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O T T A W A January 3, 1945.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1772.

Metallurgical Examination of a Belleville Spring Washer.

(Copy No. 10)

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Origin of Material and Object of Investigation:

On December 15, 1944, Mr. I. M. Banham, for Inspector of Naval Gun Mountings, British Admiralty Technical Mission, Ottawa, Ontario, submitted a portion of a Belleville spring washer for metallurgical examination to determine the cause of failure.

In a covering letter (File 11-11-5-1), Mr. Banham supplied the following information:

Reputed chemical analysis is SAE 6150.
Maximum working load, 6,720 pounds, with 0.0378 inch deflection.
Load to flatten spring, 13,440 pounds.
Spring had been in service approximately two and one-half years.

Chemical Analysis:

		AS FOUND	SPECIFICATION SAE 6150
		- Per Cent -	
Carbon	-	0.50	0.48-0.55
Manganese	-	0.69	0.65-0.90
Silicon	-	0.27	0.20-0.35
Phosphorus	-	0.028	0.040 max.
Sulphur	-	0.031	0.040 max.
Chromium	-	0.92	0.80-1.10
Vanadium	-	0.15	0.15 min.

Figure 1.

PORTIONS OF BELLEVILLE SPRING WASHER AS SUBMITTED.

Note that surface is heavily rusted.

Hardness:

The hardness, measured on transverse sections, was 496-499 Vickers, 30-kilogram load (49 Rockwell 'C').

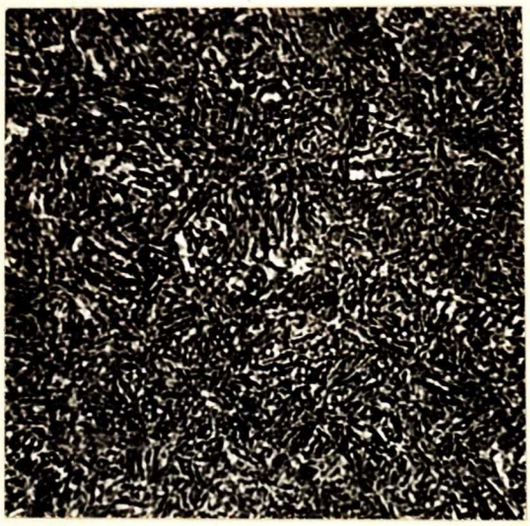
Microscopic Examination:

Microscopic examination of longitudinal and transverse specimens disclosed a clean steel which had been heat-treated to produce a uniform microstructure of tempered martensite (see Figure 2). There was no evidence of decarburization back of

(Microscopic Examination, cont'd) -

the layer of oxide (rust) at the surface.

Figure 2.



X1000, etched in 2 per cent nital.
Tempered martensite.

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Discussion:

The chemical composition of the washer is in complete agreement with the reputed specification. The hardness (49 Rockwell 'C') and the tempered martensitic microstructure indicate that the part was heat-treated to produce a satisfactory spring washer.

Failure after two and a half years of service, however, is explainable. Spring washers are so stressed in service that after they have withstood one flattening load any subsequent failure would have to be a fatigue-type failure eventually caused by alternating stresses in service. The resistance of a part to alternating stresses is dependent on two factors (1) the magnitude of the stresses, and (2) the condition of the surface of the part (scale, rust and decarburization lower the endurance limit). It may be concluded that

(Discussion, cont'd) -

the spring washer failed when the endurance limit was exceeded and, also, that the endurance limit was lowered by the rusting action at the surface.

Conclusions:

1. After 2½ years of service the Belleville spring washer failed as the result of fatigue.

2. The endurance limit, and consequently the service life, was lowered by the rusting surface.

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