5.11. MAGNETIC INTENSITY

We have seen in eq. (4) art. 5.7 that for stationary cases, the relation

$$\vec{\nabla} \times \mathbf{B} = \mu_0 \mathbf{J}_{total}$$

holds good in vacuum media. $\mathbf{J}_{total}$ is not solenoidal if polarisation **P** changes with time. To apply this relation to nonstationary cases, it is necessary for the current to remain solenoidal or the relation used in deriving the magnetic field from the current should be modified. Maxwell applied the previous concept, *i.e.*, making current solenoidal while retaining the relations that derive the magnetic field from current.

A vector field **B** is defined by the equations

$$\vec{\nabla} \cdot \mathbf{B} = 0$$

and $$\vec{\nabla} \times \mathbf{B} = \mu_0 I = \mu_0 \left(\mathbf{J}_{true} + \vec{\nabla} \times \mathbf{M} + \frac{\partial \mathbf{D}}{\partial t} \right)$$

where I is used as total current. Now in the expression for **Curl B**, total field arises due to true currents, magnetisation currents and displacement currents. Separating the part whose circulation density arises from atomic magnetisation currents, we can write

$$\vec{\nabla} \times (\mathbf{B} - \mu_0 \mathbf{M}) = \mu_0 \left(\mathbf{J}_{true} + \frac{\partial \mathbf{D}}{\partial t} \right), \qquad \ldots(1)$$

We here introduce the concept of a new vector quantity **H** given by

$$\mathbf{H} = \frac{(\mathbf{B} - \mu_0 \mathbf{M})}{\mu_0},$$

then expression (1) takes the form

$$\vec{\nabla} \times \mathbf{H} = \mathbf{J}_{true} + \frac{\partial \mathbf{D}}{\partial t} \qquad \ldots(2)$$

The quantity **H** is called *magnetic intensity*. **Curl H** shows total displacement current composed of $\frac{\partial \mathbf{P}}{\partial t}$, the polarisation currents and vacuum displacement current $\varepsilon_0 \frac{\partial \mathbf{E}}{\partial t}$.

Under stationary or quasi stationary conditions $\frac{\partial \mathbf{D}}{\partial t}$ is small and then

$$\vec{\nabla} \times \mathbf{H} = \mathbf{J}_{true}. \qquad \ldots(3)$$