Discharge coefficients for nozzles, as for orifices, vary with pipe size; they may either increase or decrease with decreasing size of pipes depending on the sharpness of the approach curvature of the nozzle. For the *A.S.M.E.* nozzles, they tend to decrease. Generally speaking, too, the coefficient for a given nozzle shape is higher if the finish of the surface is smoother.

Discharge coefficients, C, for pipes 2, 6, and 10 in. in diameter are given in Figs. 16, 17, and 18, as correlated by Bean, Beitler and Sprenkle[5], as functions of the diameter ratio β and the Reynolds number N_{Re} (Equation 66) referred to the diameter of the throat in feet.

$$N_{Re} = \frac{D_2 V_2 \rho_1}{\mu_1} \qquad (66)$$

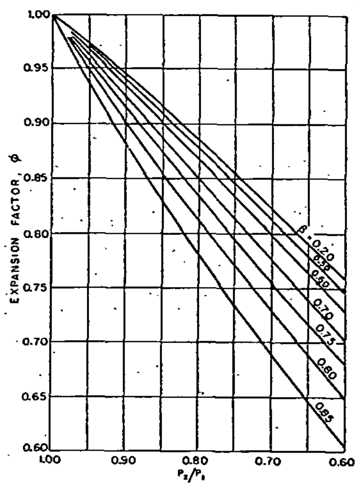

Fig. 19. Relation of Expansion Factor, φ, for Nozzles to Diameter Ratio and Pressure Loss for Air and Other Diatomic Gases

Coefficients from these curves must be multiplied by $\frac{1}{\sqrt{1-\beta^4}}$, the velocity of approach factor, in accordance with Equation 46, to obtain the value of K to use in the various equations.

The expansion factor for nozzles, designated by φ, is obtained from a rational formula, as already noted.

$$\varphi = \sqrt{\left(\frac{p_2}{p_1}\right)^{2/k}\left(\frac{k}{k-1}\right)\left(\frac{1-(p_2/p_1)^{\frac{k-1}{k}}}{1-p_2/p_1}\right)\left(\frac{1-\beta^4}{1-\beta^4\,(p_2/p_1)^{2/k}}\right)} \qquad (67)$$

This formula is plotted for $k = 1.40$ (air and other diatomic gases) and 1.30 (steam, carbon dioxide, natural gas) in Figs. 19 and 20, respectively.

FLOW MEASUREMENT BY PITOT TUBE

There remains one other head type meter useful in ventilating work; the Pitot tube, named for the Frenchman who discovered the principle. The Pitot tube is essentially a bent tube with its open end pointed upstream, combined with another tube with its end pointed crosswise to the flow or downstream, or connected to openings crosswise to the flow. Used with flowing liquid, the liquid will rise in each tube, but higher in the one pointed upstream. Used with a flowing gas, and the two tubes connected by a U-tube containing water, the liquid level in the U-tube will be displaced, with the lower level on the side connected to the tube pointed upstream. The tube directed upstream receives the impact pressure, which is the sum of the static and kinetic pressures, while the tube directed crosswise receives only the static pressure; the difference

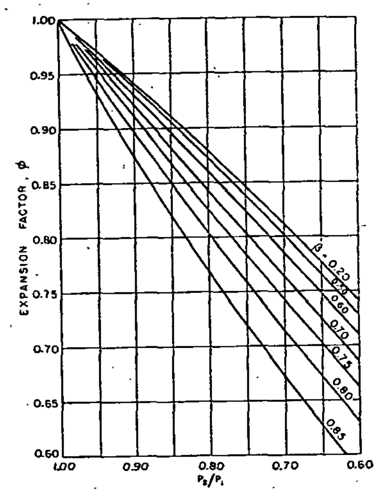

Fig. 20. Relation of Expansion Factor, φ, for Nozzles to Diameter Ratio and Pressure Loss for Steam, Carbon Dioxide and Natural Gas

between the two, as read on the separate tubes or on the U-tube is, of course, the kinetic pressure. The velocity is expressed as

$$V = \sqrt{2gh_f} \qquad (68)$$

Application of Equation 56 serves to make the formula general, assuming that water is used in the manometer connecting the two tubes. Using this equation, and mutiplying by 60 to convert feet per second to feet per minute,

$$V_m = 1096.5\sqrt{\frac{h_{aw}}{\rho}} \qquad (69)$$

in which V_m is the rate of flow in feet per minute.

It is often difficult to obtain the exact static pressure. In the usual construction of Pitot tubes, the static pressure openings are downstream from the impact pressure opening, and turbulence induced by the nose