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R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1678.

Examination of Armoured Snowmobile Sprockets.

(Copy No. 10.)

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Object of Investigation:

On June 29th, 1944, under Requisition No. 654, A.E.D.B. Lot No. 547 (Report No. 107, "D"; Test No. 16), Prof. J. U. MacEwan, of the Division of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario, submitted for metallurgical examination three unused snowmobile sprockets, to determine the cause of excessive wearing on tooth surfaces.

One of the sprockets (Sprocket C) had been assembled and painted. It had been one of the first sprockets produced; others from this same batch had been used in the test run. The two remaining sprockets, A and B, were from the second batch.

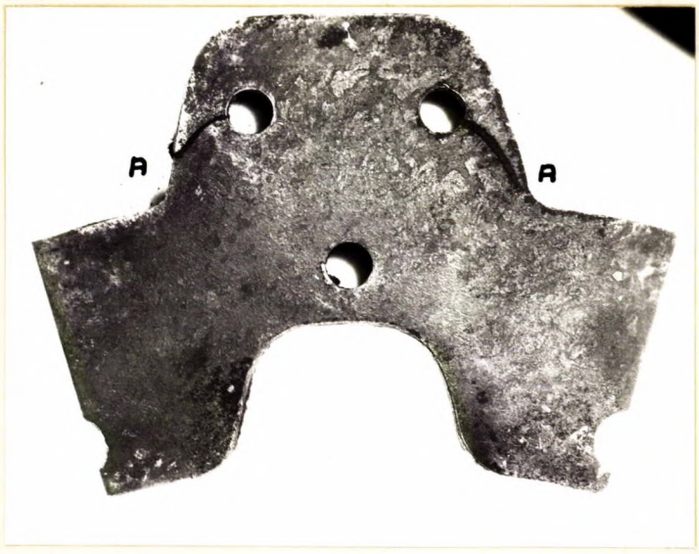
The specification called for SAE 1045 steel, flame-hardened to a depth of 5/32 ±1/32 inch, with a Rockwell "C" hardness of 57 ±3 in the hardened zone.

Macro-Examination:

Under visual examination a number of quench cracks were observed in the assembled sprocket (Sprocket C). None was apparent in A or B.

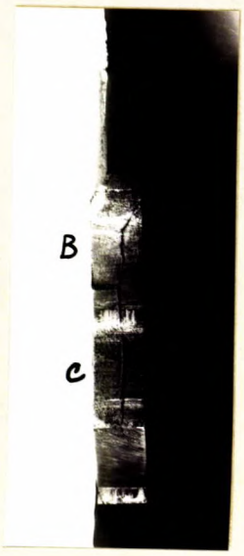
One tooth was chosen at random from each sprocket and magnafluxed. In all three, quench cracks of varying severity were observed. Some cracks ran from the wearing surface to the rivet holes (at A in Figure 1), while others ran along the wearing faces (see B in Figure 2) and along the root of the tooth (at C in Figures 2, 3 and 4). The cracks were most severe in Sprocket C.

Figure 1.



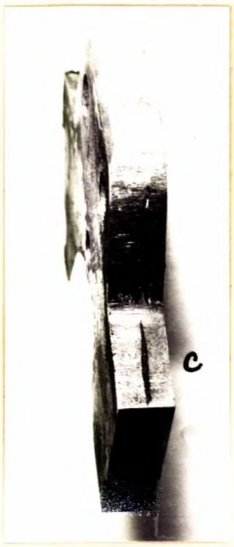
SPROCKET C.

Figure 2.



SPROCKET C.

Figure 3.



SPROCKET C.

(Macro-Examination, cont'd) -

Figure 4.

SPROCKET A.

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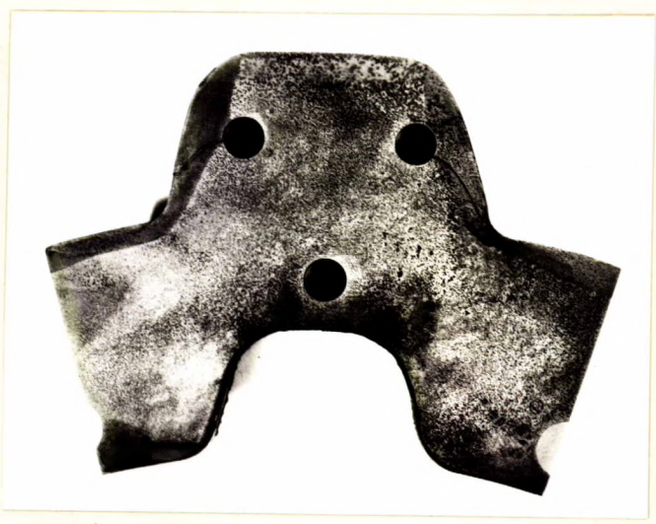
A 5 per cent nital etch was used to bring out the hardened zone. On only one of the three teeth was the flame-hardening satisfactory as to depth of hardened zone (see Figure 5).

Figure 5.



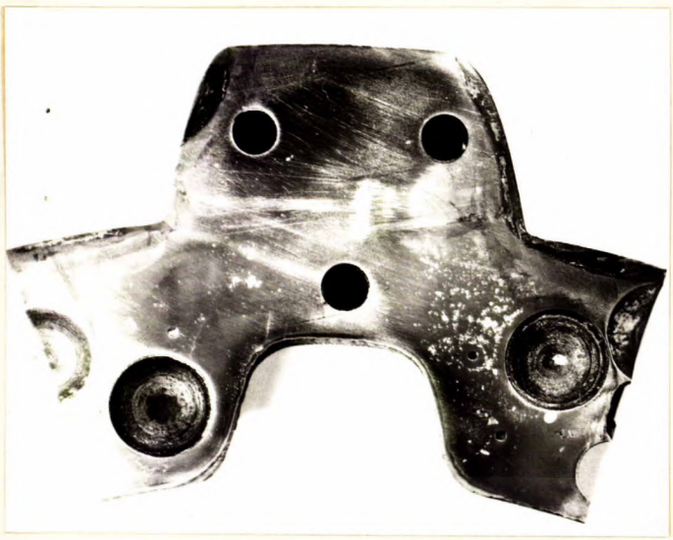
SPROCKET C.

—

On a tooth taken from each of the other two sprockets, the hardened zone was discontinuous and too shallow (see Figures 6 and 7).

(Macro-Examination, cont'd) -

Figure 6.



SPROCKET B.

Figure 7.

SPROCKET A.

Another tooth was cut from Sprocket C and examined. This proved satisfactory on only one side (Figure 8).

Figure 8.

SECOND TOOTH FROM SPROCKET C.

Chemical Analysis:

The results of the chemical analysis are as follows:

	AS RECEIVED			SAE 1045
	A	B	C	Specification
	- Per cent -			
Carbon -	0.42	0.46	0.42	0.43-0.50
Manganese -	0.85	0.68	0.68	0.60-0.90
Phosphorus -	0.023	0.018	0.027	0.040 max.
Sulphur -	0.040	0.036	0.038	0.050 max.
Molybdenum -	Trace.	Trace.	Trace.	
Chromium -	Trace.	Trace.	Trace.	

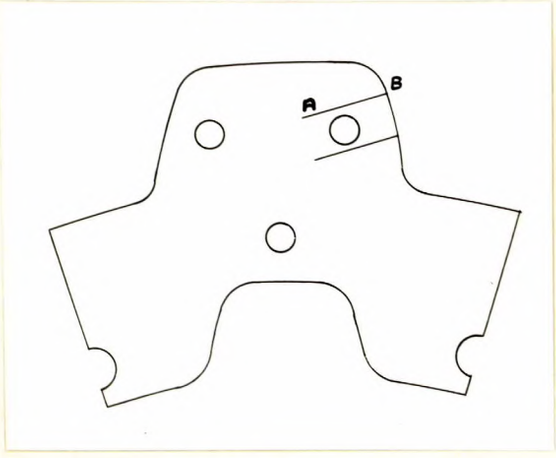
(Chemical Analysis, cont'd) -

The steel conforms to specification for SAE 1045.

Hardness Surveys:

Hardness surveys were made with the Vickers hardness tester, along line AB as shown in Figure 9; they corroborated the evidence obtained from the macro-examination. The results, converted to the Rockwell "C" scale, are shown in Table I.

Figure 9.



LOCATION OF HARDNESS SURVEYS.

TABLE I.

Sprocket A		Sprocket B		Sprocket C.		
R_c	Distance from edge, inch	R_c	Distance from edge, inch	R_c	Distance from edge, inch	
34	0.03	64.5	0.02	60.5	0.03	
< 20	0.06	58.0	0.06	60.5	0.06	
< 20	0.10	< 20	0.10	60.0	0.09	
				64.0	0.12	
<20	0.16	<20	0.17	64.0	0.16	$\frac{5}{32}" \pm \frac{1}{32}"$
				58.5	0.18	
		<20	0.25	54.0	0.21	
				24.0	0.23	
				24.0	0.26	
				25.0	0.29	

The double lines across Table I indicate the limits of the specification for depth of hardening. As can be seen,

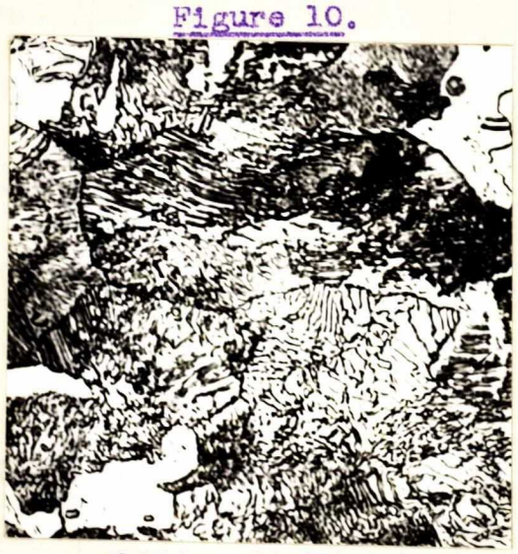
(Hardness Surveys, cont'd) -

the hardened zone is too shallow in A and B, while it is too deep in C.

Micro-Examination:

Microscopic examination showed the interior of the sprocket to consist of pearlite and pro-eutectoid ferrite (see Figure 10), while the hardened zone varied from martensite at the surface (Figure 11) to sorbite and troostite near the transition zone.

Figure 10.



X1000, nital etch.

INTERIOR OF SPROCKET

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Figure 11.

X1000, nital etch.

HARDENED ZONE NEAR SURFACE.

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Discussion:

The chemical composition of all three sprockets conforms to specification for SAE 1045.

Where the depth of the hardened zone lies within the required limits (5/32 ±1/32 inch), the Rockwell "C" values also meet specification (57 ±3). They were, in fact, higher at some points.

The absence of ferrite in the hardened zone indicates that quenching conditions were satisfactory. Quenching cracks, which would prove serious in service, might be avoided by preheating prior to flame hardening.

The excessive wear is due to the shallow and discontinuous flame-hardened zones, This, in turn, is due to lack of control in the flame hardening process. It is strongly recommended that the process be investigated with a view to improving the control.

CONCLUSIONS:

1. The flame-hardened zone is discontinuous and shallow in all but one case, indicating lack of control of the process.

2. The steel conforms to specification for SAE 1045 steel.

3. The core structure consists of pearlite and ferrite.

4. The hardened zone is tempered martensite, absence of ferrite showing that quenching conditions were satisfactory.

Recommendation:

A thorough study of the flame-hardening process is recommended, with a view to improving the control on the operation.

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