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O T T A W A June 10th, 1942.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1243.

(M. and S. No. 7/A/4.)

Examination of a Cracked Campbell, Wyant and Cannon Mark III Track Pin.

(Copy No. 16.)

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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Examination of a Cracked Campbell, Wyant and Cannon Mark III Track Pin.

Origin of Material and Object of Investigation:

On June 3rd, 1942, Dr. C. E. Drury (Department of Munitions and Supply, Ottawa), at a meeting of the Track Pin Committee held in Ottawa, presented a track pin which had been taken from a Mark III tank after it had run 1,226 miles. Cracks in the case were visible and a routine metallurgical investigation was requested to determine, if possible, the reason for failure of the case.

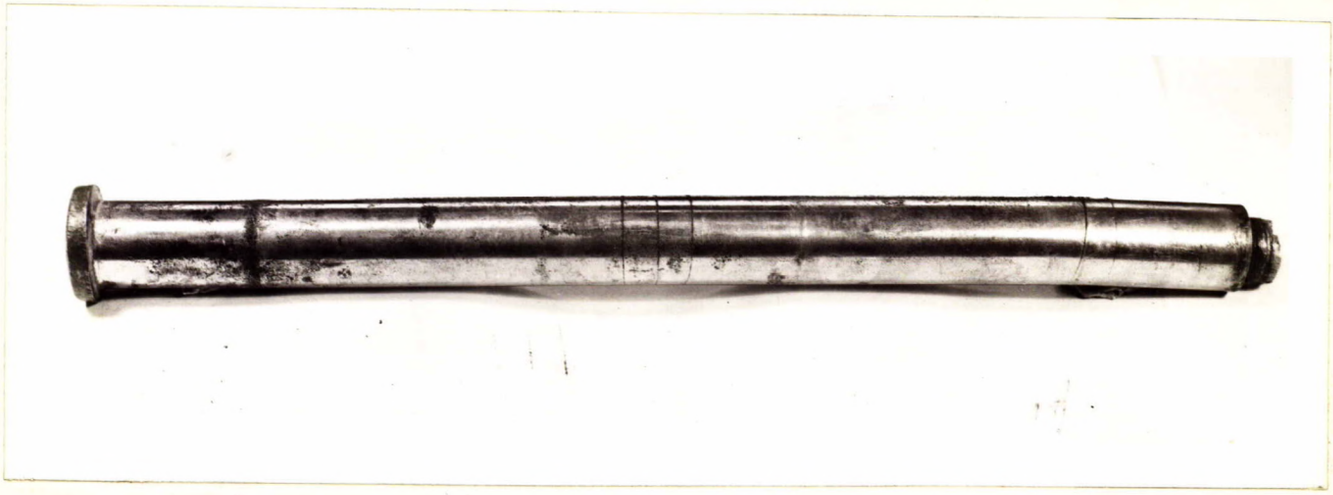
Macroscopic Examination:

The pin was magnafluxed to illustrate the cracks more clearly and to see if any sub-surface cracks were present. Figure 1 shows the pin after the magnetic test. Six cracks were observed. The distances from the head of the pin were measured.

	Distance from the head of the pin, in inches.
1st crack	2-1/8
2nd "	5-3/8
3rd "	5-3/4
4th "	6
5th "	9-3/4
6th "	10

The diameter of the pin was 0.869 inch, which is an average of ten (10) readings.

Figure 1.



Magnafluxed Pin, Showing Cracks.

Chemical Analysis:

	As found	Specification SAE 3115
Carbon	0.16	0.10 - 0.20
Manganese	0.52	0.30 - 0.60
Silicon	0.29	0.15 min.
Phosphorus	0.021	0.040 max.
Sulphur	0.017	0.050 max.
Nickel	1.23	1.00 - 1.50
Chromium	0.67	0.45 - 0.75

Case Depth and Crack Penetration:

The depth of the case was measured, using the Brinell microscope. It was 0.029 inch.

In order to see the depth of penetration of the cracks, a specimen containing the last two cracks (Nos. 5 and 6) was cut from the pin and a longitudinal section taken. The depth was found to be:

5th crack	=	0.051 inch
6th crack	=	0.034 "

Depth Hardness:

Hardness readings were taken, using the Vickers hardness machine and the 10-kilogram weight. The depth-hardness relationship is shown below:

Distance from the surface, in inches		V.P.N.
0.29	=	202
0.095	=	202
0.068	=	202
0.035	=	262
0.011	=	698
Surface	=	724

Grain Size:

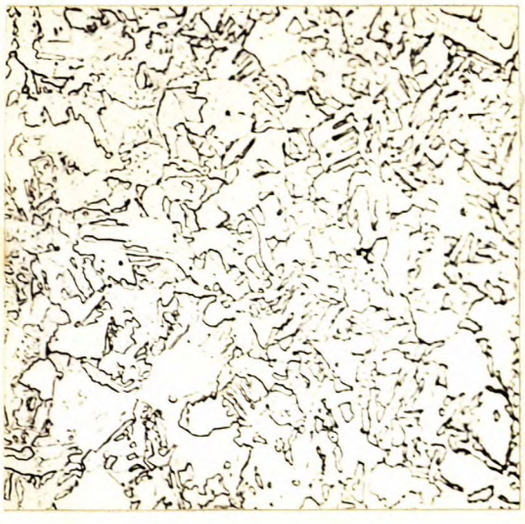
The grain size of the pin as received was 6-7.

The McQuaid-Ehn grain size, pack-carburized for 8 hours at 1700° F., was 6-7.

Microscopic Examination:

A polished specimen of the pin was examined under the microscope, both in the nital etched and the unetched condition. In the unetched state the steel was found to be quite clean. Figures 2 and 3 illustrate the structures of the core and the case, taken at X500 and X1000 magnification respectively. Figure 2 shows that the core structure is mainly ferrite. Figure 3 indicates the presence of free carbides in the case.

Figure 2.



X500, nital etched.

CORE OF THE PIN.

Figure 3.

X1000, nital etched.

CASE OF PIN.

Note presence of free carbides (white constituent).

Discussion:

The chemical analysis shows that the steel conforms to the specification limits of SAE 3115 steel.

The cracks were distributed over the entire length

(Discussion, cont'd) -

of the pin and not concentrated at one point. Measurement of the depth of penetration of two of the cracks shows that they have already started to propagate through the core, since the case depth was 0.029 inch whereas the depths of the cracks were 0.051 and 0.034 inch. It is felt that since the cracks have started to propagate through the core the pin will fail in a short time.

A reasonably fine-grained steel was employed for the production of this pin, since the McQuaid-Ehn grain size was 6-7.

Cracking of the case is characteristic of all hard-cased pins. The presence of free carbides (white constituent, Figure 3) would cause greater brittleness and the pin would break at a lower load than would a normal-cased pin.

Free carbides should be eliminated. It was not reported whether this pin was carbo-nitrided or cyanided. If it was carbo-nitrided the heat treatment cycle should be ended off at a practically neutral atmosphere (only slightly carburizing) to allow for diffusion of the carbides. If the pin received a cyanide treatment, a less concentrated bath should be employed as this would allow for greater diffusion of the carbides.

Conclusions:

1. The chemical analysis shows that the steel conforms to the specification limits of SAE 3115 steel.

2. The cracks have started to propagate through the core; thus it could be expected that the pin would fail in a short time.

3. A reasonably fine-grained steel was employed.

4. Free carbides are present in the case. This weakens it considerably and would cause early cracking.

(Continued on next page)

(Conclusions, cont'd) -

5. A diffusion treatment to eliminate the carbides should be carried out.

Recommendations:

1. If the pin is of the carbo-nitrided type, the heat treatment cycle should be ended in a practically neutral atmosphere (only slightly carburizing) to allow for diffusion of the carbides.

If the pin is of the cyanided type, a less concentrated bath should be employed as this would allow for greater diffusion of the carbides.

2. A diffusion treatment can be carried out after carburizing is completed.

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SLG:GHB.