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OTTAWA June 24th, 1942.

REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1252.

"Shatter Cracks" in Test Pieces
from 2 Pdr. Breech Ring.

(Copy No. 16.)

BUREAU OF MINES
DIVISION OF METALLIC MINERALS

ORE DRESSING AND
METALLURGICAL LABORATORIES

CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

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Origin of Material and Object of Investigation:

On June 12th, 1942, Mr. M. W. Hollands, of the Inspection Board of the United Kingdom and Canada, 58 Lyon Street, Ottawa, Ontario, submitted for examination halves of two test bars, marked Y.A.T. and Y.B.T. In his accompanying letter (June 11th, 1942, file No. 7/4/22), attention was drawn to the numerous small cracks which developed in the remainder of the parallel section of the test pieces. It was thought that this might indicate a "shatter crack" condition in the breech ring forgings. It was requested that specimens be obtained from unstrained portions of these bars

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

for microscopic examination. This work is covered by Analysis Requisition No. O.T. 3040.

The steel in question has been made and heat treated in accordance with Specification S40 "D". This steel contains nominally 3 per cent nickel and 0.4 per cent carbon.

Macroscopic Examination:

Discs were cut from the bottom of each bar and fracture tests were made. Figure 1 is a photograph of the resulting fracture, enlarged four times. Note the white areas in the fracture.

Sections from the same area as the fracture test were polished and deep etched in hot, 50 per cent HCl. Figure 2 is a macrophotograph, at twenty diameters, of the surface of one of the pieces after etching. Note the numerous small cracks. This condition, as revealed by both the fracture test and the deep etching, is characteristic of the steel in both bars.

Microscopic Examination:

Both longitudinal and transverse specimens were cut from the base of each bar for microscopic examination. Small cracks were found in both bars and seemed to lack any definite orientation. Examples of these cracks are shown in Figures 3 and 4.

It was noted that the steel was quite clean, containing no more than a normal quantity of non-metallic inclusions. The cracks usually appeared to be either partly filled with oxides or to follow a line of inclusions, although there were some cracks detected that were perfectly clean. It was impossible to photograph these, since they were very tight and scarcely noticeable.

Discussion of Results and Conclusions:

The steel in both of these test bars contained numerous very small cracks. These cracks, when opened up in the fracture test, showed shiny surfaces. The propagation of these cracks seemed to be influenced by inclusions since they apparently more or less follow the direction of forging.

The presence of these cracks is verified by deep etching and by microscopic examination. These cracks, although very numerous, are very small and very uniformly distributed. It is reported by the Inspection Board of the United Kingdom and Canada that the steel in question met specifications for both tensile and impact. This is to be expected. This steel might possess very inferior fatigue properties, however. It is not unusual to find this condition of susceptibility to form cracks in forging steels, but it is more prevalent in nickel-chromium alloy steels than in nickel alloy steels. It is normal to expect an appreciable percentage (this percentage varying with production conditions) of the forgings to be susceptible to such a type of defect. Such cracks can be detected by deep etching and fracture tests.

In the present case it is rather difficult to interpret the effect of these cracks in the light of the actual part since neither the size nor the shape of the part is known, nor is it known where the test bar was taken from in the part. If the samples submitted are representative of the metal in the forging, then this forging would be satisfactory where it would be subjected to only occasional shock loads, say a few thousand, during its useful life. If, however, this part were expected to stand up under the thousands or millions of reversals of stresses per day and to last for several months or years, this condition could be decidedly

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

dangerous.

It should be pointed out that, generally speaking, the metal in the centre of a billet will develop worse cracks than the metal near the edge of a billet. Therefore, to properly sample a forging it is necessary to have some idea of the direction of flow of the metal and to obtain a sample to show how the cracking is distributed throughout the forging. Only when this is done can the proper interpretation be placed on the results of these tests. It is not possible to base decisions on results obtained from the small pieces here tested.

Recommendations:

1. Deep etching and fracture tests should be made on sample forgings from each heat suspected of being susceptible to a cracking or flaking condition.

2. When cracks are present in forgings, such factors as the number and distribution of cracks, size of cracks, and results of other physical tests, should be weighed against the application of the forging when deciding whether any forging is or is not acceptable. It is not possible to make a definite specification for this condition.

3. It would be decidedly helpful, in arriving at a decision on the forgings in question, if a complete forging were supplied to these laboratories so that a more complete survey of the size and distribution of these cracks could be made.

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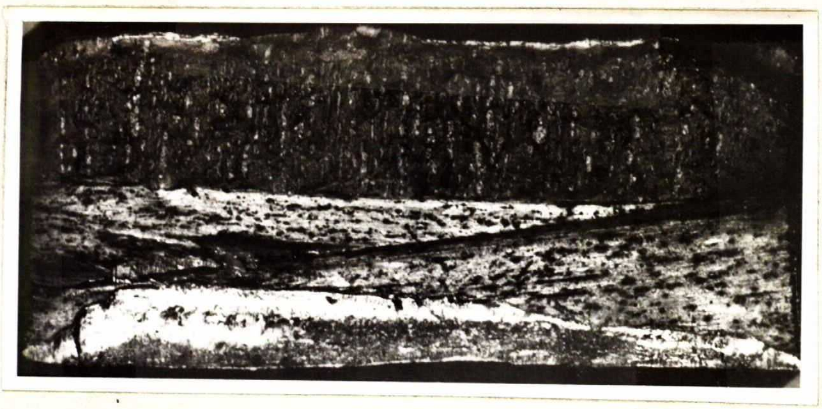
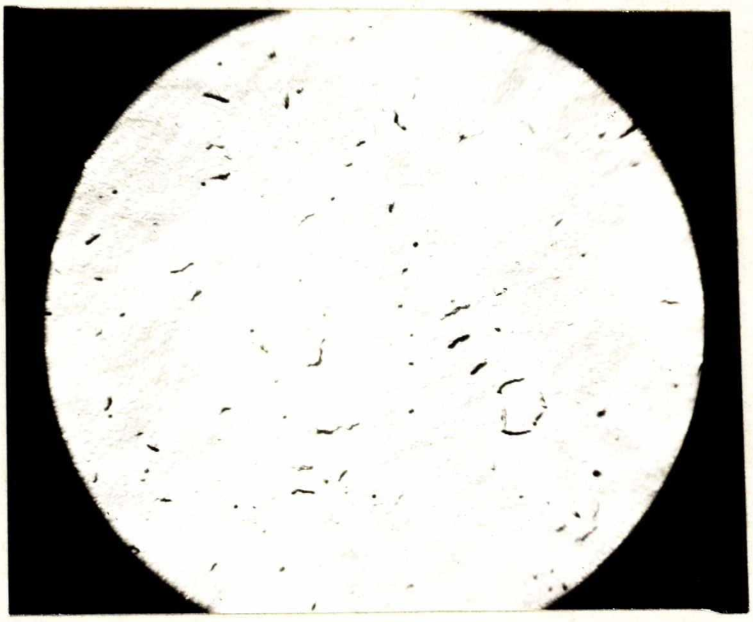
Figure 1.



Photograph, 4 times actual size, showing appearance of fracture.

Figure 2.

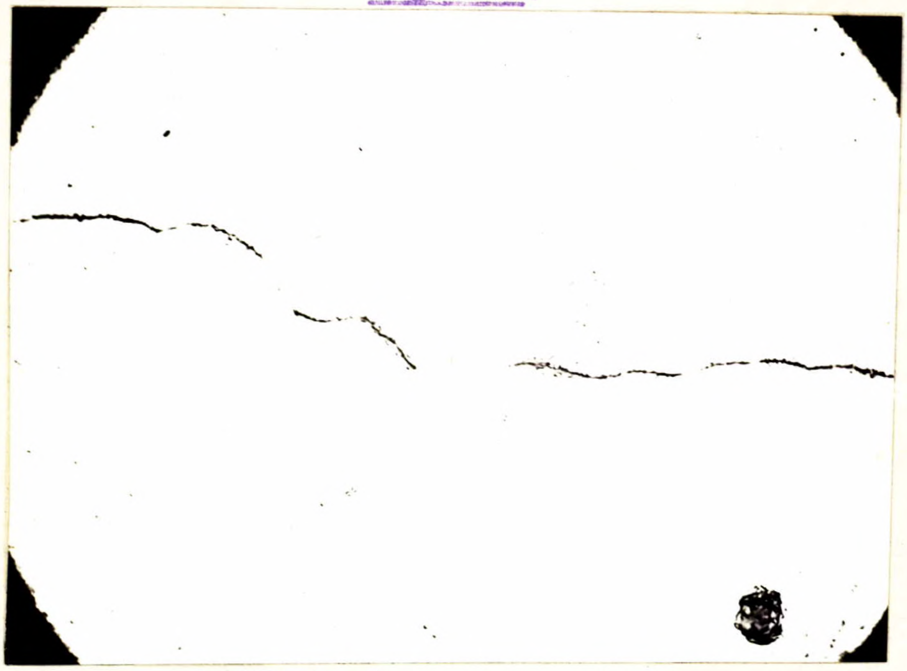


Macrophotograph, X20.
Hot 50% HCl etch.
Note small cracks.

Figure 3.

Photomicrograph, X500,
picral etch.
Note crack.

Figure 4.



Photomicrograph, X1000,
as polished. Note crack.

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