



CII. Anisotropic expansion of a drawn tube of vitreous silica

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To cite this article: H.L. Callendar M.A. LL.D. F.R.S. (1912) CII. Anisotropic expansion of a drawn tube of vitreous silica , Philosophical Magazine Series 6, 23:138, 998-1000, DOI: [10.1080/14786440608637303](https://doi.org/10.1080/14786440608637303)

To link to this article: <http://dx.doi.org/10.1080/14786440608637303>



Published online: 20 Apr 2009.



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CH. *Anisotropic Expansion of a Drawn Tube of Vitreous Silica.* By H. L. CALLENDAR, M.A., LL.D., F.R.S.*

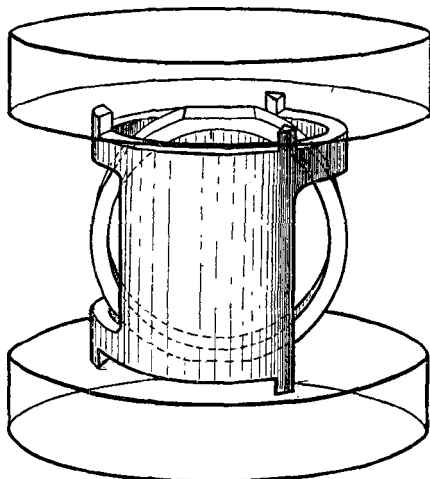
IT has been customary to assume that the expansion of an amorphous material should be isotropic, and the cubical coefficient has generally been taken as three times the linear. The discrepancy between the value of the cubical coefficient of silica from 0° to 100° C., namely 1.00×10^{-6} (deduced from the weight thermometer observations of Harlow and Eumorfopoulos by assuming the values of Callendar and Moss for the absolute expansion of mercury), and the values of the linear coefficient [$.500 \times 10^{-6}$ (Chappuis), $.465 \times 10^{-6}$ (Scheel), $.424 \times 10^{-6}$ (Randall)], has not unnaturally been regarded by Scheel and Heuse (Phil. Mag. March 1912, p. 412), and also by Eumorfopoulos (Phil. Mag. April, 1912, p. 653) as conclusive evidence of an error in the determinations of Callendar and Moss. The magnitude of the error in the cubical coefficient would vary from $.50 \times 10^{-6}$ to $.27 \times 10^{-6}$, according to the value selected for the linear coefficient.

Considering the great care taken in the testing and verification of the apparatus for the absolute expansion of mercury, and the close agreement of the observations taken before and after the whole apparatus had been dismantled and set up afresh with new tubes, it seemed to me scarcely possible that an error of this order of magnitude should exist in the results. In the April number of the Philosophical Magazine, p. 682, I, therefore, expressed the opinion, "that the explanation must be sought in the inequality of axial and radial expansion of a drawn tube due to intrinsic strain." In order to settle the question, if possible, by a direct appeal to experiment, I obtained from the Silica Syndicate of Hatton Garden, who had supplied the bulbs employed by Harlow and Eumorfopoulos, a drawn silica tube, 2 cm. in diameter, as nearly as possible similar to those from which the bulbs had been made. A tripod and a ring were cut from this tube by Messrs. Hilger, and were arranged as shown in the annexed figure for observing the difference of the axial and radial expansion by the Fizeau method. The design was exhibited and described at a meeting of the Physical Society on April 26th, but I was unable to give the results of the test at the time, as the worked specimens did not arrive until a day or two after the meeting.

With the assistance of Mr. A. Eagle, I have since succeeded in obtaining several concordant determinations of the difference between the axial and radial coefficients of expansion of this particular tube. The exact reduction of the

* Communicated by the Author.

results depends to a slight extent on the value assumed for the expansion of the 2 cm. tripod, which has not yet been



completely determined. It is possible, however, to state that the axial coefficient exceeds the radial by $\cdot 20 \times 10^{-6}$ over the range 0° to 100° C. Assuming the value $\cdot 465 \times 10^{-6}$ (the mean of the results above quoted for the linear coefficient) as being the value of the axial coefficient of the tripod, it is clear that the cubical coefficient would come out $\cdot 995 \times 10^{-6}$, which agrees as closely as could be expected with the result deduced by Harlow and Eumorfopoulos independently assuming the values of Callendar and Moss for the absolute expansion of mercury.

It may be objected that, although the axial and radial coefficients differ, the mean of the three must agree with the value for an isotropic specimen. Taking Chappuis' value $\cdot 50 \times 10^{-6}$ as representing an isotropic specimen, the axial coefficient of the tripod would have to be $\cdot 63 \times 10^{-6}$. In view of this objection, the axial coefficient of the ring, which is probably the same as that of the tripod, was measured on three days, and found to be $\cdot 455 \times 10^{-6}$; but no great stress is laid on this result (further than as confirming the value above assumed) because the ring is only 6.5 mm. wide, and was not intended for this determination.

The principal objection advanced by Eumorfopoulos against the results of Callendar and Moss at low temperatures, where the observations are admittedly more difficult, appears to be that, according to his weight thermometer, the cubical expansion of silica would vanish between 0° and 15° C. This apparently impossible result is confirmed by the observations

with the ring and tripod, which show that the difference between the axial and radial coefficients increases, while the axial coefficient diminishes more rapidly at low temperatures.

I have also investigated the expansion of a drawn silica rod, 30 cm. long, by a Newton's ring method, giving one whole ring for 10^{-6} expansion. The results will be published by the Physical Society, and are of interest as confirming the importance of the effects of strain.

CIII. *Notices respecting New Books.*

Physical and Chemical Constants and some Mathematical Functions.

By Dr. G. W. C. KAYE and Professor T. H. LABY. Pp. vi + 153. Longmans, Green & Co. Price 4s. 6d. net.

IT is not often that we would turn to a collection of data for stimulus; but there is something decidedly invigorating about this new collection of physical and chemical constants. The authors have evidently set before themselves the aim of making use of the large amount of work of precision which has been done in recent times and of discarding much that was becoming out of date. From the point of view of general interest they have had the advantage of the rapidly increasing amount of perfectly new matter in connexion with radioactivity and ionization, and especially of those data which apply particularly to the atom or molecule. The presence of these, collected for the first time in one volume, enhances the interest of the book. It gives one in summary form an idea of the great achievements effected by modern workers in science.

The book must, however, be considered chiefly in regard to its utility. The present writer, since the volume appeared, has used it at every possible opportunity with the object of estimating its utilitarian value. In making this estimate it must be remembered that it does not attempt, as Landolt and Börnstein's tables do, to give practically every datum of value. This would, of course, be impossible in a work of its modest size and insignificant price. The worker who wishes some guide as to what has been ascertained on a particular subject may therefore go away disappointed. The object clearly has been to include as many as possible of those data which are constantly required in connexion with research or teaching work; and the success is very great. There is no question that the authors will soon find their book in every physical and chemical laboratory; there is no other that comes anywhere near it in utility.

This being the case, it behoves us to point out a few particulars in which improvement may perhaps be effected.

On p. 5, the value of the gas constant R should be specified as ergs per gram molecule, not per gram. The electrical and magnetic definitions (pp. 5 & 6) require in some cases the specification of the medium (air or vacuum). The definition of specific