OTTAWA July 11th, 1941.

# REPORT

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1048.

Report on Aircraft Engine Adaptor.

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:

Group Captain A. L. Johnson, for the Chief of the Air Staff, Air Service, Department of National Defence, Ottawa, Ontario, requested (in a letter dated June 10th, 1941) the inspection, testing and breaking down to destruction of an aircraft engine adaptor. One casting was submitted.

Nature of Casting:

Figures 1 and 2 show the casting as received. Original aircraft design included a motor of English manufacture, which required 15 bolts to mount on the aircraft. It became necessary to alter the design to use another motor mounted with 8 bolts.

Figure 1.

Approx. 1/10 size.

Figure 2.

Approx. 1/10 size.

Casting as Received.

X-Ray Examination:

An examination carried out by L. W. Ball (on loan from the National Research Council, Ottawa) showed about twelve small shrinkage cavities. The location of these cavities are shown in Figures 5, 6 and 7 by mark "X" on the casting.

Torsion Test:

Figures 3 and 4 show the method of testing in torsion. Two square steel plates of identical size were bolted to the casting in such a way that when the assembly was compressed in a press, the clockwise torsion exerted by one plate was balanced by counterclockwise torsion in the other plate.

(See Figures 3 and 4 on next page)

(Torsion Test, cont'd) -

Figure 3.

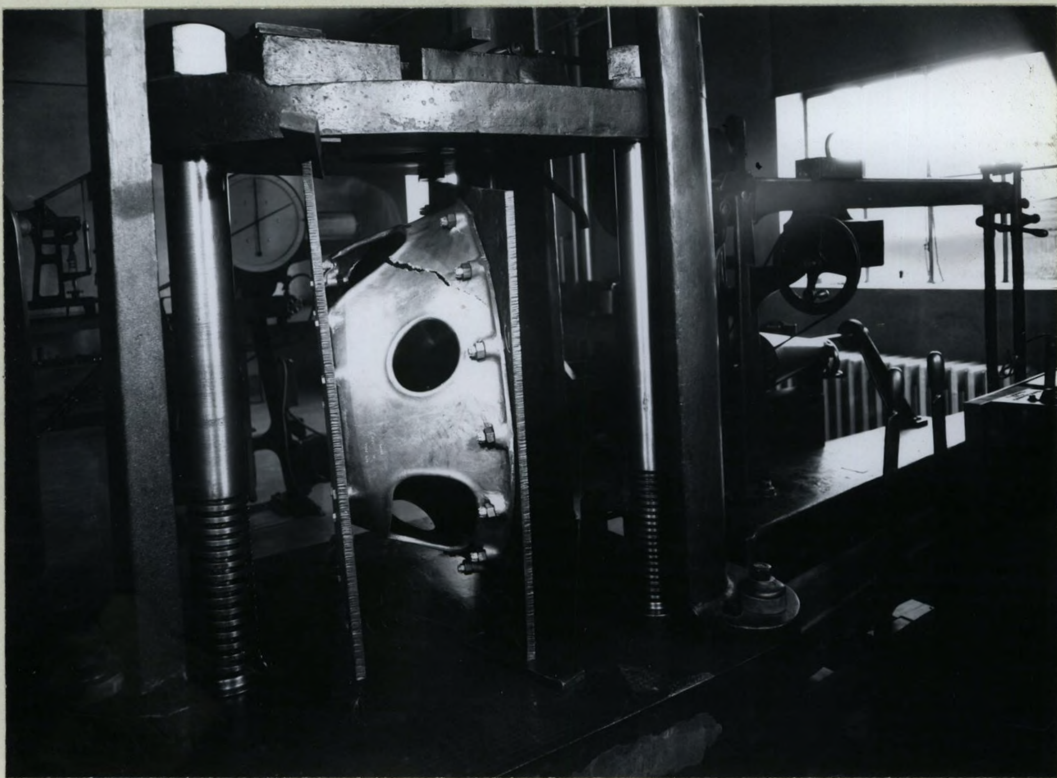


Figure 4.


TESTING IN TORSION.

(Continued on next page)

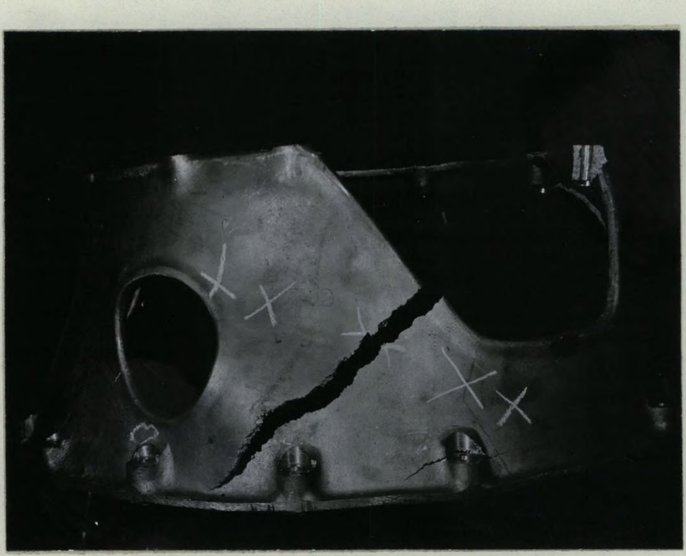
(Torsion Test, cont'd) -

When a load of 42,000 pounds was reached, the casting cracked. Measurement of the points of load application showed that the breaking force was equal to a 21,000-pound load on a 12-inch lever.

Considerable distortion occurred in the casting before it fractured.

The results of the torsion test are shown in Figures 5, 6 and 7.

Figure 5.



CASTING AFTER FRACTURE.

(See Figures 6 and 7 on next page)

(Torsion Test, cont'd) -

Figure 6.

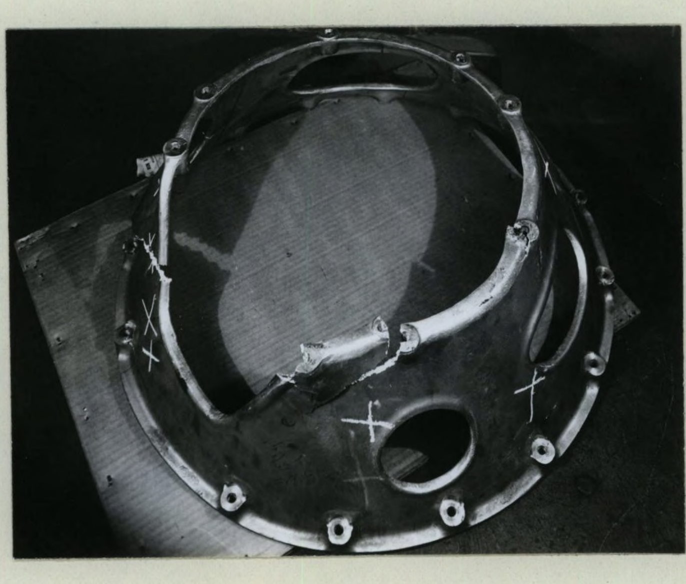
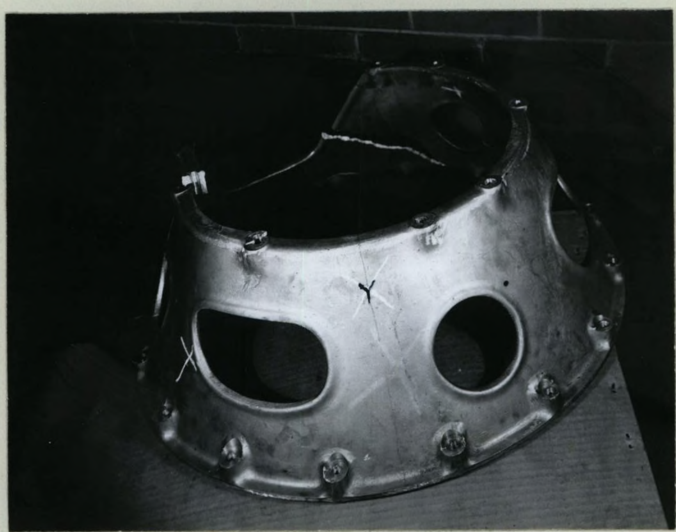


Figure 7.



CASTING AFTER FRACTURE.

(Continued on next page)

(Torsion Test, cont'd) -

It was observed that failure of this casting was general and was not due to any imperfections in the metal. The only failure occurring at a cavity is shown in Figure 5.

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## Chemical Analysis:

The casting was analysed as follows:

| | | Per cent |
|---|---|---|
| Silicon | - | 4.67 |
| Manganese | - | 0.04 |
| Iron | - | 0.75 |
| Titanium | - | 0.01 |
| Copper | - | None |
| Magnesium | - | None |
| Nickel | - | None |
| Zinc | - | Trace only |

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## Physical Tests (after Torsion Test):

Hardness - 45-60 V. H. N.

Tensile Test -

An 0.500 x 0.210 inch specimen for the tensile test was cut from the casting, the wide surfaces being left in the "as cast" condition.

The following results were obtained from this test specimen:

| | | |
|---|---|---|
| 0.1 per cent proof stress, p.s.i. | - | 15,500 |
| Ultimate tensile stress, p.s.i. | - | 11,200 |
| Elongation in 2 inches, per cent | - | 2.5⊛ |

⊛ Broke outside gauge mark.

The appearance of the fractured surfaces of the test piece indicate that the metal should be satisfactory.

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Microstructure:

The character of the cavities as located by the X-ray are shown in Figures 8 and 9.

Figure 8.

X2, rough, unetched.

Figure 9.

X15, polished, unetched.

The section shown in Figures 8 and 9 was obtained from the casting as shown in Figure 7 and marked by "Y".

The following figures show the microstructure:

Figure 10.

X500, unetched.

Figure 11.

X200, etched with Keller's reagent.*

* HF, 1 per cent; HCl, 1.5 per cent; $HNO_3$, 2.5 per cent and $H_2O$, 95 per cent.

Specification for Aluminium Alloy S.A.E. No. 35; Alcoa 43; and A.S.T.M. B26-37T, Alloy J.:

Chemical Analysis -

| | | Per cent |
|---|---|---|
| Silicon | - | 4.5 - 6.5 |
| Iron | - | 0.8 max. |
| Copper | - | 0.4 max. |
| Zinc | - | 0.2 max. |
| Titanium | - | 0.2 max. |
| Manganese | - | 0.3 max. |
| Magnesium | - | 0.05 max. |
| Other impurities | - | 0.3 max. |

Tensile Test -

| | | |
|---|---|---|
| Ultimate tensile stress - p.s.i., min. | = | 17,000 |
| Elongation in 2 inches - per cent, min. | - | 3 |

DISCUSSION OF RESULTS:

The x-ray photographs show minor casting defects and a slight mottling that is characteristic of aluminium alloy castings. For engineering purposes, the casting has a satisfactory soundness.

The torsion test shows this casting has adequate strength and does not deform brittly. However, this is a static test and is not similar to fatigue stresses which would occur in service.

The results of this examination show that the material conforms closely to the specifications for an aluminium alloy of this classification. The tensile test specimen, being taken from a section of the casting itself rather than a standard test bar, would yield lower results both in strength and elongation. The hardness should be satisfactory.

The microphotographs show a normal structure for this type of alloy cast in sand moulds.

Conclusions:

This material is satisfactory when used for non-structural aircraft parts. In the case of parts subject to fatigue stress, it would be advisable to use material with better fatigue properties, e.g., a part fabricated from pressing from wrought aluminium alloy plate.

Fabrication may be done by stamping or pressing when the alloy is in the softened condition. The assembly can then be age-hardened. Should this procedure not be possible, consideration should be given to the use of an aluminium-copper casting on account of its higher fatigue properties. It is possible, however, that casting difficulties have necessitated the use of the better flowing aluminium-silicon alloy. In the event that superior casting properties are required an aluminium-copper-silicon alloy would probably prove to be the best for the service.

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