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"The Strength of Glass containing Cracks."

By Dr. L. H. Milligan.

Discussion.

Dr. F. W. Preston (*communicated*).

Mr. Milligan's results are so interesting that I hope to repeat his experiments; up to the present I have not been able to do so, and my observations therefore are likely, I am afraid, to be of small value.

The stresses surrounding a diamond cut in glass have been investigated by A. J. Dalladay and F. Twyman.* The stresses are apparently concordant with the view that the diamond opens a downward fissure into the glass and forces into the mouth of this fissure small particles of glass debris.† The same thing happens with a glazier's wheel, or when grinding a glass surface with sand or other abrasive.‡

Examination of Dr. Milligan's polariscopic figures strongly supports the view that the stresses are "bearing stresses," due to the concentration of pressure at places where glass particles have been forced into the crevice. (The characteristic distribution of a bearing stress may be examined by pressing a steel bicycle ball with great pressure on a piece of glass, and examining the latter in the polariscope; or by cutting notches in a piece of celluloid and driving therein small wedges or bits of oversize wire.)

In a moist atmosphere, a meniscus might form between the particles and the walls of the fissure; if so, it would be drawn with no little force into the space between the two, and would add to the disrupting effect. But in the presence of much moisture there would be little effect of this sort. We therefore have to look to the head of the fissure for an explanation.

We might make the assumption that although water readily wets the clean newly-fractured glass surface, it cannot quite reach the effective head of the fissure, which is more or less of atomic width. In such a case a great bursting force could be exerted by the water,

* *Trans. Opt. Soc.*, 1921–22, **23**, 165.

† Preston, *Trans. Opt. Soc.*, 1922–23, **24**, 10.

‡ Preston, "Structure of Abraded Glass Surfaces," *Trans. Opt. Soc.*, 1921–22, **23**, 141; A. J. Dalladay, *ibid.*, 1921—22, **23**, 170.

if the ordinary laws of capillarity apply in so confined a space. Then to explain the effect of paraffin oil, we must assume, either that it can penetrate to the very head of the fissure, or that when it comes to a stop in its penetration, instead of forming a meniscus of the ordinary type, it arranges itself in some regular order adapted to bridge the gap rather than to bulge forward into it like a blunt wedge. Paraffin oil is a peculiar liquid in the readiness with which it penetrates crevices, completely wetting everything.

Soaking the glass in water for some hours probably corrodes the wedged particles to some extent, forming sodium silicate among other products. I have found this to happen with other finely-divided glass particles. This reduces the wedging action, possibly rounds the ends of the fissure slightly, and provides a trace of cement on drying. Dr. Milligan envisages some such action himself.

Wetting the glass with hydrofluoric acid would probably increase the strength more than any other treatment. This largely removes the optical strain,* and greatly increases the strength.†

The long delay that took place between making the scratch and breaking the glass probably affected the results. Glaziers say that a "cut" must always be broken "while hot," *i.e.*, immediately, otherwise it degenerates into a "scratch" and is much harder to break. The experimental evidence seems sound enough, and certain changes can be observed without difficulty, but I am not sure that I understand the spontaneous increase of strength as the cut cools off.

It seems to me that Dr. Milligan has opened a new phase of a complicated problem. Much more will have to be done before it as thoroughly understood, and whilst Dr. Milligan's contribution is a noteworthy one, I fear I am unable to comment very usefully on it in detail as yet.

Dr. Milligan (*communicated reply*) appreciated the comments of Dr. Preston, but had nothing further to add.

* Preston, *loc. cit.*

† J. T. Littleton and F. W. Preston, this J., Trans., 1929, **13**, 336.

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