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XXXIX. *Note on the Tenacity of Spun Glass.**By E. GIBSON and R. A. GREGORY*.*

IT is well known that the tenacity of metallic wires increases as the diameter diminishes, so that very fine wires will carry much larger loads than those obtained by calculation based upon the assumption that the breaking weight varies as the square of the diameter. As glass can be drawn into very fine fibres, we have made some observations on the tenacity of this material, comparing the strength of very thin threads with that of rods made from the same glass, but of much greater thickness.

The experiments were carried out in the course of our work in the Physical Laboratory of the Normal School of Science and Royal School of Mines.

In dealing with a substance so brittle as glass, it is evident that special care must be taken to ensure that the observation is not vitiated by rupture due to a shearing stress, at or near the points of support. Precautions were taken to prevent this in all cases, and no experiments are quoted in this paper in which rupture took place near the points of support, or of attachment of the weight.

Three different thicknesses of glass were subjected to experiment: viz., fibres the diameters of which were about 0·002 and 0·004 centim. respectively, and rods with diameters varying between 0·05 and 0·09 centim.

The fibres were attached at the ends of two strips of paper by means of shellac varnish; this on setting was found sufficiently strong to carry more than the breaking weight, without allowing the fibre to slip. A small paper basket suspended from the lower strip carried the load, consisting of fine shot and silica, the latter being added when the fibre was near its breaking-point.

The diameter of the thread was measured at the place of rupture by means of a Compound Microscope with micrometer eye-piece. From data thus obtained the tenacity was calculated with the following results:—

Diameter, in centims.	B. weight in grs.	Tenacity, in dynes per sq. centim.
0·00186	11·76	424×10^7
0·00159	8·70	425×10^7
0·00315	32·26	405×10^7
0·00340	43·23	466×10^7

* Communicated by the Physical Society: read February 12, 1887.

Some observations were next made on rods about 1 millim. in diameter; the method of support and the loading being changed. Two pieces of angle brass, each about 8 inches long, were substituted for the slips of paper. Through a hole drilled near the end of the angles, a piece of $\frac{1}{8}$ " wire was passed, turned up and soldered to the back. The free extremities of the wires were plaited into rings, which served to support the load and suspend the whole from a hook above.

The ends of the rod were laid in the angles, leaving the glass free for about 12 inches. Small pieces of red-ochre cement (a compound consisting of resin, red ochre, and bees-wax) were placed at intervals along the glass, and a Bunsen flame applied. The cement speedily melted, and imbedded the glass; on cooling, the whole was suspended vertically. A bottle was hung on the wire attached to the lower angle-piece, into which a fine stream of mercury flowed from a reservoir above. The apparatus was so arranged that when the rod broke mercury would no longer fall into the bottle.

The mode of measuring the diameters of the rods differed from that adopted in the case of the fibres. About half an inch of rod was broken away at the place of rupture, and mounted in wax on a piece of looking-glass, the broken section being upwards. Its diameter was then measured by means of a microscope-cathetometer, and the tenacity found as in the case of fibres. The following are the results of four experiments:—

Diameter, in centims.	Weight, in grs.	Tenacity, in dynes per sq. centim.
0·090	3908	60×10^7
0·082	4443	83×10^7
0·050	1948	97×10^7
0·042	1781	126×10^7

These observations show, in the first place, that the tenacity of fine fibres is very considerably greater than that of thick rods, and that the strength of rods increases as the diameter diminishes. It may be interesting to point out that the tenacity of glass fibres studied by us is nearly as great as that assigned by Wertheim to many of the metals; *e.g.*, the tenacity given by him for annealed steel wire 1 millim. in diameter is 499×10^7 cent.-dynes, and even in the case of drawn steel the tenacity is not greater than twice that of a glass fibre, *viz.* 998×10^7 cent.-dynes.

With steel pianoforte-wire the tenacity is, however, considerably greater; according to Sir William Thomson (Art.

‘Elasticity,’ *Encyc. Brit.*, new edition) the breaking-stress is
Cent.-dynes.

Best pianoforte steel-wire 2318×10^7

The question as to what is the most probable cause of this increase in strength as the diameter diminishes, presents some difficulty.

Quincke (*Comptes Rend. de l’Acad. de Berlin*, 1868, p. 132) has suggested that the great increase observed in the case of metals is due to a surface tension, analogous to that observed in liquids. If this were the true explanation, the breaking-weight could be expressed by the sum of two terms which vary as the diameter and the square of the diameter respectively. This suggestion does not receive much support from our observations, as the results cannot be satisfactorily expressed by means of such a formula. It is, perhaps, more probable that the heating and rapid cooling undergone by the glass when it is drawn out into a fine fibre produces an increase in tenacity; and it is at all events certain that no comparisons can be made between the strengths of different materials unless they have undergone similar treatment, and unless the sizes of the rods or wires submitted to experiment are the same.

XL. *On an Improved Form of Seismograph.*

By THOMAS GRAY, B.Sc., F.R.S.E.*

[Plate IV.]

THE apparatus described in this paper is an improved form of a seismograph which was made for Prof. Milne in the beginning of 1883, to be used by him in his investigations for the Committee appointed by the British Association to “Investigate the Earthquake Phenomena of Japan.” That apparatus was exhibited to the Geological Society of London, and a description of it by the present writer was published in the *Quarterly Journal* of that Society in May of the same year. It consisted of a combination of instruments which had been devised by Prof. Milne and the writer, and descriptions of which had appeared from time to time in the ‘*Transactions of the Seismological Society of Japan*,’ and in the ‘*Philosophical Magazine*.’ The object of the apparatus was to determine the time of occurrence, the amount, the period, and the direction of the different motions in an earthquake shock. Arrangements were made for recording three components of the motion, one vertical and two horizontal, at

* Communicated by the Author.