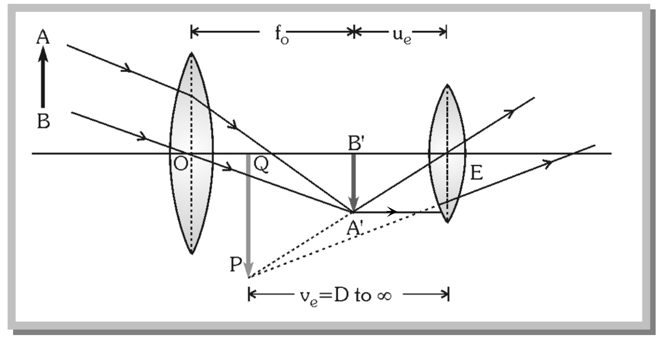
Telescope.

By telescope distant objects are seen.



(1) Astronomical telescope

(i) Used to see heavenly bodies.

(ii) $f_{\text{objective}} > f_{\text{eyelens}}$ and $d_{\text{objective}} > d_{\text{eye lens}}$.

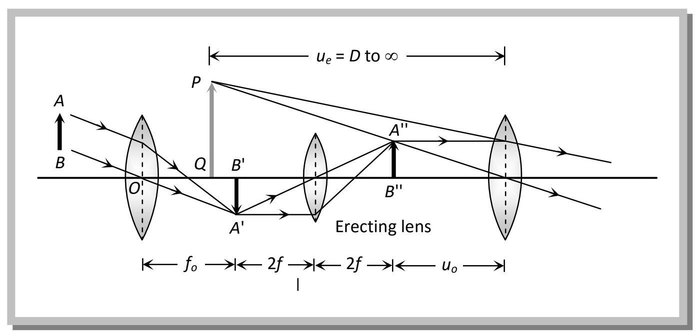
(iii) Intermediate image is real, inverted and small.

(iv) Final image is virtual, inverted and small.

(v) Magnification: $m_D = -\dfrac{f_0}{f_e}\left(1 + \dfrac{f_e}{D}\right)$ and $m_\infty = -\dfrac{f_o}{f_e}$

(vi) Length: $L_D = f_0 + u_e = f_0 + \dfrac{f_e D}{f_e + D}$ and $L_\infty = f_0 + f_e$

(2) Terrestrial telescope



(i) Used to see far off object on the earth.

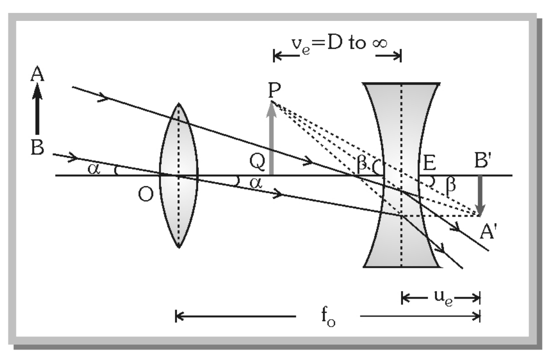
(ii) It consists of three converging lens: objective, eye lens and erecting lens.

(iii) Its final image is virtual erect and smaller.

(iv) Magnification: $m_D = \dfrac{f_0}{f_e}\left(1 + \dfrac{f_e}{D}\right)$ and $m_\infty = \dfrac{f_0}{f_e}$

(v) Length: $L_D = f_0 + 4f + u_e = f_0 + 4f + \dfrac{f_e D}{f_e + D}$ and $L_\infty = f_0 + 4f + f_e$

(3) Galilean telescope



(i) It is also a terrestrial telescope but of much smaller field of view.

(ii) Objective is a converging lens while eye lens is diverging lens.

(iii) Magnification: $m_D = \dfrac{f_0}{f_e}\left(1 - \dfrac{f_e}{D}\right)$ and $m_\infty = \dfrac{f_0}{f_e}$

(iv) Length: $L_D = f_0 - u_e$ and $L_\infty = f_0 - f_e$

(4) Resolving limit and resolving power

Smallest angular separations (dθ) between two distant objects, whose images are separated in the telescope is called resolving limit. So resolving limit $d\theta = \frac{1.22\lambda}{a}$

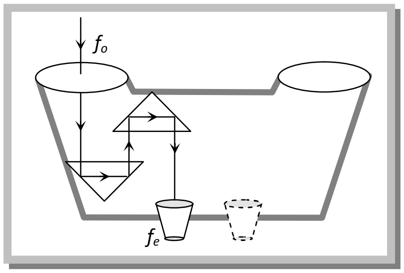
and resolving power $(RP) = \frac{1}{d\theta} = \frac{a}{1.22\lambda} \Rightarrow R.P. \propto \frac{1}{\lambda}$ where a = aperture of objective.

Note: Minimum separation (d) between objects, so they can just resolved by a telescope is – $d = \frac{r}{R.P.}$

Where r = distance of objects from telescope.

(5) Binocular

If two telescopes are mounted parallel to each other so that an object can be seen by both the eyes simultaneously, the arrangement is called 'binocular'. In a binocular, the length of each tube is reduced by using a set of totally reflecting prisms which provided intense, erect image free from lateral inversion. Through a binocular we get two images of the same object from different angles at same time. Their superposition gives the perception of depth also along with length and breadth, i.e., binocular vision gives proper three-dimensional (3D) image.

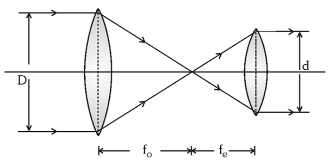


Concepts

As magnifying power is negative, the image seen in astronomical telescope is truly inverted, i.e., left is turned right with upside down simultaneously. However, as most of the astronomical objects are symmetrical this inversion does not affect the observations.

Objective and eye lens of a telescope are interchanged, it will not behave as a microscope but object appears very small.

In a telescope, if field and eye lenses are interchanged magnification will change from (fo / fe) to (fe / fo),

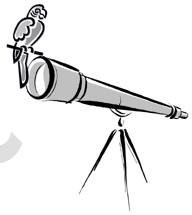


i.e., it will change from m to (1/m), i.e., will become (1/m2) times of its initial value.

As magnification for normal setting as (fo / fe), so to have large magnification, fo must be as large as practically possible and fe small. This is why in a telescope, objective is of large focal length while eye piece of small.

In a telescope, aperture of the field lens is made as large as practically possible to increase its resolving power as resolving power of a telescope ∝ (D/λ)*. Large aperture of objective also helps in improving the brightness of image by gathering more light from distant object. However, it increases aberrations particularly spherical.

For a telescope with increase in length of the tube, magnification decreases.



In case of a telescope if object and final image are at infinity then :

$$m = \frac{f_o}{f_e} = \frac{D}{d}$$

If we are given four convex lenses having focal lengths $f_1 > f_2 > f_3 > f_4$. For making a good telescope and microscope. We choose the following lenses respectively. Telescope $f_1(o), f_4(e)$ Microscope $f_4(o), f_3(e)$

If a parrot is sitting on the objective of a large telescope and we look towards (or take a photograph) of distant astronomical object (say moon) through it, the parrot will not be seen but the intensity of the image will be slightly reduced as the parrot will act as obstruction to light and will reduce the aperture of the objective.