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O T T A W A  September 20, 1946.



R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 2105.

(Subsequent to Investigation
(Reports Nos. 1991, 2002, 2014,
(and 2015, Jan.-March, 1946.

# Research on Optimum Thread Form for Proposed Anglo-American-Canadian Screw Thread.

## PART V. - Metallurgical Examination of Five Low-Tensile Threaded Studs, Failed in Fatigue.

(This research is performed in
( collaboration with the National
( Bureau of Standards, Washington,
( U. S. A., the National Physical
( Laboratory, Teddington, England,
( and the National Research Council,
( Ottawa, Canada.

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( No. 2105.

## Abstract

A microscopic examination made on five studs which had failed prematurely in fatigue tests revealed no evidence of faulty machining. It did, however, disclose the presence of long stringers of non-metallic inclusions which may be responsible for the failures.

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Origin of Material and Object of Investigation:

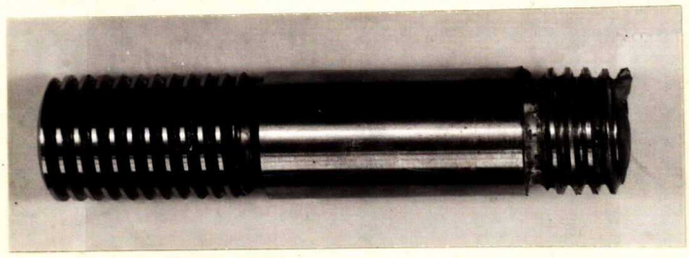
In April and May of 1946, the broken portions of five studs which had failed prematurely in the above fatigue tests, were submitted for a metallurgical examination in order to determine the possible reasons for such failures. Longitudinal sections were cut from each of the specimens submitted. The following table gives the numbers of the test specimens, the load range employed, and the number of cycles elapsed before failure:

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

| Stud No. | Minimum Stress, p.s.i. | Stress Range, p.s.i. | Cycles to failure |
|---|---|---|---|
| L 3B2/1 | 10,000 | 18,000 | 10,836,000 |
| L 3B2/5 | " | 17,000 | 2,030,000 |
| L 3B2/6 | " | 17,000 | 5,890,000 |
| L 5B3/3 | " | 18,000 | 2,541,000 |
| L 5B3/6 | " | 16,000 | 1,222,000 |

Figures 1 and 2 are typical of the fracture obtained in these tests.

Figure 1.



TYPICAL FRACTURE.

Figure 2.

X2.

TYPICAL FATIGUE FRACTURE IN LOW-TENSILE STUD.

Chemical Examination:

A chemical analysis was made on a sample cut from

(Chemical Examination, cont'd) -

stud No. L 3B2/5. The results are as follows:

| | Per cent |
|---|---|
| Carbon | - 0.20 |
| Manganese | - 0.74 |
| Silicon | - 0.20 |
| Sulphur | - 0.024 |
| Phosphorus | - 0.018 |
| Nickel | - Trace. |
| Chromium | - Nil. |
| Molybdenum | - Trace. |

Microscopic Examination:

Figure 3, taken at X30 magnification, shows a typical satisfactory thread.

Figure 4, taken at X50 magnification, shows the microstructure of the steel and the form of thread.

Figures 5 and 6, taken at X100 magnification, show typical inclusions encountered in the steel.

Figure 7, taken at X100 magnification, shows typical non-metallic inclusions extending into the threaded area.

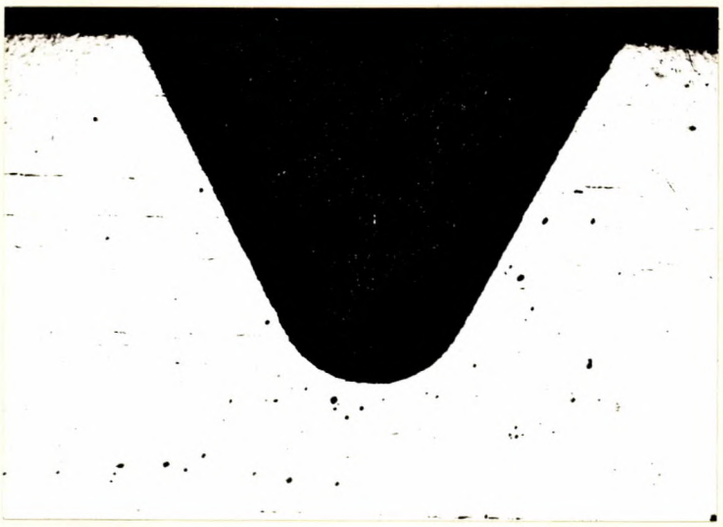
Figure 8, taken at X100 magnification, shows cracks in the centre of stud No. L 5B3/3 following the paths of the inclusions at right angles to the fracture.

Figure 9 shows the appearance of inclusions in stud No. L 5B3/3, at X6 magnification.

(Figures 3 to 9 follow, on Pages 4 to 7. Text is resumed on Page 7.)

(Microscopic Examination, cont'd) -

Figure 3.



X30, unetched.

LATHE-CUT, LOW TENSILE, 55° STUD (NO. L 3B2/5) SHOWING A TYPICAL SATISFACTORY THREAD.

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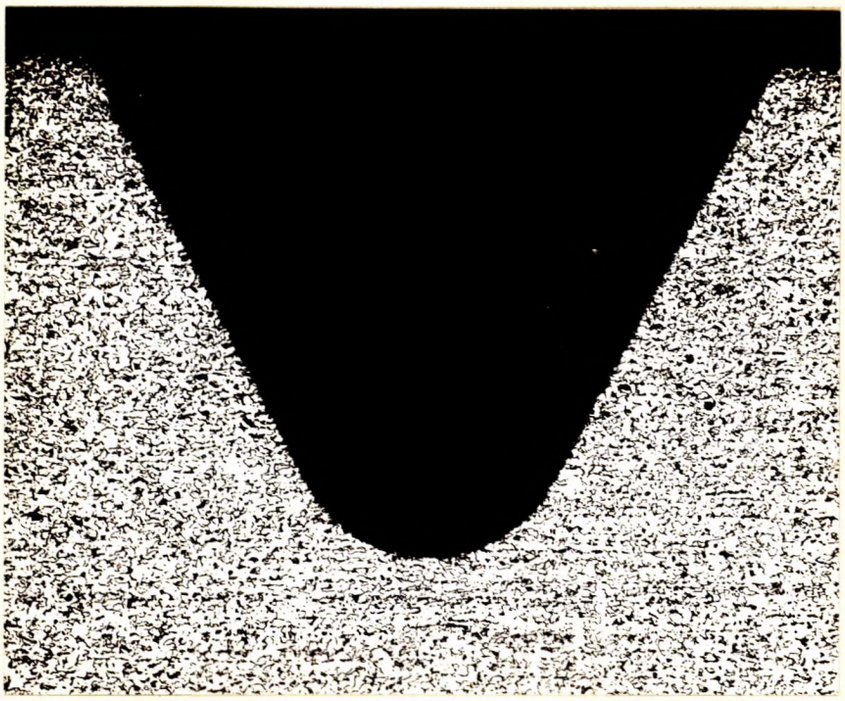
Figure 4.



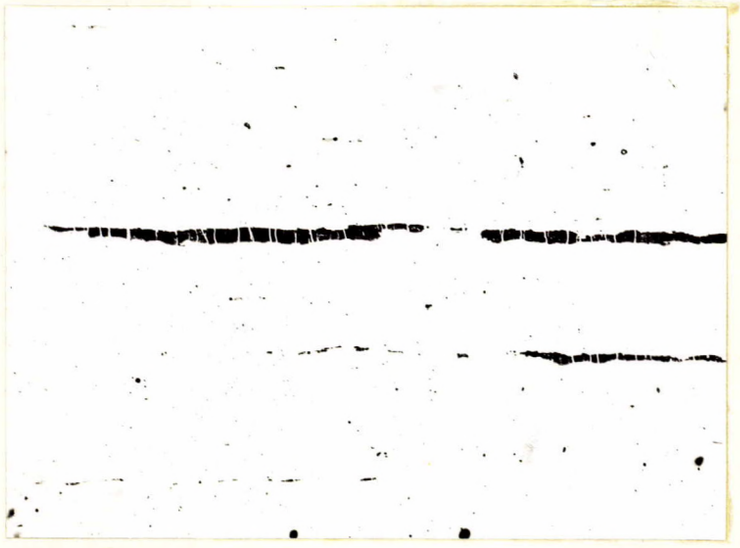
X50, nital etch.

LATHE-CUT, LOW TENSILE, 55° STUD (NO. L 3B2/5) SHOWING MICROSTRUCTURE AND FORM OF THREAD.

-

(Microscopic Examination, cont'd) -

Figure 5.



X100, unetched.

LATHE-CUT, LOW TENSILE, 65° STUD (NO. L 5B3/6) SHOWING TYPICAL INCLUSIONS.

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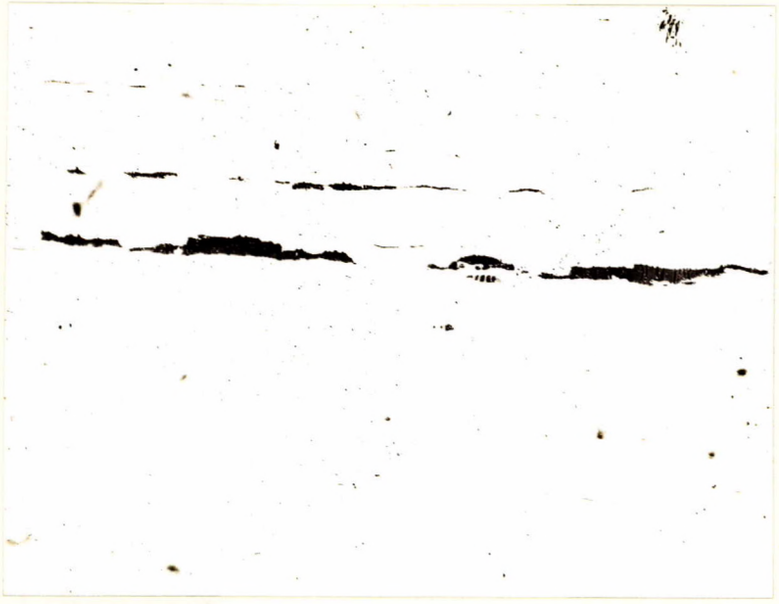
Figure 6.



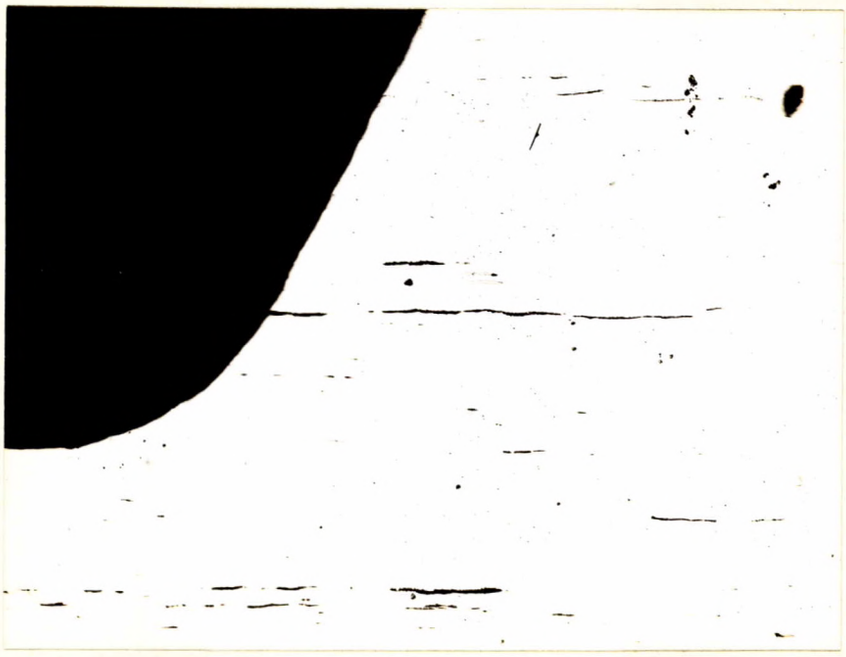
X100, unetched.

LATHE-CUT, LOW TENSILE, 65° STUD (NO. L 5B3/3) SHOWING INCLUSIONS.

-

(Microscopic Examination, cont'd) -

Figure 7.



X100, unetched.

LATHE-CUT, LOW TENSILE, 55° STUD (NO. L 3B2/5) SHOWING TYPICAL NON-METALLIC INCLUSIONS EXTENDING INTO THREADED AREA.

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Figure 8.

X100, unetched.

LATHE-CUT, LOW TENSILE, 65° STUD (NO. L 5B3/3) CRACKS IN CENTRE OF STUD FOLLOWING THE PATHS OF THE INCLUSIONS AT RIGHT ANGLES TO THE FRACTURE.

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(Microscopic Examination, cont'd) -

Figure 9.

X6, unetched.

LATHE-CUT, LOW TENSILE, 65 STUD
(NO. L 5B3/3) SHOWING INCLUSIONS?

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Discussion and Conclusions:

The form of the threads as revealed by the microscopic examination was found to be satisfactory in all five studs (see Figures 3 and 4), and no evidence of faulty machining was apparent. However, the microscopic examination revealed the presence of long stringers of inclusions (see Figures 5, 6, and 7). The majority of these stringers were located in the centre of the studs but some were found to exist near the surface. The presence of such stringers extending into the threaded areas (see Figure 7) may be responsible for the premature failures of the studs in question.

The cracks, shown in Figure 8, which occur near the centre of the stud at right angles to the break appear to follow the path of the inclusions in the steel.

Although the microstructure (see Figure 4) and the chemical analysis are satisfactory, the presence of excessive

(Discussion and Conclusions, cont'd) -

quantities of inclusions is highly undesirable and can only be detected by a microscopic examination. It would therefore appear desirable to subject samples of steel which are to be used for fatigue tests to a thorough microscopic examination.

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