with the general objective of reaching an accuracy of the order of a few parts in 10^5, at any rate over the first few thousand atmospheres. A preliminary description of the early stages of this work has been given by the author (Dadson 1955), but the investigation has now proceeded a good deal further and the present paper summarizes the progress made up to the present time.

It is convenient to divide the work into two separate parts; firstly the establishment of an accurate value for the effective area of a pressure balance at low pressures where distortion has no appreciable effect, and secondly the determination of the variation of this effective area consequent on the distortion of the balance when subjected to high pressures.

For the present purpose the condition with the piston of the balance freely rotating as recommended by Michels (1923, 1924) ~~has been consistently adopted~~.

ABSOLUTE DETERMINATION OF EFFECTIVE AREA AT LOW PRESSURES

In the determination of the effective area of a pressure balance at low pressures it has been possible to use two distinct and independent methods, one depending on measurement of the dimensions of the components, and the other depending on comparison with a low-pressure mercury column.

If the piston-cylinder assembly consists of a perfectly straight and uniform piston moving in a perfectly straight and uniform cylinder, both being accurately circular in cross-section, then a simple calculation indicates that the effective area of the combination should be equal to the mean of the cross-sectional areas of the piston and cylinder bore. In practice, cylinder bores are not likely to be sufficiently perfect for this simple result to be applicable, although the piston itself can normally be made with much greater uniformity. For the most part, accurately ground and lapped cylinder bores show some degree of bellmouthing near the ends and this may be sufficient to upset the validity of the simple formula. Recently, however, very accurate methods have been introduced for the measurement of the internal diameters of cylinder bores in which a notable contribution has been made by the Metrology Division of the N.P.L. (Taylerson 1955). Provided the diameter is accurately determined as a function of the position along the axis and any small departures from circularity are measured, the effective area of the assembly can be calculated, though by a somewhat more complicated formula than in the simple case. It may be shown by analysis of the flow of the pressure transmitting fluid through the gap between piston and cylinder that the effective area A_0 of the assembly may be represented by the formula

$$A_0 = \pi a^2 \left(1 + \frac{2}{a}\int_0^l h^{-2}dx \Big/ \int_0^l h^{-3}dx\right) \quad \ldots\ldots \quad (1.39)$$

where a is the radius of the piston, $2h$ the width of the gap at distance x along the axis, and l the total length of engagement of the piston and cylinder. This evidently reduces to the result formerly given in the case where the gap between piston and cylinder is a constant. With an assembly of nominal diameter of the order of 0·5 inch, the expression (1.39) may be arrived at with a standard error of the order of only 1 part in 10^5.

The second arrangement employed for the measurement of an effective area at low pressures is that of direct comparison with a mercury-in-glass manometer of the general type frequently employed in previous work, and of which no detailed description need be given. If proper attention is given to various details of design such as the accuracy of scales, verniers and sighting arrangements, the choice of appropriate diameters for the tubes, and careful correction for the effects of any temperature variations on the mercury, the subsidiary oil columns, or the scales, it is possible to obtain measurements at pressures of the order 3-5 atm. ~~with a standard~~ error which is again in the region of 1 or 2 parts in 10^5.

Mercury Column

These two independent methods have been used at the N.P.L. to calibrate gauges of the direct-loading type with piston diameters of about 0·5 in., the two methods giving results which agree to within 2 parts in 10^5. The following example relates to a certain assembly of nominal area 0·2 sq. in. at 20 deg. C.:

effective area from diametral measurements	0·199897 sq. in.
effective area from comparison with mercury manometer	0·199894 sq. in.

The validity of the first method—that depending on calculation from the measured dimensions of piston and cylinder—may be checked independently of the mercury manometer by comparing the relative effective areas of different piston-cylinder assemblies with the relative values obtained by direct balancing of the assemblies one against another. ~~The determination~~ of the ratio of two effective areas by direct balancing can, with suitable precautions, be ~~carried out with~~ considerably higher accuracy than an absolute determination, and is limited only by the sensitivity of the balances to small changes in load and the accuracy to which the loading weights and any other factors affecting the load are known. Provided the load is not too small, so that the piston and load assembly can rotate without interference for sufficient time for a precise balance measurement to be made, such balancing experiments can normally be carried out to an accuracy of a few parts in 10^6. Table 1.28 ~~shows some~~ examples ~~of comparisons~~ between the ratios of the effective areas of different pairs of assemblies determined in this manner with the corresponding ratios derived by calculation from the piston and cylinder dimensions.