CCCXLIV.—*A Sensitive Direct-reading Mercury Manometer.*

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DURING the course of an investigation of the oxidation of phosphorus trioxide vapour at low pressures, a direct-reading manometer was required which was sensitive to at least 0·001 mm. of mercury. Since the use of the simple U-tube manometer employing oil or sulphuric acid was precluded owing to the solubility of the phosphorus trioxide in these liquids, a manometer was devised employing a principle which, it is believed, has not been previously used in this connexion.

The manometer consists essentially of a small inverted glass cup (C) floating in mercury as shown in Fig. 1. The simple theory is as follows. Let the pressures of gas on the outside and inside of the cup be identical; the cup will then sink into the mercury until the weight of liquid displaced is equal to the weight of the cup. If the pressure is now increased on the outside of the cup by Δp the total force exerted downwards on the cup is proportional to $\pi r^2 . \Delta p$, where r is the radius of the cup. This will result in the cup sinking further into the mercury by a distance Δx,* the weight of mercury displaced being equal to $\Delta x . 2\pi r t \rho$, where t is the thickness of the cup and ρ the density of mercury. For equilibrium, then,

$$\Delta p \,.\, \pi r^2 = K \,.\, \Delta x \,.\, 2\pi r t \rho,$$

where K is a constant depending only on the units used to express Δp. The sensitivity $\Delta x/\Delta p$ is thus given by $\Delta x/\Delta p = r/2Kt\rho$, and in order to make this large, r must be large and t small. Calculation showed that if $r = 1$ cm., $t = 10^{-2}$ cm., and the smallest value of Δx which can be detected is 10^{-3} cm. (by means of a microscope fitted with an eye-piece scale), the required sensitivity could be reached.

Two different forms of the manometer were constructed as shown in Figs. 1 and 2. They differed only in the arrangement of the guides for the cup. The glass cups were made from 1 cm. tube by drawing and blowing it simultaneously. The tubing was then cut into convenient lengths by covering the selected parts with paraffin wax, drawing a furrow in the wax with a fine steel point, and etching through with hydrofluoric acid. For practical purposes, the limit to the thickness was about 10^{-2} cm.: cups were made

* In addition the levels of the mercury outside and inside the cup change but this motion is small compared with the motion of the cup in this particular case and is therefore neglected in the simple theory.

with $t = 5 \times 10^{-3}$ cm. or less, but they were rather fragile and were easily broken when being attached to their guide rods. The cup was attached to the glass rod (*R*) as shown in Fig. 1. At the lower end of the rod a small tube (*M*) filled with mercury was fused on in order to sink the cup well into the mercury and bring the centre of mass of the floating system below the surface of the mercury. This tube moved in a glass guide, and a guide (*P*) of platinum wire or foil served at the upper end of the rod. The large ground joint facilitated the adjustment and removal of the cup, and the tap allowed the manometer to be used differentially.

The second design is shown in Fig. 2. In this case the cup was

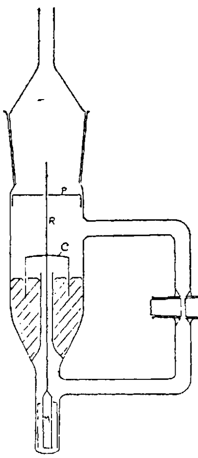

FIG. 1.

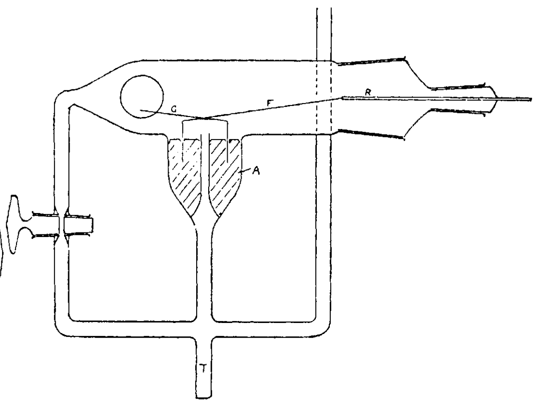

FIG. 2.

supported by two thin glass fibres (*F*) so that vertical motion could easily take place, whereas horizontal movement was prevented. These were attached to a glass rod (*R*), which in turn was fused to one half of a ground joint as shown. The large joint was necessary for the insertion and removal of the cup. The small joint was made slightly eccentric with respect to the large one so that the cup could be accurately adjusted when the manometer was evacuated. The motion of the cup was observed by means of a fine glass pointer (*G*). A considerable magnification of the motion can be obtained by making the pointer much longer than the supporting fibres. The side tube (*T*) prevented the blocking of the tube leading to the apparatus in the event of mercury being forced out of *A* by sudden pressure changes in the apparatus.

Although the manometer in Fig. 2 is not quite so compact as that in Fig. 1, the absence of glass and metal guides eliminates to a large extent any tendency to stick. During experiments with manometer 2 the highest sensitivity reached was 2×10^{-4} mm. of mercury. An attempt was made to increase this still further by replacing the mercury by concentrated sulphuric acid (compare expression for $\Delta x/\Delta p$), but there was no increase in sensitivity, showing that the limit was governed by the elasticity of the supporting fibres.

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