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OTTAWA March 20, 1945.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1815.

Investigation of T-16 Carrier Track Pins
from Somerville Testing Grounds.

(Copy No. 10.)

Bureau of Mines
Division of Metallic
Minerals
-
Physical Metallurgy
Research Laboratories

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
Mines and Geology Branch

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Origin of Material and Object of Investigation:

On February 13, 1945, Capt. V. J. Sharkey of the Inspection Board of United Kingdom and Canada, 409 Ford Building, Detroit, Michigan, submitted a number of broken T-16 Carrier track pins for examination. An accompanying letter (File No. 50028) stated that during the course of two vehicles tested at Somerville, one supplied with tracks containing W.D. 8650 pins and the other SAE 3115 pins, the track with the homogeneous pins lasted only 1,100 miles during which 43 pins broke. The first break occurred at 550 miles and the remainder between 1,000 and 1,110 miles.

A new method of retaining the pin by crimping the washer was being tested. All breakages occurred about 1½ inches from the crimped collar end. In the case of pins made from SAE 3115 steel, about 37 pins broke during 2,500 miles of running with breakages occurring throughout the life of the test. These pins were produced supposedly in accordance with Specification O.A. 214. A complete metallurgical examination was requested.

General:

In answer to enquiries, it was stated by teletype that

(1) The W.D. 8650 pins were centreless ground and austempered by Commercial Heat Treating Co., Detroit, Michigan.

(2) No previous experience of pin failures of this type had been observed when the collars were welded.

(3) No change in heat treatment was made for this particular batch of pins.

(4) No laboratory tests had been made on these pins prior to field test.

(5) 16,000 to 20,000 pounds hydraulic pressure was used in crimping the collars.

W.D. 8650 PINS.

Macro-Examination:

The fractured surfaces of the pins were examined. Some of these showed the duplex structure typical of fatigue failure. Others appear to have broken shortly after the first crack since no area of the fractured surface has been smoothed off by rubbing.

Chemical Analysis:

Two pins were analysed:

		Pin A	Pin B	Specification W.D. 8650
Carbon	-	0.56	0.56	0.48-0.53
Manganese	-	0.95	0.95	0.75-1.00
Sulphur	-	0.026	0.026	0.050 max.
Phosphorus	-	0.030	0.028	0.050 max.
Nickel	-	0.52	0.52	0.40-0.70
Chromium	-	0.48	0.48	0.40-0.60
Molybdenum	-	0.18	0.18	0.15-0.25
Silicon	-	0.25	0.24	0.20-0.35

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Hardness Tests:

Transverse microspecimens were cut from the pins and hardness tests were made on the core, using the Rockwell machine. The results are shown below:

Pin No.		Hardness, Rockwell 'C'
1	-	54
2	-	52
3	-	53
4	-	54
5	-	54
6	-	54

McQuaid-Ehn Test:

The McQuaid-Ehn grain size was 4-5.

Microscopic Examination:

Transverse microspecimens and longitudinal specimens were cut from the pins and examined under the microscope. In the unetched condition, the steel was found to be fairly clean. The specimens were etched in 2 per cent nital and re-examined. The longitudinal specimens gave no evidence of banding. Figure 1 (X1000) illustrates the acicular structure obtained in all specimens. Figure 2 (X1000) taken from a previous report (Investigation No. 1655, June 1, 1944) illustrates the finer more densely packed martensitic structure of a previously examined 0.46 carbon W.D. 8650 steel supposedly treated the same way as the pins here examined. Some carbide nodules are also present in the structure shown in Figure 2.

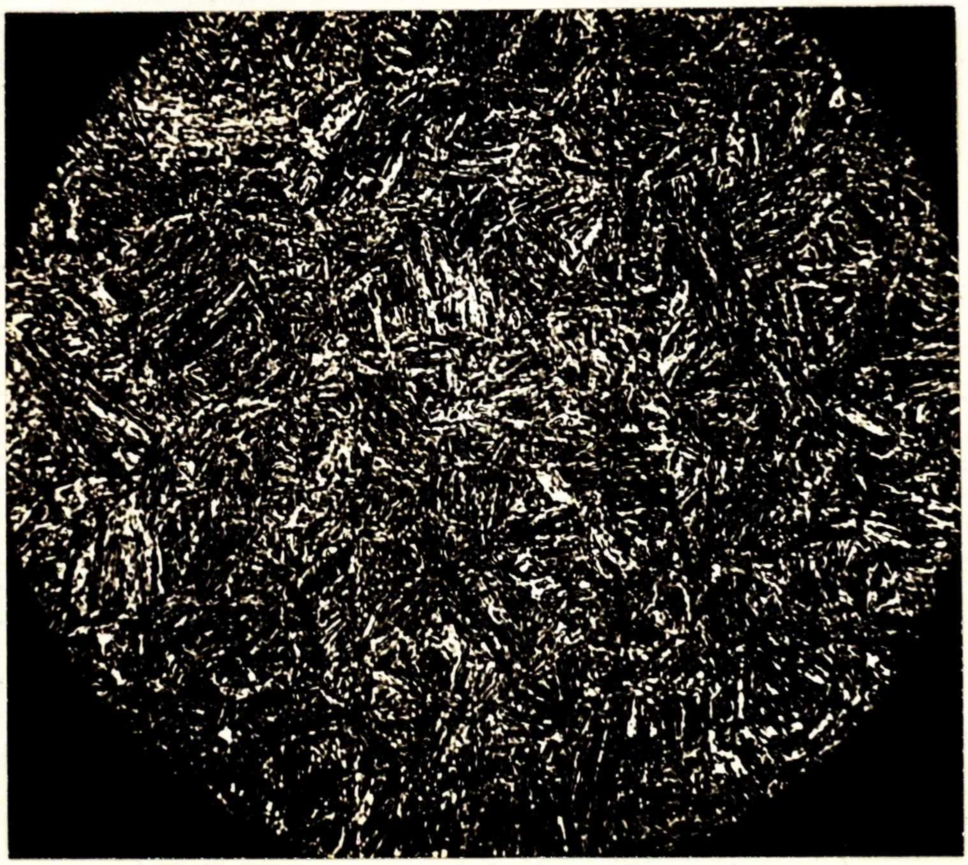
(Continued on next page)

Figure 1.

X1000, nital etch.

COARSE ACICULAR MARTENSITE (0.56 PER CENT CARBON).

Figure 2.



X1000, nital etch.

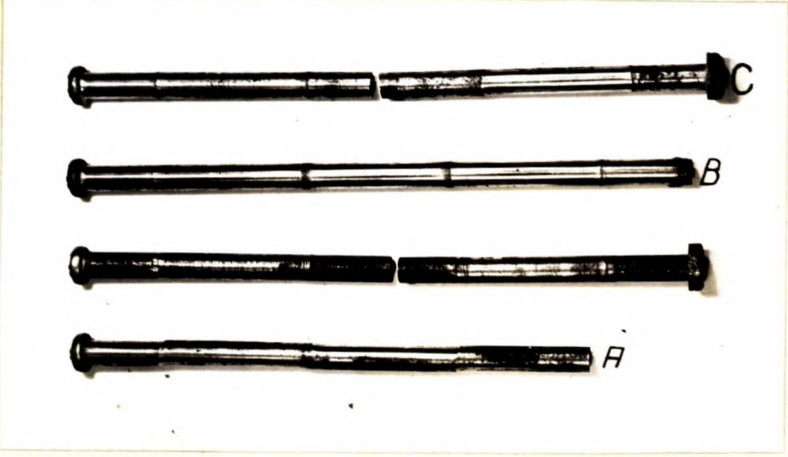
TEMPERED MARTENSITE AND NODULES OF FREE CARBIDE (0.46 PER CENT CARBON).

CASE HARDENED SAE 3115 UNIVERSAL CARRIER TRACK PINS.

Macro-Examination:

Failure of the cased universal carrier track pins occurred in one of three ways, as shown in Figure 3. Of the ten pins submitted, one broke close to the welded end, one pin was removed because the welded washer broke off and the remaining eight broke at approximately the centre of the pin.

Figure 3.



(A) One pin broke close to the riveted end.

(B) One pin failed when the riveted washer came off.

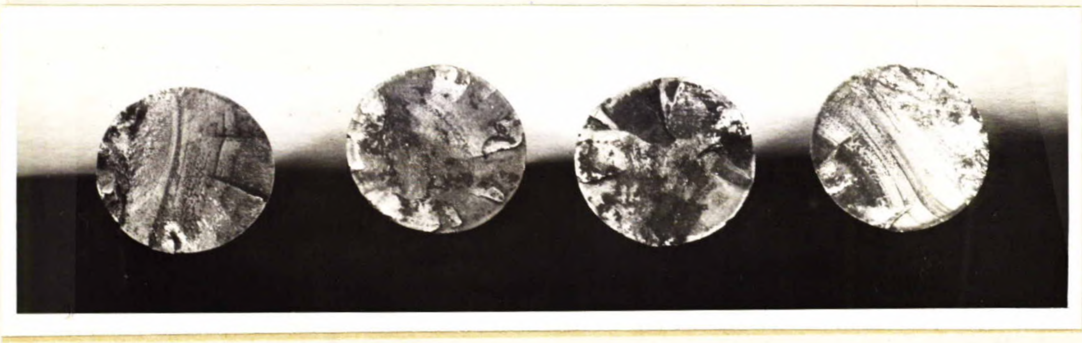
(C) Eight broke at approximately the centre of the pin.

The fracture surfaces at the points of failure on all pins were characteristic in appearance of fractures resulting from fatigue type failures. Four such typical fractures are shown in Figure 4.

(Continued on next page)

(Macro-Examination, cont'd) -

Figure 4.



FRACTURE SURFACES TYPICAL OF FATIGUE FAILURES.

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Identification:

The location on the track and the mileage record of only six of the ten pins submitted could be identified from the tags. Consequently, only these pins were used for the balance of the investigation. The six pins are identified as follows:

No.

1. Hull #7666, replaced at 500 miles, welded end snapped off.
2. Hull #7666, left track, replaced at 1,207 miles; broke near welded end.
3. Hull #7666, left track, replaced at 1,590 miles; broke at centre.
4. Hull #7666, right track, operated 450 miles.
5. Hull #7666, right track, operated 525 miles.
6. Hull #7666, right track, operated 553 miles.

Chemical Analysis:

TABLE I.

No.		Carbon	Manganese	Silicon	Nickel	Chromium
		- Per Cent -				
1	-	0.16	0.50	0.23	1.33	0.29
2	-	0.17	0.55	0.24	1.28	0.28
3	-	0.18	0.56	0.24	1.33	0.30
4	-	0.21	0.54	0.24	1.35	0.30
5	-	0.17	0.50	0.22	1.28	0.28
6	-	0.20	0.56	0.24	1.28	0.30

Hardness and Case Depth:

The core hardness of these pins is shown in Table II. Surface hardness and case depth values were also determined and recorded but should not be considered representative of these pins before service.

TABLE II.

Pin No.		Core Hardness*, Rockwell 'C'	Surface Hardness, Rockwell 'C'	Case Depth, inches Minimum		Maximum
1	-	18-19	78-79	0.009	-	0.012
2	-	18-20	75-76	0.003	-	0.016
3	-	22-24	75-76	Nil	-	0.016
4	-	21-23	75-76	0.007	-	0.014
5	-	16-18	78-79	0.003	-	0.014
6	-	21-23	75-76	0.007	-	0.016

* Specifications require a core hardness of 24 to 32 Rockwell 'C'.

Microscopic Examination:

Microscopic examination of transverse specimens cut from each pin showed the microstructure of all pins to be similar.

As shown in Figure 5, the core structure consisted of ferrite and low carbon martensite. The higher carbon case was largely worn away in some spots (Table II) but the remaining portions had a fine martensitic microstructure (see Figure 6).

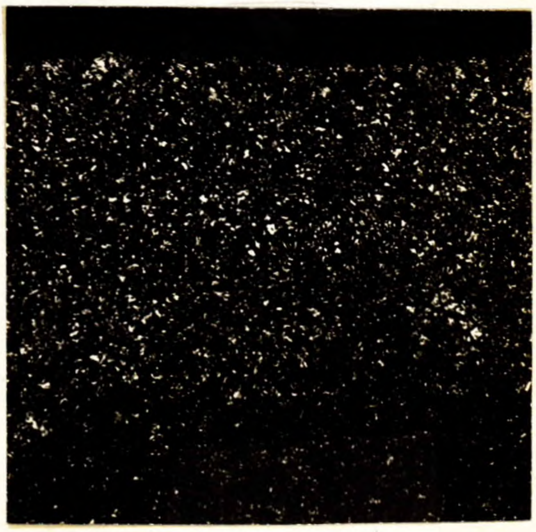
Figure 5.

X500, etched in 2 per cent nital.

PIN NO. 5.

Core structure of ferrite and low carbon martensite.

Figure 6.



X250, etched in 2 per cent nital.

PIN NO. 5.

Case structure of fine martensite.

Discussion:

W.D. 8650 Pins.

This report should be read in conjunction with our Report of Investigation No. 1655, issued June 1, 1944.

The carbon content of these pins is over the maximum of 0.53 per cent which is specified. In a salt-quenching treatment such as these pins received, the additional carbon should not be too serious. It may be interesting to present several possibilities, however. It could be expected that the M_s point will be lowered somewhat by the higher carbon content. If the heat treatment remains constant for various carbon content steels a high retained austenite content would result from the higher carbon steels. This retained austenite transforms to martensite on cooling in air from the salt bath temperature with an accompanying change in volume. This change from austenite to martensite also occurs when the pin is stressed in service. Internal stress is set up which may result in somewhat inferior service in the field.

Failure by fatigue is indicated by some of the pins. These pins are at the upper specification range of the hardness. It would then be expected that the fatigue strength of the pin is at a maximum, provided the surface is notch-free. Lowering the hardness would only aggravate the condition. It is felt that these pins, in all probability, failed due to a localized stress concentration caused by:

(1) The pin being jammed in the link, possibly due to the crimping operation, and/or

(2) Some difference in the set-up of the vehicle, e.g., tracks, suspension, etc., as run in this field test.

(3) Under the above conditions a notch could be formed on the surface which would make the higher hardness pins more prone to fatigue.

The microstructure shows a coarser acicular structure than was obtained in the tests carried out in these Laboratories

(Discussion, cont'd) -

on heat-treated pins, supplied by Commercial Heat Treating Co. in June 1944. This would indicate that a higher quench temperature was employed. This is also suggested by the almost complete absence of spheroidal carbides (provided that spheroidized steel is still being used). These are present in Figure 2. It would be interesting to check the structure of the bar stock to see whether the mills are consistently supplying a spheroidized material.

Case Hardened SAE 3115 Universal Carrier Track Pins.

The appearance of the fracture surfaces at the points of failure indicates that failure was due to fatigue.

The chemical composition is similar for all pins and typical of SAE 3115 steel previously used in the production of pins.

Low core hardness is a likely cause of earlier failure, since it has been fairly well established that fatigue failure on the cased pin starts in the transition zone. Microscopic examination has substantiated this low core hardness in indicating that the pin structure is composed of a non-uniform ferrite-martensite aggregate.

Low core hardness should not be considered the only likely cause of failure. It is believed that the cased pin is overstressed in the T-16 carrier and that breakages may be expected if any abnormal condition, such as faulty assembly of the track, causes an increase in the operating stresses.

CONCLUSIONS:

W.D. 8650 Pins.

1. A high carbon content heat of steel has been used for these pins. For a salt quench treatment, this should not be too serious a factor.

2. Several pins indicate failure due to fatigue. Higher

(Conclusions, cont'd) -

stress concentration than normal could have been caused by the method of pin retention, or by irregularities of the vehicle used for test.

3. The microstructure shows coarse acicular martensite. Pins previously examined here were finer grain. A higher quenching temperature appears to have been used for these pins especially if a spheroidal bar stock was heat treated.

4. The McQuaid-Ehn grain size was 4-5 which is slightly coarser than specified.

Case Hardened SAE 3115 Universal Carrier Track Pins.

1. Macroscopic examination has shown that failure was of the fatigue type.

2. There are two likely reasons for early failure:

(a) Low core hardness, which affords poor resistance to fatigue.

(b) Some mechanical fault in the assembly of the track which produced alternating stresses greater than the endurance limit of the pins.

Recommendations:

1. Laboratory tests should be carried out on pins prior to any field test. It would then be possible to determine whether pins used are representative of the normal type produced.

2. If breakages had been reported from the field having had the normal welded pin retention process then reconsideration of the specification would have been advisable.

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