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OTTAWA August 24th, 1944.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1703.

Metallurgical Examination of Three Spring Leaves.

(Copy No. 10.)

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 23rd, 1944, under Analysis Requisition No. O.T. 4244, three spring leaves representing different failures (see Figures 1 and 2) were submitted by the Inspection Board of the United Kingdom and Canada, Ottawa, Ontario. The covering letter, dated June 23rd, File 12/4/16, requested that metallurgical examinations be made on all three springs, to establish the cause of the failures.

For purposes of identification, the leaves were labelled A, B, and C.

(Continued on next page)

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

Figure 1.

SHOWING FRACTURE OF SPRING LEAF "A".

(Approximately full size).

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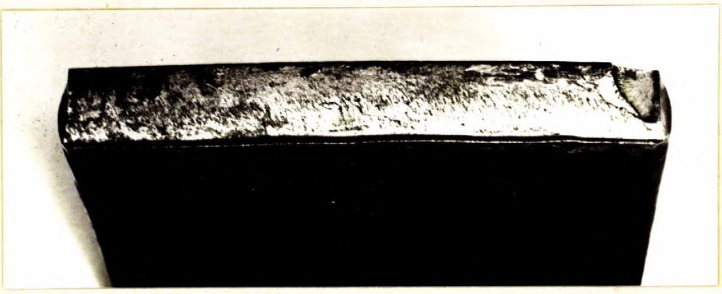
Figure 2.



SHOWING FRACTURE OF SPRING LEAF "B".

(Approximately full size).

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A photograph of the fracture of Spring Leaf "C" was not included, because of the difficulty in determining whether the end of the leaf submitted was an actual fracture or whether it was cut off by means of a saw.

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Chemical Analysis:

The results of the chemical analyses are as follows:

		Leaf A	Leaf B	Leaf C	SAE 9255
			- Per	Cent -	
Carbon	-	0.54	0.60	0.61	0.50-0.60
Silicon	-	2.09	2.16	2.03	1.80-2.20
Sulphur	-	0.029	0.026	0.025	
Phosphorus	-	0.019	0.020	0.021	
Manganese	-	0.82	0.75	0.75	0.60-0.90
Nickel	-	Nil.	Nil.	Nil.	
Chromium	-	Nil.	Nil.	Nil.	
Molybdenum	-	Trace.	Trace.	Trace.	
Vanadium	-	Nil.	Nil.	Nil.	

These results show that all three steels fall within the limits of SAE 9255 steel.

Hardness Test:

The results of the hardness tests are as follows:

		Brinell	Rockwell 'C'
Leaf A	-	388	39-41
Leaf B	-	534	52-53
Leaf C	-	415	41-43

According to the specifications, SAE 9255 steel should be from 380 to 420 Brinell.

Microscopic Examination:

Photomicrographs were taken of sections cut from all three leaves.

Figures 3, 4, 5 and 6 are photomicrographs from Leaf A; Figures 7 and 8 are from Leaf B; Figures 9 and 10 are from Leaf C.

Figure 3 (unetched) is a typical crack found in Leaf A. These cracks are very numerous and extend inward from both flat surfaces of Leaf A. No such cracks were found in Leaves B and C.

The inclusions shown in Figure 4 are typical of all

(Microscopic Examination, cont'd) -

three leaves.

The microstructures of all three leaves are normal for that of SAE 9255 steel quenched and drawn, that is, tempered martensite.

Figures 5, 7 and 9 show the extent of the decarburization occurring in Leaves A, B and C, respectively.

Discussion of Results; Conclusions:

The results of the chemical analyses indicate that all three leaves are made from SAE 9255 steel, and fall within the limits of the specifications.

The hardness tests show that Leaves A and C have the specified hardness, but that Leaf B is harder than that called for by the specifications. Incidentally, experience with track pins indicates that this steel is still fairly tough at 48 Rockwell 'C'. Consideration, then, might well be given to increasing the maximum hardness allowed to this figure as the harder material has higher fatigue strength.

Micro-examinations reveal that the steels are dirty but not excessively so. The heat treatment has been correct except in Leaf B, which should have been drawn at a slightly higher temperature for a longer period of time.

All three leaves reveal considerable decarburization, which is very detrimental to the endurance value of the springs. The A.S.M. Metals Handbook has the following to say regarding decarburization:

> "Surface decarburization should be maintained at a minimum because recent investigation has demonstrated that decarburization as small as three thousands of an inch will materially reduce the endurance value of spring steels."

Since the fractures shown in Figures 1 and 2 are

(Discussion of Results; Conclusions, cont'd) -

typical of fatigue fractures, it is reasonably safe to assume that the spring leaves failed in fatigue as a result of surface decarburization.

Recommendation:

Surface decarburization in spring steels should be entirely avoided by heat treating in a properly controlled atmosphere, in order to prevent a reduction in the endurance value of the steels. Some consideration should be given to raising the maximum hardness allowed to 48 Rockwell 'C'. Endurance limit of the properly heat-treated springs could be further increased, if this should prove necessary, by a shotblasting operation.

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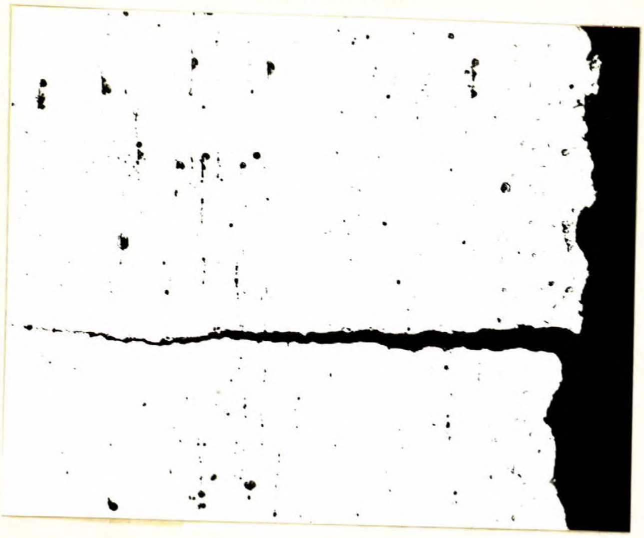
Figure 3.



X100, unetched.

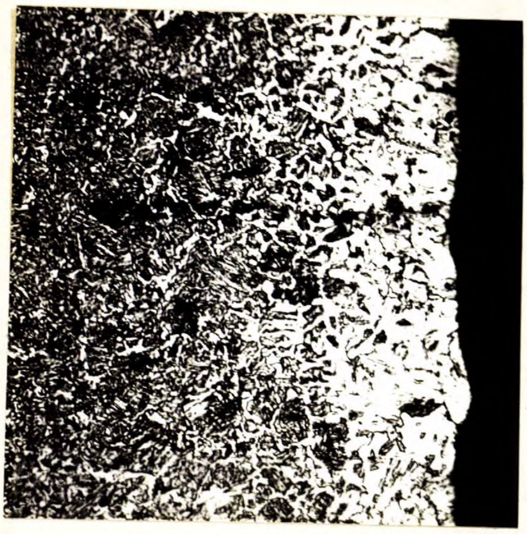
SHOWING TYPICAL CRACK

Figure 4.

X100, unetched.

SHOWING INCLUSIONS.

Figure 5.



X250, nital etch.

SHOWING DECARBURIZATION.

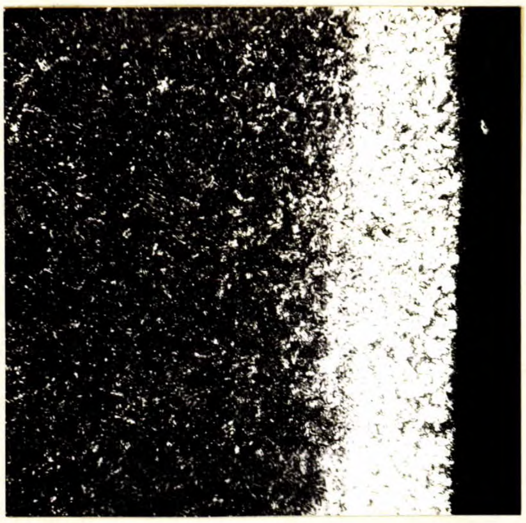
Figure 6.

X500, nital etch.

SHOWING MICROSTRUCTURE.

SPRING LEAF "A"

Figure 7.



X250, nital etch.

SHOWING DECARURIZATION.

Figure 8.

X500, nital etch.

SHOWING MICROSTRUCTURE.

SPRING LEAF "B"

Figure 9.

X250, nital etch.

SHOWING DECARBURIZATION.

Figure 10.

X500, nital etch.

SHOWING MICROSTRUCTURE.

SPRING LEAF "C"

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