Construction of a Robust Torsion Microbalance*.

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With 9 Figures.

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Introduction.

When the need arises to detect differences in weight of a few micrograms, the expense of a good microchemical balance and the care involved in its installation and use may be too great for a small laboratory. Instead, the worker often turns to the published descriptions of special microbalances employing springs or torsion fibres of quartz or other materials; the choice is by now fairly large\(^1,2\) and the correct selection perhaps difficult in consequence. One instrument may be capable of great accuracy, but the maximum load it will bear may be too small, and its construction from quartz fibres a little formidable; while another employing a simple cantilever or helical spring may have too small a load range. There seems to be a gap in the range of compromises between sensitivity, load capacity and ease of construction, and this gap may perhaps be filled by the instrument described here. In brief, it carries a load of 0.5 g which can be weighed with a standard deviation of about 10 µg in ordinary laboratory surroundings. It is robust, quick to use and fairly simple to make from materials readily available; the highest accuracy is not claimed.

Description.

The object to be weighed and the weights in a pan are suspended one below the other from one end of a beam, and balanced against a bob at the other end. The beam is supported at the centre on a horizontal stretched ribbon of phosphor bronze, torsion of which achieves the final balance point and gives the last three significant figures of the weighing.

* The balance is the subject of a Patent application.
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i.e. the fractions of a milligram. A small mirror is fixed to the beam and the image in it of an illuminated crosswire as seen through a telescope shows the position of the beam.

Phosphor bronze is not as close as quartz to the ideal elastic material. It shows a noticeable elastic hysteresis and a variation of elastic modulus with temperature, and it can take on a permanent set, whereas for quartz the limit of elasticity coincides with the breaking point. However, construction is simplified by its use.

For a torsion balance using a phosphor bronze element to be successful, the latter must be kept at a constant tension, and this should be chosen so as to stress the metal to only a small fraction of the limit of proportionality. Only in this way can stability of the zero reading and linearity of the scale on the torsion head be achieved.

The tension of the ribbon is regulated by a spring bow of ample dimensions, so that slight axial movements of the torsion head, for instance, do not affect the tension too much. Since the torsion sensitivity (degrees of rotation per milligram) is dependent upon the tension of the ribbon, it is clear that the conventional symmetrical arrangement of pans, one at each end of the beam, would lead to unacceptable variations with load of the torsion sensitivity. This accounts for the fixed bob on one side and the two pans on the other, an arrangement which ensures that there is always the same load on the beam, to within one quarter of 1\%, whatever the weight of the specimen*. There are also other advantages: the beam itself is always flexed to the same extent, so that the sensitivity (response to unit mass of load) remains constant for all loads, and there is no arm-length correction — which otherwise would be large in a construction of this kind — since the specimen and the weights in the pan are hung from the beam on the same suspension.

The arm-length of the beam must remain constant within fine limits in order to secure a stable zero, because if the point of attachment of the pans to the beam moves by as little as $10^{-4}$ mm, the zero reading will change appreciably. The effective arm-length is greatly influenced by deformations of the suspension element near its point of attachment to the beam. Quartz cannot suffer such bends, by virtue of its elastic properties mentioned earlier, but in the case of phosphor bronze wire they frequently occur by accident, later to straighten out in part when a temporary large stress is applied, with the result that the zero reading may change abruptly from time to time. Direct attachment of the wire to the beam is therefore not feasible, but a metal suspension wire can be employed if it is attached to the beam in the following way: the end

* The load on the beam will vary within a range of 3.5 mg according to the setting of the torsion head necessary for balance.