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.

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

$$h_f = \frac{\Delta p}{\rho} = \frac{v_f(\rho_f - \rho)}{A_f \rho} \tag{66}$$

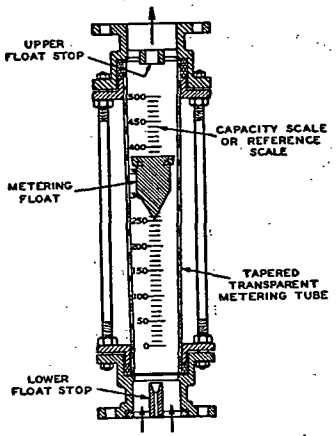

FIG. 18. SCHEMATIC DIAGRAM OF VARIABLE AREA FLOW METER

The volume flow follows from equation (53) as

$$Q = KA_2\sqrt{2gv_f(\rho_f - \rho)/\rho A_f} \tag{67}$$

and the mass flow as

$$w = \rho Q = KA_2\sqrt{2gv_f(\rho_f - \rho)\cdot\rho/A_f} \tag{68}$$

The flow for any selected fluid is, accordingly, very nearly proportional to the area, so that a convenient calibration of the tube may be obtained. The behavior of the flow coefficient, K, has been investigated[6] and the action of the flow meter as just outlined, experimentally confirmed. The flow coefficient variation for any float must be known in order to use the meter for different fluids. Some developments have been carried on in the design of the float to reduce the variation of the flow coefficient with Reynolds number, and also with regard to float materials, to reduce the dependence of mass flow calibration on fluid density.

This type of flow meter is usually furnished in standard sizes calibrated for specific fluids by the manufacturer. The compactness, reliability, and ease of installation are particularly advantageous when many measurements of essentially the same type are to be made.

LETTER SYMBOLS USED IN CHAPTER 4

β = ratio, throat or orifice diameter to pipe diameter.
μ = absolute viscosity, pounds per foot second.
μ/ρ = kinematic viscosity, square feet per second.
ρ = density of flowing fluid, pounds per cubic foot.
ρ_m = proper mean density.
ρ_w = density of water at 60 F (62.37 lb per cubic foot).
ρ_f = density of float in variable area meters.
ϕ = expansion factor for nozzles.
a = velocity of sound, feet per second.
A = cross-sectional area of flow, square feet.
C = correction factor (coefficient of discharge) for flow through orifice, nozzle or Venturi.
c_p = specific heat of gas at constant pressure.
c_v = specific heat of gas at constant volume.
D = diameter of fluid stream, feet.
d = internal diameter of pipe, feet.
d_H = hydraulic diameter, feet.
e = absolute roughness of pipe surface, feet.
F_c = correction factor for differential head in compressible flow.
f = dimensionless friction coefficient.
g = gravitational acceleration, feet per (second) (second).
g_c = gravitational conversion factor = 32.174 (pounds mass per pound force) × feet per (second) (second).
h = enthalpy, Btu per pound of fluid.
h_f = loss of head, feet of fluid.
h_t = total head, feet of fluid.
J = mechanical equivalent of heat = 778 foot pounds per Btu.
K = flow coefficient (correction factor), including velocity of approach correction factor, for flow through orifice, nozzle or Venturi.
k = ratio of specific heat at constant pressure to specific heat at constant volume.
L = perpendicular distance from axis of pipe, feet.
l = length of pipe, feet.
M = Mach number.
N_{Re} = Reynolds number.
p = pressure, pounds per square foot.
p^0 = stagnation pressure.
p_c = critical pressure.
Q = discharge rate, cubic feet per second.
q = heat transferred to the fluid per pound of fluid flowing.
R = gas constant.
r = radius of pipe in feet.
s = entropy of fluid in Btu per (pound) (Fahrenheit degree).
T = temperature, Fahrenheit degrees, absolute.
u = internal energy, Btu per pound of fluid.
V = velocity, feet per second.
V_c = critical velocity, feet per second.
v = specific volume, cubic feet per pound.
W = mechanical work, foot pounds per pound of fluid flowing.
w = mass flow of gas, pounds per second.
Y = expansion factor—correcting for expansion of gas under reduced downstream pressure.
z = elevation above some arbitrary datum, feet.

REFERENCES

[1] Friction Factors for Pipe Flow, by Lewis F. Moody (*ASME Transactions*, *66*, 1944, 671–678; Discussion, idem. *66*, 1944, 678–684); also, An Approximate Formula for Pipe Friction Factors (*Mechanical Engineering*, 69, 1947, 1005–1006).