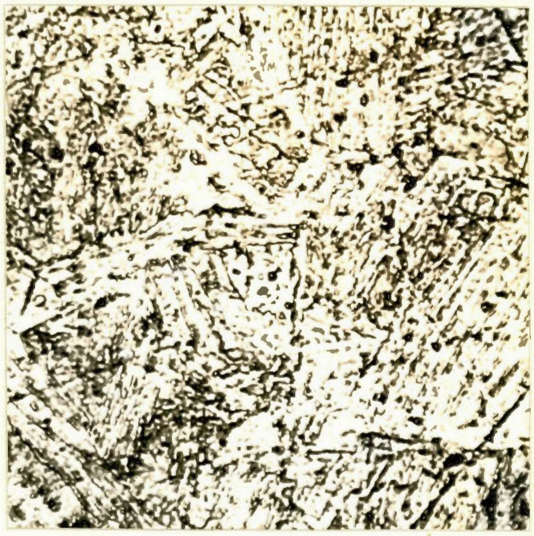


X1000, nital etch.

CORE STRUCTURE OF PIN AS RECEIVED.

Note large amount of ferrite.

Figure 5.

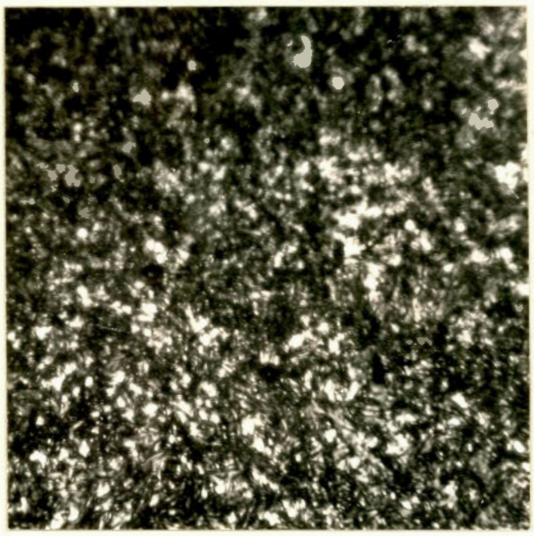


X1000, nital etch.

AFTER HEAT TREATMENT.

Note more uniform structure.

Figure 6.

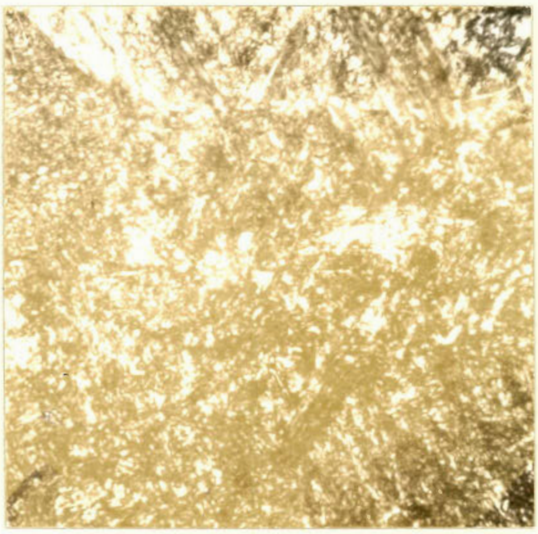


X1000, nital etch.

STRUCTURE OF CASE AS RECEIVED.

Note presence of free carbides (white spots).

Figure 7.



X1000, nital etch.

AFTER DIFFUSION TREATMENT.

Carbides have been absorbed.

SLG:GHB.