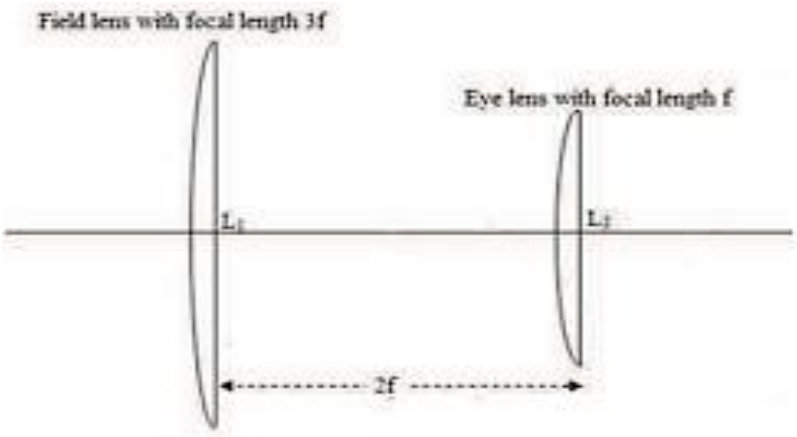
HUYGEN'S EYEPIECE

CONSTRUCTION

Huygens's eyepiece consist of a combination of two coaxial plano convex lenses having focal length in the ratio 3:1 separated by the distance between them is equal to the difference in their focal length. The focal length and the positions of the two lenses are such that the system is free from chromatic as well as spherical aberrations. The field and eye lenses are placed with their convex surface towards the incident ray.



Condition of Achromatism: For achromatism the distance d between two lenses should be

$$d = \frac{f_1 + f_2}{2}$$

In case of Huygen's eyepiece $f_1 = 3f$ and $f_2 = f$

$$\therefore \quad d = \frac{3f + f}{2} = 2f$$

This is the distance between field lens and eye lens. Hence Huygen's eyepiece is free from chromatic aberration

Condition for Minimum Spherical Aberration: The distance between the two lenses for minimum spherical aberration should be

$$d = f_1 - f_2$$

In case of Huygen's eyepiece $f_1 = 3f$ and $f_2 = f$

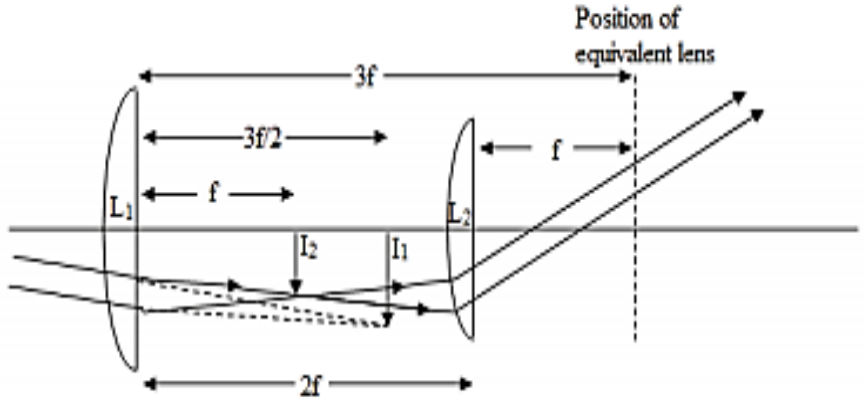
$$\therefore \quad d = 3f - f = 2f$$

This is the distance between field lens and eye lens in Huygen's eyepiece hence Huygen's eyepiece is free from spherical aberration.

WORKING

Like Ramsden's eyepiece when eye piece is adjusted for normal vision, the final image formed by it is at infinity. For this the image formed by the field lens should lies in the first focal plane of the eye lens i.e. at a distance f to the left of eye lens or at a distance f to the rigt of field lens as the distance between eye and field lens is 2f. The inverted image I_1 of a distant object, formed by objective, acts as an object for the field lens. This gives rise to a virtual image I_2. I_2 in turns serves as an object for the eye lens therefore it must be at distance equal to focal length f from eye lens to make final image at infinity.

For field lens if u is the distance of I_1 from the field lens, than from lens formula



$$\frac{1}{v}-\frac{1}{u}=\frac{1}{f}$$

Since here $v = f$ and $f = 3f$ we have

$$\frac{1}{f}-\frac{1}{u}=\frac{1}{3f} \quad or \quad \frac{1}{u}=\frac{1}{f}-\frac{1}{3f}=\frac{2}{3f} \quad or \quad u=\frac{3}{2}f$$

The positive sign indicates that image I_1 formed by field lens as well as image I_2 formed by objective lies on the same side, i.e., the field lens focused the rays at I_2 which otherwise would be focused at I_1 by objective. The rays coming from I_2 emerge from the eye lens as a parallel beam.

Equivalent focal length

Equivalent focal length of Huygen's eyepiece is given by,

$$1/F = 1/f_1 + 1/f_2 - d/f_1f_2$$

Here, $f_1=3f$, $f_2=f$ and $d= 2f$

$$1/F = 1/3f + 1/f - 2f/3f^2$$

or $1/F = 2/3f$

or $F = 3f/2$

When eye piece is adjusted for normal vision, the final image formed by it should be at infinity. For this, the image formed by the equivalent lens must be at infinity. .For this equivalent lens must be placed at a distance 3f/2 to the right of I_1 or at a distance f to the right of eye lens.

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COMPARISION OF RAMSDEN'S AND HUYGEN'S EYEPIECE

S.N.	Huygen's Eyepiece	Ramsden's Eyepiece
1.	Construction: a) Lens Type: Two planoconvex lenses made of same material with their convex side facing the incident light. b) Ratio of focal length of field lens and eye lens is 3:1. c) Distance between field lens and eye lens is 2f where f is focal length of eye lens.	Construction: a) Lens Type: Two planoconvex lenses made of same material with their convex side facing each other inwards. b) Ratio of focal length of field lens and eye lens is 1:1. c) Distance between field lens and eye lens is 2/3f where f is focal length of eye lens.
2.	Huygen's eyepiece is a negative eye piece as the image formed by objective lens of the instrument lies between field lens and eye lens.	Ramsden's eyepiece is a positive eye piece as the image formed by objective lens of the instrument lies in front of the field lens.
3.	In this eyepiece generally crosswire cannot be used. Cross wire if used is magnified by eye lens; while the image of the object is magnified by both field lens and eye lens hence magnification is different for two.	In this eyepiece generally crosswire can be used. Cross wire and the image of the object is magnified by both field lens and eye lens hence magnification is same for two.
4.	As the cross wires are put outside the eyepiece it involves no mechanical difficulty.	Cross wires if used has to be placed between the field lens and eye lens which causes mechanical difficulty to fit them.

5.	The condition for minimum spherical aberration ($d=f_1-f_2$) is completely satisfied.	The condition for minimum spherical aberration ($d=f_1-f_2$) is not satisfied. But it is reduced by using the planoconvex lenses with their convex surface facing each other.
6.	The condition for minimum chromatic aberration [$d = (f_1+f_2) / 2$] is completely satisfied. Therefore, can be used for white colour.	The condition for minimum chromatic aberration ($d= (f_1+f_2)/2$) is not satisfied. Therefore generally used for monochromatic (single) colour. Even if used for heterogeneous light measurement is made for a particular colour at a time.
7.	It exhibits other type of aberration like coma and distortion.	Other types of aberration are better eliminated. Coma is absent and distortion is less than Huygen's eyepiece.
8.	It is used for qualitative purposes in microscopes and telescopes.	It is used in microscopes and telescopes for accurate quantitative measurements.
9.	It cannot be used as a simple magnifier.	It can be used as a simple magnifier.

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