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# R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1318.

Examination of Track Link, Track Pin and Cotter Pin from a German P.Z. K.W.III Tank.

(Copy No. 38.)

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 Track Link, Track Pin and Cotter Pin from a German P.Z. K.W.III Tank.

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Origin of Material and Object of Investigation:

On October 3rd, 1942, a track link, a track pin and a cotter pin, taken from a German P.Z. K.W.III tank, were received from the Inspector General, Inspection Board of United Kingdom and Canada, 70 Lyon Street, Ottawa, Ontario, for examination. The following excerpt is from the request letter (File ADH/ 1-109), dated September 30th, 1942, addressed to this Department:

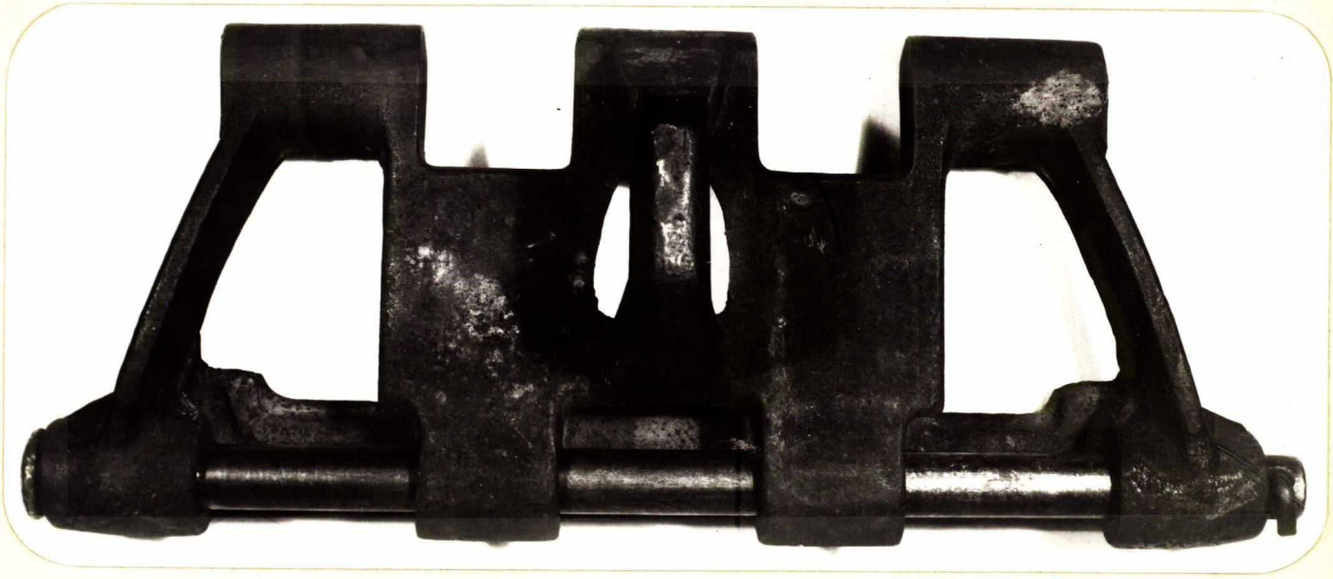
> "We shall be obliged if you will examine these parts and supply us, at your earliest convenience, your findings. In particular we would like to have the weight and photographs of the complete shoe and pin taken prior to mutilation; in addition, chemical analysis of the material used, physical properties together with suggestions of appropriate heat treatment used to obtain these properties; the formation of the head of the pin."

Macro-Examination:

The dimensions of the link, pin, and cotter pin are given in Drawing No. A.D. Tech. M12 of the Inspection Board of United Kingdom and Canada, Ottawa, Ontario. Figures 1 and 2 are pictures of the link and pin assembly with the guiding lug facing the camera.

Figure 3 is a picture of the assembly showing the contact face of the shoe.

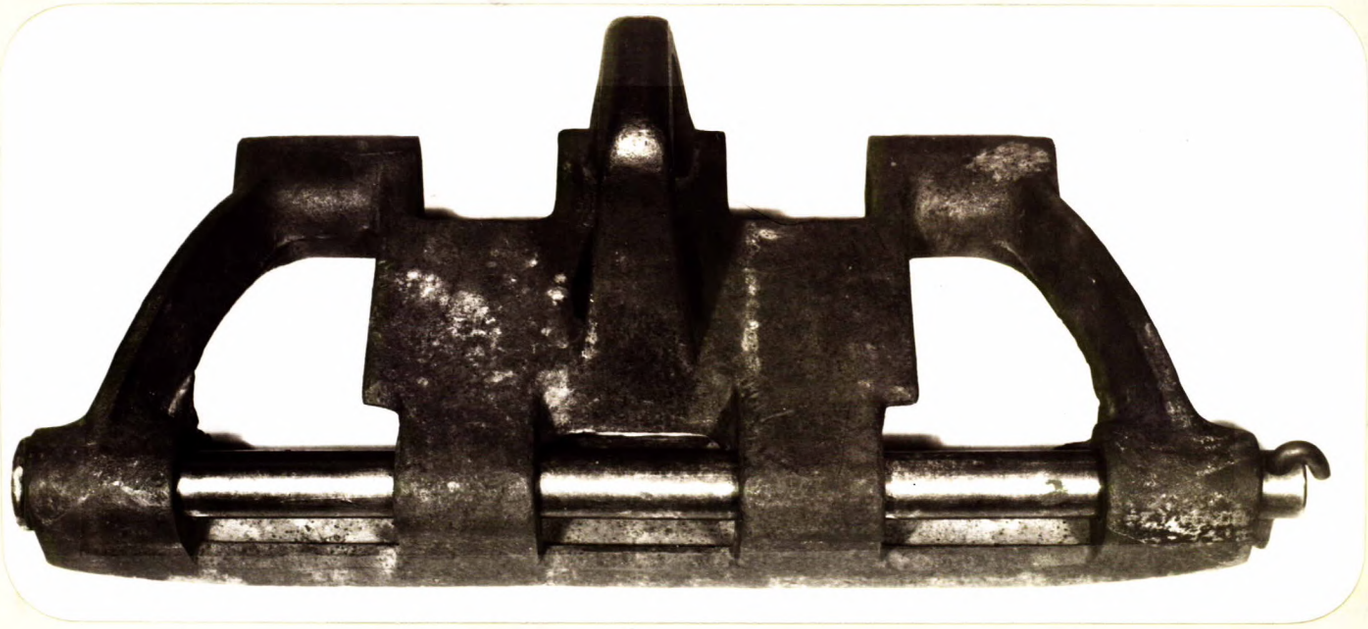
Figure 1.



Photograph, taken from above, showing the centre guiding lug of link.

(Approximately $\frac{1}{2}$ size).

Figure 2.



Photograph, taken at an angle, showing assembly with cotter pin.
(Approximately ½ size).

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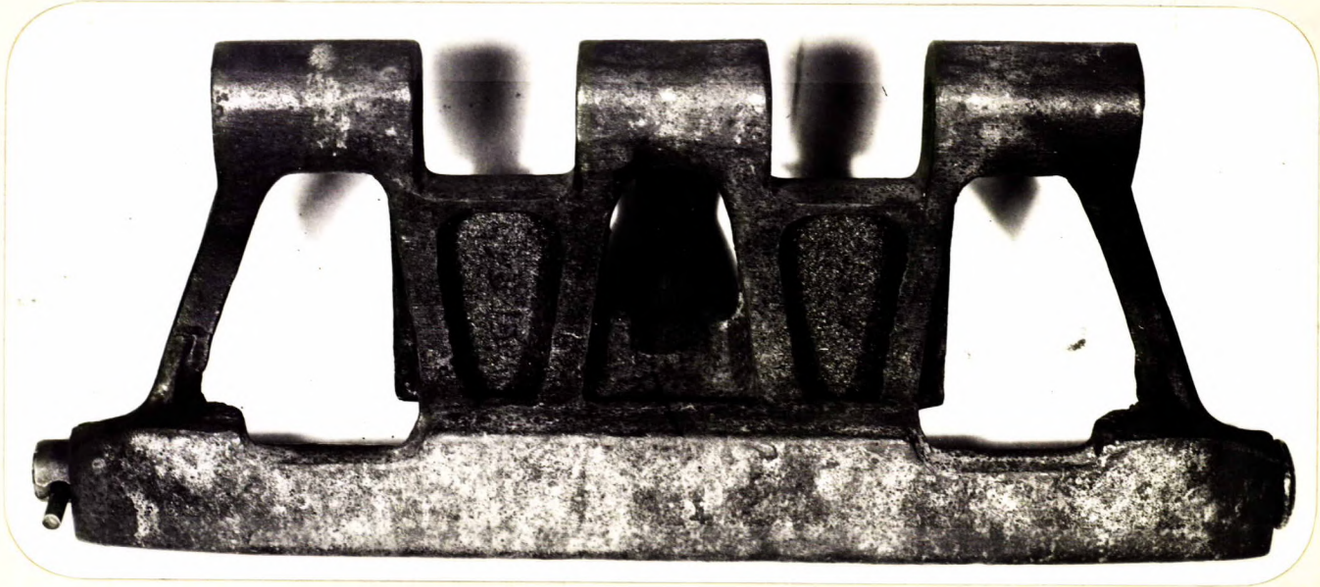
Figure 3.



Photograph showing contact surface of link.
(Approximately ½ size).

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WEIGHT OF SAMPLES:

| | | |
|---|---|---|
| The weight of the shoe | = | 13 lb. 1 oz. |
| The weight of the pin | = | 2 " 1 " |
| The weight of the shoe and pin | = | 15 " 3 " |

## T R A C K  L I N K.

Chemical Analysis:

Drillings were taken from the link, for chemical analysis.

| | | As Found | Recommended Specification |
|---|---|---|---|
| | | - Per cent - | |
| Carbon | = | 1.03 | 1.00 - 1.40 |
| Manganese | = | 12.84 | 10.00 - 14.00 |
| Silicon | = | 0.86 | 0.30 - 1.00 |
| Sulphur | = | 0.011 | 0.05 max. |
| Phosphorus | = | 0.047 | 0.10 " |
| Chromium | = | 0.16 | - |

Hardness:

The Brinell hardness of the link was 197.

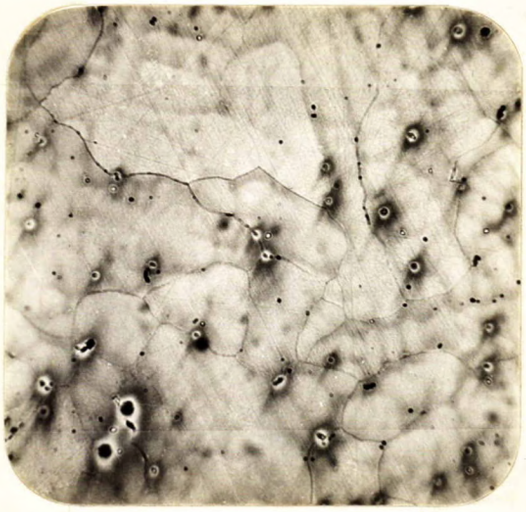
Micro-Examination:

Specimens were cut from the link and examined under the microscope. The unetched specimens showed that the steel was quite clean. The nital-etched specimens showed the structure illustrated in Figure 4, taken at X100 magnification.

(Continued on next page)

(Micro-Examination, cont'd) -

Figure 4.



X100, nital etch.

STRUCTURE OF LINK.

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## T R A C K  P I N.

Chemical Analysis:

Drillings were taken from the core of the pin for chemical analysis.

| | | As Found | SAE 1010 |
|---|---|---|---|
| | | - Per cent - | |
| Carbon | - | 0.10 | 0.05 - 0.15 |
| Manganese | - | 0.34 | 0.30 - 0.60 |
| Silicon | - | 0.15 | 0.15 min. |
| Phosphorus | - | 0.015 | 0.045 max. |
| Sulphur | - | 0.032 | 0.055 " |
| Chromium | - | Trace. | - |
| Nickel | - | Not detected. | - |
| Molybdenum | - | Not detected. | - |

Method of Heading:

The pin size, 20 mm. diameter, would indicate that a hot-heading operation was employed. X-ray diffraction tests by the back-reflection method were used, however, to definitely establish this fact. X-rays of a known cold-headed pin and a

(Method of Heading, cont'd) -

known hot-headed pin were taken. The X-ray obtained for the German pin compared with that of the hot-headed pin. It might be mentioned that the cold-headed pin gives a diffused pattern, indicating crystal distortion, whereas the hot-headed pin gives a regular pattern.

Physical Tests:

A length of $5\frac{1}{8}$ inches was cut from the pin. The remainder was used for the bend test (see below). A specimen was cut from the core, of 0.505-inch diameter and 2-inch gauge length. Results obtained were:

| | | |
|---|---|---|
| Ultimate strength | = | 80,000 p.s.i. |
| 0.1 per cent proof stress | = | 55,600 " |
| Elongation | = | 17.5 per cent |
| Reduction of area | = | 64 " |

Bend Tests:

A bend test was carried out on an Amsler Universal testing machine using a 12-inch radius and 8-inch centres.

A chart of increment vs. load was plotted. The elastic limit, permanent bend and case break point were then determined from the chart and the angles calculated geometrically. The method used was illustrated in the report of a previous investigation, No. 1197 (April 2nd, 1942), carried out in these laboratories. The results obtained were as follows:

| | | Load, in pounds | Angle |
|---|---|---|---|
| Elastic limit | = | 3,420 | 1°42' |
| Permanent bend | = | 4,370 | 3°15' |
| Case break point | = | 4,900 | 4°45' |

Case Depth:

A transverse section of the pin was polished and etched in 2 per cent nital. The case depth was measured,

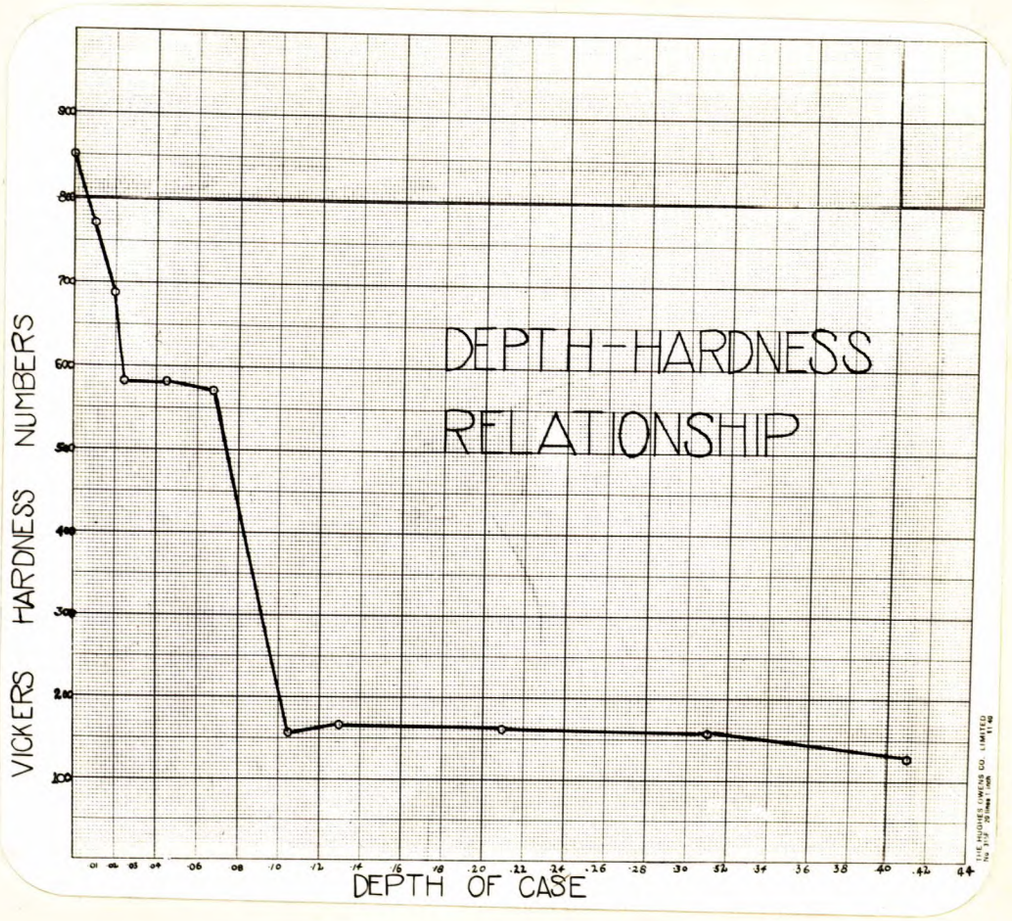
(Case Depth, cont'd) -

using the Brinell microscope. The depth varied between 0.029 and 0.032 inch.

Depth-Hardness Relationship:

A transverse section of the pin was cut and hardness readings were taken across the face of the section, using the Vickers hardness machine and a 10-kilogram load. Figure 5 is a depth-hardness chart plotted from the hardness results obtained. It may be seen from this chart that the surface hardness is 850 V.P.N. and the core hardness 130 V.P.N.

Figure 5.



Microscopic Examination:

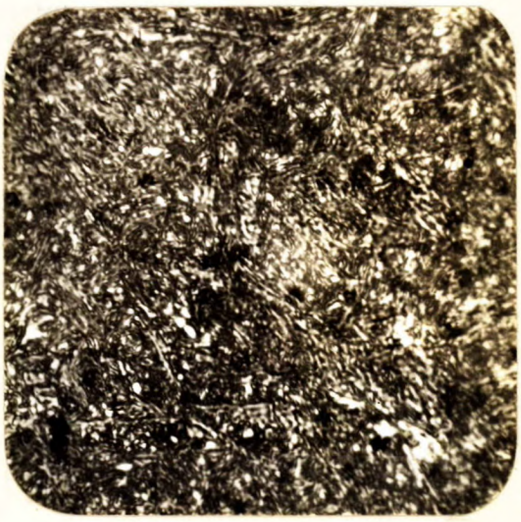
A transverse section was cut from the pin and polished. The unetched specimen showed that clean bar stock was used. The nital-etched specimen illustrates the structure of the core and case. Figures 6 and 7, one at X500 and the other at X1000 magnification, are of the core and case respectively.

Figure 6.

X500, nital etch.

CORE OF PIN.

Figure 7.



X1000, nital etch.

CASE OF PIN.

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C O T T E R  P I N.

A carbon analysis was carried out by the ordinary combustion method.

Carbon - 0.20 per cent.

Since not enough sample could be obtained for a complete chemical analysis, a spectral analysis was carried out. The roughly estimated quantities of the alloys found were as follows:

(Continued on next page)

(Cotter Pin, cont'd) -

| | | |
|---|---|---|
| Chromium | = | 0.10 per cent. |
| Copper | = | Trace. |
| Molybdenum | = | Trace. |
| Nickel | = | Trace. |

The spectrum of this steel was compared against standard Hilger pure iron electrodes. The quantities are estimates based on the analysis of these electrodes.

DISCUSSION:

Track Link -

The analysis shows that the link is of a high manganese steel. It is within the recommended specification for this type of steel. The chromium content is too small to have any decided effect. A higher chromium content usually aids wear resistance by causing the steel to work-harden faster.

The relatively fine grain size shown in the photo-micrograph, Figure 4, indicates that the steel was poured at very close to the lower limit of the pouring range temperature. Figure 4 also shows that the link has received a good heat treatment, since free carbides are not evident. The heat treatment for a high manganese steel is as follows:*

Heat to 1830 - 1940° F.
Quench rapidly in cold water.

When the composition of the steel is within the correct limits, this treatment results in all the carbide being taken into solid solution in the austenite and produces a uniform austenitic structure and a high degree of strength and toughness.

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* Metals Handbook, A.S.M., 1939 Edition.

(Discussion, cont'd) -

Track Pin -

The chemical analysis indicates that the steel used for the track pin corresponds to SAE 1010. It might be mentioned that up to the present time nickel steel is used for track pins in this country. There is no doubt that nickel steel properly heat treated gives better core properties.

The case bend test shows that, as with all cased pins, the bend angle obtained for the first crack in the case is low.

The core structure indicates that the pin has been quenched from a high temperature. The core physicals would also seem to indicate this fact. The low core hardness obtained is due to the low carbon content.

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Cotter Pin -

The cotter pin material appears to be equivalent to SAE 1020.

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CONCLUSIONS:

Track Link -

1. Made out of high manganese steel according to the recommended specification for high manganese steel.

2. Relatively fine grain size indicates that the pouring temperature was near the lower limit of the range.

3. Absence of free carbides shows that the link was given a good heat treatment.

Track Pin -

1. Made out of SAE 1010 steel.

(Continued on next page)

(Conclusions, cont'd) -

2. Core physicals and structure indicate a relatively high quenching temperature.

3. Surface hardness is 850 V.P.N.

Core hardness is 130 V.P.N.

4. Case depth is 0.029 to 0.032 inch.

Cotter Pin -

The cotter pin material appears to be made of SAE 1020 steel.

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SLG:GHB.