Bending of Aluminium-Crystals

By

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Abstract

The effect of bending upon the aluminium plates composed of large single crystals was investigated by means of distortions of the Laue-spots. The orientations of the micro-crystals, produced by the destruction of the single crystal at the time of bending, were found to be scattered around the axis of bending including the initial orientation, so that the micro-crystals revolve to some extent around this axis of bending, and finally their arrangement becomes fibrous by the process of bending. The same result was also obtained in the case of aluminium-wires each composed of a single crystal when they were subjected to a slight bending.

It is well known that when a metal crystal is subjected to various regular cold workings it is regularly destroyed by this process, and that finally the micro-crystals produced by the destruction of the crystal take a definite arrangement which is peculiar to the kind of working and that of the metal. In this paper is reported the results of an investigation with X-rays of the effects of bending upon the aluminium plates and wires each composed of a single crystal. The test-pieces of the plates measured 10 cm. × 2 cm. × 1.5 mm., and the diameter of the wires examined was 3 mm. The large single crystals were obtained by the stress-annealing method.

The orientations of the crystals in the plates were first determined by taking their Laue-photographs. These plates were then bent by being pressed against the surface of a circular cylinder, so as to have the same radius of curvature as the radius of the cylinder. Then they were bent more and more in succession by using circular cylinders of smaller radii, and finally they were folded into two without using any cylinder. At each stage of bending a Laue-photograph was taken by letting the X-rays strike the specimen in the direction of the radius of curvature of the plate. In the photographs thus taken the sharp Laue-spots of the initial single crystal became more and more diffuse and lengthened nearly in the direction radial from the central spot as the process of bending proceeded. This phenomenon was also seen when the single crystal was subjected to other cold workings such as rolling, extension or tortion, and seems to be caused by the scattering of the orientations of the micro-crystals, which are produced by the destruction of the single crystal, for some angles around a certain axis of revolution

At the suggestion of Prof. U. Yoshida the writer tried to determine the axis of revolution of the micro-crystals in the case of bending; and he obtained the photographs shown in Figs. 1 and 2, Plate I, by using general X-rays from the tungsten anticathode. These figures are of two different specimens, and in both cases the radius of curvature of bending is 1.85 cm., and the horizontal direction in each figure is parallel to the axis of bending.

The axis of revolution around which the orientations of the micro-crystals are scattered was determined by the following consideration. The whole assemblage of the end-points, which represent the positions of both ends of every lengthened Laue-spot, must be two sets of ordinary Laue-spots due to the micro-crystals at two different orientations. Thus, if we can select, by taking either one of the two end-points of every lengthened Laue-spot respectively, one half of all the end-points above mentioned which constitute one set of ordinary Laue-spots due to the micro-crystals at a certain orientation; then, the remaining end-points will belong to another set of the ordinary Laue-spots due to the micro-crystals at another orientation rotated a little from the former. These two different orientations of the micro-crystals are two extreme ones, and the intermediate portion between the two extremities of every lengthened Laue-spot, will be caused by the micro-crystals at the intermediate orientations between the two extreme ones. By means of the globe and the spherical scale devised by Prof. U. Yoshida,[1] these two extreme orientations of the micro-crystals, and consequently the axis of their revolution were determined.

The writer determined the axis of revolution of the micro-crystals for many single crystals of aluminium of different orientations, and could

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1 Jap. J. Phys., 4, 133 (1927)

find that this axis of revolution of the micro-crystals coincided always with the axis of bending irrespective of the orientation of the initial single crystal. This point was confirmed by the agreement of the photographs with the diagrams calculated under the above consideration. Figs. 1 and 2 are the calculated diagrams which correspond to Figs. 1 and 2, Plate I, respectively, and they are both drawn by taking 7° as the angle of revolution of the micro-crystals around the axis of bending. In these figures the dots indicate the positions of the initial Laue-spots.

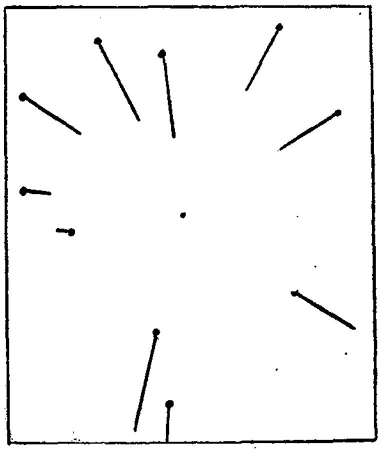

Fig. 1

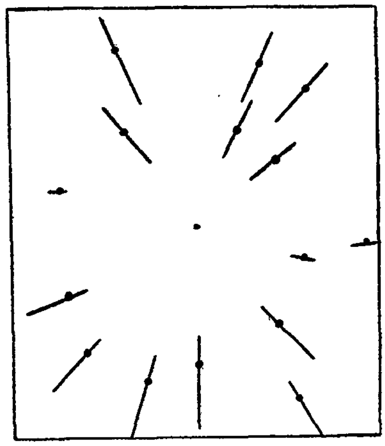

Fig. 2

The angle of revolution of the micro-crystals becomes larger with a smaller radius of curvature of the plate, and the arrangement of the micro-crystals approaches more to the fibrous one. Figs. 3 and 4 Plate I, are the photographs taken with the same plates as in Figs. 1 and 2 Plate I respectively, when they are folded into two, and show almost the same features as those of a fibrous arrangement of the micro-crystals. Fig. 3 shows, in stereographic projection, the initial orientations of these specimens I and II in reference to the crystallographic axes of the crystals; here the dot indiacates the direction of the axis of bending or the common axis of the fibrous arrangement, and the small circle the direction lying in the plane of the plate and perpendicular to the axis of bending. Fig. 4 and Eig. 5 are the diagrams, for the Laue-photographs Fig. 3 and Fig. 4, Plate I, respectively, calculated by taking 90°

equally on both sides of the initial orientation as the angle of revolution

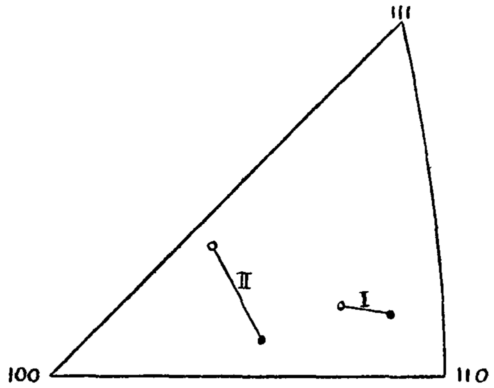

Fig. 3

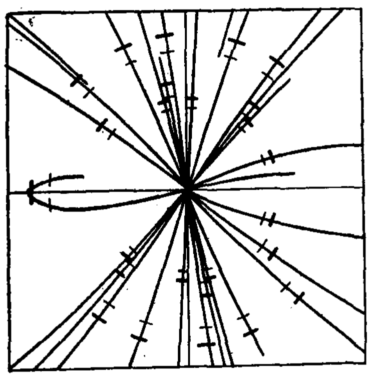

Fig. 4

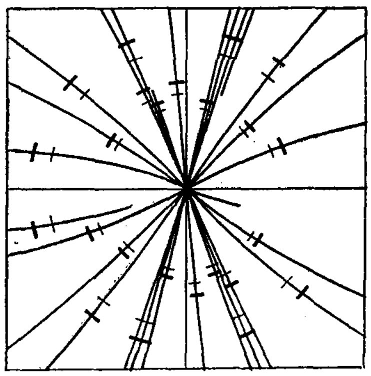

Fig. 5

of the micro-crystals around the axis of bending; and they show a close agreement with Fig. 3 and Fig. 4, Plate I, respectively.

Thus we can obtain merely by bending the fibrous arrangement of the micro-crystals, which has any crystallographic axis in the direction parallel to the axis of bending, as the axis of the fiber. This seems not to be without interest, because with some regular cold workings, some particular crystallographic axes become always the axis of the fiber.

To see whether the same result as the above one can be obtained in the case of aluminium wires each composed of a single crystal, the writer examined the wire, subjected to a slight bending at a small portion of it, by illuminating the wire with divergent X-rays passing through a narrow and long slit.[1] In this case the bending of the wire was so small that the distance between the bent portion of the wire and the photographic plate could be regarded as unaltered by the bending. One of the photographs thus taken is shown in Fig. 5, Plate I. We can see from the difference of the distortions of the diffraction-lines that the effect of bending upon various reflecting atomic planes of the crystal differ with the orientation of the atomic planes. By determining the orientations of various reflecting atomic planes, to which are due the diffraction-lines appearing in several photographs taken at different orientations of the wire, it was ascertained that the smaller the angle between the normal of the reflecting atomic plane and the axis of bending, the smaller the distortion of the diffraction-line which is caused by the atomic plane. This shows that, in the case of the wire, we have also the same scattering of the orientations of the micro-crystals as in the case of the plate.

In conclusion, the writer wishes to express his sincere thanks to Prof. U. Yoshida for his kind guidance in the research.

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1 Nature, **118**, 912 (1926)

Plate I.

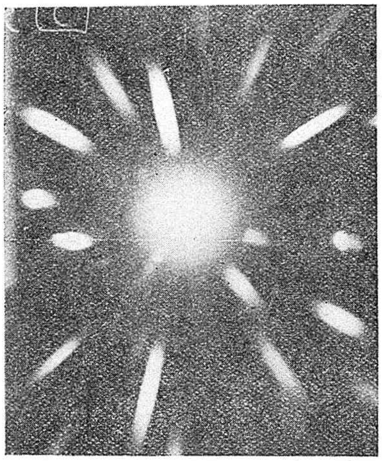

Fig. 1

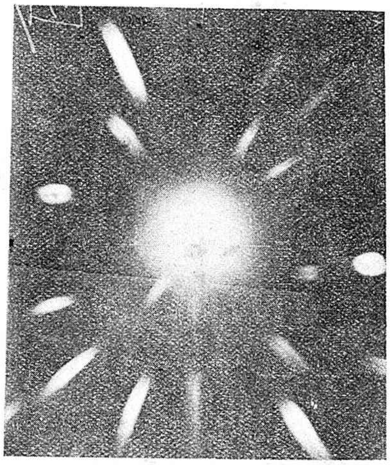

Fig. 2

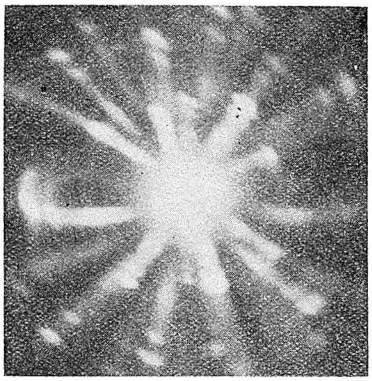

Fig. 3

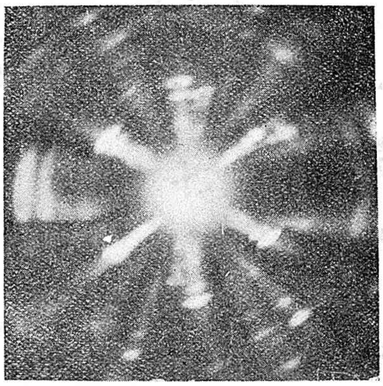

Fig. 4

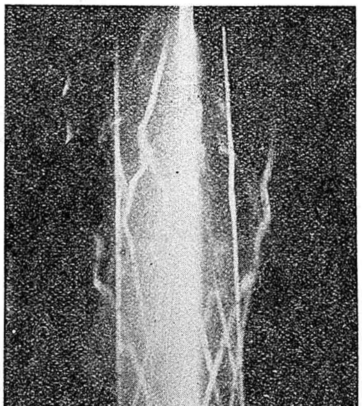

Fig. 5