O T T A W A February 5th, 1942.

R E P O R T

of the

ORE DRESSING AND METALLURGICAL LABORATORIES.

Investigation No. 1153.

Examination of Extruded Aluminium Alloy Shapes.

(Copy No. 7.)

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:

In a letter dated January 13th, 1942, Mr. K. S. Rawlins, Assistant Chief Inspector (Materials), British Air Commission, Washington, D. C., requested the examination of two samples of aluminium alloy extrusions. It was stated that the extrusions were made from aluminium alloy 24S, Sample No. 1 being in the "as extruded" condition and Sample No. 2 having been heat-treated.

It was requested that a macro-examination be made

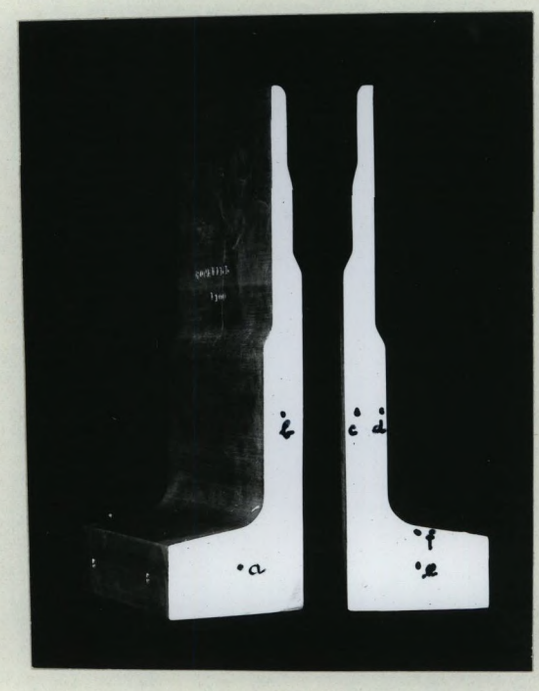
(Origin of Material and Object of Investigation, cont'd) -

to determine evidence of any discontinuities. It was stated that cracks had previously been discovered near the inside radius of the right-angle bend. It was further requested that both of the samples submitted be examined microscopically to determine the general soundness of the material.

In his letter, Mr. Rawlins stated that some of the sections similar to those from which the samples have been cut have exhibited a spongy appearance at the ends very similar to the surface of a casting.

Figure 1 shows the samples as received.

Figure 1.



SAMPLES AS RECEIVED.

(Approximately 1/2 size).

Macro-Examination:

In making the macro-examination the following two etching reagents were used:

1. 50 per cent NaOH + 50 per cent H_2O.

2. Tucker's Reagent: 15 per cent HF,
45 " HCl,
15 " HNO_3,
25 " H_2O.

(This was subsequently immersed in concentrated HNO_3.)

The samples as received were first etched in Solution No. 1 and showed no defects. They were then prepared and etched in Solution No. 2. Again no defects were observed.

To check these results both samples were given an X-ray examination by Dr. G. C. Laurence, of the National Research Laboratories, Ottawa. No indications of defect in the material were shown.

Each sample was then cross-sectioned into five pieces about one-half inch thick. These ten sections were prepared for etching and treated in Solution No. 2. Again no section showed traces of any discontinuities.

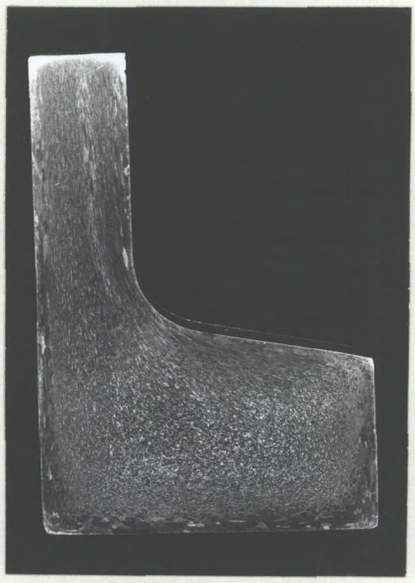
Sample No. 1 showed, after etching, uniform hardness with very faint indication of the re-entrant angle portion of material flow.

Figure 2 shows the appearance of a part of the etched surface in the heat-treated sample (No. 2). On the outside of the shape a coarse-grain area may be observed.

(Continued on next page)

(Macro-Examination, cont'd) -

Figure 2.



Macro-structure of a part
of Sample No. 2 (heat-treated).

Natural size.

The results of this examination were sent to Mr. K. S. Rawlins, in Washington, by telegram on January 21st, 1942, as follows:

> "Macrographic and X-ray examinations of aluminium alloy extrusions show no defects. Complete report following."

Chemical Composition:

	Sample No. 1.	Sample No. 2.
	(Per cent)	
Copper --	4.35	4.37
Magnesium --	1.54	1.54
Manganese --	0.62	0.62
Silicon --	0.16	0.15
Iron --	0.23	0.23
Titanium --	0.01	0.01

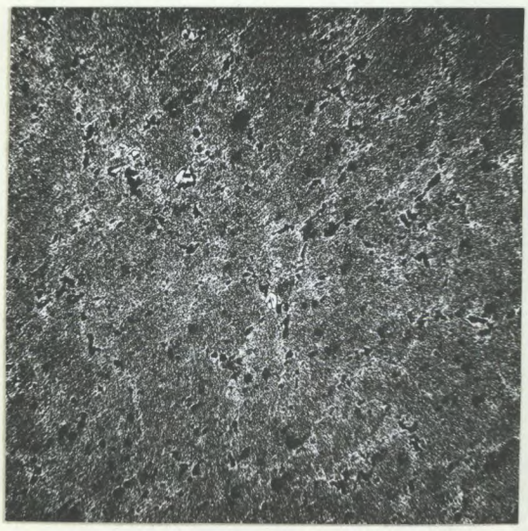
Hardness:

Sample No. 1, as extruded - 60 to 70 V.H.N.

Sample No. 2, heat-treated - 130 to 140 V.H.N.

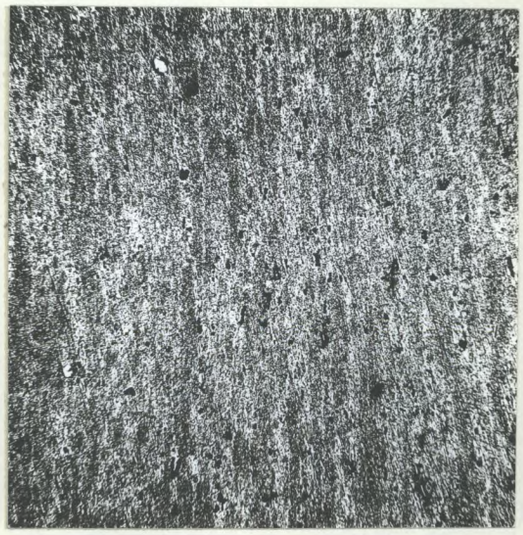
Micro-Examination:

Figure 3.



X100, etched.*
(Location "a" in Figure 1).

Figure 4.



X100, etched.*
(Location "b" in Figure 1).

SAMPLE NO. 1 (AS EXTRUDED).

Figure 3 shows the microstructure inside the heavy section in the "as extruded" condition. The picture shows no effect of plastic deformation and appears similar to the structure of partly annealed material.

In the thin section of the shape (Figure 4) the structure is distorted and fragmented from plastic deformation in the extruding process.

Although Figures 6 and 8 were obtained from the outer coarse-grained area there is no apparent evidence of this coarseness of grain in the photomicrographs. This is because the structure was so coarse that it is difficult to show it in a 100-magnification photomicrograph. Actually, the fine-grained area in the centre of this photomicrograph is from one grain, while the other areas are from other

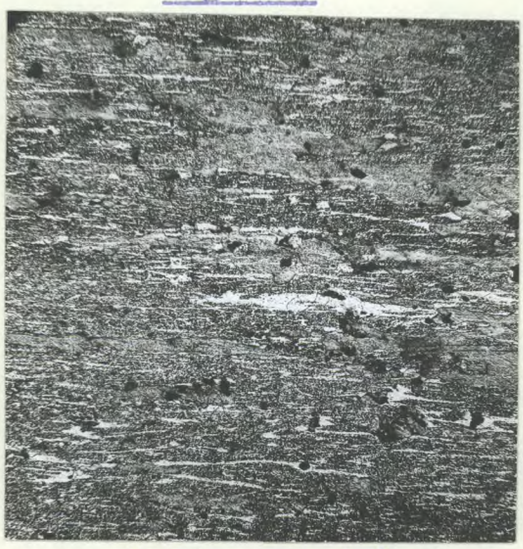
* Keller's Reagent: 1% HF, 1.5% HCl, 2.5% HNO_3, and 95% H_2O.

(Micro-Examination, cont'd) -

grains.

Figure 7 shows random orientation which is more typical of a cast structure. The structure in Figure 5 shows the direction of flow of the metal very clearly. It would appear that in the thin sections the cast structure is well broken up, while heavy sections remain essentially with a structure resembling the original ingot.

Figure 5.



X100, etched.*
Location, "c" in Figure 1.

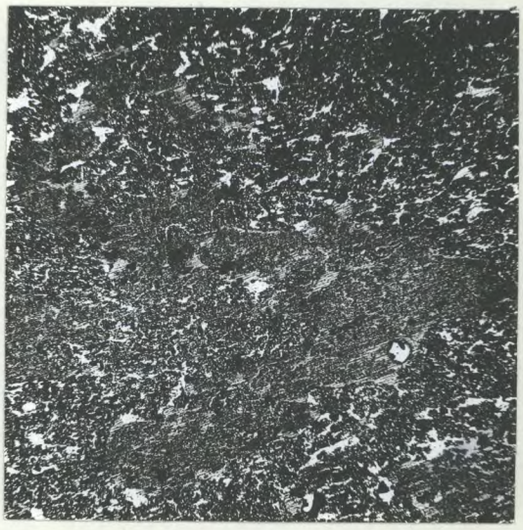
Figure 6.

X100, etched.*
Location, "d" in Figure 1.

Figure 7.

X100, etched.*
Location, "e" in Figure 1.

Figure 8.



X100, etched.*
Location, "f" in Figure 1.

SAMPLE NO. 2 (HEAT-TREATED).

(* Keller's Reagent: 1% HF, 1.5% HCl, 2.5% HNO_3, and 95% H_2O.)

(Micro-Examination, cont'd) -

Figures 5 and 6 show a full heat-treated structure.

In Figure 7, taken from a location inside the heavy section of the shape, the microstructure shows the effect of only partial heat-treatment. This results from the lesser amount of plastic deformation in the extrusion and insufficient solution heat-treatment (lower temperature and shorter time than in thinner sections). In shapes of varying thicknesses this is normal and unavoidable.

Discussion of Results:

Macrographic and X-ray examinations showed no material defects in the submitted samples.

Chemical analysis and hardness tests are normal for this aluminium alloy type.

Micro-examination shows this material to be satisfactory. The coarse-grain area shown in Figures 3, 6 and 8 is caused by recrystallization which occurs during the solution heat-treatment due to the material being critically cold-worked in the outer areas in the extruding process.

This non-uniformity of the structure could be responsible for lowering the mechanical properties and may be overcome only by quenching the material immediately after extruding (without reheating) or by satisfactorily cold-working before heat treatment.

Conclusions:

The submitted samples show no material defects. No spongy appearance or areas were observed. The coarse grain boundary is normal for extruded shapes quenched after reheating.

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