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O T T A W A June 3rd, 1944.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1658.

Metallurgical Examination of Horseshoe Heel Plates Used for Army Boots.

(Copy No. 12.)

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Metallurgical Examination of Horseshoe Heel Plates Used for Army Boots.

Origin of Request and Object of Investigation:

On May 29th, 1944, under Analysis Requisition O.T. 4220, eight samples of horseshoe heel plates--six manufactured by Engineering Products Limited, Montreal, Quebec, and two by the Guelph Stove Company Limited, Guelph, Ontario--were received from the Inspection Board of United Kingdom and Canada, Ottawa, Ontario, for examination.

The accompanying request letter (dated May 28th, File No. 12/4/21) stated that the heel plates, used on army boots, were not giving sufficient mileage under service conditions. It was also stated that the plates were made from a carburizing grade of steel and had been case-hardened. It was requested that a metallurgical examination be made to determine the surface hardness depth; also that recommendations be made regarding new materials or revised heat treatment, in order that the life of the plates be extended.

Hardness Examination:

An attempt was made to ascertain the hardness of the case by means of the Rockwell and the Vickers machines, but the results were negative due to the insufficient depth of the case.

A micro-hardness test of the case, made by means of the Tukon hardness tester, gave the following results:

Guelph Stove Company -

		Hardness Number
Knoop	-	745
Vickers	-	700 (converted).
Rockwell 'C'	-	60 (converted).

Engineering Products Limited -

Knoop	-	330
Vickers	-	330 (converted).
Rockwell 'C'	-	34 (converted).

Chemical Analysis:

The results of the chemical analysis of each of the plates are as follows:

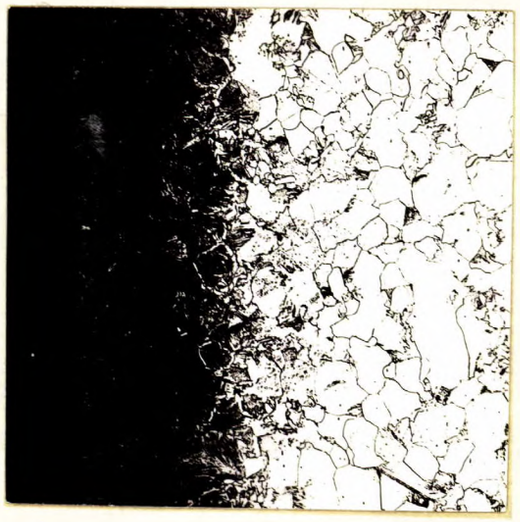
		Engineering Products Limited - Per Cent -	Guelph Stove Company - Per Cent -
Carbon	-	0.13	0.09
Manganese	-	0.34	0.28
Silicon	-	Trace.	Trace.
Sulphur	-	0.058	0.052
Phosphorus	-	0.016	0.008
Nickel	-	Nil.	Nil.
Chromium	-	Nil.	Nil.
Molybdenum	-	Trace.	Trace.

Microscopic Examination:

Sections for microscopic examination were obtained from the two samples. Figures 1 and 2, photomicrographs taken at magnifications of 100 and 50 respectively, were obtained from cross-sections of a sample from Guelph Stove Company. Figure 3, at X125 magnification, was obtained from a cross-section of a sample from Engineering Products Limited.

(Figures 1, 2 and 3)
(follow on Page 3.)

Figure 1.



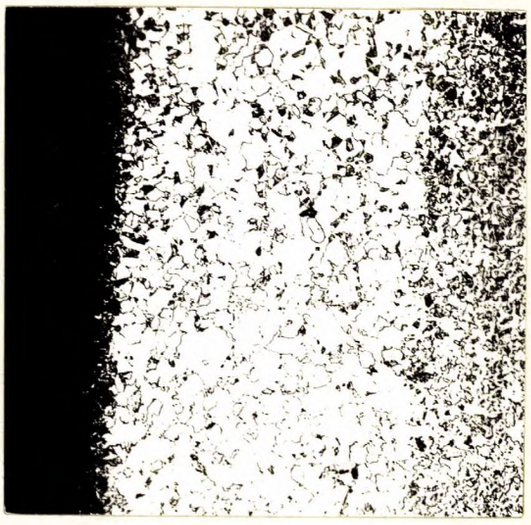
X100, nital etch.

Guelph Stove Company.

SHOWING CASE, APPROXIMATELY
0.007 INCH THICK.

—

Figure 2.



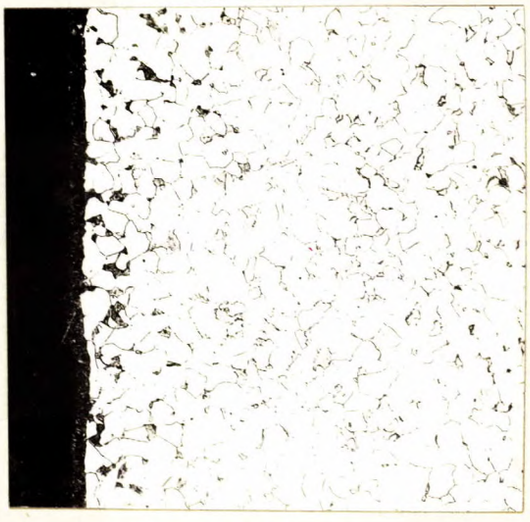
X50, nital etch.

Guelph Stove Company.

SHOWING CASE, DECARBURIZED
ZONE AND BANDING.

—

Figure 3.



X125, nital etch.

Engineering Products Limited.

SHOWING VERY FINE CASE,
LESS THAN 0.002 INCH THICK.

—

Discussion of Results; Conclusions:

Chemical analysis shows that the steels from both sources are practically identical, i.e., plain carbon, SAE 1010 steel.

The photomicrographs indicate an extremely fine case, less than 0.002 inch, on the sample from Engineering Products, and a slightly larger case, approximately 0.007 inch, on the sample from Guelph Stove Company. These cases, which are probably put on by a cyanide dip, are entirely inadequate and account for the premature wearing of the plates.

Examination of Figure 2 indicates that the bar stock used by the Guelph Stove Company was decarburized and badly banded. However, this would not affect the wearing properties of a properly case-hardened steel.

Recommendations:

The following heat treatment, using the same materials but carried out in a liquid activated carburizing bath, should result in a case of between 0.025 and 0.027 inch:

Carburize in liquid activated bath at 1650° F. for three hours and then oil quench.

This method is considered the most economical if a case-hardening treatment is to be adopted.

An alternative to this would be to use a plate made from austempered 0.80 per cent carbon steel (with grain size and manganese content controlled to allow for hardening by austempering) treated to a Rockwell 'C' hardness of approximately 50. This could probably be accomplished by quenching from 1500° F. into a salt bath at about 500° F. and holding in the salt bath for about ½ hour. It is thought that this material might well give better service than the cased material,

(Recommendations, cont'd) -

as the austempering would give sufficient ductility to avoid the cracking of the high carbon steel and the material would wear uniformly until very thin, while the cased shoe would wear rapidly once the case is gone.

Comparative tests on cased and austempered materials should be made.

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