l'électrode 'moniteur', il suffit de brancher le picoampèremètre correspondant sur l'entrée du système et de procéder de la même manière. Les résultats sont du même ordre.

Ce dispositif est particulièrement intéressant pour des expériences de diffusion par un jet de gaz. En effet si n est la densité du jet, I_0 l'intensité du faisceau électronique et $d\sigma/d\Omega$ la section efficace différentielle de diffusion dans l'angle solide $d\Omega$, l'intensité diffusée recueillie sur le moniteur est

$$I_M = KI_0 n \int_{\Omega_M} \frac{d\sigma}{d\Omega}\, d\Omega$$

où K est une constante. Pour un gaz donné l'intégrale

$$\int_{\Omega_M} \frac{d\sigma}{d\Omega}\, d\Omega$$

sur l'angle solide Ω_M sous-tendu par le moniteur fixe est également une constante. Si notre dispositif stabilise I_M, le produit $I_0 n$ est maintenu constant.

Ainsi dans une expérience de collisions où l'on étudie des sections efficaces différentielles en fonction de l'angle de diffusion et/ou de l'énergie, le signal reçu par le détecteur

$$I = KI_0 n \Delta\Omega_{\text{dét}} \frac{d\sigma}{d\Omega}$$

reste-t-il directement proportionnel aux sections efficaces malgré les fluctuations de densité de gaz.

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A capacitance manometer with a stainless steel bellows-sealed membrane

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Abstract A bakeable differential manometer for comparing a high-vacuum system with an unbaked reference system containing a hydrostatic gauge is described. The principal features of the design are that it can sustain a large pressure difference between the systems and that no special precautions are necessary for protection of the instrument against thermal expansion. Using an electrical bridge technique at a frequency of 2 kHz a pressure difference of about 3·25 Pa can be detected. The device is proposed for measuring pressures in the 0·1 Pa range.

1 Introduction

High-vacuum systems are required to ensure high gas purity. Experiments are frequently done over a range of gas pressure greater than 10^{-4} Pa, and although for absolute measurements of pressure, liquid manometers and McLeod gauges are considered most reliable, their use in experimental systems is restricted when degassing by high-temperature baking of the system is necessary to achieve low background pressure (10^{-7} Pa). To overcome this difficulty different forms of bakeable differential manometer have been proposed, based on indirect measurement of pressure in the high-vacuum system by comparison with an unbaked reference system containing a liquid manometer. A glass capacitance manometer previously built for experiments at University College London (Chantry 1961) yielded a membrane displacement sensitivity of $1{\cdot}9\times10^{-5}$ cm Pa^{-1}. The membrane was blown on a glass bulb and was metal-coated to provide an electrical connection through a platinum wire on the side of a low-pressure vacuum system. An all-glass construction has the advantage of being chemically non-reactive. However, the performance became unreliable over a long period; the major cause of its deterioration was high-temperature baking which often cracked the metal film on the glass membrane under the strain cycles of differential pressure and temperature. Due to a poor conducting surface, a continuous drift from the null position of the scale was observed.

A metal membrane version of a capacitance manometer was first proposed (Heylen 1960) to take account of large pressure differences between systems. This necessitates the use of a perforated guard plate for the protection of the membrane mounted on thinner copper bellows. There are several expensive diaphragm instruments commercially available. A recent electronic manometer series under the trade name Baratron† employs sensor heads containing a tensioned metal diaphragm in combination with digital readout units.

† MKS Instruments Inc., Burlington, Massachusetts, type 200 with electronic and digital readouts.

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2 Design and construction

The design of a simple metal membrane version of a bakeable manometer is presented here, as shown in figure 1, which is within the capability of a laboratory workshop. All parts of the manometer are made of a stainless steel alloy containing 0·1% C, 18% Cr, 8–10% Ni, weldable by argon arc, except for the knurled knob and its supporting bracket which are made of brass. Stainless steel is resistant to the effects of elevated temperature to which it can be exposed during the degassing of the system; the expansion of alloy of the type used was about 10^{-5} K^{-1} at 673 K with a thermal conductivity of 0·2 W cm^{-1} K^{-1}. Both properties are comparable with those of glass.

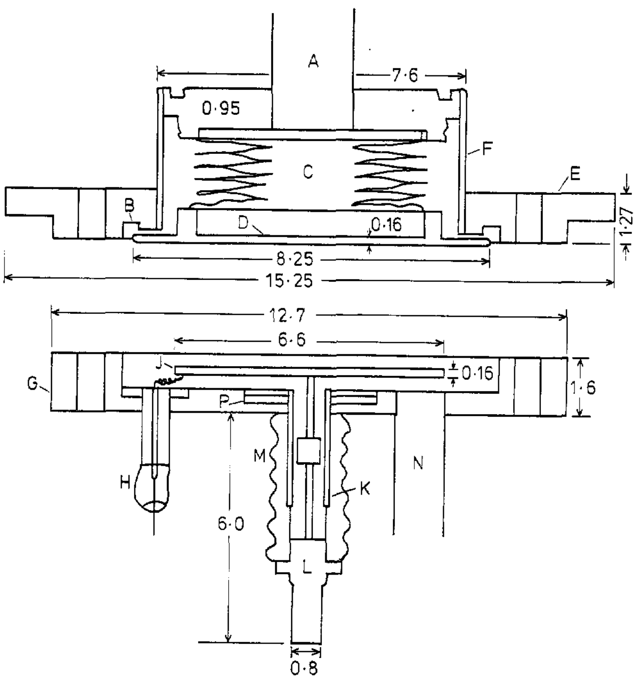

Figure 1 The capacitance manometer (all dimensions in centimetres). A, glass-to-metal seal to high-vacuum system; B, welding point between bellows and membrane; C, stainless steel bellows; D, upper membrane; E, upper flange; F, stainless steel tube; G, lower flange; H, leadthrough; J, movable circular plate; K, insulating sleeve; L, support for knurled knob and sleeve; M, stainless steel bellows for adjustment of plate; N, metal tube to reference system; P, pumping disc with holes.

A thin, electrically conducting metal membrane formed the boundary layer between the two systems. Stainless steel bellows were supplied by Palatine (Surbiton) Ltd, UK. The bellows C were welded by argon arc to the membrane at the point B shown in figure 1, the length of tube F being kept so that on assembly the end-plate D was just projecting from the flange E. The bellows consisted of five pairs of corrugations having an external diameter of 6·6 cm, a gauge length of 0·0127 cm, an effective area of 36·3 cm^2 and a pressure sensitivity of 0·04 cm/pair/kg. A pressure difference of about 100 Pa would cause the centre of the membrane to move by 0·01 cm, which was many times more sensitive than the glass membrane which had a sensitivity of less than $1{\cdot}9 \times 10^{-5}$ cm Pa^{-1}.

The circular plate J parallel to the membrane was made a tight push fit into an insulating sleeve K. The motion of J relative to the upper membrane was achieved by means of the bellows M, consisting of 20 corrugations. The overall length of L was such that when the bellows were in a free position, J remained just short of the face of flange G. It was required to evacuate both portions of the manometer. In the low-vacuum side the disc P was provided with small holes for pumping. The size of P was such as to make it a tight push fit into the flange G, and also to allow the insulating sleeve K to slide through it easily from the central hole. The manometer was mounted on to the support with a glass-to-metal seal A entering a vacuum system and the metal tube N sealed to the reference system.

Electrical contact with plate J was provided through a tungsten–Pyrex leadthrough H. To allow free movement of J, the lead-in had to be extended further by a thin, flexible wire insulated with glass sleeving and arc-welded to the edge of the plate. The mating surfaces G and E had a scratch-free finish. A gold O-ring between the two flanges provided the corrosion-resistant vacuum seal.

3 Measuring procedure

An impedance bridge circuit, in which the capacitance manometer formed one arm, was employed; a null-point reading on a DC microammeter indicated the pressure balance in the two systems. The bridge was operated at a frequency of about 2 kHz. Harmonics of the input signal would reduce the bridge sensitivity, and it was necessary to minimise their effect by varying the frequency of the oscillator and adjusting the capacitance of the manometer under vacuum conditions. The out-of-balance signal was displayed on an oscilloscope. This allowed the exact frequency necessary for operation at maximum sensitivity to be chosen. The signal current was amplified prior to its rectification for reading on the microammeter.

Pressure measurements were made after retuning the amplifier to a small gain and shunting the microammeter. A sensitivity of 4×10^{-7} μA Pa^{-1} was achieved. It is possible to take absolute pressure readings from an oil manometer in the low-vacuum system with a reading accuracy of $\pm 0{\cdot}5$ mm, which corresponds to a pressure of about 3·25 Pa. The error involved in taking two readings of the oil level is therefore not greater than 6·5 Pa. Good stability and sensitivity could therefore be obtained with a full-scale meter reading corresponding to 3·25 Pa. Measurement of gas pressure over a wide range from 10^4 down to 10^{-1} Pa could easily be achieved with an accuracy of 0·5–1·5% of the reading which includes sources of error: the hysteresis of the system, 0·015–0·03%; the effects of ambient temperature variation, 290 ± 10 K, and the scale readings of the oil level and the microammeter. A sudden burst of pressure to 10^5 Pa would not damage the metal membrane.

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