Modification in Ampere's Law & Displacement Vector :-

According to the Ampere's law we know that "In a particular loop (closed surface) the line integral of magnetic field is equal to the μ_0 times of the total current flowing in the loop enclosed by the surface i.e;

$$\int \vec{B} \cdot d\vec{l} = \mu_0 I$$

or $$\int B \cdot dl = \mu_0 I \quad \text{——— (1)}$$

From the definition of current density,

$$J = \frac{dI}{ds}$$

or $$dI = J\,ds$$

on integrating $$I = \int J\,ds \quad \text{——— (2)}$$

put in (1)

$$\int B \cdot dl = \mu_0 \int J\,ds \quad \text{——— (3)}$$

on applying stoke's theorem in L.H.S of above eq^n, we get

$$\int \text{curl } B \, ds = \mu_0 \int J \, ds$$

$$\int (\text{curl } B - \mu_0 J) \, ds = 0$$

here $\int ds \neq 0$, then bracket term should be equal to zero.

$$\text{curl } B - \mu_0 J = 0$$

$$\text{curl } B = \mu_0 J$$

[$\because B = \mu_0 H$]

$$\text{curl } H = J \quad \text{--- (4)}$$

taking divergence on both sides, we get

$$\text{Div } (\text{curl } H) = \text{Div } J$$

From vector calculus the Div. Curl of a vector quantity is always equal to zero.

Then from above eqn, we get

$$\boxed{\text{Div } J = 0} \quad \text{--- (5)}$$

This is the ampere's law for electrostatics.

From eqn of continuity, we know

$$\text{div } J + \frac{d\rho}{dt} = 0$$

$$\boxed{\frac{d\rho}{dt} = 0}$$

which is only possible in electrostatic.

Hence, a modification was made in Ampere's law which give the exact result of current flowing in a particular loop.
For this a term J_D is added in Ampere's law which is known as Displacement vector (Displacement current density).
Then the Ampere's law converts in the form of :-

$$\boxed{Curl\ H = J + J_d} \quad (6)$$

Now taking div. on both sides

$$Div\ Curl\ H = Div\ J + Div\ J_d$$

$$Div\ J + Div\ J_d = 0 \quad (7)$$

This modification in Ampere's law is based upon the Maxwell's law and is also known as Maxwell's Modification.

From maxwell's eq^n we know that

$$Div \vec{D} = \rho \quad \text{--- (8)}$$

where D is electric displacement vector and whose value is given by :- ~~E = permittivity~~

$$\vec{D} = \epsilon E + P \quad \text{--- (9)}$$

$\rightarrow$ Polarisation

put the values of eq^n (8) and (9) in eq^n (A)

$$Div\ J + \frac{d}{dt}(Div \vec{D}) = 0$$

or

$$\boxed{Div\ J + \frac{d}{dt} Div(\epsilon \vec{E} + P) = 0}$$

on comparing with eq^n (7), we get

$$\boxed{J_d = \frac{\delta D}{\delta t}} \text{ or } \quad \because Div\ P = 0$$

$$\boxed{\epsilon \frac{\partial E}{\partial t} = J_d}$$

put in eq^n (6)

$$\boxed{Curl\ H = J + \frac{\delta D}{\delta t}} \text{ or } \boxed{Curl\ H = J + \epsilon \frac{dE}{dt}}$$