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O T T A W A June 26th, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1670.

Examination of an Italian Track Link Assembly.

(Copy No. 13.)

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 June 5th, 1944, Mr. V. W. G. Wilson, for the Director of Tank Design, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario, submitted an Italian track shoe, track pin and retaining cap for metallurgical examination. The covering Requisition No. 650, A.E.D.B. Lots Nos. 542 and 543, Report No. 13, Test No. 63 was received through the Division of Metallurgy and stated that the assembly was used on Italian Tanks M.11/39 and M.13/40.

General Information:

In an accompanying letter, Mr. V. W. G. Wilson submitted the following information, which is taken from "School of Tank Technology", Preliminary Report No. 11, March, 1943:

Tracks -

Type:	Single pin - 4/5 lugs.
Material:	Stamped - magnetic.
Pitch of link:	5 inches.
Width of link:	10¼ inches.
Shoes per track:	80.
Weight of link (including pin and retaining cap):	13 lb. 5 oz.
Diameter of pin:	16 mm.
Method of pin retention:	Convex cap flattened by blow to locate in annular groove in the outer lug. The pin is retained in the inner lug by a shoulder.

LINK.

Macro-Examination:

Figure 1 illustrates the surface of the link which is in contact with the bogie wheels. It will be noticed that this shoe has a centre guide lug. Figure 2 shows the ground contact face of the link.

An X-ray examination carried out by the National Research Council, Ottawa, indicated that the shoe was very sound. No flaws were visible.

A macro-etch on a piece cut from the shoe showed definitely that it was forged. Flow lines were evident.

Chemical Analysis:

	AS FOUND - Per Cent -	SPECIFICATION SAE 5140* - Per Cent -
Carbon -	0.39	0.35-0.45
Manganese -	0.75	0.60-0.90
Silicon -	0.19	0.15-0.30
Sulphur -	0.050	0.050 max.
Phosphorus -	0.022	0.040 max.
Nickel -	0.18	-
Chromium -	0.93	0.80-1.10
Vanadium -	Nil.	-
Molybdenum -	Trace.	-
Copper -	Nil.	-

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

Hardness:

The Brinell hardness of the link was 285.

Grain Size:

After the conventional McQuaid-Ehn pack-carburizing heat treatment, the grain size was found to be 4 to 5.

Microscopic Examination:

A microspecimen was cut from the link. It was polished and then examined under the microscope. In the unetched condition the steel was fairly clean. The specimen was etched in 2 per cent nital and re-examined. Figure 3 (X500) illustrates the sorbitic structure obtained.

PIN.

Macro-Examination:

Figure 4 shows the pin as received. Its length was 10 inches and its diameter 0.621 inch.

Chemical Analysis:

Drillings were taken from the core for chemical analysis. The results were:

	AS FOUND	SPECIFICATION SAE 3215*
	- Per Cent -	
Carbon -	0.15	0.10-0.20
Manganese -	0.42	0.30-0.60
Silicon -	0.32	0.15 min.
Sulphur -	0.31	0.050 max.
Phosphorus -	0.013	0.040 max.
Nickel -	2.30	1.50-2.00
Chromium -	0.81	0.90-1.25
Molybdenum -	Trace.	-
Vanadium -	Nil.	-

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

Hardness:

The surface hardness of the pin was found to be

(Hardness, cont'd) -

59-61 Rockwell 'C'.

The core hardness is 29 Rockwell 'C'.

Case Depth:

The case depth was determined by etching a transverse specimen in 2 per cent nital, then measuring the black etching zone with the Brinell microscope. It was 0.043 inch.

Grain Size:

The McQuaid-Ehn grain size was 2 to 4.

Microscopic Examination:

A transverse specimen was cut from the pin, polished, and examined under the microscope. In the unetched condition the steel was clean. It was then etched in 2 per cent nital and re-examined. Figure 5 (X500) illustrates the core structure, which consists of low-carbon martensite and ferrite. Figure 6 (X1000) is a photomicrograph taken of the case, close to the surface of the pin. Cementite envelopes (white constituent) are clearly visible, outlining the austenitic grain boundaries. The structure of the case is mainly fine nodular martensite.

RETAINING CAP.

The photomicrograph, Figure 7 (at X100), indicates that the retaining cap has been produced from cold-rolled steel (SAE 1010).

The hardness was determined, using the Vickers microscope and a 10-kg. load. It was 170.

Discussion:

The link was fabricated by forging a relatively clean metal. The chemical analysis corresponds to SAE 5140. On this continent, this type of steel is very often used for gears. The conventional heat treatment after forging is to oil-quench from 1500 to 1600° F., then draw to the required hardness. Since the link is 285 Brinell and the microstructure is sorbitic it can be assumed that the link was oil-quenched and then drawn at approximately 1150 to 1200° F.

The analysis of the pin closely resembles SAE 3215. The British and Canadian cased Valentine and Universal Carrier pins were made with B.S.S. 5005/102 steel. This latter steel is similar to SAE 3215 except as to chromium content. The British specification contains no chromium.

The case depth of the pin is 0.043 inch. It would appear that the case was produced by pack carburizing. This treatment is usually used when a case depth of over 0.030 inch is required. For cased pins over 0.5-inch diameter it is felt that the specification of 0.020-0.035 case depth produces the most satisfactory pin. It was found that when case depths were in excess of the maximum specified, pin breakages in the field would result. It should, of course, be mentioned that our tanks were constructed with single-bogie drive, and the links designed for these vehicles may have had larger bending moments, requiring more ductile pins. The Italian vehicle, on the other hand, has a double-bogie wheel drive and the links (especially with the 4 and 5 hinges) may not have a high bending moment. The pins would not have to be capable of bending to any extent and a thick-cased pin might give satisfactory service.

The case structure revealed the presence of cementite

(Discussion, cont'd) -

envolopes. This indicates that in the heat treatment the rate of carburizing exceeded the rate of carbon diffusion. Pins having cementite, especially around the grain boundaries, are extremely brittle and may fail on impact. They also have lower fatigue life. The design of the shoe assembly, however, is such that if a pin fails the vehicle is not stalled. The track still functions, as the pieces of the pin are locked into the shoe by the surclip and pin retaining cap.

The ferrite in the core may be due to a quench from below the critical point of the core and/or a slow quench. The former results in patches of ferrite, whereas the latter usually produces ferrite around the grain boundaries. The pins were probably pack-carburized at 1650 to 1700° F., held in the box to about 1375 to 1400° F. (a point below the AR_3), and finally oil-quenched.

A steel of coarse grain size (2 to 4) has been used for the pin. This is consistent with the European practice of not killing their steel with aluminium. Our specification requires aluminium-killed steel, with a grain size of 6 to 8, for pins. Better resistance to impact is obtained with a fine-grained steel.

CONCLUSIONS:

LINK.

1. The link has been forged from steel conforming to SAE 5140 specification.

2. X-ray examination revealed no flaws.

3. The grain size is 4 to 5, McQuaid-Ehn.

4. The link has been oil-quenched and drawn to give a hardness of 285 Brinell and a sorbitic structure.

PIN.

1. The pin is of the cased type.

2. The steel is close to SAE 3215.

3. The case depth is 0.043 inch. With this depth of case it is most likely that the case was produced by pack carburizing.

4. The surface hardness is 59 to 65 Rockwell 'C'. The core hardness is 29 Rockwell 'C'.

5. A coarse-grained steel has been used, having a grain size of 2 to 4.

6. Cementite envelopes are present in the case, which would make the pin brittle.

7. The pin has most probably been pack-carburized at about 1650 to 1700° F., held in the box at a point somewhat below the AR_3 point of the core (1375 to 1400° F.), and then quenched in oil.

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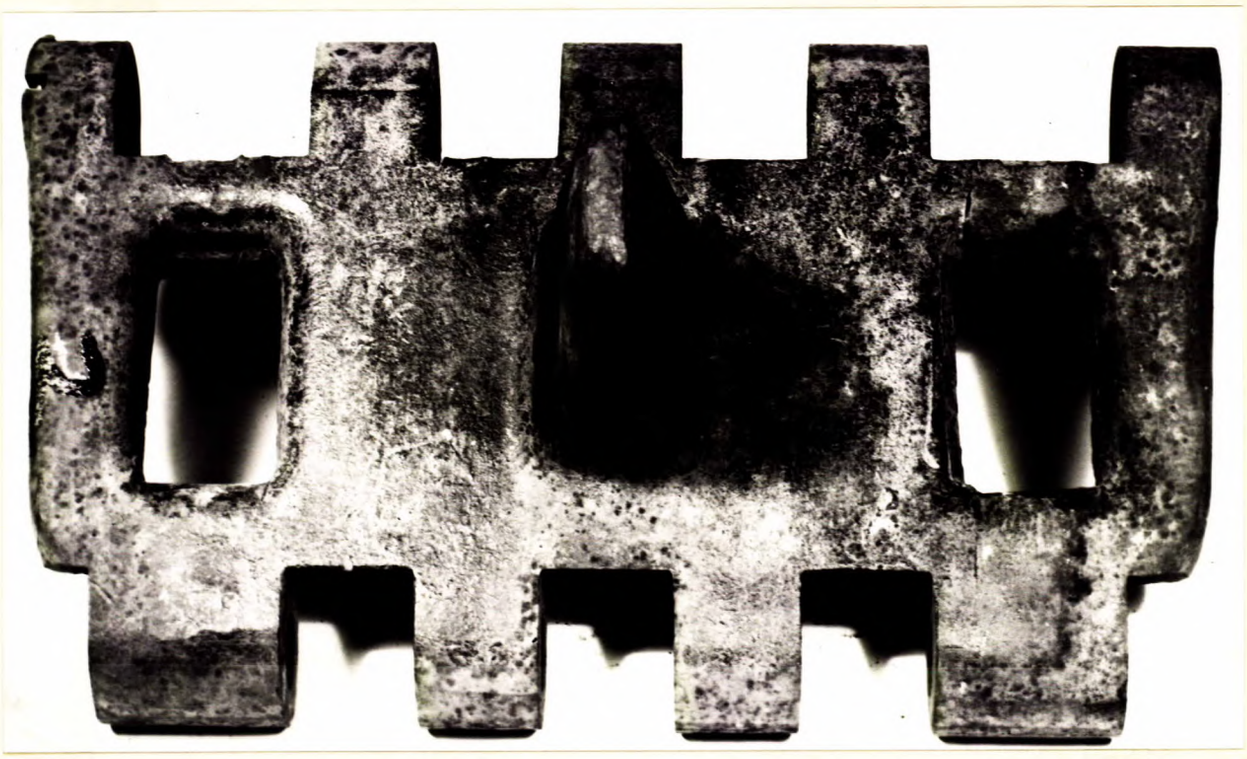
SLG:GHB.

Figure 1.



(Approximately 2/3 size).

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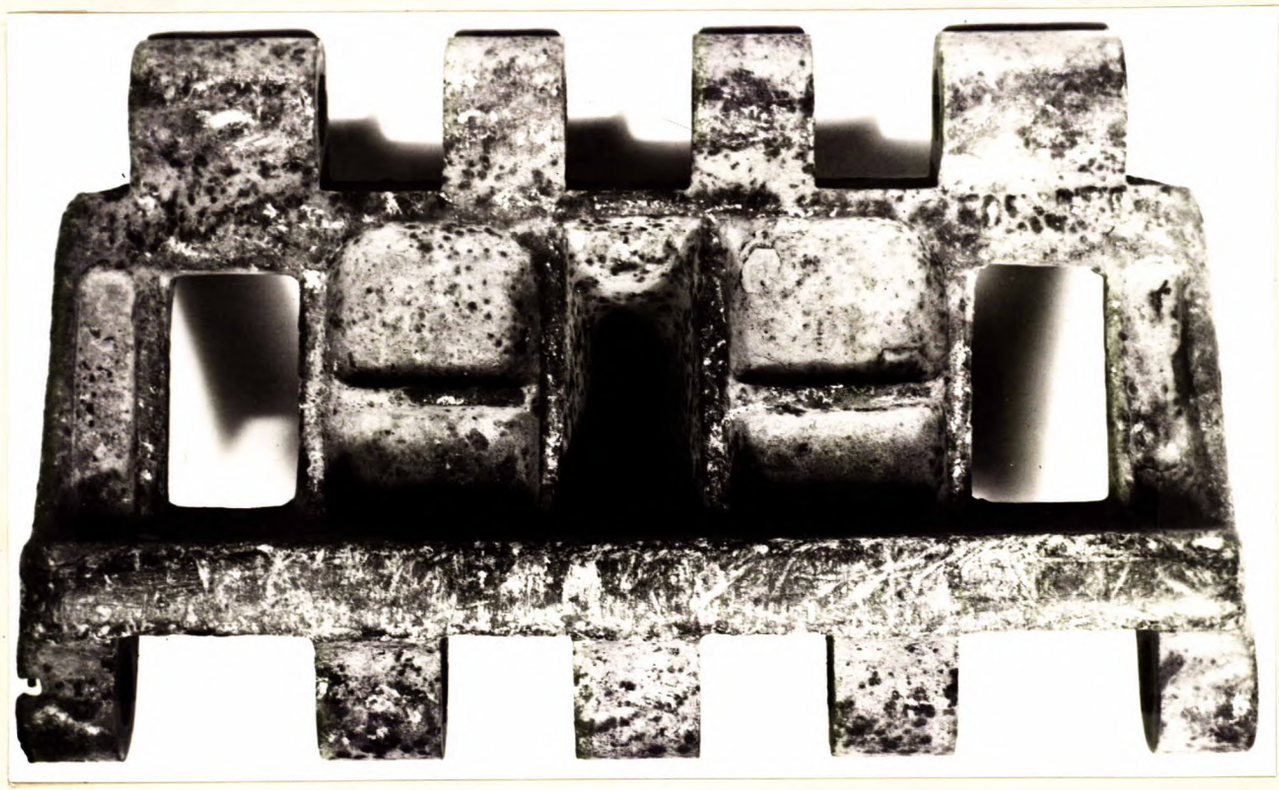
Figure 2.



(Approximately 2/3 size).

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PHOTOGRAPHS OF LINK.

Figure 3.

X500, nital etch.

STRUCTURE OF LINK.

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Figure 4.

PIN AS RECEIVED.

(Approximately 2/3 size).

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Figure 5.

X500, nital etch.

STRUCTURE OF PIN CORE.

Low-carbon martensite and ferrite.

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Figure 6.

X1000, nital etch.

STRUCTURE OF CASE.

Cementite envelopes - white constituent.

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X100, nital etch.

Figure 7.

X100, nital etch.

STRUCTURE OF RETAINING CAP.

Cold-rolled steel.

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