4.

i) change of capacity due to change of diameter (length unchanged) δV_1

$$\mathcal{E}_\theta = \frac{2\pi(R+\delta R) - 2\pi R}{2\pi R} = \frac{\delta R}{R} \quad \text{—— (1)}$$

Increase in cross-sectional area (of enclosed space)

$$\delta A = \pi(R+\delta R)^2 - \pi R^2$$

$$= \pi(R^2 + 2R\,\delta R + \delta R^2) - \pi R^2$$

$$\delta A = \pi . 2R\,\delta R$$ neglecting products of small quantities.

$\therefore$ from (1)

$$\delta A = 2\pi R^2 \mathcal{E}_\theta$$

$$\therefore \quad \delta V_1 = L.\delta A = 2\pi R^2 L\,\mathcal{E}_\theta = 2V\mathcal{E}_\theta$$

ii) change of capacity due to change of length (diameter unchanged) δV_2.

increase in length $\delta L = L\mathcal{E}_L$

$$\delta V_2 = \pi R^2 . \delta L = \pi R^2 L\,\mathcal{E}_L = V\mathcal{E}_L$$

$$\delta V = \delta V_1 + \delta V_2 = \underline{V(2\mathcal{E}_\theta + \mathcal{E}_L)}$$