Unit II
SURFACE TENSION

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Surface Tension:

Molecular phenomenon

- **Molecular Forces:**
- 1) Adhesive force or Forces of Adhesion:
- 2) Cohesive Force or Force of cohesion
- Different from ordinary gravitational force
- Does not obey ordinary inverse law
- Varying inversely probably as 8^{th} power of distance
- Decreases rapidly with distance
- Cohesive force is greatest in solid than liq and less in gases

Surface Tension:

Molecular phenomenon

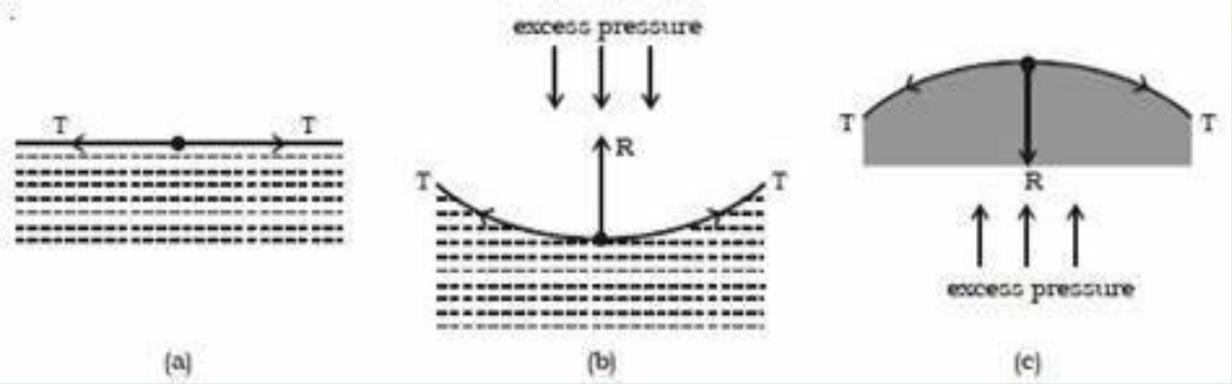
- Negligible at ordinary temperature and pressure
- That's why solid has definite shape, liquid has free surface and gas has neither
- Molecular Range:
- : Maximum distance up to which force of cohesion between two molecules can acts
- Sphere of influence:
- Sphere drawn around a molecule as a centre with radius equal to its molecular range

Surface Tension:

Molecular phenomenon

- Molecule is affected only by molecule inside this sphere
- Surface Tension:
- Force per unit length of line drawn in the liquid surface , acting perpendicularly to it at every point and tending to pull the surface apart along the line
- S I Unit

Pressure difference across liquid surface



1) Resultant force due to ST on a molecule on its surface is Zeroand cohesion pressure is negligible
2) If surface of liquid is concave ,Resultant force due to S T would be upward and cohesion pressure is decreased
3) If liquid surface is convex ,Resultant force due to ST on molecule on surface is directed downward Cohesion pressure is increased

EXCESS PRESSURE INSIDE A LIQUID DROP

Molecules near surface expriences resultant pull inward

Pressure inside greater than pressure outside

r is radius of drop

T is S.T.
In equilibrium of one half of drop

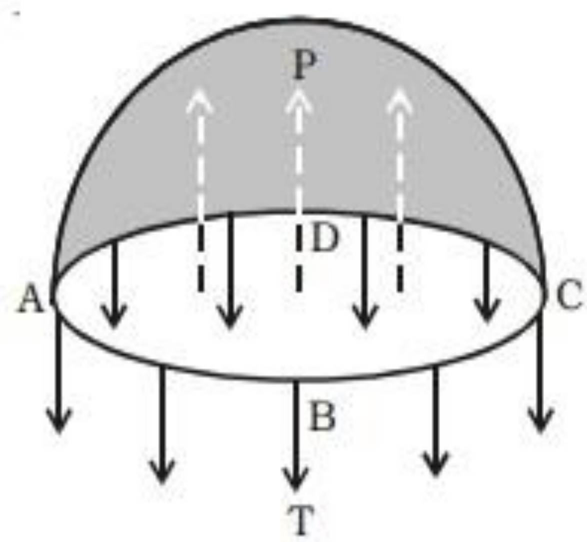


Fig. Excess pressure inside a liquid drop

EXCESS PRESSURE INSIDE A LIQUID DROP

Upward thrust on plane face ABCD due to excess pressure p is

$=p\pi\, r^2$ ---(1)

Force due to S.T. Acting downward around its edge

$=T\, 2\, \pi\, r$....(2)

Under equilibrium

$p\pi\, r = T\, 2\, \pi\, r$

$p = 2T/r$

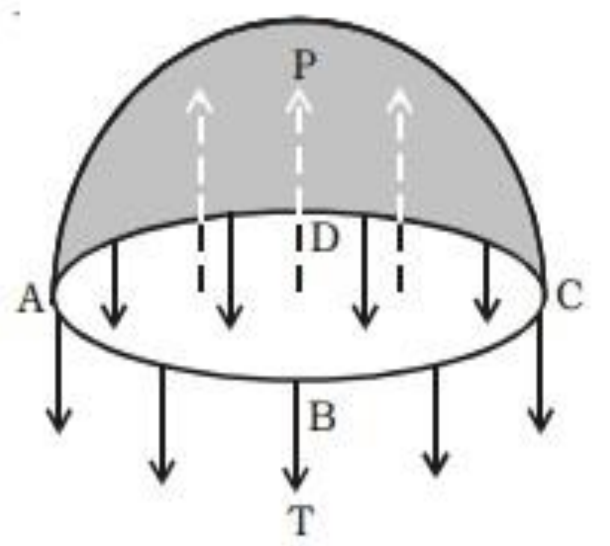


Fig. Excess pressure inside a liquid drop

S.T. BY JAEGER'S METHOD:

Construction:

Long, thin glass tube CD

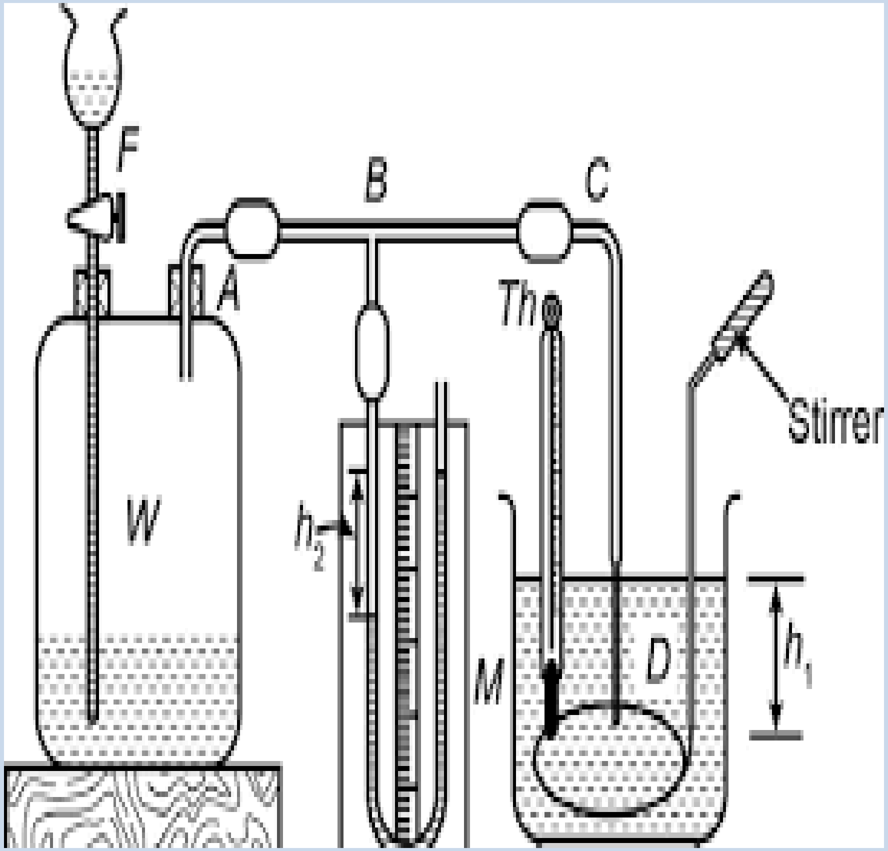
Lower end fine jet about .2to.5mm

Tip cut smooth and square

So perpendicular to axis

Dipped in experimental liquid

CD connected to manometer M and Woulff's bottle W



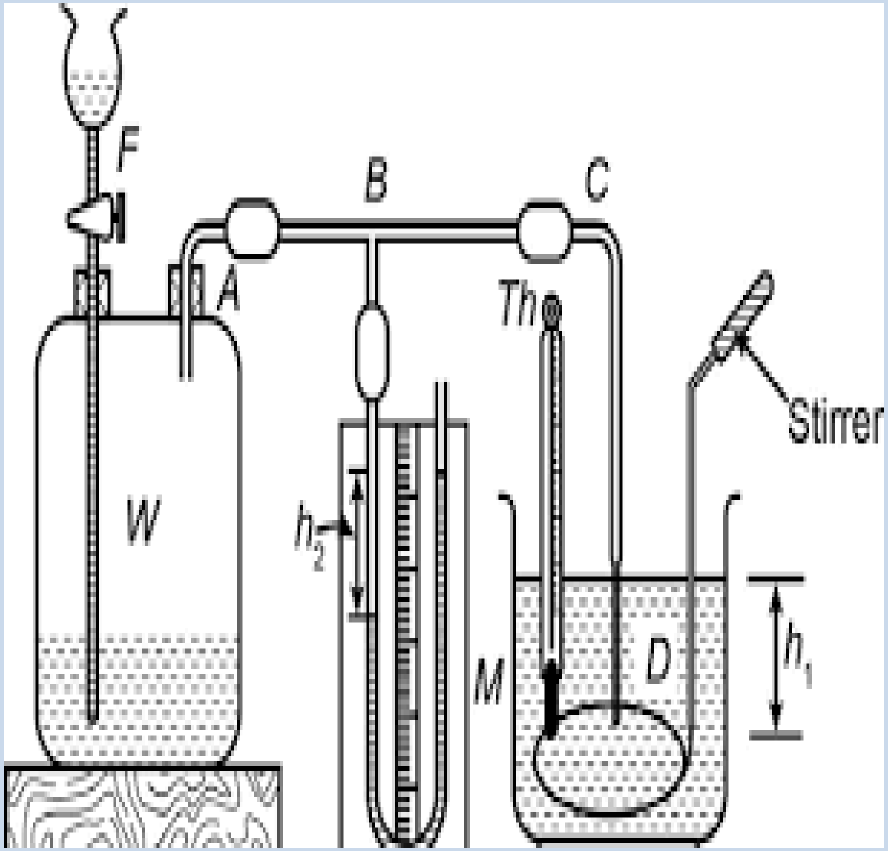
S.T. BY JAEGER'S METHOD:

Construction:

Woulff's bottle is filled with dropping funnel F containing water

M measures pressure difference between two limbs

M is filled with liquid of low density such as xylol



S.T. BY JAEGER'S METHOD:

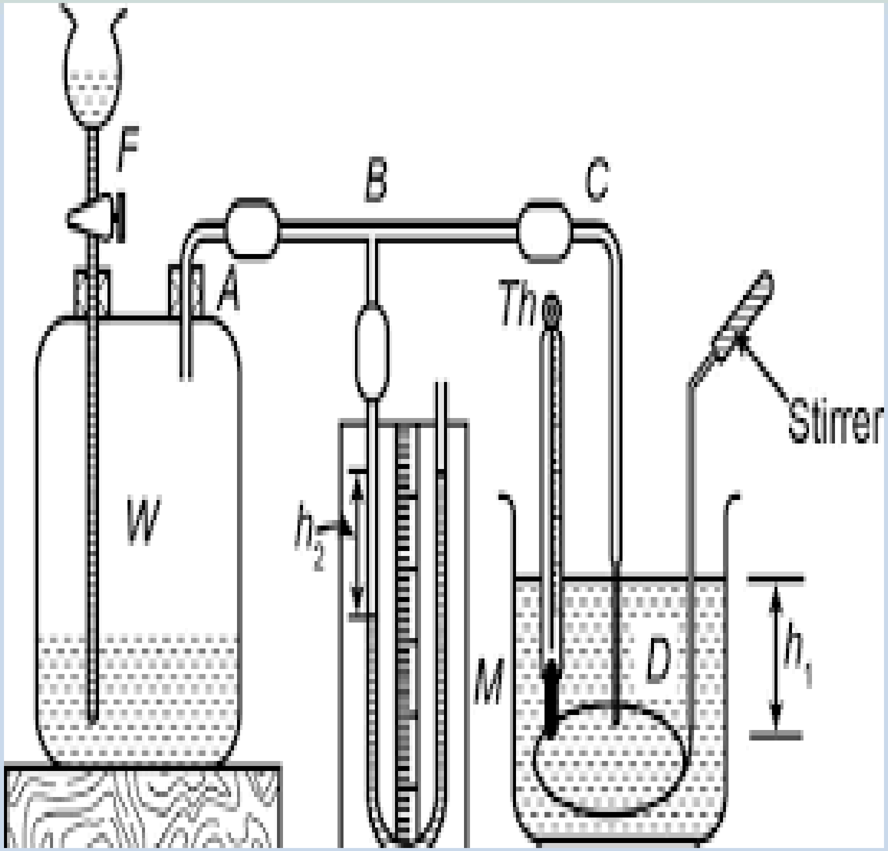
Working:

Due to capillary action, some liquid rises into tube CD meniscus being hemispherical

By dropping water in W, air forced into tube CD and displaces it's own volume

Liquid column in CD slowly moves down till D and bubble is formed

Radius of bubble is equal to radius of tube at D

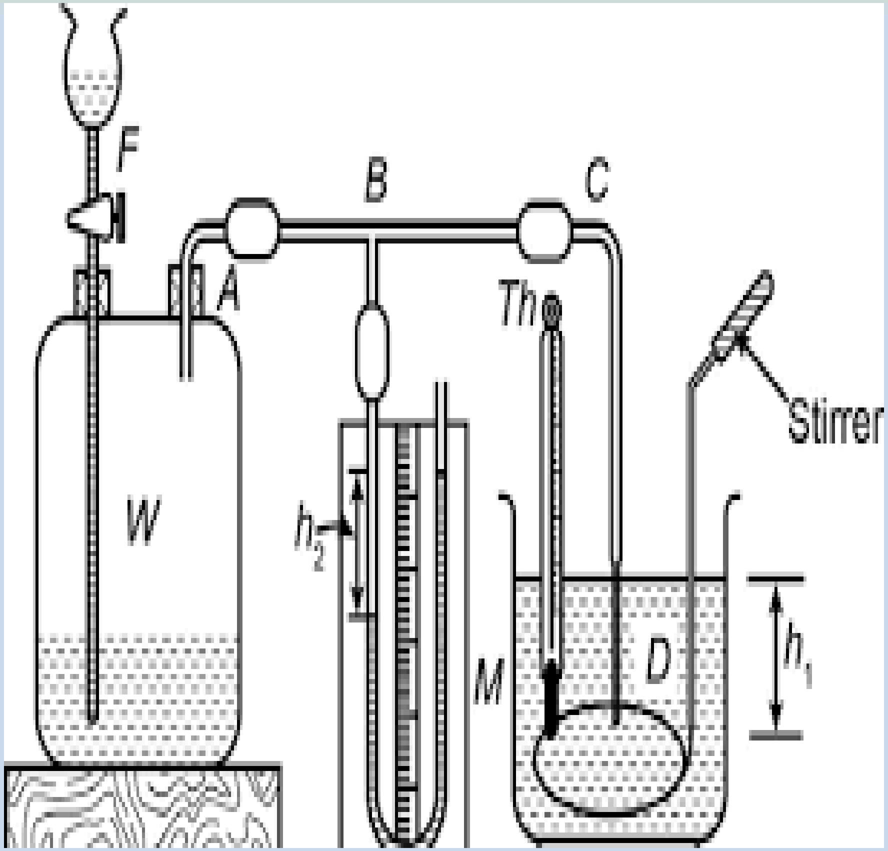


S.T. BY JAEGER'S METHOD:

Working:

Pressure inside bubble being maximum and indicated by M
Bubble becomes unstable and increase in radius corresponds to decrease in pressure

Thus measuring pressure difference from M and radius of capillary tube CD



S.T. BY JAEGER'S METHOD:

Just before bubble breaks from D, pressure inside it is equal to h2

Pressure inside bubble

$=P + h2.\rho g$

P is atmospheric pressure

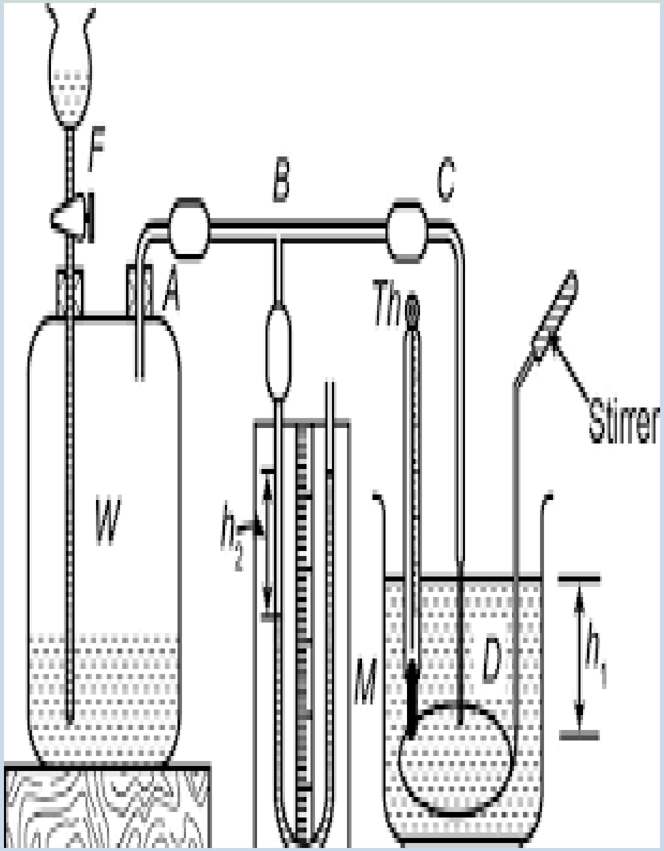
$h2.\rho g$ is pressure due to liquid column h2 in manometer

When bubble breaks from D, pressure on it equal to h1

Pressure outside bubble

$=P + h1\ d\ g$

h1 is depth of tip D



S.T. BY JAEGER'S METHOD:

Excess pressure inside bubble

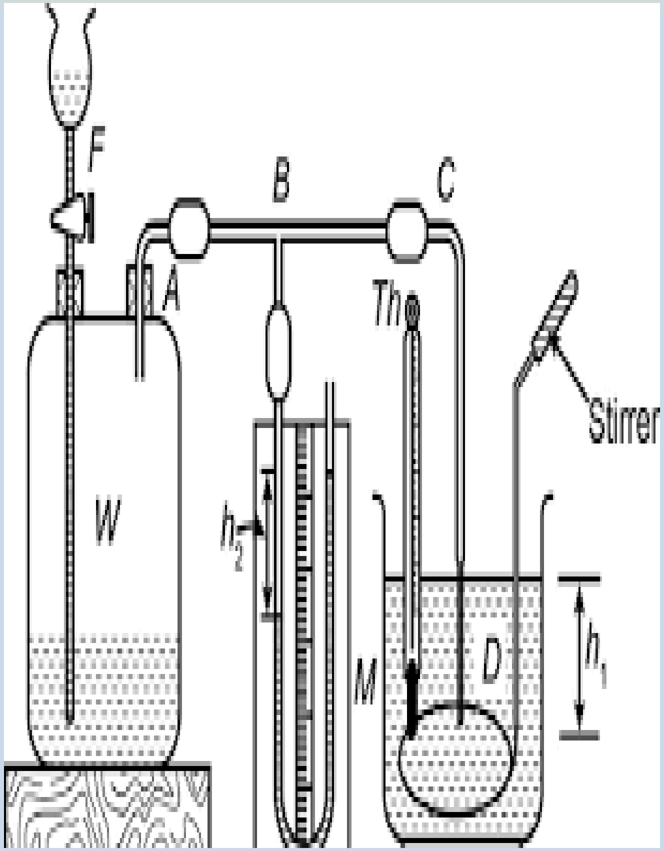
$=(P + h_2.\rho g) - (P + h_1\, d\, g)$

$= g(h_2.\rho - h_1.d)$

But excess pressure = $\frac{2T}{r}$

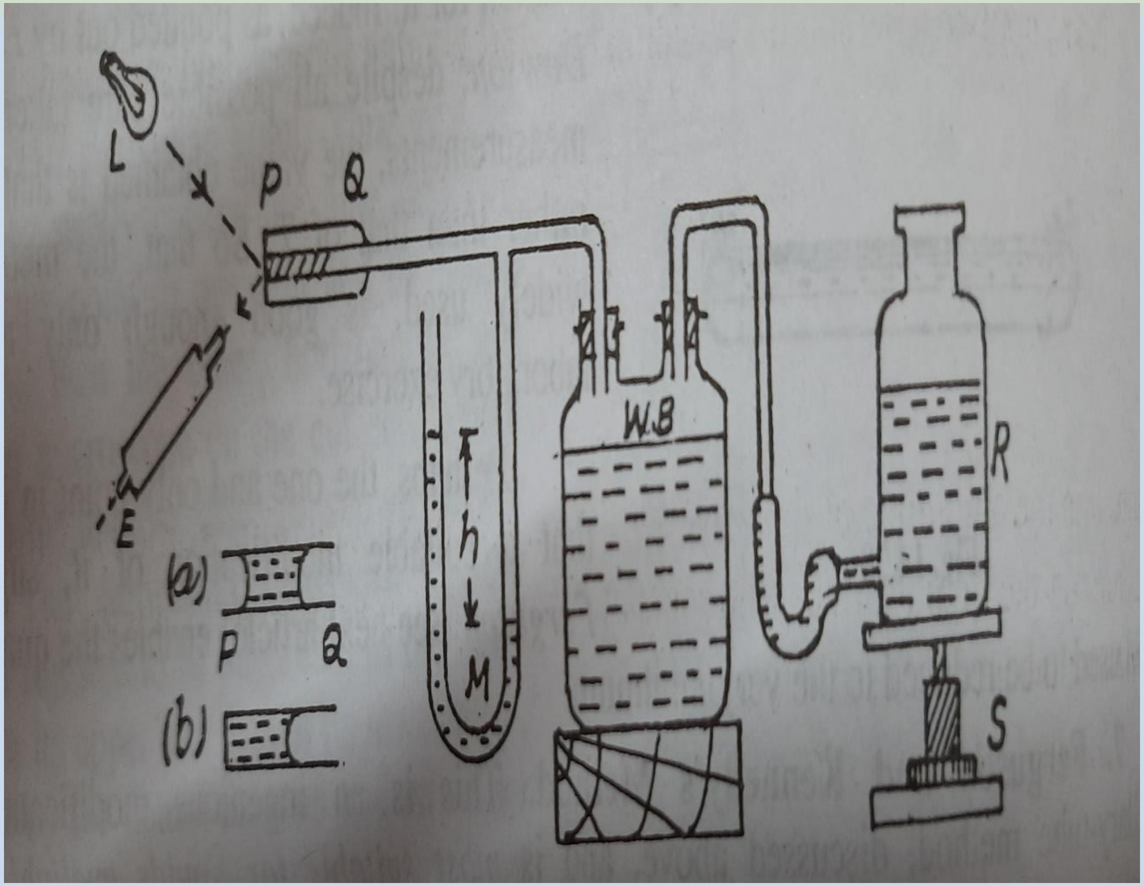
$\therefore \frac{2T}{r} = g(h_2.\rho - h_1.d)$

$T = \frac{rg(h_2.\rho - h_1.d)}{2}$



S.T. BY FERGUSON METHOD:

Modification of capillary tube method
Suitable for liquid in small quantities



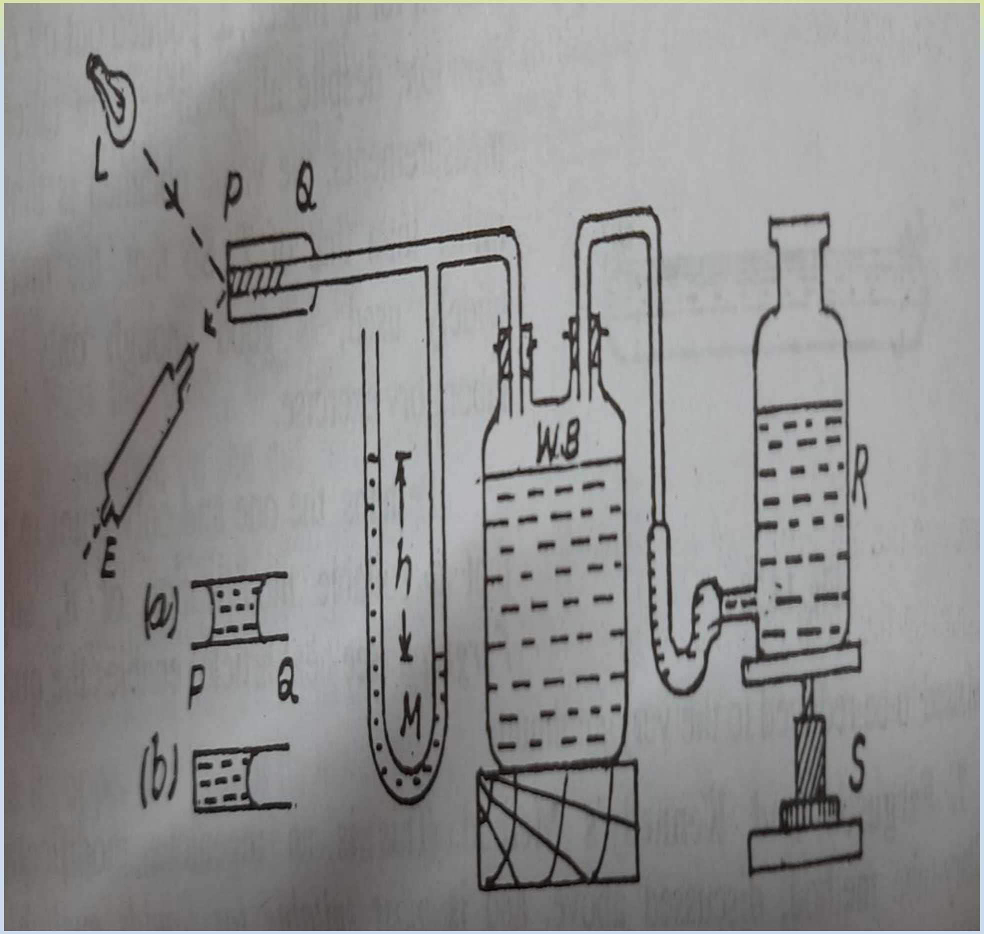
S.T. BY FERGUSON METHOD:

Apparatus:

A clean glass tube with capillary portion PQ mounted horizontally and connected to manometer M

Pressure varying arrangement with Woulf’s bottle WB and reservoir R

R is raised or lowered at will

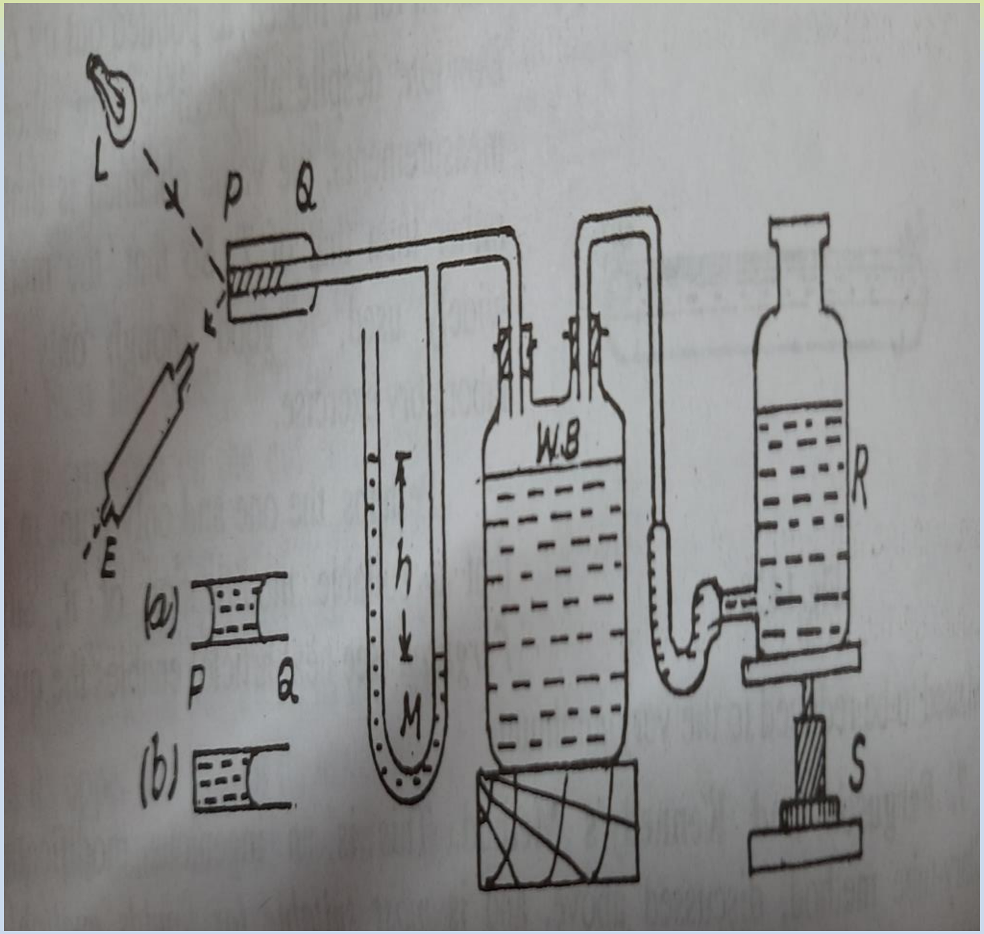


S.T. BY FERGUSON METHOD:

Working:

Small quantity of experimental liquid is introduced into capillary tube at P

When there is no pressure difference ,drop remains equally concave outward

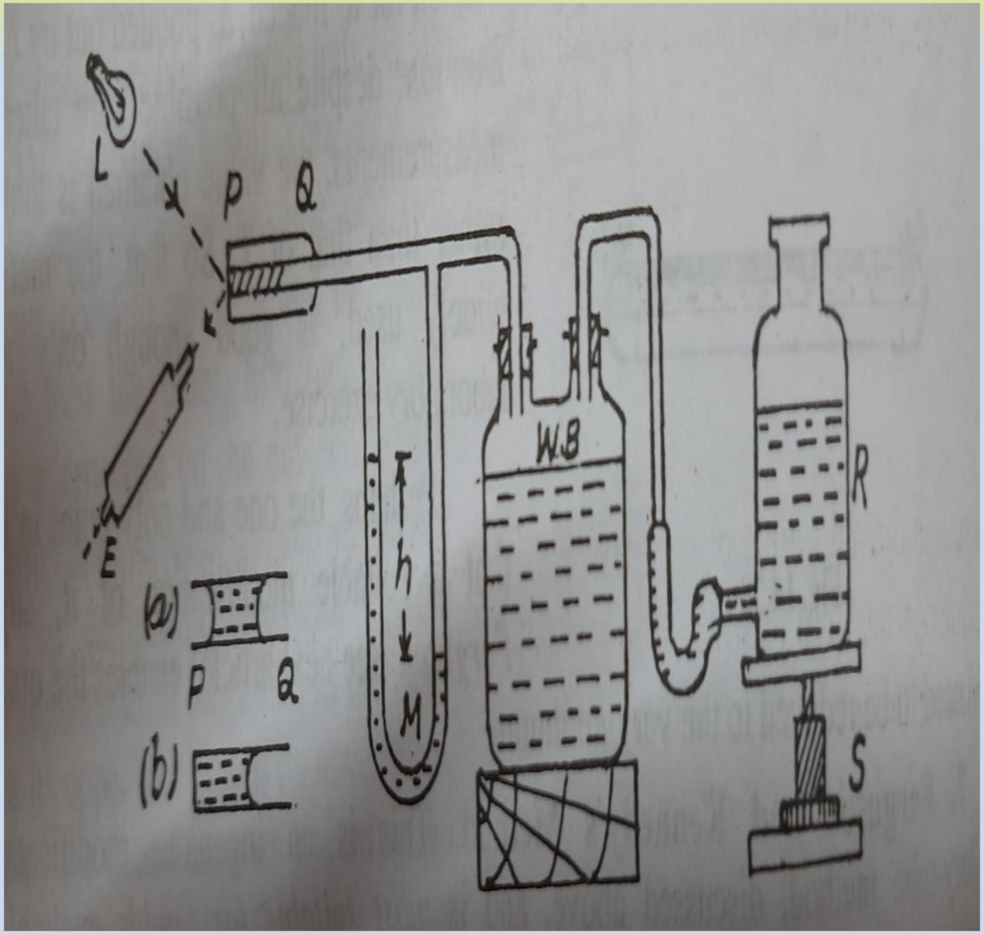


S.T. BY FERGUSON METHOD:

Working:

When pressure is increased by dropping water in WB, liquid column not only moves outward but curvature of its outer end also progressively decreasing and becomes plane

This is tested by electric lamp and microscope



S.T. BY FERGUSON METHOD:

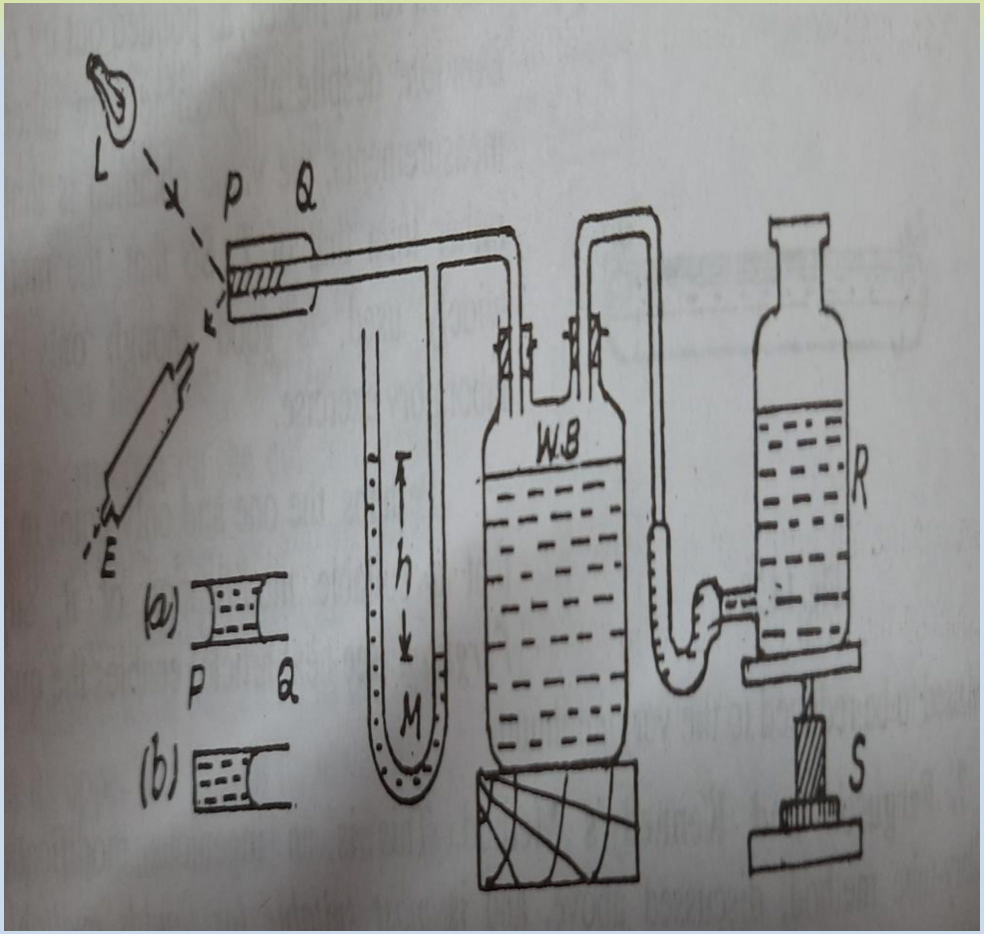
Working:

At end P now no pressure difference

At Q excess pressure due to curved meniscus given by manometer

If h is height of manometer

ρ is density of liquid



$$Excess\ Pressure = h\rho g$$

S.T. BY FERGUSON METHOD:

Total thrust on meniscus acting towards left

$= \pi r^2 h\rho g$ --- (1)

Force due to ST acting towards right

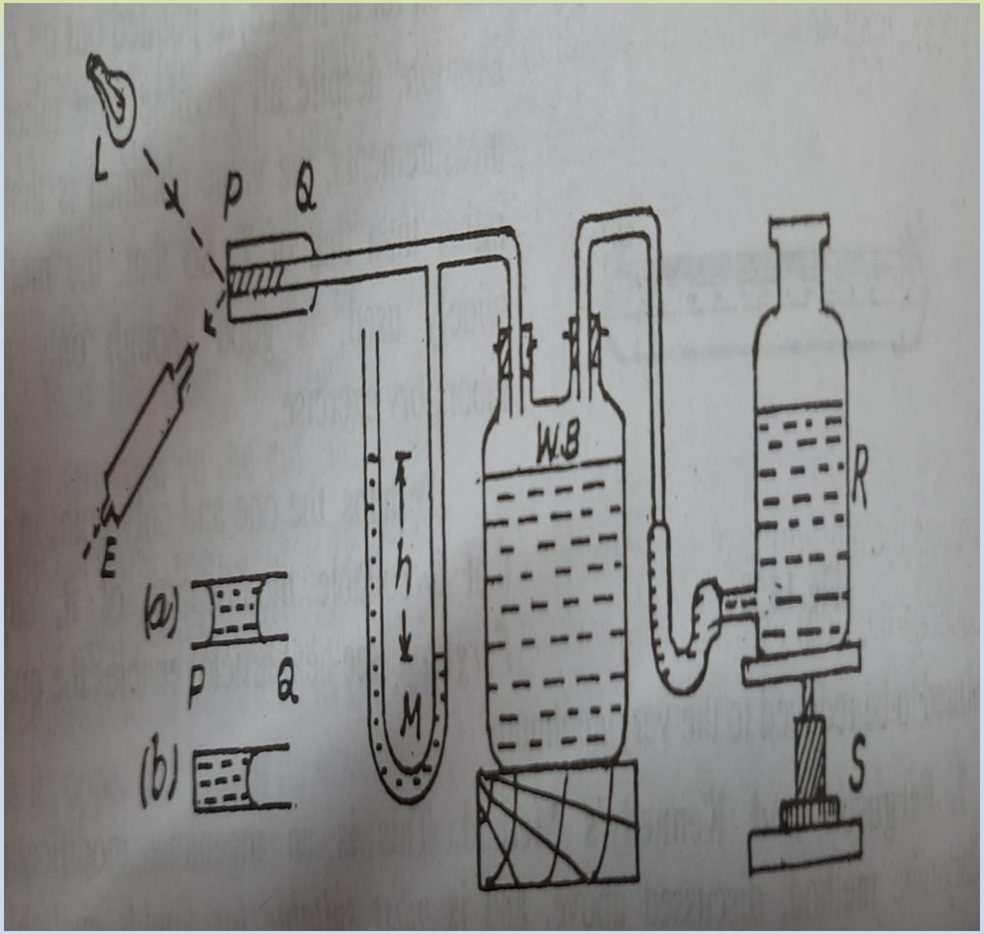
$= 2\pi r T cos\theta$ ---- (2)

θ is angle of contact

At equilibrium

$2\pi r T cos\theta = \pi r^2 h\rho g$

$$T = \frac{hr\rho g}{2\cos\theta}$$



S.T. BY FERGUSON METHOD:

For liquid which wet tube

$\theta = 0^0$ cos $= 1$

ST by Fergusion method

$$T = \frac{hr\rho g}{2}$$