Photo-Elastic Effect in Barium Nitrate

DURING the course of our investigations on photo-elasticity, we have found that single crystals of barium nitrate behave in many respects in an exceptional manner. Differences between the stress-optical constants as determined by a Babinet compensator are $(q_{11} - q_{12}) = -23{\cdot}81 \times 10^{-13}$, $(q_{11} - q_{13}) = -18{\cdot}06 \times 10^{-13}$ and $q_{44} = -1{\cdot}62 \times 10^{-13}$ C.G.S. units for the sodium D lines. $(q_{11} - q_{12})$ and $(q_{11} - q_{13})$ furnish a measure of the birefringence caused when pressure is applied along a cube axis.

Values given above for barium nitrate are the largest so far obtained for any cubic crystal. These values are not only larger than those hitherto reported for other cubic crystals, but are also larger than the corresponding value for most glasses, which does not generally exceed 10×10^{-13}. Barium nitrate crystals belong to the T_h class and we would expect $(q_{11} - q_{12})$ to be different from $(q_{11} - q_{13})$. It is an interesting feature that the difference in this case is nearly 27 per cent, and is much larger than that observed by us earlier in potassium and ammonium alums[1]. It is also to be noted that for this substance the birefringence produced by a pressure along a cube axis is nearly fifteen times that produced by an equal pressure along a cube diagonal. This should be regarded as a large anisotropy, as the corresponding figure for potassium alum, its nearest approach, is only eight times.

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Inclusions in Aluminium Crystals

IT appears from various experiments that the ease with which a crystal can grow in a deformed matrix depends very much on the mutual orientation of growing and disappearing lattice domain. This is already obvious from the fact that, in a recrystallizing coarse-grained material, the new crystals show corrugated boundaries, demonstrating visibly that some of the original grains are consumed at a faster rate than others[1]. Recent experiments give a far more striking proof of this phenomenon.

It was observed by Carpenter and Elam[2] in their original paper on the preparation of aluminium crystals by the stress-strain method that the large crystals so obtained often contain small included domains with deviating orientation, which were obviously unabsorbed grains from the original fine-grained material. These inclusions proved to be very stable against prolonged heat treatment (see, for example, Seumel[3]).

It struck us that in a crystal with a number of inclusions, several of these domains reflected incident light at the same moment, thus pointing to a more or less identical orientation. It seemed worth while to determine this orientation, and to look for a relation between the orientation of the 'mother crystal' and the orientation of the included domains. As the dimensions of these domains depend on the grain size of the matrix, they can vary considerably, so that it is not always possible to determine the orientation of an inclusion by X-ray methods. In these cases the etch method, developed for aluminium by Lacombe and Beaujard[4], was used. By this method tiny cubic etch-pits are developed, and the boundary lines of the pits are therefore traces of (100) planes on the surface of the test piece. Starting from the orientation of the mother crystal (determined from a Laue transmission photograph), the (100) traces to be expected for the four spinel twin orientations were constructed by means of stereographic projection. It was found that the pits in the inclusions had orientations which coincided with the four twin possibilities within about 5°. Fig. 1 shows two different twins in the same mother crystal.

The orientation of larger inclusions (approximately 0·2 mm. diameter) could be obtained by X-ray methods (Laue transmission photographs). These photographs consisted of the superimposed Laue patterns of mother crystal and inclusion; as the pattern of the included domain showed a marked asterism as a result of the deformation before recrystallization (this proves at the same time that the included domain is no new crystal), it was not difficult to separate them. The photographs confirmed the relationship between the orientations already found by the etch method. Fig. 2 shows the Laue patterns of mother crystal and inclusion superimposed; the enclosed spots would have coincided for an exact twin relationship.

According to these experiments, it seems to be difficult for a growing crystal to consume those lattice blocks which occupy approximately a twin position. From this it might be deduced that in order to prepare large aluminium crystals by the stress-strain method without such inclusions, one has to start from fine-grained material of such 'narrow' texture that a growing crystal has no chance of meeting its (approximate) twin position. A second point is the striking difference in behaviour between grains in *approximate* twin position and lattice blocks which give rise to exact twins. As was found in earlier work[5], a growing crystal may induce ('stimulate') a block to become an active nucleus, which develops into an exact twin with regard to the stimulating crystal (for a more extensive account on exact twins in aluminium and the idea of 'stimulation' we refer to ref. 6).

At the moment, we have not yet been able to analyse the geometrical relationship between two

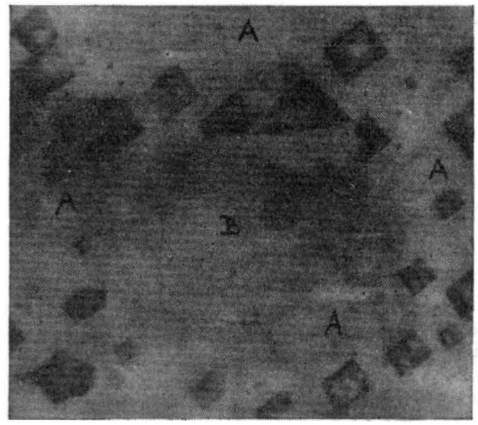

Fig. 1. Part of an aluminium crystal, A, containing an 'unconsumed' inclusion, B, with cubic etch pits. From the relative position of the etch pits it can be deduced that the inclusion B is approximately a spinel twin with regard to A. × 300