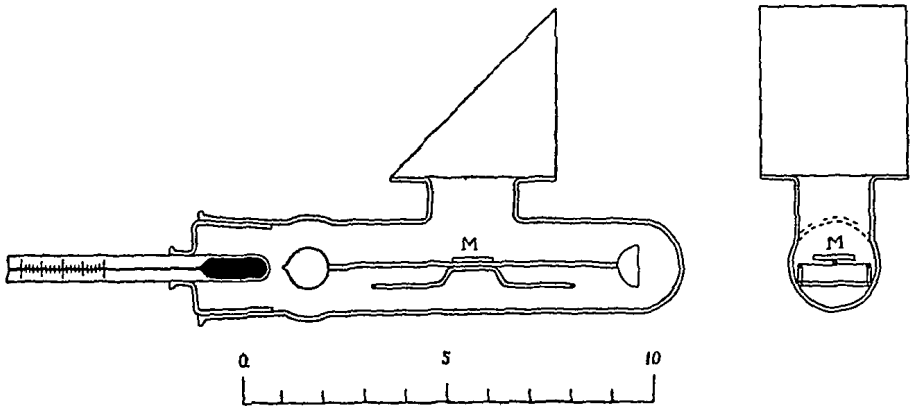
Physics. — *"Application of the Baroscope to the Determination of the Densities of Gases and Vapors."* By ARTHUR W. GRAY. [Preliminary Notice.] (Communication No. 94*a* from the Physical Laboratory at Leyden by Prof. H. KAMERLINGH ONNES).

For determining the densities of gases, especially while flowing continuously, the principle of the baroscope has been variously applied by FITZGERALD [1]), LOMMEL [2]), SIEGERT and DURR [3]), MESLANS [4]), PRECHT [5]), and others. In the apparatus here described the aim has been great sensitiveness combined with simplicity, ease of operation and small volume.



The accompanying figure illustrates the essential features. A capillary glass tube carries at one end a closed bulb, and at the other a hemispherical shell of the same diameter, weight, and kind of glass. This is fastened to a horizontal quartz fiber stretched on a glass frame, and carries a small mirror M, so that rotations about the quartz fiber [6]) as axis can be measured with telescope and scale. The whole is placed within a glass tube containing a sensitive thermometer of some sort, and communicating with a manometer.

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1) G. F. FITZGERALD. Fortschritte der Physik 41, 102, 1885.

2) E. LOMMEL. Wied. Ann. 27, 144, 1886.

3) A. SIEGERT and W. DURR. Zs. f. Instr.k. 8, 258, 1888.

4) M. MESLANS. Comptes Rend. 117, 386, 1893.

5) H. PRECHT. Zs. f. Instr.k. 13, 36, 1893.

6) The use of the quartz fiber was suggested by the delicate chemical balance of NERNST and RIESENFELD, Beibl. 28, 380, 1904, to which Prof. KAMERLINGH ONNES had drawn my attention. Much more delicate instruments are, however, the quartz thread gravity balance of THRELFALL and POLLOCK R. S. Trans. 193, A, 215, 1900, and the magnetograph of WATSON, Proc. Phys. Soc. London. 19, 102, 1904.

If the instrument has once been calibrated, the scale reading gives immediately the density of the gas within; while the thermometer and the manometer permit the calculation of the density under standard conditions, if the compressibility of the gas is known. The calibration may be made either with a single gas whose density at various pressures is known with sufficient accuracy for any one temperature, or by employing in turn several different gases under known conditions of pressure, temperature and density, or with a rider. Counterpoising the closed sphere with the hemispherical shell of equal surface tends to eliminate errors that would be introduced if the apparatus contained a vapor which condensed on the glass. The instruments should, of course, be protected from changes of temperature by proper jacketing or by immersion in a liquid bath. A fixed reference mirror (not shown in the figure) is desirable to indicate any change in the leveling of the apparatus.

In order to get an idea of the sensitiveness that could be expected from such an instrument, some rough preliminary measurements were made.

The dimensions were as follows:

Diameter of bulb	1.0 cm.
„ „ capillary beam	0.1 „
Length „ „ „	7.0 „
Mass of entire suspended system	0.67 gms.
Length of quartz fiber	1.4 cm.

The apparatus was filled with dry air, and the scale readings noted for various pressures ranging from 0.3 cm. to nearly 90 cm. of mercury. With a fiber about 0,005 cm. in diameter and the scale 255 cm. from the mirror, 0.1 mm. change in the deflection was found to indicate a change of about 0,0002 $\frac{\text{gm.}}{\text{liter}}$ change in the density; and this was the same for all densities tried; that is to say, a change of 0.1 mm. in the scale reading indicated a change of about one part in 6000 in the density of air under ordinary conditions. The scale might easily have been placed much farther from the mirror and the sensitiveness could have been greatly increased by using a larger bulb, a longer beam, and a longer and thinner fiber. And since the change in deflection is, in the first approximation at least, directly proportional to the change in density, an accurate knowledge of the deflections for a few densities is sufficient for the calibration of the instrument. Certain corrections, as, for instance,

for the effects of changes of temperature on the quartz fiber, must, of course, be applied when the greatest accuracy is desired.

This instrument was devised in order to follow the course of a separation of atmospheric gases by fractional distillation at low temperature, which Prof. KAMERLINGH ONNES wished to be made and to be controlled by density measurements; but it is evident that its use is not confined to this field. It might be used for determining the densities of gases or vapors under various conditions, and therefore, their compressibilities; but it is especially useful as an indicator of minute changes of density. Professor KAMERLINGH ONNES has already suggested its use to determine the composition of coexisting vapor and liquid phases in cases where a chemical analysis would be difficult or impossible, for example, in a mixture of two of the inert gases of the atmosphere.

Constructional details and refinements, together with the results of more careful and more varied tests will be communicated in a later paper.

(May 25, 1905).