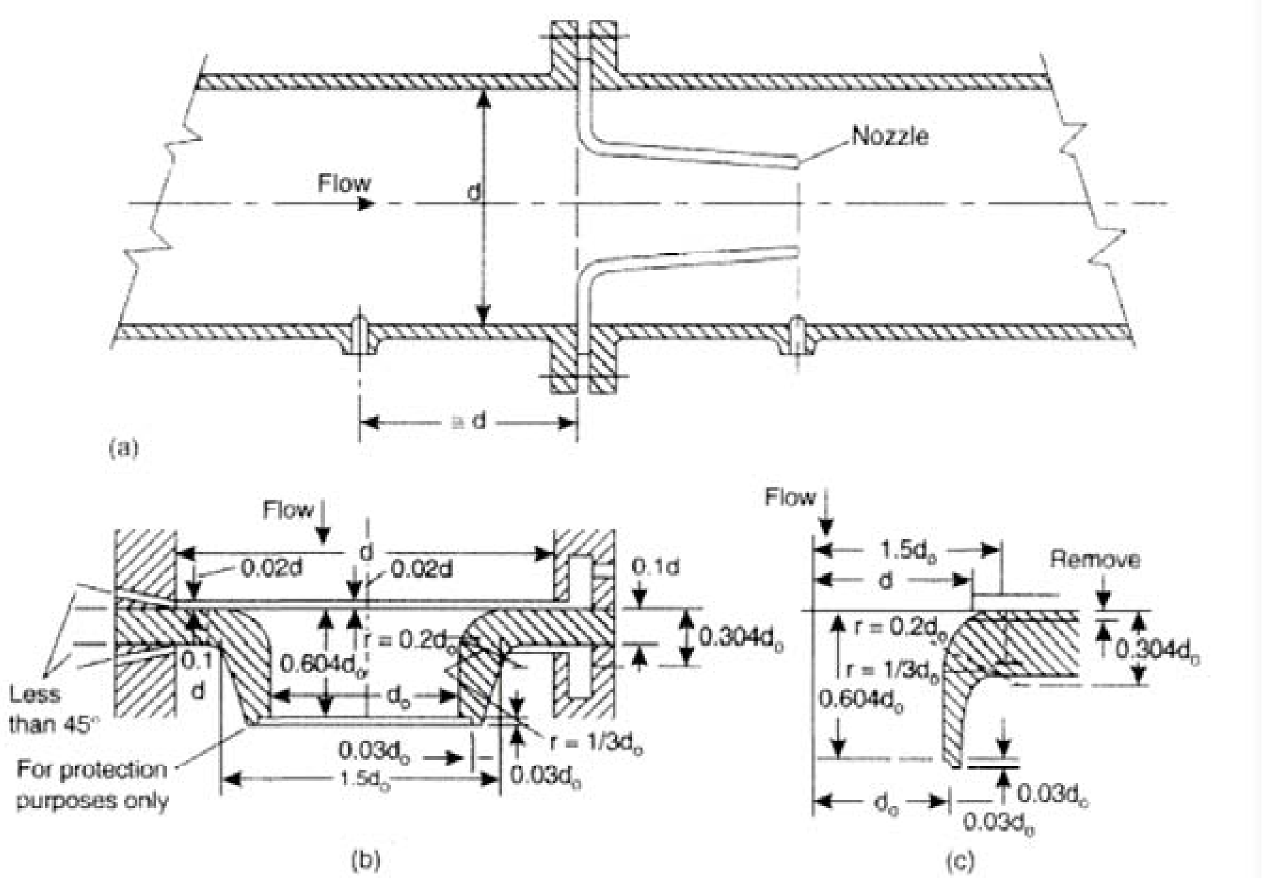
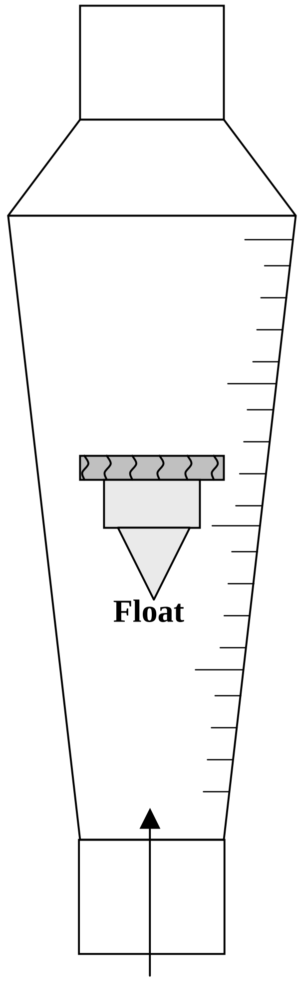
7.2.2.3 <u>The Nozzle</u>

The nozzle is similar to <u>the orifice meter</u> other than that it has a *converging tube* in place of the orifice plate, as shown in below. The velocity of the fluid is gradually increased and the contours are so designed that almost frictionless flow takes place in the converging portion; the outlet corresponds to the *vena contracta* on the orifice meter. The nozzle has a constant high coefficient of discharge (ca. 0.99) over a wide range of conditions because the coefficient of contraction is **unity**, though because the simple nozzle is not fitted with a diverging cone, the head lost is very nearly the same as with an orifice. Although much more costly than the orifice meter, it is extensively used for metering steam. When the ratio of the pressure at the nozzle exit to the upstream pressure is less than the critical pressure ratio ω_c, the flow rate is independent of the downstream pressure and can be calculated from the upstream pressure alone.



Figures of nozzle (a) General arrangement (b) Standard nozzle (A_o/A_1) is less than 0.45. Left half shows construction for corner tappings. Right half shows construction for piezometer ring (c) Standard nozzle where (A_o/A_1) is greater than 0.45

7.2.3 <u>Variable Area Meters - Rotameters</u>



In the previous flow rates the area of constriction or orifice is **constant**, and *the pressure drop is dependent on the rate of the flow* (due to conversions between the pressure energy with kinetic energy).

In the Rotameter *the drop in pressure is* **constant** and *the flow rate is function of the area of constriction*. When the fluid is flowing the float rises until its weight is balanced by the up thrust of the fluid. قوة الطفو او القوة الدافعة للمائع. *Its position then indicting the rate of flow*.

Force balance on the float

Gravity force = up thrust force + Pressure force

$$V_f \rho_f g = V_f \rho g + (-\Delta P) A_f$$

$$-\Delta P = \frac{V_f g(\rho_f - \rho)}{A_f} \quad \text{i.e. constant}$$

where, V_f ρ_f, and A_f are float volume, float density, and maximum cross- section area of the float.

$(-\Delta P)$ is the pressure difference over the float, $(-\Delta P) = P_1 - P_2$.

The area of flow is the annulus formed between the float and the wall of the tube. This meter may thus be considered, as an orifice meter with a variable aperture, and the equation of flow rate already derived are therefore applicable with only minor changes.

$$Q = C_d \sqrt{\frac{2(-\Delta P)}{\rho}} \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}}$$

$$Q = C_d \sqrt{\frac{2V_f g(\rho_f - \rho)}{\rho A_f}} \frac{A_1 A_2}{\sqrt{A_1^2 - A_2^2}}$$

where, A_1 : cross-section area of the tube when the float arrived.

A_1 : cross-section area of the annulus (flow area).