[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF ILLINOIS]

A NEW ABSOLUTE MANOMETER FOR LOW PRESSURES

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The mercury manometer, including its more refined form, the McLeod gage, is preëminently the best type of manometer for measuring pressures below one atmosphere. It cannot be used, however, with gases which react with or dissolve appreciably in mercury, nor with gases which condense at the temperature at which the manometer is maintained, and the temperature range of operation is limited by the physical properties of mercury. The glass diaphragm manometer as developed by Daniels[1] and others is highly satisfactory at pressures above 10 mm. and such a manometer has recently been used in this Laboratory with success at 300°. In order to secure accuracy at low pressures, however, the glass diaphragm must be made so thin that it is too fragile for practical use. Various other ingenious forms of manometers have been devised, such as the Knudsen gage, Pirani gage and numerous types of ionization gages.[2] They all appear to be unsatisfactory, however, in that they are either difficult to operate or that they are not absolute but must be calibrated for each particular gas, which means that some other manometer must be used ultimately.

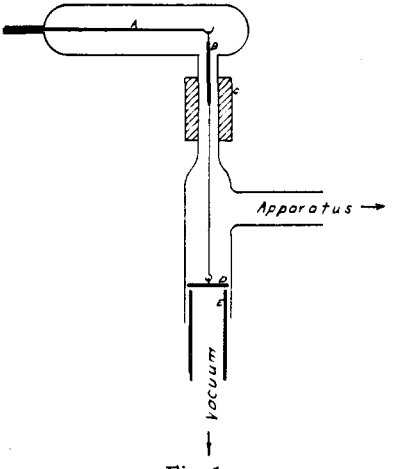

Fig. 1.

In connection with problems in this Laboratory, a manometer was needed which could be used for the measurement of very low vapor pressures of substances at any temperature and also for the measurement of thermal transpiration effects at low pressures. Such a manometer has been developed. It is essentially an absolute manometer which can be constructed of a single material resistant to corrosive gases (for example, Pyrex or silica glass) and which can be used at any temperature that the material will withstand. The pressure range is substantially that of the McLeod gage.

The construction of the manometer is shown in Fig. 1. D is a disk of graphite, the lower surface of which is ground to seat on the ground end of the glass tube. B is a small bob of soft iron, enclosed in glass, and A is an

[1] Daniels and Bright, THIS JOURNAL, **42**, 1131 (1920).

[2] For a discussion of various types of manometers see Dushman, High Vacuum, *Gen. Elec. Rev.*, Schenectady, **1922**.

arm made from a quartz fiber by which the system is suspended. C is a coil through which a current is passed to bring an electromagnetic traction on B. When the disk is seated on the tube at low pressures the leakage is slight and a nearly perfect vacuum may be maintained in the tube E while pressure equilibrium is attained above.

In operation sufficient current is passed through the coil to seat the disk firmly on E and time is allowed for pressure equilibrium to be established.

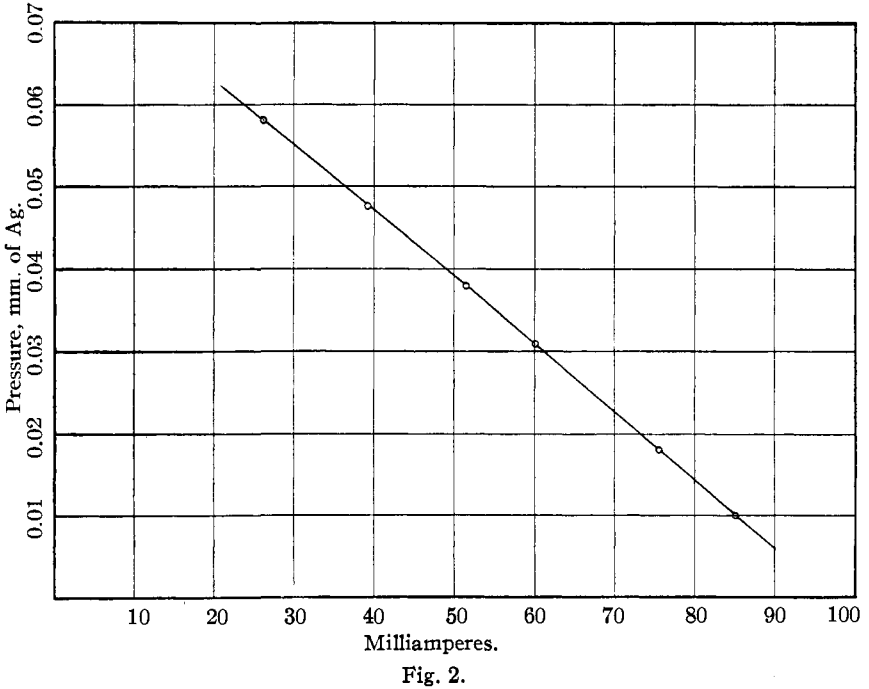

Fig. 2.

The current is decreased until the disk rises from its seat on the end of the tube. At this point the apparatus functions as an electromagnetic balance. The upward pull of the bent arm A is equal to the weight of the system plus the pressure of the gas plus the electromagnetic force. The current at which the disk begins to rise from its seat is easily determined because as soon as the disk rises slightly the gas flows into E and the pressure is equalized above and below the disk so that what is observed is a sudden rise of the disk to a height of nearly a millimeter above its seat. It was feared that irregularities in the seating of the disk or sticking might cause irregular behavior but no such difficulty was experienced. The current value for the balance at a given pressure is highly reproducible.

The disk D as constructed has an area of about 3 cm^2. and a pressure of 0.01 mm. exerts a downward pull of about 40 mg. so that it is not difficult to get sufficient sensitivity. While the manometer can be calibrated ab-

solutely by loading the disk with weights, it is more convenient to check it against a McLeod gage using air in the apparatus. The calibration curve is shown in Fig. 2. The curve is nearly linear but there are several effects which might cause a slight curvature.

For use at higher temperatures a furnace is placed around the tube in the neighborhood of D. For some purposes it may be desirable to interchange the connections to pressure and vacuum and invert the disk D and its seat.

The "zero point" of the apparatus will change somewhat with temperature but it can always be checked against a vacuum. The manometer is, of course, not suitable for use where the escape of gas from the apparatus must be avoided.

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[CONTRIBUTION FROM THE FIXED NITROGEN RESEARCH LABORATORY OF THE UNITED STATES BUREAU OF SOILS]

THE COMPRESSIBILITY ISOTHERMS OF HYDROGEN, NITROGEN AND MIXTURES OF THESE GASES AT 0° AND PRESSURES TO 1000 ATMOSPHERES. A CORRECTION

BY EDWARD P. BARTLETT

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A gage of the dead-weight type was used in the determination of the pressures recorded in a recent publication[1] concerning the compressibility of hydrogen, nitrogen and their mixtures.

An accurate calibration of the gage, made possible through recent acquisition of new equipment, shows that it was correct to within 0.1% at pressures to 100 atmospheres. At pressures of 200 atmospheres and above, an unsuspected error has been introduced, through the use of an incorrect ratio for the multiplying power of a lever attached to the gage only at these higher pressures. The maximum error in published results is 0.62% at 200 atmospheres, and becomes less at higher pressures.

The corrected results follow. The table number refers to the corresponding table in the original paper.

At pressures to 100 atmospheres the corrected results agree with those of Holborn and Verschoyle to within a maximum difference of 0.26% in the case of pure hydrogen and within 0.11% in the case of pure nitrogen. At 200 atmospheres the agreement with Amagat's results is almost exact. The maximum deviation from Amagat's results above 200 atmospheres is 0.34%. Corrected results for the three gas mixtures agree with those of Verschoyle at pressures to 100 atmospheres to within 0.10%. At 200 atmospheres the later results are larger by a maximum of 0.4%.

[1] Bartlett, THIS JOURNAL, **49**, 687 (1927).