O T T A W A December 30th, 1941.

# R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1142.

## Examination of a Defective Strut Attachment from a Stranraer Aircraft.

BUREAU OF MINES
DIVISION OF METALLIC MINERALS
—
ORE DRESSING AND
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CANADA
DEPARTMENT
OF
MINES AND RESOURCES
MINES AND GEOLOGY BRANCH

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Origin of Material and Object of Investigation:

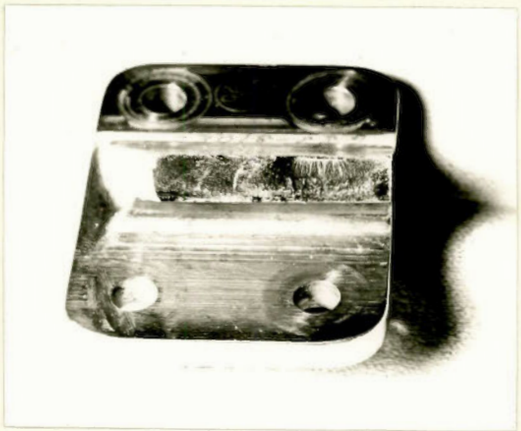
On December 10th, 1941, Flight Lieutenant A. J. Smith, of the Department of National Defence (Air Services), Ottawa, Ontario, submitted a broken lug, tail-plane strut No. 23018-229, for examination. In an accompanying letter, from Group Captain A. L. Johnson, for Chief of the Air Staff, (File No. 1021-20-11 (AMAE DAI)), it was stated that Specification S.80 - High Chromium

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

Steel - governs in regard to the material. It was requested that the part be examined for strength characteristics and also be analysed metallurgically.

The broken part as received is shown in Figures 1 and 2 (top and side views).

Figure 1.



BROKEN LUG AS RECEIVED. (Approximately $\frac{3}{4}$ size)

Figure 2.

Chemical Analysis:

| | Defective Strut. | Specification S.80 |
|---|---|---|
| Carbon, per cent | 0.16 | Not more than 0.25. |
| Manganese, " | 0.95 | " " " 1.00. |
| Silicon, " | 0.36 | " " " 0.50. |
| Chromium, " | 16.95 | Between 16.0 and 20.0. |
| Nickel, " | 2.29 | Not less than 1.00. |

Hardness Tests:

The Vickers hardness tester was used.

| Defective Strut | Specification S.80 |
|---|---|
| 290 V.H.N. | Not less than 241 (Brinell) |

The Vickers and Brinell hardness values are practically identical up to a hardness of about 300.

Tensile Tests:

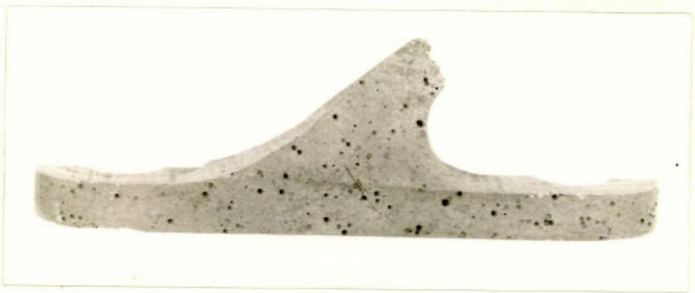
Two test pieces were obtained from the submitted specimen and were tested on a TENSOMETER testing machine. The results obtained by testing these small pieces are comparable, although perhaps not identical, with the standard-sized test pieces.

Gauge length - 0.400 inch.
Cross-sectional area - 0.02342 sq. in.

| | No. 1. | No. 2. | Spec. S.80 |
|---|---|---|---|
| Elastic limit, p.s.i. - | 103,500 | 103,500 | |
| 12.5 per cent proof (load at 0.050 in. permanent set), p.s.i. - | 116,000 | 120,500 | |
| Ultimate strength, p.s.i - | 133,500 | 133,500 | 123,000 min. |
| Elongation, per cent - | 10% | 20% | 15% minimum. |
| Reduction of area, per cent - | 20% | 35.5% | |

Macrographic Examination:

Figure 3.



Section of Broken Lug,
after etch in 1:1 HCl.

Microscopic Examination:

Figure 4.

X500, etched in
ferric chloride and HCl aqueous
solution.

Remarks:

The use of a miniature-size test piece was unavoidable, owing to the small size of the sample. From the two physical tests it is probable that the original material met physical as well as chemical requirements of Specification S.80.

The microstructure shows the three phases typical of heat-treated stainless steel of the 17 per cent chromium 2 per cent nickel type, with the banded structure produced by rolling and/or forging.

Cause of Failure:

The fracture has the typical smooth "oyster shell" surface which is characteristic of fatigue fractures. A point to be noted is that machining marks run parallel to the path of the fracture. Since the metal did not appear to deviate from the specification S.80, it must be concluded that in service repeated alternating stresses were imposed upon the lug which were not anticipated in the design of the aircraft.

Discussion and Recommendations:

With this type of metal the impact strength drops rapidly as hardness increases above 250 B.H.N. The following results are quoted from the Atlas Steels Limited catalogue:

(Continued on next page)

(Discussion and Recommendation, cont'd) -

Mechanical Properties, 1-inch Rod -
(Oil-quenched from 1750° F. and drawn for 1 hour)

| Draw | Tensile strength, p.s.i. | YIELD, p.s.i. | Elongation, per cent | Reduction of area, per cent | Izod | B.H.N. |
|---|---|---|---|---|---|---|
| 800°F. | 205,000 | 178,000 | 15 | 48 | 10 | 387 |
| 1000°F. | 175,000 | 163,000 | 17 | 51 | 12 | 332 |
| 1200°F. | 137,000 | 117,000 | 21 | 55 | 47 | 255 |

It is to be noted that a B.H.N. of 290 is in the borderline zone between high and low impact strength. It would be desirable to maintain the hardness of this part within 240 to 270 B.H.N. and to avoid the use of draw temperatures between 800° F. and 1100° F.

It was noted that the fracture occurred at right angles to the rolling direction. This would be expected to be the weakest plane in the metal.

It is therefore suggested that:

(1) Transverse and longitudinal test pieces be prepared and tested to determine the difference in properties, if any.

(2) If the metal is weaker transversely the lug should be re-oriented to make use of the greatest strength of the material.

More specific recommendations could be made if more material were available for examination. This would

(Discussion and Recommendation, cont'd) -

make it possible to determine the exact relationship between hardness and physical properties for this metal, and also the transverse strength could be compared with the longitudinal strength.

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