O T T A W A February 4th, 1942.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1154.

An Examination of Tank Track Pins.

(Copy No. 14.)

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 January 17th, 1942, under Requisition No. O.T. 28, Mr. R. Boult of the Inspection Board of United Kingdom and Canada, 58 Lyon Street, Ottawa, Ontario, submitted three track pins for examination. These were taken from a batch produced by the Taylor-Wharton Iron and Steel Company, High Bridge, New Jersey.

Dimensional Examination:

Using micrometers, the dimensions of the three pins (which will henceforth be designated as a, b, and c) were checked with the specification drawing. All measurements recorded in Table I are in inches.

Table I.

Part of Pin Measured	Specification	a	b	c
Head	1.125	1.125	1.132	1.050
Diameter	0.875 ± 0.001	0.872	0.882	0.875
Outer diameter of countersunk part	0.500	0.500	0.435	0.525
Diameter at the end of pin	0.620 - 0.625	0.614	Egg-shaped: Long diam., 0.622; Short diam., 0.600.	0.618
Length of end of pin	0.400	0.400	0.415	0.400
Height of head	0.30	0.30	0.29	0.30
Body length of pin	11.18	11.21	11.185	11.18
Total length of pin	11.88	11.82	11.75	11.79
Flat part on edge of the head of pin	0.20	0.175	0.20	0.175

All the fillets were found to be satisfactory and free from flash. The countersunk part of the pins were also found to be satisfactory.

Chemical Analysis:

		Per cent
Carbon	-	0.17
Manganese	-	0.54
Silicon	-	0.32
Sulphur	-	0.019
Phosphorus	-	0.029
Nickel	-	1.16
Chromium	-	0.64
Molybdenum	-	Trace.

Drillings were taken from the core of the pin.

Magnaflux Tests:

The pins were magnafluxed, both circularly and longitudinally, using the residual powder method. 1,500 amperes was used for circular and 1,000 amperes for longi-

(Magnaflux Tests, cont'd) -

tudinal magnetization.

No cracks or strains were revealed in any of the pins.

Physical Tests:

A tensile test specimen of 0.505 inch diameter was prepared from the core of Pin "a" by machining off the case under the action of a coolant. The following results were obtained:

Tensile strength - 131,500 p.s.i.
Reduction in area - 58 per cent.
Elongation - 19 "

Bend Tests:

Bend tests were carried out on Pins b and c in an Amsler universal testing machine, using 12-inch radii and 8-inch centres.

Table II.

Pin	Bend of break, in degrees.	Breaking load, in pounds
b	5.10	6,800
c	4.50	6,750

Hardness Tests:

Using the Vickers method and a 10-kilogram load, hardnesses were taken of the etched samples at varying distances from the surface. The depth-to-hardness relationships are shown in Table III. The hardnesses at uniform distances from the surface for both pins were obtained from curves b and c in Figure 1.

(Continued on next page)

(Hardness Tests, cont'd) -

Table III.

Pin	Vickers Hardness Numbers At depths in inches from the surface.							
	At surface	0.005	0.010	0.020	0.030	0.040	0.050	0.060
b	813	795	780	733	579	336	302	277
c	770	724	685	572	436	336	275	272

Figure 1.

GRAPH SHOWING DEPTH-HARDNESS RELATIONSHIPS.

Depth of Case:

Samples were polished and etched and the depth of case was measured microscopically to an accuracy of one-thousandths of an inch. The case depth was taken from the outside edge to the middle of the transition zone.

Pin b = 0.030 inch
Pin c = 0.026 "

Microscopic Examination:

All the photomicrographs were taken at X1000 magnification.

Figure 2 shows the case structure of Pin b and reveals free carbides present.

Figure 3 shows the acicular case structure of Pin c.

Figure 4 shows the microstructure of the core of the pins (similar in both). A large amount of free ferrite is evident.

Pin b was treated to 1660° F. for ½ hour, then quenched and drawn at 1000° F. for one hour (to its original hardness). The structure of the core, as revealed in Figure 5, shows the elimination of a great deal of free ferrite formerly present, resulting in a more uniform structure.

Discussion of Results:

The chemical analysis obtained shows that the bar stock used conforms to the limits set for S.A.E. 3120 steel.

The magnaflux examination revealed no cracks or strains, showing that in the manufacturing process no immediately evident sources of possible failure in the pins exist.

Since an ultimate stress of 131,500 pounds has been obtained, it should be possible to obtain, by proper heat-treatment, a reduction in area up to approximately 64 per cent. The importance of a greater reduction in area can be shown by

(Discussion of Results, cont'd) -

the following equation:

$$\text{Rupture strength} = \frac{\text{Ultimate stress}}{100 - \text{Reduction in area}}.$$

The increase in rupture strength that would result from a more adequate heat-treatment can now be calculated by substituting in the above equation:

$$\text{Rupture strength at present} = \frac{131,500}{100 - 38} = 2,120 \text{ pounds.}$$

$$\text{Possible rupture strength} = \frac{131,500}{100 - 64} = 3,650 \text{ pounds.}$$

With a higher rupture strength the pin can absorb more energy before failure.

The formation of a closer core structure by quenching from a higher temperature, as shown by Figure 5, is desirable since it will result in a more uniform and tougher pin. The difference in the structures of the cases for Pins b and c is probably due to the fact that these represent two extremes within which the structure varies.

Results of the bend tests show that the pins do not meet the specification requirements.

In a previous investigation (No. 1133, December, 1941), carried out in these laboratories, it was shown that pins with surface hardnesses of 500-600 V.P.N. gave the most satisfactory bend tests and would be less likely to crack under a concentrated strain than the harder-surfaced pins.

The depth of case is satisfactory in both pins. It is believed that for LABORATORY comparison of the depth of case a more accurate and scientific method can be

(Discussion of Results, cont'd) -

evolved than is presently being employed.

Depth of case can be derived from a graph such as Figure 1. An arbitrary Vickers hardness number 500 (indicated by the arrow) is chosen and the distance from the surface is taken for each pin at this hardness. By this method:

Pin b = 0.034 inch
Pin c = 0.025 "

The microscopic measurement of depth of case always involves the factor of personal error. It is, however, not recommended that this method be employed in a foundry as it is time-consuming.

Conclusions:

1. The bar stock used for these pins is S.A.E. 3120 steel.

2. Magnaflux tests show that the pins have not been cracked in the process of manufacture.

3. A satisfactory depth of case has been obtained.

4. Bend tests give results that are below specification limit of 8°.

5. The reduction in area obtained for steel which has an ultimate stress of 131,500 p.s.i. is low.

6. A more uniform core structure is desirable.

Recommendations:

1. Although the specification in the present form does not allow it, a surface hardness of 500-550 V.P.N. is preferred so that any stress concentration at a certain area would be less likely to result in pin breakage.

2. Quenching from a higher temperature would give

(Recommendations, cont'd) -

a more uniform core structure and consequently a tougher pin with an improved rupture strength.

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SLG:GHB.

Figure 2.

X1000, nital etch.

Case structure of Pin b, showing presence of free carbides.

Figure 3.

X1000, nital etch.

Acicular case structure of Pin c.

Figure 4.

X1000, nital etch.

Microstructure of the core of the pins (similar in both), showing large amount of free ferrite present.

Figure 5.

X1000, nital etch.

Microstructure of core of Pin b after heat treatment. It will be noted that the structure is more uniform, much of the ferrite having been eliminated.

SLG:PES.