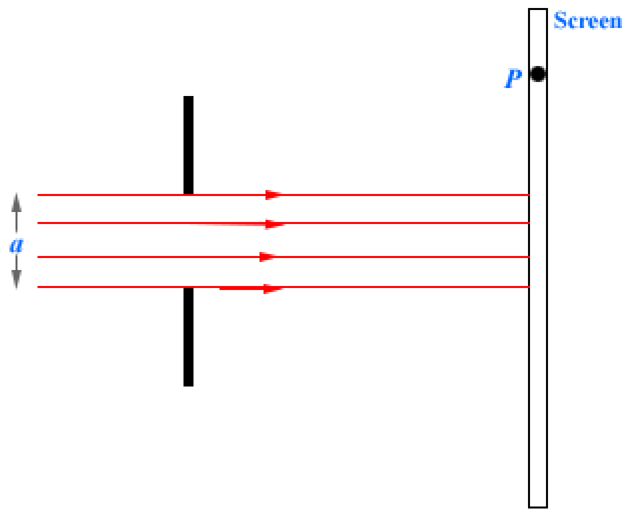
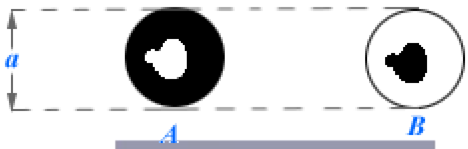
655.

<u>Problem 46.14 (RHK)</u>

A monochromatic beam of light is incident on a "*collimating*" *hole of diameter* a ? λ. *Point P lies in the geometrical shadow region on a distant screen, as shown in the figure. Two obstacles, shown in the figure below, are placed in turn over the collimating hole. A is an opaque circle with a hole in it and B is the* "*photographic negative*" *of A. Using the superposition concepts, we have to show that the intensity at P is identical for the two diffracting objects A and B* (*Babinet's principle*). *In this connection it can be shown that the diffraction pattern of a wire is that of a slit of equal width.*





Solution:

As the obstacles complement each other and when superimposed over each other will be identical with the circular hole of diameter a. We can thus imagine that the circular hole consists of superposition of A and B, as shown in the figure. Let the amplitude at P due to the holes A and B, when placed one by one at the position of the slit, be E_A and E_B, respectively. By the superposition principle the amplitude of the light wave at P due to the circular hole will be

$$E = E_A + E_B \ .$$

If the point P is the diffraction minima of the collimating hole, the amplitude E at P will be zero. This can happen only if

$$E_A = -E_B,$$

or

$$|E_A| = |E_B| \; .$$

As the intensity is proportional to the square modulus of the amplitude, the intensity at P due to the obstacle A will be equal to the intensity at P due to the complementary obstacle B. This property is known as the Babinet's principle.