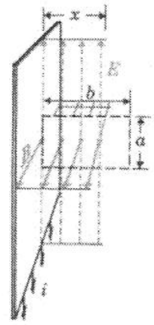
Fig. 8-23. Wave E and B traveling out from surface current of i statamp/cm. The electromagnetic wave has traveled a distance x.



$$0 = -\mu_0 i a + \varepsilon_0 \mu_0 \frac{\Delta N_E}{\Delta t}$$

$$\frac{\Delta N_E}{\Delta t} = 2 E a \frac{\Delta x}{\Delta t} = 2 E a v$$

$$0 = -\mu_0 i a + \varepsilon_0 \mu_0 \cdot 2 E a v$$

$$E = \frac{\mu_0 i \cancel{a}}{2 \varepsilon_0 \mu_0 \cancel{a} v} = \frac{1}{\varepsilon_0 \mu_0 v} \frac{\mu_0 i}{2}$$

THE FACTOR $\frac{\mu_0 i}{2}$ IS THE VALUE OF B

WE HAVE $E = \frac{1}{\varepsilon_0 \mu_0} \frac{B}{v}$ (1)

Now consider the case where originally there is no current and then the current i is suddenly turned on (see Fig. 8-23). The procedure will be to assume that the field $B = 2\pi i/c$ travels outward from the infinite plane with a velocity v. We also will assume that a uniform electric field E accompanies B and is perpendicular to B. In other words, we are assuming that a wave or step function of E and B travels away from the infinite plane with velocity v. Then Eqs. 8-25 and 8-26 can be used to solve for the values of E, B, and v. We will obtain the solutions $E = B = 2\pi i/c$ and $v = c$. Hence such an outgoing wave traveling with $v = c$ does indeed satisfy Maxwell's equations and thus is the correct solution for the situation where i is suddenly turned on.

In Fig. 8-12 consider the situation shortly after the current has been turned on and the wave of $B = 2\pi i/c$ has only traveled a distance x where x is less than b. Then B is still zero at the ends of the rectangle and Eq. 8-25 gives

$$0 = \frac{4\pi(-ia)}{c} + \frac{1}{c}\frac{\Delta N_E}{\Delta t} \qquad (8\text{-}27)$$

The minus sign is because we have chosen the up direction as positive. The electric flux N_E is the area $2ax$ times E.

Thus $\frac{\Delta N_E}{\Delta t} = 2E\frac{a\Delta x}{\Delta t} = 2Eav$

is the time rate of change of the electric flux through this rectangle. Substituting into Eq. 8-27 gives

$$0 = -\frac{4\pi}{c} ia + 2\frac{Eav}{c}$$

$$E = \frac{2\pi i}{c} \times \frac{c}{v}$$

Since the factor $(2\pi i/c)$ is the value of B we have

$$E = B\frac{c}{v} \qquad (8\text{-}28)$$

To solve for v, another equation is needed. This is obtained using the vertical rectangle of Fig. 8-23. The