

stresses on the end surfaces, which are not taken into account in the calculation so that the rather close agreement observed in this particular instance may be partly fortuitous.

The application of the similarity method determines the distortion coefficients of the type a) and type b) assemblies quite independently of one another. Since the two types are found to have appreciably different coefficients, a direct comparison, e.g. by balancing a steel assembly of type a) against one of type b), is now able to provide an additional check of the overall accuracy of the procedure. The results of experiments on these lines are shown in Fig. 4, which compares the values of the distortion factors of a type b) assembly derived in two independent ways:

- i) by direct application of the similarity method to the type b) assembly, and
- ii) by comparison of the same type b) assembly with assemblies of type a), the distortion factors of which had previously been determined by direct application of the similarity method.

It will be seen that the results obtained by the two methods are practically indistinguishable; the actual mean values of several determinations of the distortion

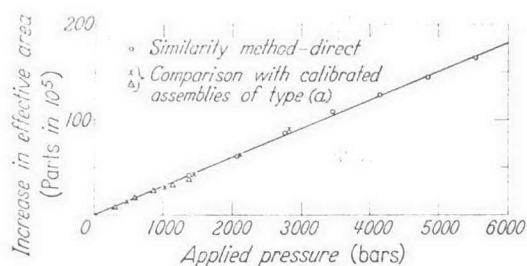


Fig. 4. Distortion factor of assembly of type b determined by two methods

factor for the type b) assembly are  $3.0_2 \times 10^{-7}$  and  $2.9_5 \times 10^{-7}$ /bar for procedures i) and ii) respectively. This independent check thus supports the estimates of accuracy put forward in the foregoing section.

#### d) Practical applications

Once the effective area of a pressure balance assembly has been measured in absolute terms as a function of pressure over a given range, it is possible to calibrate almost any other assembly covering the same range, and using the same pressure transmitting fluid, by the process of direct balancing. In the course of the present investigation a large number of individual balances of different patterns have been calibrated, including many for other users. Balances involving piston-cylinder assemblies of types a) and b) — Fig. 2 — have already been discussed. These show, for a given fluid, fairly consistent distortion coefficients, typified by the values given above in sections 4 b) and 4 c). In such cases, it may be sufficient for many purposes to take an average figure as typical of assemblies of a given pattern.

Another type of balance in common use, of which a considerable number have been calibrated, is that employing a simple piston-cylinder assembly consisting of a bronze cylinder combined with a steel piston. This type also exhibits fair consistency as regards dependence of effective area upon pressure, the distortion coefficient being about  $8 \times 10^{-7}$ /bar.

Calibrations have also been made of a number of differential piston-cylinder assemblies of the well known form shown diagrammatically in Fig. 5. In this type of assembly the actual effective area is the difference between the effective areas of the two constituent piston-cylinder combinations, the upper combination being varied in diameter to suit the desired pressure range. The considerations leading to the approximate equation (2.6) may easily be extended to include this differential type of assembly (e.g. Zhukovskii 1960) and lead to the expectation of a distortion coefficient in the region  $3$  to  $4 \times 10^{-7}$ /bar, with a gradual decrease as the diameter of the upper unit is reduced. Experience at the National Physical Laboratory so far has indicated, however, that this

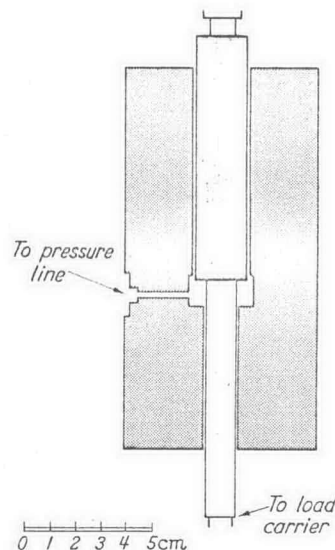


Fig. 5. Diagram of differential piston-cylinder assembly

type of assembly does not exhibit the kind of consistency found in the case of the simple piston-cylinder assemblies. In a group of ten such differential assemblies coefficients ranging from about zero to  $11 \times 10^{-7}$ /bar were found, with no indication of any regular dependence on the constituent piston diameters. This may be due to the fact that in many cases the effective area is the difference between two much larger areas so that the effect of any abnormality on the part of either of the constituent piston-cylinder combinations may be considerably magnified. It could also be associated in part with the difficulty of constructing such assemblies with the two cylinders exactly coaxial. Whatever the explanation, however, it seems that each assembly of this type requires individual calibration and that the assignment of typical values of the distortion coefficient, or reliance on calculated values, would not be satisfactory in this case.

## 5. The Flow Method

### a) Principle of the method

The flow method was developed in order to provide an independent check of the changes of effective area of a pressure balance assembly determined by the similarity method, by means which would be independent of the considerations on which the similarity method is based, but which would still depend entirely on the properties of the assembly itself without reference to other standards of pressure.