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THE STRENGTH OF SINGLE CRYSTALS OF INORGANIC SALTS.

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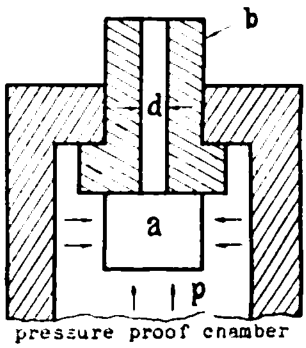
Introduction.

Glass and quartz are used ordinarily as optical windows to measure the optical properties of materials under high pressure. The pressure ranges of glass and quartz for the optical window are already reported[1], and the authors measured the strength of single crystals of sodium chloride, potassium chloride and lithium fluoride to determine the pressure range for the optical window.

Experimental.

Materials. The test pieces are single crystals of sodium chloride, potassium chloride and lithium fluoride[2], produced in our laboratory except the sodium chloride imported for industrial use. Each test piece is formed as a cylinder, which is 13~15 mm in diameter and 2~11 mm in thickness. The surfaces of the test pieces are polished to be optically flat.

Apparatus and method. The apparatus used for the experiment is a pressure proof chamber as Fig. 1. One surface of the test piece (a) is set on the steel case of the window (b), and exposed to the atmospheric pressure through the hole (d), and the other surfaces are set under pressure. The steel surface and the test piece surface are polished for optical use, and no packing is used for pressure sealing.



pressure proof chamber
Fig. 1

A gas compressor is used for pressing to 500 kg/cm^2, and an intensifier[3] for the pressures higher than 500 kg/cm^2. The speed of pressing is 50 kg/cm^2 per minute under the pressures less than 500 kg/cm^2, and 200 kg/cm^2 per minute under the pressures higher than 500 kg/cm^2. The experiments are carried out at room temperature.

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1) R. Kiyama, *This Journal*, **19**, 17 (1945)
2) R. Kiyama and S. Minomura, *This Journal*, **21**, 69 (1951)
3) R. Kiyama, *This Journal*, **19**, 1 (1945)

Experimental results.

Sodium chloride.

At first, the test piece is pressed with the window of 2 mm in diameter for a short time (20~150 min.). The sections of the test pieces in Fig. 2 show the effects of all the stages of pressing. There is no change until 400 kg/cm² (A). When the pressure exceeds 500 kg/cm², a plastic flow is observed and a part of the test piece protrudes into the hole of the atmospheric side (B). The height of the protrusion increases as the pressure rises, and under the same pressure, it increases as the time of pressing. When the pressure exceeds 2000 kg/cm², a bursting state suddenly takes place,—the top of the protrusion cracks as (C) and (D), and at the pressure increases higher, a hemispherical defect appears as if pulled from the atmospheric side as (E). And when the pressure increases moreover, many concentric crack lines are observed around the defect and the region of these cracks gradually increases. When the pressure reaches 2500 kg/cm², the test piece becomes opaque from the surface of the atmospheric side as (F), and is crushed at last.

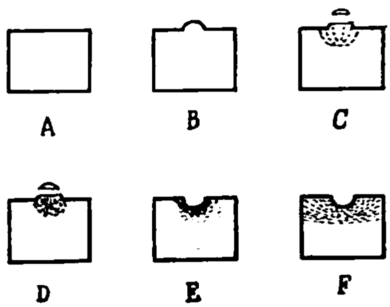

Fig. 2

The test pieces made of the imported sodium chloride of poly-crystal for industrial use, show the smaller strength than the artificial sodium chloride. The (B), (C) and (E) state are observed at 500, 1200 and 1500 kg/cm² respectively.

The same experiment is carried out with the hole of a window case, 4 mm in diameter. The results are as follows: the pressure effects are the same as the window of 2 mm hole under lower pressure, and the effects as (B), (C) and (F) are observed at 500, 1500 and 2000 kg/cm² respectively.

No change is observed after 46 hours under 400 kg/cm² with 4 mm hole window.

Potassium chloride.

With regard to potassium chloride, the effects as (B), (C) and (E) are observed at 400, 1200 and 1500 kg/cm² respectively with the hole of 2 mm in diameter.

No change is observed after 25 hours under 250 kg/cm² with the hole of 4 mm in diameter.

Fig. 3 shows the test pieces corresponding with the states of (B)~(F) in

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Fig. 2. (B′) shows the intermediate state between (B) and (C).

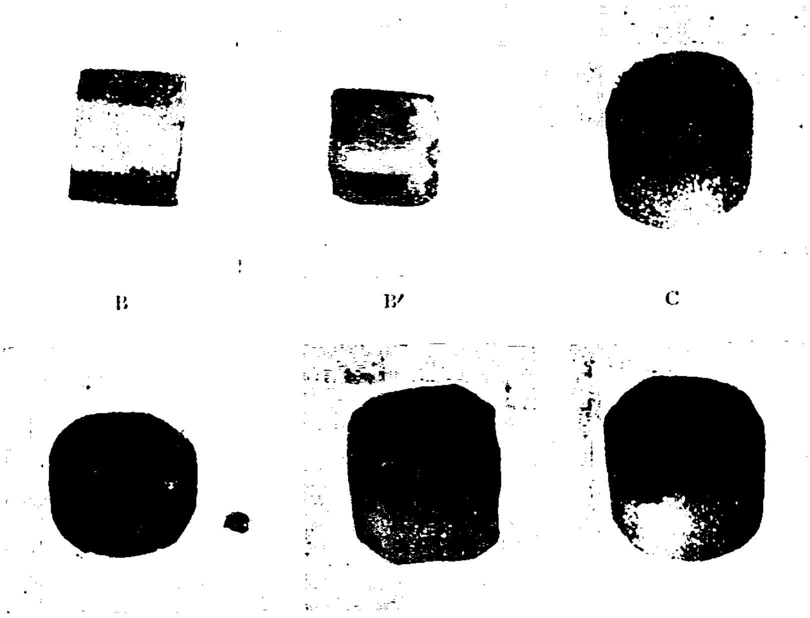

Fig. 3

Lithium fluoride.

The test pieces which are 2∼8 mm in thickness are pressed with a 4 mm hole window. No change is observed at 2000∼4000 kg/cm^2 practically.

Supplement.

The strength is nearly the same value irrespective of the direction of crystal axes.

The moisture in the compressed air is separated by the separator of the compressor, and the strength shows the same value independent of the condition of the weather. When the measurement for a long-time, a dewpoint is reached by the change of room temperature and the part of the piece is dissolved by condensed water, but it does not burst because of sufficient thickness of the piece as Fig. 4.

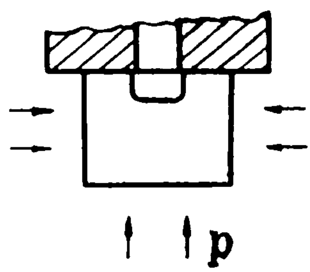

Fig. 4

Sodium chloride and potassium chloride are plastic beyond the elastic limit, and in this range, the thickness of the part of the piece in contact with the steel surface decreases, and a part of the atmospheric side protrudes into the hole. The center part of the other plane of pressing side

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becomes hollow slightly. In a thiner cylinder, blowing out of the pieces is possible. It is supposed that the phenomena are due to the slide of crystal lattice. Under the pressure beyond this range, the crack lines grow to the direction of crystal axes, the test piece is broken in small cubic pieces, and it smashes at last.

Sodium chloride, potassium chloride and lithium fluoride can be used as optical windows under 400, 250 and 4000 kg/cm^2 respectively.

These salts have their own optical properties and lithium fluoride is water proof. The mechanical strength of sodium chloride surpasses potassium chloride, and the mechanical strength of lithium fluoride is much greater than the above two. From the above reasons, lithium fluoride has many exellences which can be used as optical window in wide high pressure range.

In conclusion, the design of the optical window of inorganic salts under high pressure is formed.

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