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O T T A W A February 19, 1945.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1795.

Metallurgical Examination of Forged Steel Spring Clips.

(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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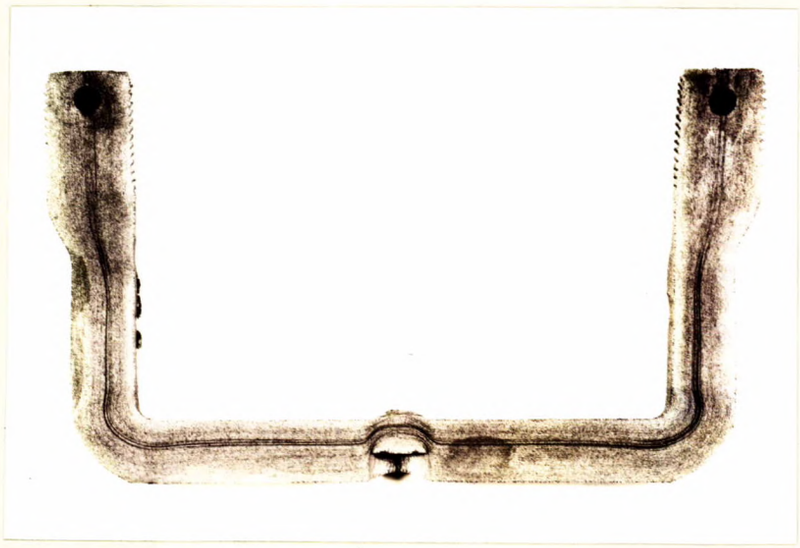
Origin of Material and Object of Investigation:

In a letter dated February 12, 1945 (File No. 12/4/16, Requisition O.T. 4328), Mr. R. O. McGee, I. O. M., for Inspector of Materials, Inspection Board of United Kingdom and Canada, Ottawa, Ontario, requested a metallurgical examination of two forged steel spring clips in order to determine whether the steel had been properly heat-treated or whether additional heat treatment would prevent the elongation that is taking place in service. It was also requested that a chemical analysis be carried out on the steel in order to verify the fact that it is SAE 1040. Suggestions as to further requirements which should be added to the drawing to ensure proper functioning of these spring clips in service were also requested.

Macro-Examination:

The dimensions of the two clips submitted were checked against those given in D.N.D. Drawing No. 10500, and they were found to conform to the specification. However, it was observed that the outside diameters of the threads varied from seven to ten thousandths of an inch less than the 5/8-inch specified. One of the spring clips was sprung slightly out of alignment. This defect probably occurred in removing the clip from the spring assembly. Figure 1 is a photograph showing the macro-etched structure of one of the forged clips.

Figure 1.



SHOWING FLOW LINES OF FORGING.
(Approximately 4/5 actual size).

Chemical Analysis:

The steel forging was sampled for chemical analysis, care being taken to remove the decarburized surface for the carbon sample. The results and the composition limits specified for SAE 1040 are given in Table I.

(Continued on next page)

(Chemical Analysis, cont'd) -

TABLE I.

	Specified SAE 1040	As Found
	- Per Cent -	
Carbon -	0.37-0.44	0.33
Manganese -	0.60-0.90	0.86
Silicon -	0.10-0.30	0.13
Phosphorus -	0.04 max.	0.025
Sulphur -	0.05 "	0.018

Hardness Test:

Hardness tests carried out on a ground surface gave a Brinell value of 175. SAE 1035 steel of this hardness should have an ultimate strength of approximately 85,000 p.s.i. and a yield strength of 50,000 p.s.i.

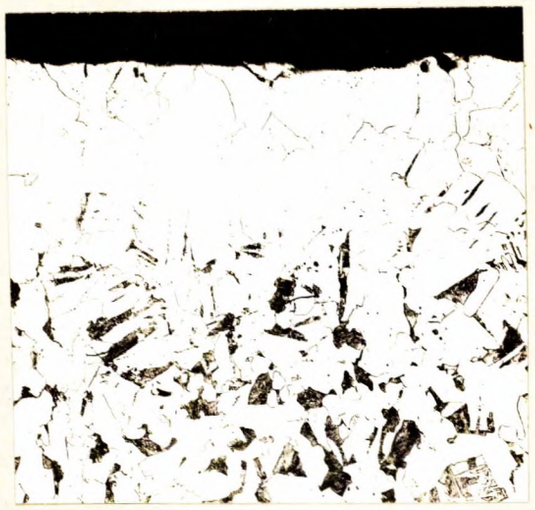
Microscopic Examination:

Cross-sectional specimens of a spring clip were mounted in bakelite, polished, and examined under the microscope in the unetched condition. The steel was found to be fairly clean. After etching in a solution of 2 per cent nital, the steel was re-examined. Figures 2 and 3 are photomicrographs, at X100 magnification, showing the nital-etched structure at, respectively, the surface and the middle section of the forging. Figure 2 illustrates the extent of the decarburized surface and Figure 3 shows the coarse-grained structure of the steel. The structure consists of pearlite, the iron-iron carbide constituent, the dark etching material, and ferrite, the iron constituent, the light material.

(Continued on next page)

(Microscopic Examination, cont'd) -

Figure 2.



X100, etched in 2 per cent nital.

SHOWING DECARBURIZED SURFACE OF FORGING.

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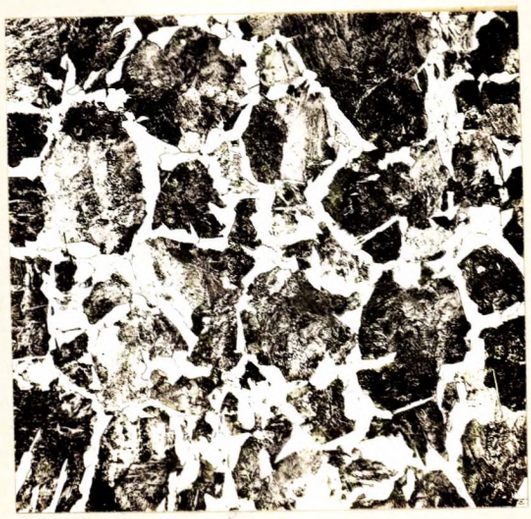
Figure 3.



X100, etched in 2 per cent nital.

SHOWING LARGE GRAIN STRUCTURE OF STEEL.

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Discussion of Results:

The dimensions of the spring clips examined were within the tolerances specified on the drawing and no evidence of the elongation complained of was observed. The carbon content was slightly lower than that specified for SAE 1040

(Discussion of Results, cont'd) -

steel. The macroscopic examination showed that the flow lines of the forging were quite satisfactory. The coarse-grained structure of the steel indicates that the part probably had not been heat-treated subsequent to forging. The steel was heavily decarburized on the surface. Steel in this condition would have much lower fatigue strength and its resistance to wear would also be reduced. Surface decarburization can be prevented by heating the steel in a controlled atmosphere. The SAE 1040 steel specified for these spring clips is considered to be satisfactory. However, it is recommended that the steel be given at least a normalizing heat treatment after the forging operation, as this would raise the yield strength to about 60,000 p.s.i. Quenching and drawing would give even better properties, and a yield point of 80,000 p.s.i. could be obtained by quenching in oil from 1575° F. and drawing at 800° F. If it can be confirmed that this part is yielding in service this heat treatment is recommended.

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