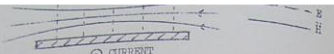

Fig. 2.3

The parallel strip line satisfies the boundary conditions, but if side walls are added to form a rectangular waveguide it will be seen that boundary conditions are not satisfied at the side walls. A T.E.M. wave cannot therefore travel directly down a waveguide, and propagation is only possible because the wave 'bounces' from side to side, the boundary conditions being satisfied at each point of contact, as described below. This bouncing or zigzag wave produces an unusual field pattern.

2.4 Reflection at a Conducting Boundary

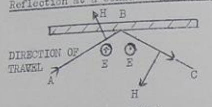

Fig. 214(a)

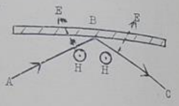

Fig. 2.4(b)

Suppose a (TEM) ray ABC is reflected by a perfect conductor; then angle of incidence = angle of reflection. Figs. 2.4(a) and (b) show two cases in which E and H are respectively perpendicular to the plane of the paper.

In Fig. 2.4(a), for the boundary conditions to be satisfied, E must suffer phase reversal at the boundary, and the corkscrew rule then determines the direction of H. At B the E and H fields from rays AB and BC combine vectorially to give a resultant E field which is zero and a resultant H which is parallel to the boundary.

In Fig. 2.4(b) the resultant E field is perpendicular to the boundary and the resultant H is parallel.

Thus although a transverse electromagnetic wave cannot travel parallel to a conducting surface, since E would then be parallel, the combination of an incident and reflected wave satisfies the boundary conditions.

Reflection at a boundary may also be illustrated by drawing the wavefront at positions of zero and maximum E and H (Fig. 2.4(c)).

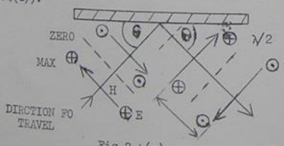

Fig.2.4(c)

is used to draw the pattern produced by the incident and reflected wavefronts as they travel through each other, the following is obtained (Fig. 2.5(a)).

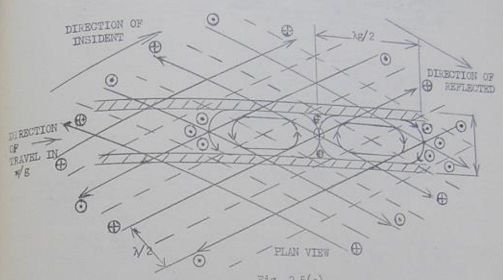

Fig. 2.5(a)

If the magnetic field is added vectorially at all points the resultant will be found to be a series of ellipses, two groups of which are shown. The electric fields combined to produce zero in planes such as A and B, which correspond to the reflecting boundary. Thus along planes such as A and B, boundary conditions are satisfied and hence conducting walls may be placed there without disturbing the pattern. Similarly, walls placed at right angles to A and B do not disturb the pattern. The result is a rectangular waveguide.

As the incident and reflected waves travel on their zigzag paths down the guide, they combineito produce a wave pattern which travels along the length of the guide. Three views of the resultant pattern are shown in Fig. 2.5(b).

A pictorial representation of the guide and the E and H fields appears in Fig. 2.5(c).

This type of wave is a transverse electric wave and is known as an H_{01} wave. The H shows that there is a component of H in the direction of propagation whereas E is entirely transverse. The first figure, 0, shows the number of half cycles of variation in the E vector in the narrow side of the guide (a); the second figure 1, shows the number of half cycles of variation of E across the wide side (b).

It is clear that b has to be chosen carefully and affects the guide wavelength, whereas a is not critical, except in determining the power handling capacity of the waveguide. In fact a is usually about $\frac{1}{2}$ b.

If b is altered the pattern elongates or contracts as shown in Fig. 2.5(d).

It is also seen from Fig. 2.5(a) that λg , the guide wavelength, is greater than λ , the free space wavelength.