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R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1907.

Metallurgical Examination of a Broken Spring Leaf.

(Copy No. 10.)

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Source of Material and Object of Investigation:

On July 5, 1945, under Requisition No. 1001, a broken spring leaf (A.E.D.B. Lot No. 594, Report No. 13, Lot No. 78) was submitted by the Division of Metallurgy, Army Engineering Design Branch, Department of Munitions and Supply, Ottawa, Ontario. A metallurgical examination was requested in order to determine, if possible, the cause of failure.

Macro-Examination:

Figure 1 is a photograph showing the fracture of the spring leaf.

Figure 1.

SHOWING FRACTURE OF THE SPRING LEAF.

(Approximately 1½ times actual size).

Chemical Analysis:

The results of chemical analysis are as follows:

	Specified, G.M. 5150	As Found
	- Per Cent -	
Carbon -	0.45-0.55	0.56
Manganese -	0.60-0.90	0.96
Silicon -	--	0.25
Sulphur -	0.04 max.	0.020
Phosphorus -	0.04 max.	0.018
Nickel -	--	0.10
Chromium -	0.80-1.10	0.82
Molybdenum -	--	0.01

Hardness Tests:

A hardness survey was carried out, by the Tukon method, on a specimen cut from the spring leaf adjacent to the fracture, in order to determine the amount of decarburization if any. The following results were obtained:

Location of Reading	Tukon Hardness Number
Surface -	327
0.10 mm. from surface -	450
0.20 " " " -	452
0.30 " " " -	518

Decarburization found = 0.008 inch.
" allowed = 0.010 inch*

* General Motors Drawing, Part No. 5802279.

(Hardness Tests, cont'd) -

Brinell hardness readings taken on the surface of the spring gave the following value:

	Brinell Hardness
Found -	477
Specified -	364-444

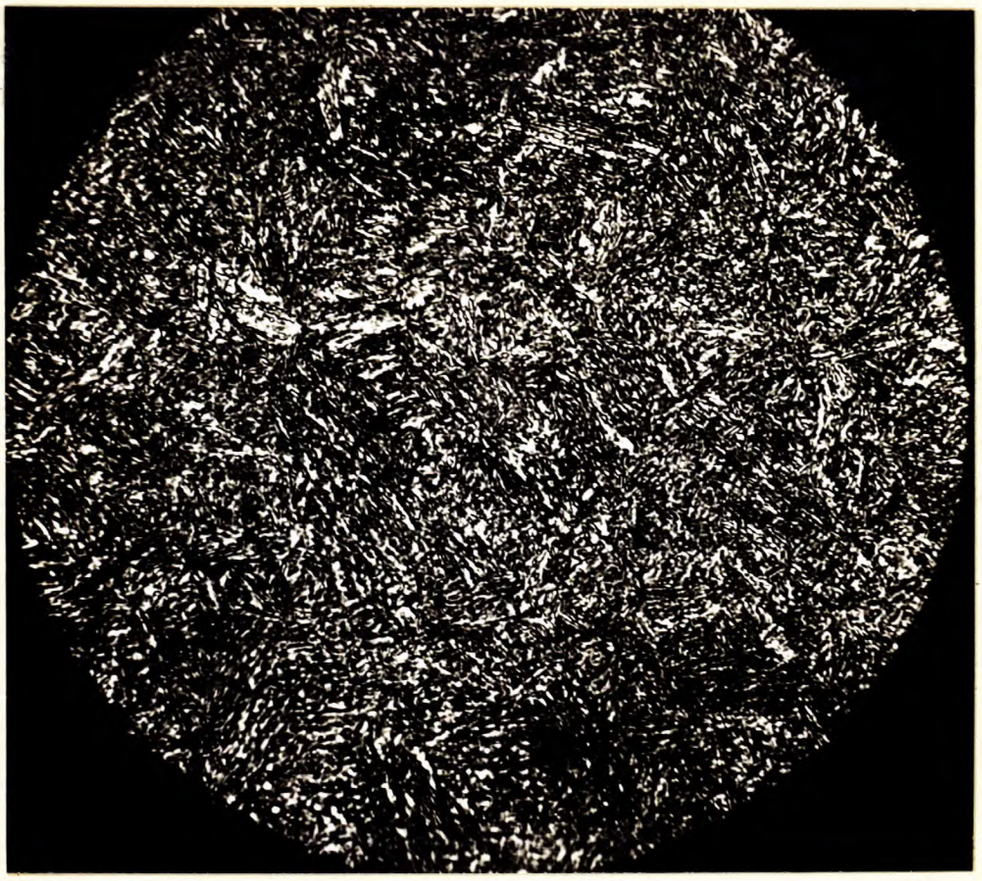
Microscopic Examination:

A specimen taken adjacent to the fracture of the spring leaf was mounted in bakelite, polished, and examined in the unetched condition under the microscope. The steel was observed to be fairly clean. After etching in a solution of 2 per cent nitric acid in alcohol the steel was re-examined. Figure 2 is a photomicrograph, at X1000 magnification, showing the nital-etched structure of the steel, which structure consists of tempered martensite. Slight decarburization was observed on the surface of the microspecimen. Since decarburization is not easily determined on a quenched steel, a specimen was annealed in lead at 1600° F. Figures 3 and 4 are photomicrographs, at X500 magnification, showing the nital-etched structure of undecarburized and decarburized areas, respectively, after annealing in lead.

(Continued on next page)

(Microscopic Examination, cont'd) -

Figure 2.



X1000, etched in
2 per cent nital.

STRUCTURE OF STEEL IN THE "AS RECEIVED" CONDITION.

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Figure 3.

X500, etched in
2 per cent nital.

UNDECARBURIZED AREA AFTER ANNEALING IN LEAD
AT 1600° F.

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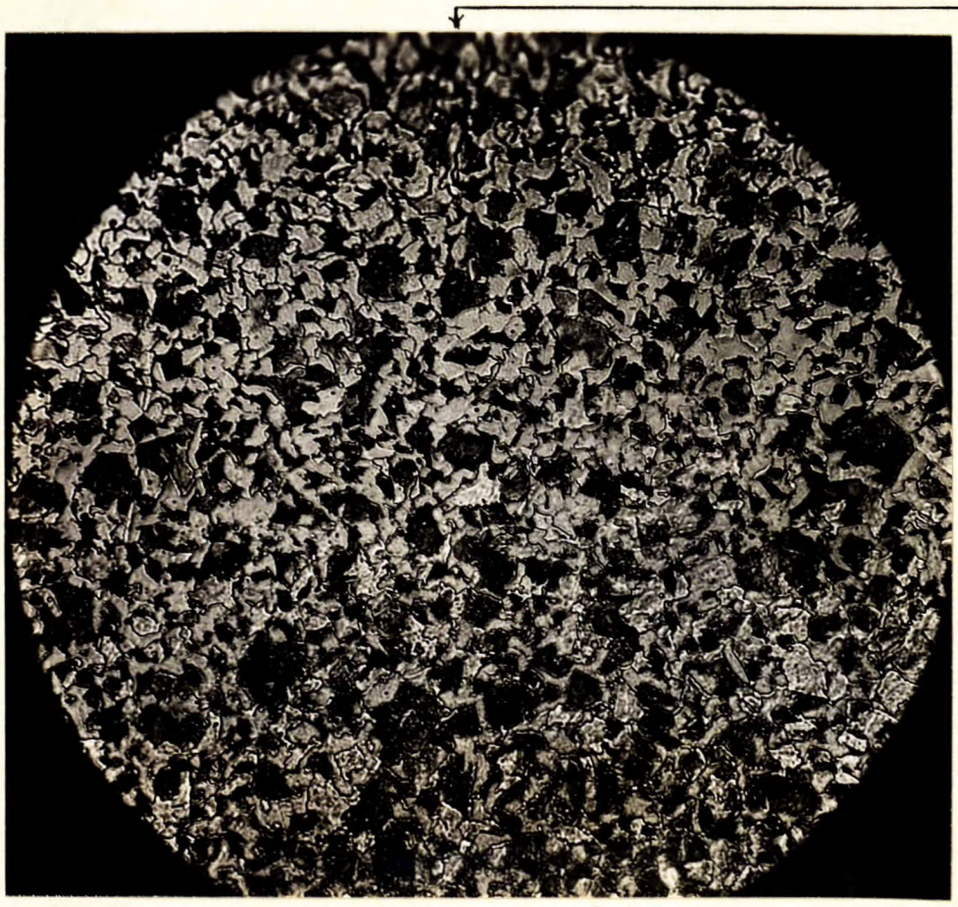
(Microscopic Examination, cont'd) -

Figure 4.



X500, etched in
2 per cent nital.

DECARBURIZED AREA AT SURFACE OF SPRING LEAF
AFTER ANNEALING IN LEAD AT 1600° F.

Discussion of Results:

The broken spring leaf submitted was found to have a chemical composition within the limits specified for G.M. 5150 steel, except for the carbon content which was one point above the upper limit. This is not considered to be an important discrepancy.

The Brinell hardness as determined on the surface was above the value specified. This hardness, however, is not sufficiently high to seriously increase notch sensitivity and therefore should increase the fatigue strength of the spring. The high hardness, then, is not considered to be a cause of failure.

(Discussion of Results, cont'd) -

The micro-examination revealed that the steel was fairly clean and that the structure was typically tempered martensite. A Tukon hardness survey indicated that the steel was slightly decarburized on the surface. This was confirmed in the micro-examination. According to the General Motors drawing for this part, 0.010 inch of decarburization is allowed. However, it has been demonstrated by many investigators that decarburization will materially reduce the endurance value of spring steels. From theoretical considerations, any decarburization is undesirable and should be avoided if possible.

The fracture shown in Figure 1 is of the duplex type and is typical of a fatigue failure.

The results of this investigation would indicate that the spring leaf failed in fatigue as a result of surface decarburization. It is recommended that these springs be heat-treated in a controlled atmosphere, in order to prevent reduction of the endurance limit of the spring by decarburization. Some consideration should also be given to shotblasting as this procedure has been demonstrated to increase materially the fatigue life of such parts as springs, crankshafts, etc.

A better life of the spring might have been secured if G.M. 6150 steel had been used instead of G.M. 5150.

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