File.

O T T A W A June 11, 1945.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1887.

Metallurgical Examination of Broken Track Reinforcing Cleats from Armoured Snowmobile.

(Copy No. 10.)

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Origin of Material and Object of Investigation:

On April 17, 1945, three broken armoured snowmobile track reinforcing cleats (see Figure 1) were submitted for metallurgical examination, under Requisition No. 693, A.E.D.B. Lot No. 586, Report No. 107, Section D, Test No. 29, by the Division of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario.

The requisition, dated April 14, 1945, File No. 17/D/T 29, contained the following information:

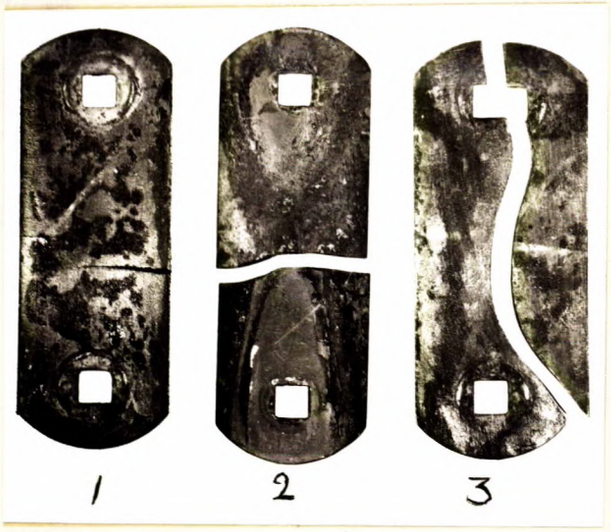
> "Cleats (Dwg. No. A-32006), made from No. 14 Gauge (0.074 inch) Steel, SAE 1060 or optional SAE 4130; NE 8630.
> "Part to be heat treated, quenched in oil, and drawn to Rockwell C 42 plus or minus 3."

For purposes of identification, the cleats have been assigned the numbers 1, 2 and 3 (see Figure 1).

(Continued on next page)

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

Figure 1.



BROKEN ARMOURED SNOWMOBILE
TRACK REINFORCING CLEATS.

(Approximately ½ actual size).

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Chemical Analysis:

The results of the chemical analysis are compared with the specifications for SAE 4130 steel in the following table:

	Sample No. 1	Sample No. 2	Sample No. 3	Specification, SAE 4130.
		- Per cent -		
Carbon -	0.32	0.34	0.39	0.25-0.35
Manganese -	0.58	0.65	0.53	0.50-0.80
Silicon -	0.24	0.20	0.28	
Sulphur -	0.016	0.022	0.019	
Phosphorus -	0.018	0.018	0.013	
Nickel -	Trace.	0.24	Trace.	
Chromium -	0.45	0.92	0.83	0.50-0.80
Molybdenum -	0.22	0.18	0.19	0.15-0.25
Vanadium -	Nil.	Nil.	Nil.	

Hardness Tests:

Hardness tests were made on the three samples, using a Vickers hardness tester with a 30-kilogram load. The results are given in the following table:

(Continued on next page)

(Hardness Tests, cont'd) -

	HARDNESS	
	Vickers (30-kg. load)	Rockwell "C" (converted)
Cleat No. 1 -	467-473	46.5-47.0
" " 2 -	499-523	49-51
" " 3 -	602-618	55-56

The specified hardness was 42 ±3 Rockwell "C".

Microscopic Examination:

Photomicrographs (Figures 2, 3, and 4), taken at X1000 magnification, show the microstructure of Cleats Nos. 1, 2 and 3 respectively. The structure in all three cases is martensite, with ferrite evident in Figure 3.

Figure 2.

X1000, nital etch.

CLEAT NO. 1.

Martensite.

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(Microscopic Examination, cont'd) -

Figure 3.

X1000, nital etch.

CLEAT NO. 2.

Martensite and ferrite.

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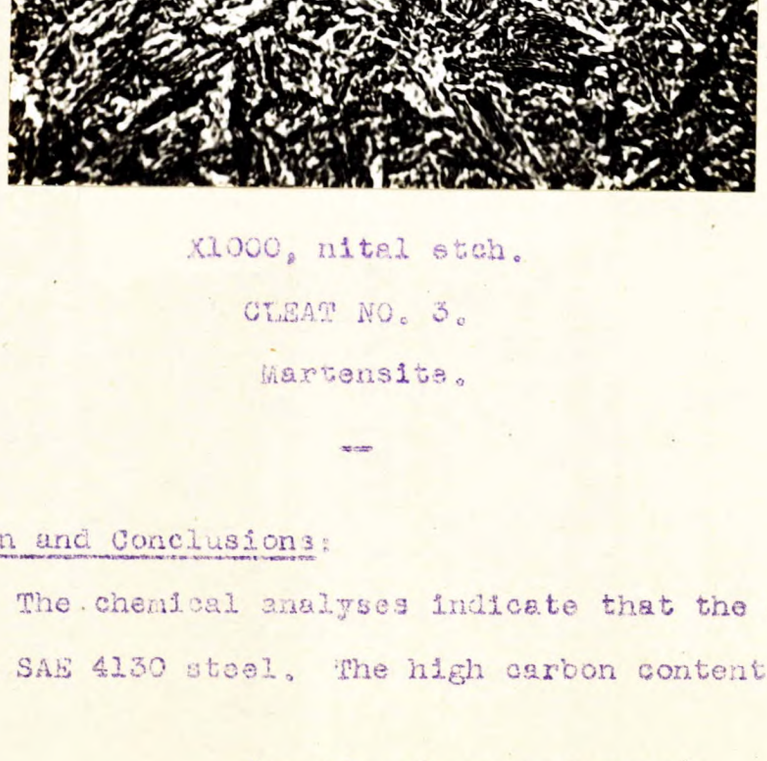
Figure 4.



X1000, nital etch.

CLEAT NO. 3.

Martensite.

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Discussion and Conclusions:

The chemical analyses indicate that the cleats were made from SAE 4130 steel. The high carbon content of Cleat No. 3

(Continued on next page)

(Discussion and Conclusions, c ont'd) -

would classify this steel as SAE 4140 rather than SAE 4130.

The hardness values obtained on the three cleats, varying from 46½ to 56 Rockwell "C", are considerably higher than the 42 Rockwell "C" specified and indicate a too low draw temperature, or an absence of drawing after quenching. It is almost certain that Cleat No. 3, the hardness range of which was 55 to 56 Rockwell "C", was not tempered and was placed into service in the "as quenched" condition.

Because SAE 4130 steel has lower impact strength at high hardness ranges, it is thought that failure resulted because of the brittle condition of the steel.

The complete absence of decarburization means that the steel would have its full fatigue strength. The haphazard location of the failures also indicates that failure was not by fatigue.

SAE 4130 steel may be quenched in either oil or water, but the former is recommended because of the increased toughness. The minimum draw temperature usually recommended for this steel after oil quenching is 800° F., and the resultant hardness is 37 Rockwell "C". Lower draw temperatures can be used but at a sacrifice to toughness.

In summary, failure resulted because of the excessive brittleness caused by either the complete absence of a draw after quenching, or by drawing at too low a temperature.

Recommendation:

It is recommended that the SAE 4130 cleats be so heat-treated as to produce a hardness of 37 ±3 Rockwell "C". This may be accomplished by resorting to the following heat treatment:

Heat at 1600° F.,
Quench in oil, and
Draw at 800° F.

References

1. "Physical Properties of Bethlehem Steels." - Issued by Bethlehem Steel Co., Bethlehem, Pa.

2. "Molybdenum in Steel." - Issued by Climax Molybdenum Company, New York.

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