downstream in any degree, a suction effect is produced to falsify the reading. In instruments having the static pressure opening pointed downstream, the coefficient may be as low as 0.86. Consequently, for accurate work, Pitot tubes should be calibrated, and the pertinent coefficient should be applied to Equation 72. In a sense, this coefficient is advantageous, since it results in a higher differential reading, which, in turn, enables more accurate readings at low flows.

In using Pitot tubes, it is generally necessary to make a traverse of the pipe or duct to determine the course of the velocity pattern. In a pipe, for instance, one of the profiles shown in Fig. 5 would be obtained. Near a valve or fitting, however, the profile might be quite distorted, a fact which would be revealed by the traverse. If the pipe or duct is divided

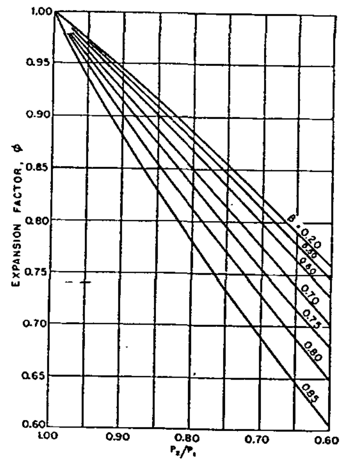

FIG. 19. RELATION OF EXPANSION FACTOR, φ, FOR NOZZLES TO DIAMETER RATIO AND PRESSURE LOSS FOR AIR AND OTHER DIATOMIC GASES.

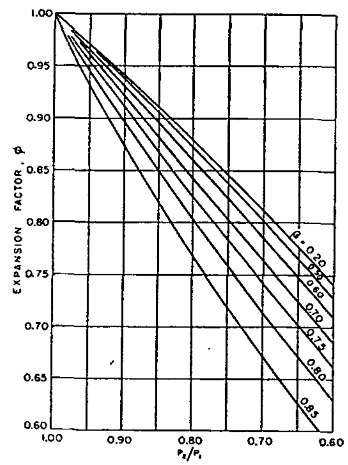

FIG. 20. RELATION OF EXPANSION FACTOR, φ, FOR NOZZLES TO DIAMETER RATIO AND PRESSURE LOSS FOR STEAM, CARBON DIOXIDE AND NATURAL GAS.

into equal areas, and a determination of h_{aw} is made for each, the average velocity would be obtained by using the average of the square roots of h_{aw} in Equation 73.

INSTALLATION OF NOZZLES AND ORIFICES

A final note should be made of the installation of orifices and nozzles. Generally speaking, the orifice or nozzle, together with a holding arrangement, including pressure taps, is available from the manufacturer. In making the installation, the user should make certain that the flow approaching the nozzle or orifice is steady and evenly distributed, *i.e.*, with velocity profiles similar to those shown in Fig. 5. Fittings and valves, which tend to direct the flow to one side and which in some cases cause it to rotate as it advances, must be far enough upstream from the orifice or nozzle to permit the disturbed stream to straighten out to the even form before reaching the meter. Minimum conditions in the installation for avoiding trouble from fittings and valves are shown in Fig. 21. If necessary, straightening vanes may be used upstream from the orifice or nozzle at a distance of not less than 8 pipe diameters.

VARIABLE AREA FLOW METERS

In the routine measurements of many liquids and gases, satisfactory results may be obtained by the use of variable area flow meters, frequently called rotameters. In their most common form these devices consist essentially of a float which is free to move vertically in a transparent tapered tube. The fluid to be metered enters at the narrow bottom end of the tube and moves upward, passing at some point through the annulus formed between the float and inside wall of the tube. At any particular rate of flow the float assumes a definite position in the tube, its location being indicated by means of a calibrated scale on the tube.

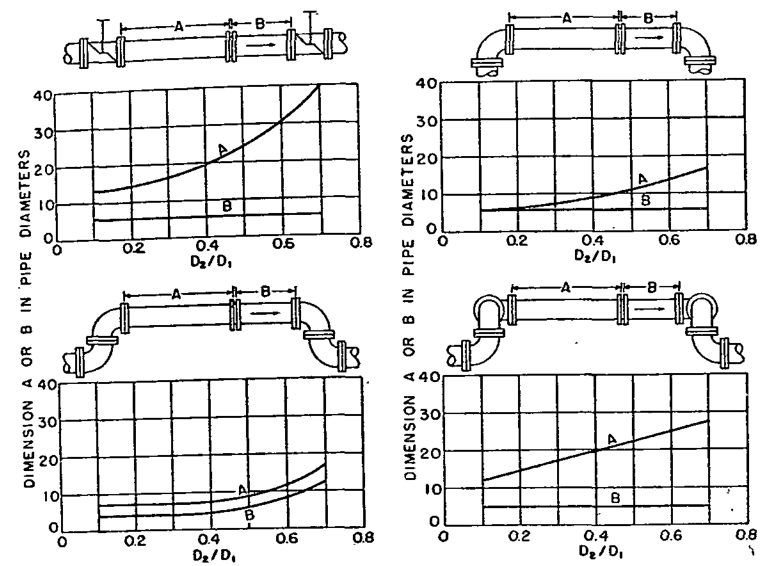

FIG. 21. MINIMUM CONDITIONS TO BE OBSERVED WHEN INSTALLING ORIFICES AND NOZZLES BETWEEN FITTINGS AND VALVES

The position of the float is established by a balance between the fluid pressure forces across the annulus and the weight of the float itself. The buoyant force which must support the float, $v_f(\rho_f - \rho)$, is balanced by the pressure difference acting on the cross section area of the float, $A_f\Delta p$, where ρ_f, A_f, v_f, are, respectively, the float density, float cross section area, and float volume. Accordingly, the difference in head across the annulus is given by

$$h_f = \frac{\Delta p}{\rho} = \frac{v_f(\rho_f - \rho)}{A_f\rho} \quad (74)$$

The volume flow follows from equation (51) as

$$Q_v = KA_2\sqrt{2gv_f(\rho_f - \rho)/\rho A_f} \quad (75)$$