In steam measurement, a constant head of water is maintained over each leg of the manometer by means of condensing chambers, in order to keep the heat of the steam away from the meter. As the mercury level fluctuates, the difference in head as recorded on the chart, therefore, is not that due to mercury alone, but to mercury minus an equivalent head of water. To correct for this, the equation

$$h_{aw} = h_w \frac{12.557}{13.557} \tag{59}$$

is applied to Equation 58. The denominator in Equation 59 is the specific gravity of mercury; and the numerator is the difference in specific gravity between mercury and water. Equation 58, hence, becomes

$$Q_f = 345.65\, KD_2^2 \sqrt{\frac{h_w}{\rho}} \tag{60}$$

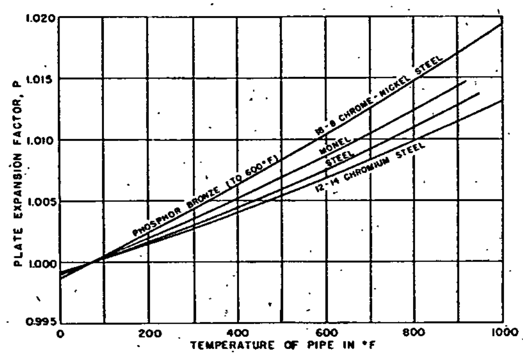

Fig. 15. Variation of Orifice Plate Expansion Factor, P, with Temperature and Material

Steam is commonly measured in terms of weight, and since

$$W = \rho Q_f \tag{61}$$

where

W = the rate of flow in pounds per hour.

$$W = 345.65\, KD_2^2 \sqrt{h_w \rho} \tag{62}$$

The expansion factor Y, and the factor P, correcting for the expansion of the orifice plate with the temperature must then be applied, so that

$$W = 345.65\, KYPD_2^2 \sqrt{h_w \rho} \tag{63}$$

which is the *final form of the equation for the flow of steam through orifices.* Values of K may be obtained from Figs. 7, 8, 9, and 10, according to the pressure taps used. Y may be computed from Equations 55 or 56. Fig. 15 gives values of the correction factor P, according to the temperature and the material of the orifice plate. Values of the density, ρ, may be obtained from steam tables, such as Keenan and Keyes[4], which are widely used.

METERING LIQUIDS

Orifices are also used for metering liquids, and Equation 48 serves again as a starting point for developing the working formula. Again, too, it is necessary to convert h_f to h_{aw}, the actual head in inches of water, by substituting Equation 57. It is also necessary to correct for the weight of the fluid above the manometer, and since this may be other than water, it is better to use an equation of more general form than Equation 59:

$$h_{aw} = h_w \frac{13.557 - \dfrac{\rho_f}{\rho_w}}{13.557} \tag{64}$$

where

ρ_f = the density of the fluid over the mercury in the manometer.
ρ_w = the density of water at 60 F.

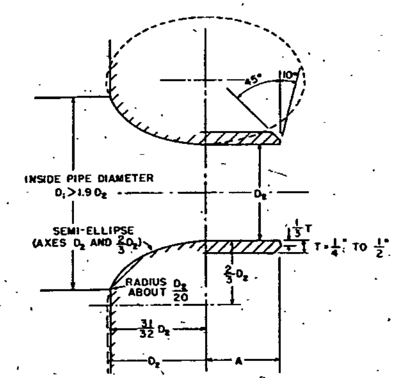

Fig. 16. Shape of *ASME* Long Radius Nozzle When Ratio of Throat to Pipe Diameter is 0.53 or Less

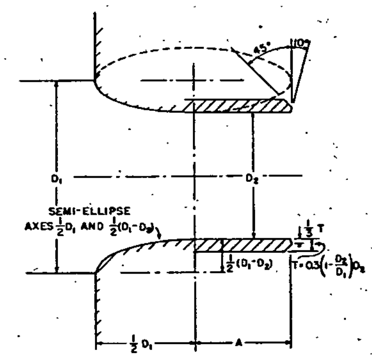

Fig. 17. Shape of *ASME* Long Radius Nozzle When Ratio of Throat to Pipe Diameter is 0.4 to 0.7

Substituting Equations 57 and 64 in Equation 48 gives

$$Q_f = 44.764\, KD_2^2 \sqrt{h_w \left(\frac{1}{\rho_f} - 0.00118\right)} \tag{65}$$

Then, since liquids are generally measured in gallons instead of cubic feet, and since there are 7.4805 gal in 1 cu ft,

$$Q_w = 334.86\, KD_2^2 \sqrt{h_w \left(\frac{1}{\rho_f} - 0.00118\right)} \tag{66}$$

in which Q_w is the discharge or rate of flow, in gallons per hour.

Since liquids, for practical purposes, are incompressible, no expansion factor is necessary. If circumstances demand, the factor P for the expansion of the orifice may be applied. Also, if it is necessary to correct the volumetric discharge to a base temperature, application of the known expansion characteristics of the liquid will enable the conversion. Values