

Physics. — “*Accuracy and Sensitiveness of a Pressure Balance Based on a So-Called Amagat Cylinder.*” By A. MICHELS. (14th communication of results obtained in researches for the VAN DER WAALS-fund). (Communicated by Prof. P. ZEEMAN).

(Communicated at the meeting of June 28, 1924.)

Somewhat less than a year ago¹⁾ a communication could be made about the causes to which it is due that the sensitiveness of a pressure balance increases so greatly when the piston is set rotating. The researches were continued, now with the intention of obtaining more numerical results.

First the sensitiveness and the accuracy of adjustment could be determined of a pressure balance that was at our disposal (type *S* and *B*) up to 250 atm. For this purpose a tube with platinum contacts of the same type as is used for the determination of isotherms²⁾, was filled with hydrogen gas, put under pressure, and the position of the same contact was determined by means of the pressure balance several times in succession. In the following lines we shall call this apparatus briefly the hydrogen manometer.

In the determination of the contacts care had to be taken that always a uniformly increasing load was worked with. In order to attain this a cylindrical trough was mounted on the axis of the balance, which trough was slowly filled with oil. At the very moment the contact was formed, an electrical tap stopped the oil-supply.

As result we may state that the sensitiveness appeared to be independent of the pressure. Up to the highest load, in our case 250 kg., an accuracy of adjustment of one and a half grams was found. Just as we had expected, the position of the piston proved to play a part, though an insignificant one. This influence is the result of a slight conic shape of the piston, which causes a different effective diameter for each different position. Hence in pressure measurements it deserves recommendation to determine the level of the piston, and to apply a correction for this. There also appeared to be a temperature function. This, however, is entirely to be considered

¹⁾ These Proceedings, 26, p. 805.

²⁾ KOHNSTAMM and WALSTRA, Hydrogen Isotherms. These Proc. 17, p. 203.

as a surface aerial-dilatation of the diameter of the piston. Its influence therefore, can be found by a simple numerical calculation in every observation.

The second task we had set ourselves was to try and solve the question what is to be understood by the effective diameter of the piston. Is the cross-section of the piston itself to be taken for this, or of the hole in which it rotates, or perhaps a value between them?

We first tried to find experimentally the numerical value of the effective diameter and its dependence on the pressure, if existing. For this purpose the position of the same contact in the hydrogen manometer was determined in two different ways. First the hydrogen manometer was directly connected with the pressure balance, and the position of a contact was determined. Then the pressure balance was connected with a *U*-shaped tube, which was half filled with mercury. The second leg of the *U*-tube was in communication with the hydrogen manometer. The pressure in the manometer could now be taken equal to the pressure exerted by the pressure balance, hence $\frac{\text{load}}{\text{effective diameter}}$ diminished by the difference of level of the mercury in the two legs.

If however the contact is made, the pressure in the manometer is equal to that obtained in the direct measurement through the balance. From the data obtained in this way the effective diameter may be calculated in an elementary way.

In order to determine the position of the mercury in the *U*-tube, the upper- and the lower-end of this tube partly consisted of a glass-capillary in which the menisci were clearly visible. At the moment of contact in the hydrogen manometer the two mercury levels and a scale division behind them were photographed in order to ascertain their position.

The accuracy of this method is limited by the admissible height of the mercury column. In our case it was about 4.80 m., which corresponds to a pressure of about 6 kg. per cm^2 . In this way an accuracy of measurement of 1/2400 could be attained. Within this limit the effective diameter appeared to be no pressure-function. For want of space we cannot afford to enter more fully into the different corrections to be applied. For a full discussion we may refer to the Ann. d. Physik Bd. 73, p. 577—623.

After this experimental determination we tried to get theoretically some further information about the different influences which would determine the effective diameter. The results obtained have also been published in the cited article in the Ann. der Physik.

Only an enumeration of the conclusions we thought ourselves justified in making, will be given below.

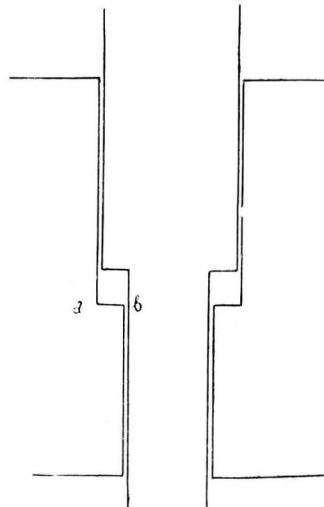


Fig. 1.

The piston has a shape as is seen in figure 1; the forces acting on it, may be divided into three groups:

1. the purely hydrostatic forces;
2. forces exerted by the flowing of the liquid which leaks out between axis and mantle;
3. the frictional forces resulting from the descent of the piston.

The forces mentioned under 1 give a result equal to the difference of pressure in the diameters of the lower and the upper part of the piston.

The forces under 2 give as consequence that instead of diameter should be read the arithmetical means between diameter of axis and hole.

The forces under 3 give an apparent increase of diameter which is independent of the pressure, and may be valued in our case at 1/10000 of the original value.

Attention is drawn to the fact that none of the above-mentioned influences appears to be a pressure-function.

Besides, the deformation of piston and hole in consequence of the load is also to be taken into account.

The piston is subject to two variations of form:

1. Transverse contraction of its lower part in consequence of the extension caused by the load.

2. Compression of the two parts of the piston through the pressure. As the pressure in the space between axis and mantle gradually decreases, this compression has not the same value at every height.

The first influence brings about an increase of the effective diameter to an amount of:

$$\frac{3}{2.2 \times 10^7} \times p,$$

the second a diminution of:

$$\frac{7}{2.2 \times 10^7} \times p.$$

The mantle of the hole too extends, the lower hole also undergoing a deformation through the pressure exerted on the plane

a—b. This change of form only gives a modification in consequence of the frictional influence of the oil that leaks away; moreover the compression of the piston contributes to this, which had not yet been taken into account in the calculation of this compression. The two influences can, however, be simply determined together, and then give an increase of the effective diameter to an amount of:

$$\frac{p}{2.5 \times 10^6}.$$

All the influences together cause an increase of diameter of:

$$\frac{p}{4.6 \times 10^6},$$

hence a function of the pressure, which for the present still lies quite out of our possibility of observation, even with our maximum load of 250 atm.

With the second pressure balance up to 5000 atm. we had at our disposal, an influence will very certainly demonstrate itself. Before it is possible, however, to take this into account, this apparatus must be studied more thoroughly.
