Ans. (a) Fabry-Perot-Interferometer :

Construction : The Fabry-Perot interferometer is constructed of two parallel glass plates *A* and *B* thinly silvered on their inner surfaces and separated by a thin film of air by a known distance. In this instrument the distance is variable. It can be increased to about 7 cms. Sometimes

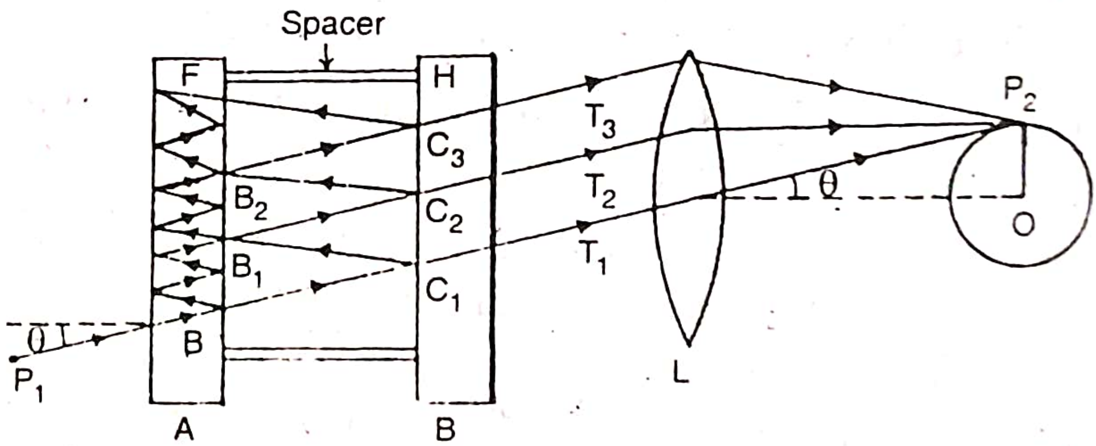

Fig. (10)

instrument of fixed distance between the plates are constructed. They are called Fabry-Perot-etalons. The plates are sometimes also made up of Quartz. Their faces are plane accurately and they are mounted in such a way that the adjacent faces are parallel. These parallel surfaces are coated with a metallic film which can transmit part of the light and reflect a high portion of the remainder. A sketch of the F.P. interferometer is shown in Fig. (10).

Theory : Let a ray of light of single wave-length λ from the point P_1 is incident upon the metallic coating of plate A at an angle θ. Part of it is reflected and a part is transmitted to the surface B. At the latter surface part of the incident light is reflected and part of it is transmitted. Of the part reflected back and go forth between the two surfaces, a fraction is transmitted through B at each incident ray upon it. For angles of incidence greater than zero, each beam undergoes a small sidewise displacement due to refraction. But this is the same in both the plates for all beams having the same angle of incidence, and so may be neglected. We may thus consider the interferometer to be essentially a pair of parallel surfaces of as high reflecting power as possible. The path difference between two consecutive transmitted rays can be found out with the help of Fig. (11).

Let us consider the path difference between two transmitted rays

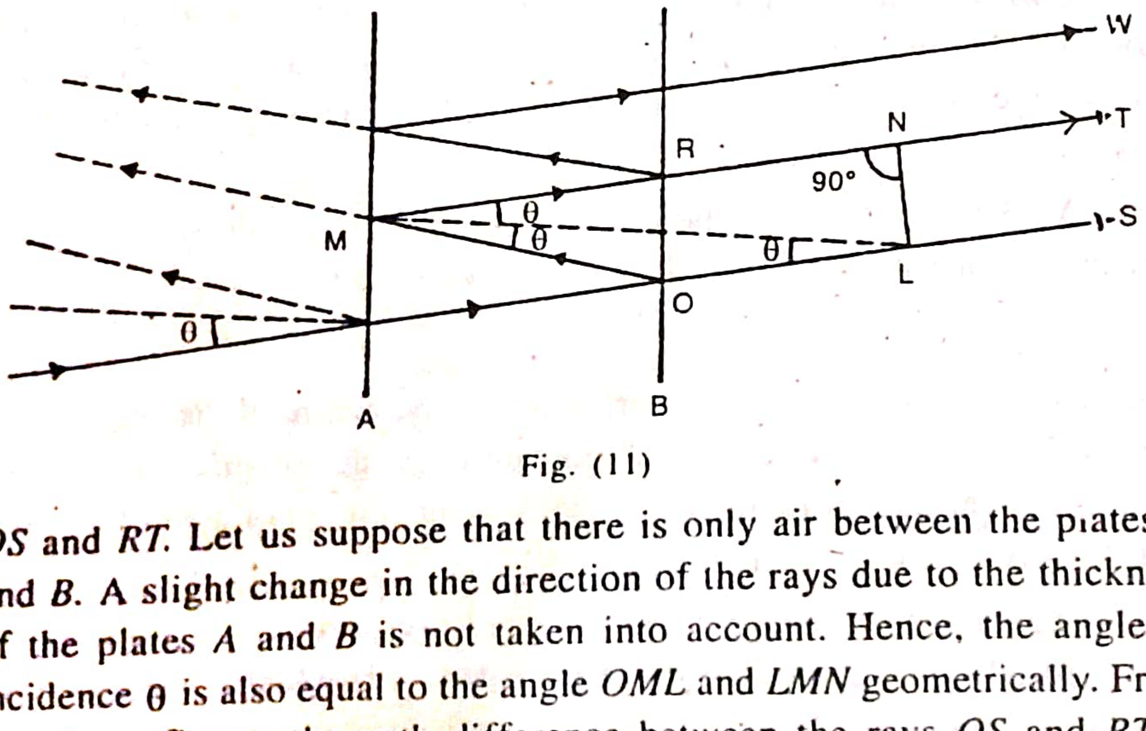

Fig. (11)

OS and RT. Let us suppose that there is only air between the plates A and B. A slight change in the direction of the rays due to the thickness of the plates A and B is not taken into account. Hence, the angle of incidence θ is also equal to the angle OML and LMN geometrically. From the above figure, the path difference between the rays OS and RT is equal to

$$OM + MR + RN - OL$$

because NL is drawn perpendicular to either line. Hence the path difference

$$\begin{aligned}\Delta &= OM + MR + RN - OL \\ &= OM + MN - OL \\ &= MN \qquad [\because\ OM = OL \text{ from } \Delta\, OML] \\ &= ML \cos\theta \ \ [\text{from } \Delta\, MLN] \\ &= 2d \cos\theta\end{aligned}$$

where d is the separation between AB.

$$\therefore \qquad \Delta = 2d \cos\theta \qquad \text{...(1)}$$

The condition for the reinforcement of the transmitted rays of P_2 in Fig. (11) is given by

$$2d \cos\theta = m\lambda \text{ ... (maxima)} \qquad \text{...(2)}$$

where $m = 1, 2, 3, \ldots$etc.

This condition will be satisfied by all points on a circle through P_2 with its centre at O, the point of intersection of the axis of the lens with the plane of the circle. When the angle θ is decreased, the cosine will increase until another maxima is reached for which m is greater by 1, 2, 3 .... so that we have for the maxima a series of concentric rings on the plane of OP_2.

If m is a whole number, the difference of path between successive rays will be an integral number of wavelength, and the amplitudes of successive rays will add to give a maximum of intensity in the form of a circular fringe.

At the centre of the pattern, the intensity will depend upon the difference of path for $\theta = 0$. In this case equation (2) becomes

$$2d = n\lambda \qquad \text{...(3)}$$

where n denotes the order of interference at the centre of the ring system. But m is used in equation (2) to indicate the order of interference for a bright fringe. Except in an occasional instance, n is not a whole number while m is always a whole number.

The path difference for the reflected rays which are similar to the transmitted rays can be found out from fig. (12) which yields a similar result like equation (1) where medium is air i.e. $\mu = 1$ and r, the angle of refraction which is equal to the angle of incidence θ. Thus

$$\Delta = 2d \cos r \qquad \text{...(4)}$$

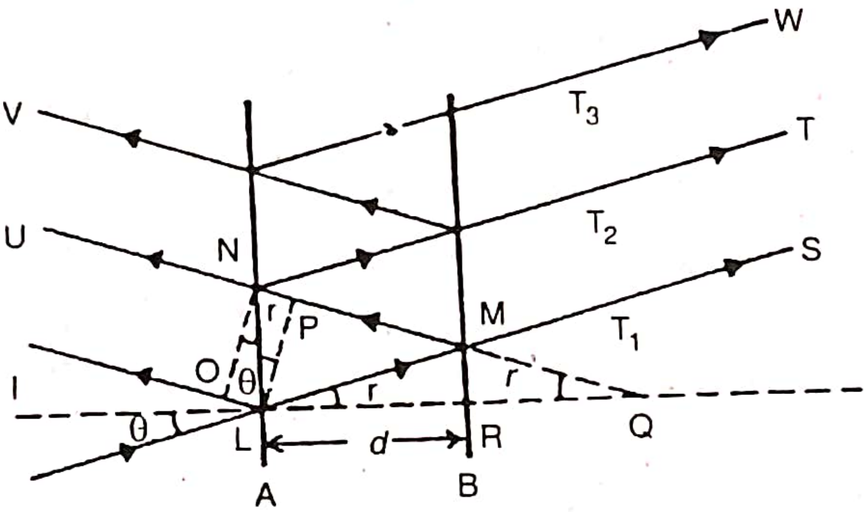

Fig. (12)

The condition for reinforcement of the transmitted rays is given by equation (4) with $\mu = 1$ for air and $r = \theta$, the angle of incidence, so that

$$\Delta = 2d\cos\theta \qquad ...(5)$$

which is the same as equation (1).