LONDON EQUATIONS AND PENETRATION DEPTH :-

These are the equations which relate the current to the electromagnetic fields in and around superconductor.

According to London brothers*, there are two types of electrons in superconductors

i) Normal electrons

ii) Superfluid electrons

Let n_n = No of normal electrons per unit volume (i.e. normal electron density)

v_n = velocity of normal electrons

n_s = electron density of superfluid electrons

v_s = velocity of superfluid electrons

If n_0 = total number of electrons per unit volume

then $n_0 = n_n + n_s$ ------- (1)

Equation of motion of superfluid electrons is given by

$$m\frac{\partial v_s}{\partial t} = -e\vec{E} \quad \text{------ (2)}$$

Also $\vec{J}_s = -en_s\vec{v}_s$ ** ($\vec{J}_s$ = superfluid current density)

$$\Rightarrow \frac{\partial \vec{J}_s}{\partial t} = -en_s\frac{\partial \vec{v}_s}{\partial t}$$

$$= -en_s\left(-\frac{e}{m}\vec{E}\right)$$

$$\boxed{\frac{\partial \vec{J}_s}{\partial t} = \frac{n_s e^2}{m}\vec{E}} \quad \text{------ (3)}$$

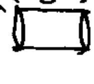
This is First London Equation

Taking curl of (3)

$$\nabla\times\frac{\partial J_s}{\partial t} = \frac{n_s e^2}{m}\nabla\times\vec{E} \quad \text{--- (4)}$$

---

* Fritz London and Heintz London.

$J_s = \frac{I_s}{A} = \frac{q}{tA} = \frac{qS}{ASt} = \frac{q}{V}\cdot v_s = -en_s v_s$  V = AS = Volume

But $\nabla \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$ ------(5)

(4) and (5) $\Rightarrow$ $\nabla \times \frac{\partial \vec{J_s}}{\partial t} = -\frac{n_s e^2}{m} \frac{\partial \vec{B}}{\partial t}$.

Integrating w.r.t. time

$$\boxed{\nabla \times J_s = -\frac{n_s e^2}{m} . \vec{B}} \text{ ------(6)}$$

This is 2nd London ~~eq~~ equation and is applicable to ~~only~~ superconductors only