The Effect of Cutting Single-Crystal-Plates of Aluminium with Knife Edge

By

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Abstract

The effect of cutting an aluminium plate composed of a large single crystal with a knife edge was investigated by means of X-rays.

When a single-crystal-plate of aluminium was cut with a knife edge, the single crystal was broken up into microcrystals, and they were so arranged in an imperfectly fibrous manner that the axis of the fiber was parallel both to the cut made by the knife edge and to the plane of the test-piece irrespectively of the initial orientation of the crystallographic axes of the single crystal.

As for the relationship among the maximum angle of rotation of the microcrystals around the fiber axis, the thickness of the test-piece and the angle of the knife edge, it was found that the maximum angle of rotation of the microcrystals decreased almost in a linear relation according as the test-piece became thicker irrespectively of the velocity of the cutting, and also slightly decreased when the angle of the knife edge increased.

The range of the influence of the cutting upon the test-piece increased almost in a linear relation with increase of the thickness of the test-piece, and slightly decreased with increase of the angle of the knife edge.

The size of the test-pieces of single-crystal-plates of aluminium used in the present experiment was about 10 cms. × 2 cms. × 0.4 – 1.5 mm., and they were prepared by the stress-annealing method.

The orientations of the crystals in the plates were determined, by taking first their Laue-photographs, and then by treating the Laue-spots with the crystallographic globe devised by Prof. U. Yoshida[1].

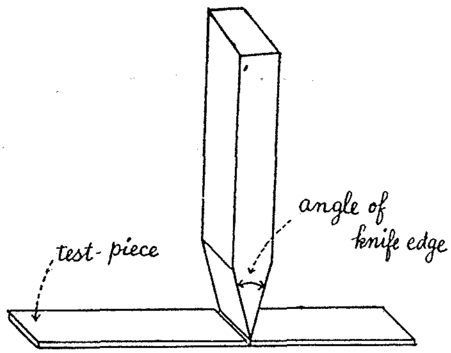
These plates were then cut perpendicularly to their planes into two pieces with the knife edge, as shown in Fig. 1, the angle of

1 U. Yoshida: Japanese J, Phys., **4**, 133 (1927)
S. Takeyama: These Mem., **12**, 257 (1929)

which was either 15° or 88°.

By sending to the cut thus obtained a narrow and circular beam of X-rays perpendicularly to the original flat surface of the test-piece, the Laue-photograph shown in Fig. 1, Plate I was obtained, which shows an imperfectly fibrous arrangement of the microcrystals.

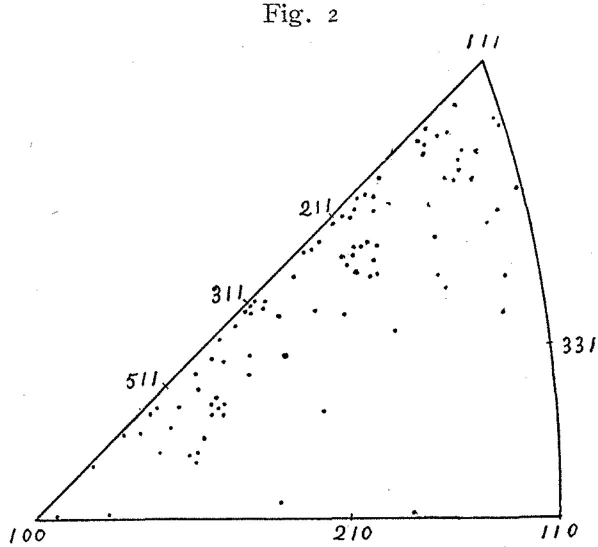
Fig. 1



The writer tried to find the common axis of rotation of the microcrystals by using the crystallographic globe, in the same way as K. Tanaka[1], and he was able to ascertain that the direction of such axis of rotation of the microcrystals, unaltered by the process of cutting, was parallel both to the line of the cut made by the knife edge and to the flat surface of the test-piece, irrespectively of the orientation of the crystallographic axis of the initial single crystal.

The initial crystallographic orientations of about 100 test-pieces which were investigated in the above experiment are shown in Fig. 2. The dots in the figure show, in stereographic projection, the initial orientation of the direction of the normal to the flat surface of the plates in reference to the directions of the crystallographic axes.

Fig. 2



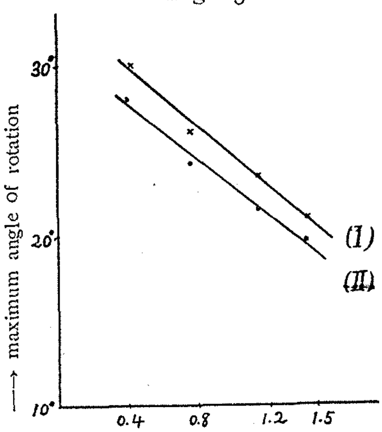
As compared with the results obtained by K. Tanaka from the bending of a single-crystal-plate and that of a wire of aluminium, and the one obtained by T. Fujiwara[2] from the

1 K. Tanaka: These Mem., **11**, 199 (1928)
2 T. Fujiwara: These Mem., **13**, 109 (1930)

bending of a single-crystal-wire of tungsten and molybdenum, in all which cases the common axis of rotation of the microcrystals was parallel to the axis of bending irrespectively of the orientation of the initial single crystal, it seems that the process of cutting a metal crystal with a knife edge is analogous to the bending of the crystal and that the axis of bending coincides with the direction of the cut.

When the relation among the maximum angle of such rotation of the microcrystals around the fiber axis, the thickness of the test-piece and the angle of the knife edge were investigated, it was found that, as is shown in Fig. 3, the maximum angle of rotation of the microcrystals decreases almost in a linear relation as the test-piece becomes thicker, irrespectively of the velocity of the cutting, and also slightly decreases when the angle of the knife edge increases.

Fig. 3

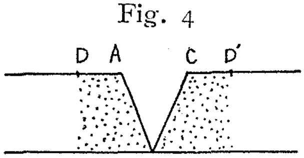


In the case of curve (I) in Fig. 3, the angle of the knife edge is 15°, and in the case of curve (II) the angle is 88°.

Besides, as the test-piece becomes thicker, the radiant band of the Laue-photograph becomes broader. This shows that the thicker the test-piece is, the less the parallelism of the fiber axis becomes, and this tendency can also be seen in the case where the angle of the knife edge increases.

Next, the writer investigated to what extent the influence of the cutting extended beyond what could be seen by his own eyes directly, that is to say, how far the microcrystals were then made, apart from the visible cut made by the knife. In Fig. 4, a certain cross section of the plate perpendicular to the cut is shown. When ABC is the cut and the dots are microcrystals, the length of AD or CD′ remains to be measured.

Fig. 4



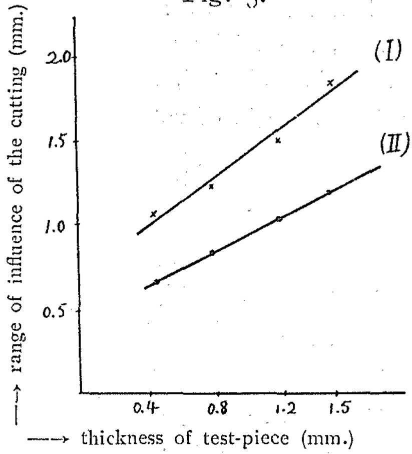
In this experiment the writer used the Narrow and Long Slit Method devised by Prof. U. Yoshida and Mr. K. Tanaka[1]. The cut made by the

1 U. Yoshida and K. Tanaka: Nature, **118**, 912 (1926)

knife edge was placed perpendicularly to the narrow and long slit, and the Laue-photograph was taken by sending X-rays perpendicularly to the flat surface of the test-piece. This is shown in Fig. 2, Plate I.

If the length of dd′ is measured on this photograph, the length DD′ in Fig. 4 can be deduced from it.

Fig. 5.



Next by subtracting from this length DD′ the actual breadth AC of the cut, which was measured by a comparator, the length of AD or CD′ was obtained.

The result is shown in Fig. 5, which shows that the range of the influence of the cutting upon the test-piece increases almost in a linear relation with increase of the thickness of the test-piece, and slightly decreases with increase of the angle of the knife edge. In the case of curve (I) in Fig. 5, the angle of the knife edge is 15°, and in the case of curve (II) the angle is 88°.

As there is more or less inaccuracy in the measurement of the two ends of the diffuse figure in the Laue-photograph, the absolute values of the maximum angle of rotation of the microcrystals around the fiber axis and the range of the influence of cutting have some inaccuracy, but it seems that the aforesaid linear relations can be ascertained.

The writer is now examining the influence of cutting the single crystal plate at every layer parallel to the flat surface of the plate, and this present experiment is reported rather as a preliminary one.

In conclusion, the writer wishes to express his sincere thanks to Professor U. Yoshida and Mr. K. Tanaka of Kyoto Imperial University for their kind guidance during the research.

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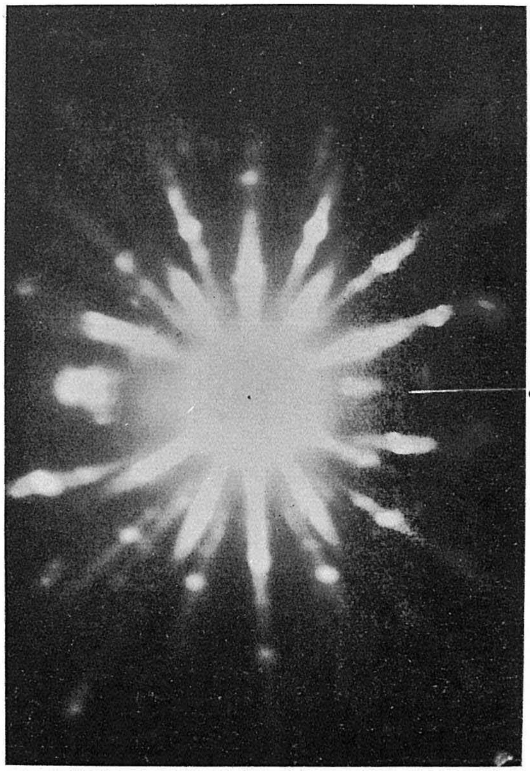
Plate I

Fig. 1



direction of the cut.

Fig. 2