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# R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1868.

## Metallurgical Examination of Snowmobile Sprocket and Cross Link after Field Test.

(Copy No. 10.)

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Origin of Material and Object of Investigation:

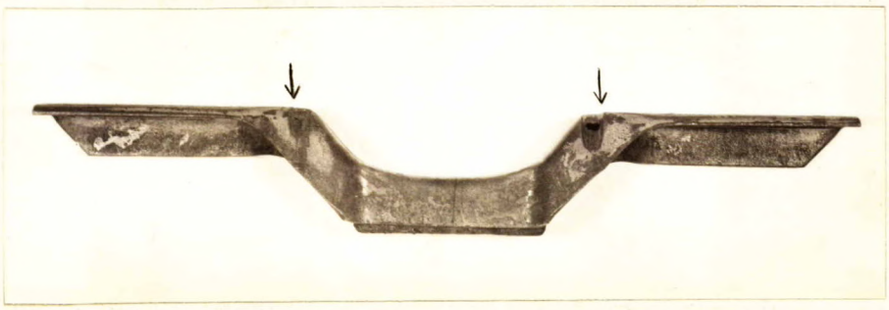
In March 1945, the Army Engineering Design Branch, Department of Munitions and Supply, 433 St. Martin Street, Montreal, Quebec, submitted, for metallurgical examination, a snowmobile sprocket and cross link. It was reported that these parts had been taken from a field test after approximately 900 miles of service. The formal request letter (File No. 73-V-16) for this work was received on May 15, 1945.

The cross link and sprocket "as received" are

(Origin of Material and Object of Investigation, cont'd) -

shown in Figures 1 and 2 respectively.

Figure 1.



SNOWMOBILE CROSS LINK.

Arrows indicate bearing surfaces, points of excessive wear.

-

Figure 2.

SNOWMOBILE SPROCKET.

Arrows indicate bearing surfaces, badly worn.

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Chemical Analysis:

Chemical analysis and specified composition for each part are shown in Table I.

TABLE I.

| | Sprocket | Specification, SAE 1050 | Cross Link | Specification, SAE 4340 |
|---|---|---|---|---|
| | | - Per Cent - | | |
| Carbon - | 0.49 | 0.48-0.55 | 0.47 | 0.38-0.43 |
| Manganese - | 0.66 | 0.60-0.90 | 0.88 | 0.60-0.90 |
| Silicon - | 0.23 | 0.15-0.30 | 0.23 | |
| Phosphorus - | 0.023 | 0.040 max. | 0.022 | 0.040 max. |
| Sulphur - | 0.031 | 0.050 max. | 0.020 | 0.040 max. |
| Nickel - | | | 1.86 | 1.65-2.00 |
| Chromium - | | | 0.82 | 0.70-0.90 |
| Molybdenum - | | | 0.22 | 0.20-0.30 |

Hardness Survey:

Cross Link -

| | Rockwell "C" Hardness |
|---|---|
| On surface - | 45-46 |
| On cross-section - | 45-46 |

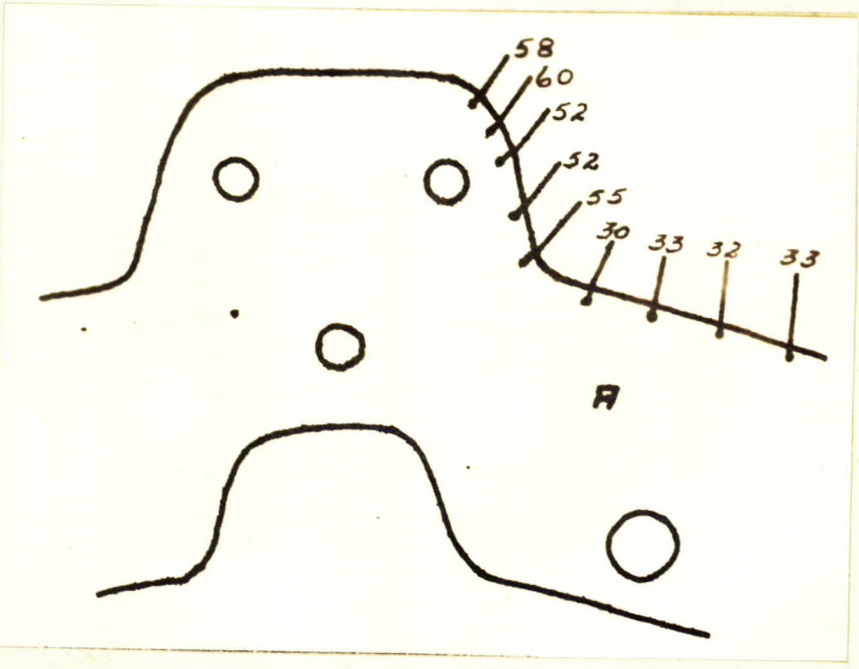
Sprocket -

Hardness readings were taken on the sprocket about 1/16 inch from the bearing surface, as shown in Figure 3. Readings were taken with a Vickers machine (using a 10-kilogram load) and converted to Rockwell "C".

(Continued on next page)

(Hardness Survey, cont'd) -

Figure 3.




HARDNESS SURVEY.

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Hardness values varied from 30 to 58 Rockwell "C", highest results being obtained on the tooth.

Microscopic Examination:

Microscopic examination of transverse sections cut from the sprocket showed a difference in microstructure corresponding to the variations in hardness. At approximately 1/16 inch from the bearing surfaces of the sprocket teeth the structure

(Microscopic Examination, cont'd) -

was completely martensitic (see Figure 4). At points of lower hardness the microstructure consisted of troostite as well as martensite (see Figure 5).

Surfaces of the sprocket which had not been exposed to wear (e.g., point A in Figure 3) were partially decarburized to a depth of 0.008-0.010 inch (see Figure 6).

The microstructure of sections cut from the cross link was uniformly tempered martensite without any partial decarburization at the surface (see Figure 7).

Figure 4.

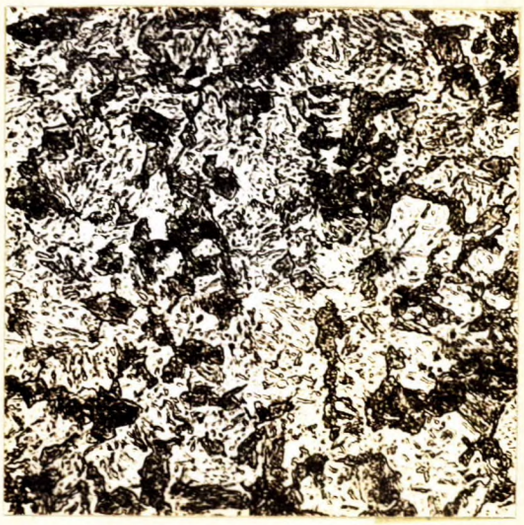
X500, etched in
2 per cent nital.

SNOWMOBILE SPROCKET.

Martensitic structure.

Hardness, 55 to 58
Rockwell "C".

Figure 5.



X500, etched in
2 per cent nital.

SNOWMOBILE SPROCKET.

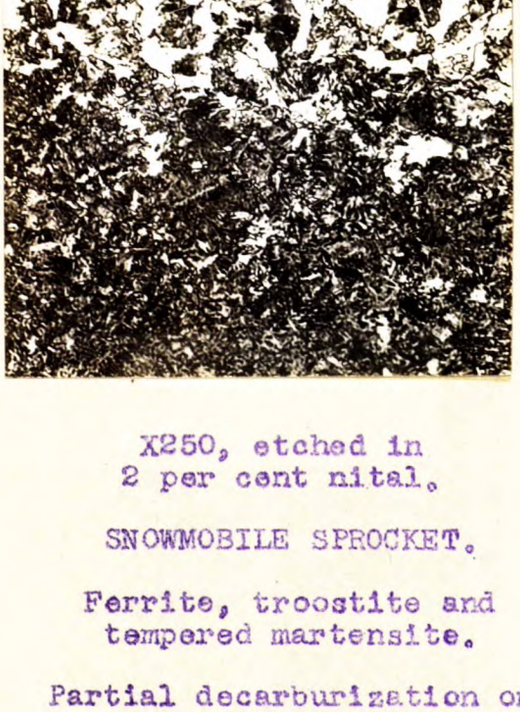
Tempered martensite
and troostite.

Hardness, 30 to 33
Rockwell "C".

(Continued on next page)

(Microscopic Examination, cont'd) -

Figure 6.



X250, etched in
2 per cent nital.

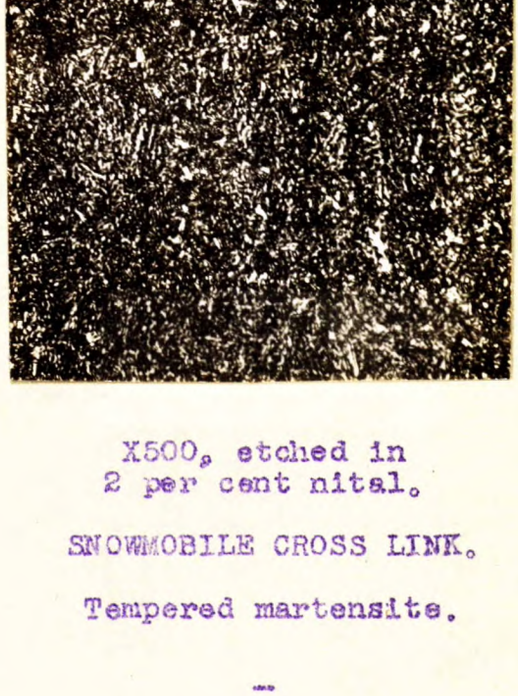
SNOWMOBILE SPROCKET.

Ferrite, troostite and
tempered martensite.

Partial decarburization on
sprocket surface which had
not been exposed to wearing
conditions.

-

Figure 7.



X500, etched in
2 per cent nital.

SNOWMOBILE CROSS LINK.

Tempered martensite.

-

Discussion:

The chemical analysis of the snowmobile cross link is in agreement with the specification for SAE 4340 steel, with the exception of the carbon and manganese contents which are slightly higher. Hardness determinations and microscopic examination have shown that the link has been properly quenched and drawn to the specified hardness of 42-47 Rockwell "C".

Specifications required that the sprocket bearing surfaces be induction-hardened to Rockwell "C" 57 ±3 to a depth of 5/32 ±1/32 inches, but this original surface has worn away and it is not possible to arrive at any definite conclusion regarding its hardness or microstructure. Comparison of the

(Discussion, cont'd) -

worn sprocket with others which had not been in service showed that there has been as much wear on the side of the tooth as on the bay of the sprocket. Therefore, the hardness variations shown in Figure 3 are the result of non-uniform depth of hardening on the original bearing surface.

The partial decarburization observed on the unworn parts, if present on the bearing surfaces before field test, would have been the cause of very rapid wear down to a depth of 0.010 inch.

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CONCLUSIONS:

Cross Link.

1. The Snowmobile cross link has been homogeneously hardened to the specified 42-47 Rockwell "C" without decarburization at any of the surfaces.

2. If excessive wear should continue to be a problem with these cross links, the resistance may be improved by the use of a somewhat higher carbon content. Past experience with wear problems has shown that better wear resistance, for the same hardness, is obtained with carbon contents above 0.50 per cent.

Sprocket.

1. The Snowmobile sprocket has a chemical analysis corresponding to SAE 1050 specifications.

2. The hardness 1/16 inch from the bearing surface varied from 30 to 60 Rockwell "C". The higher values were obtained on the tooth of the sprocket. This variation in hardness indicates non-uniform depth of hardening on the original bearing surface, either because of faulty heat treatment or partial

(Conclusions, cont'd) -

decarburization.

3. A discussion regarding the suitability of SAE 1050 steel and its heat treatment for this purpose will be found in a previous report (O.D.M.L. Report of Investigation No. 1849, April 24, 1945).

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THM:GHB.