OG*o*I, BG*bi*. The second shows the progress of the axes of the different pencils proceeding through the centre of the object-glass. The focuses of this pencil of axes show the places where an image of the object-glass is formed ; and this field determines the field of vision, the apertures of the lenses, and the amplification or magnifying power. The three rays OGoI, OFEI, OHPI, form this figure.

See also fig. 24, where the progress of both sets of pen­cils is more diversified.

The perfection of a telescope is to represent an object in its proper shape, distinctly magnified, with a great field of vision, and sufficiently bright. But there are limits to all these qualities ; and an increase of one of them, for the most part, diminishes the rest. The brightness depends on the aperture of the object-glass, and will increase in the same proportion (because *iι'* will always be to AB in the proportion of EF to FO), till the diameter of the emergent pencil is equal to that of the pupil of the eye. Increasing the object glass any more, can send no more light into the eye. But we cannot make the emergent pencil nearly so large as this when the telescope magnifies much ; for the great aperture of the object glass produces an indistinct image at GF, and its indistinctness is magnified by the eye-glass.

A great field of vision is incompatible with the true shape of the object; for it is not strictly true that all rays flowing from O are refracted to I. Those rays which go to the margin of the eye-glass cross the axis between E and I ; and therefore they cross it at a greater angle than if they passed through I. Now had they really passed through I, the object would have been represented in its due proportions. Therefore, since the angles of the marginal parts are enlarged by the aberration of the eye-glass, the marginal parts them­selves will appear enlarged, or the object appear distorted. Thus a chess-board viewed through a reading glass appears drawn out at the corners, and the straight lines are all changed into curves, as is represented in fig. 17.

The circumstance which most peremptorily limits the extent of field is the necessary distinctness. If the vision be indistinct, it is useless, and no other quality can com­pensate this defect. The distortion is very inconsiderable in much larger angles of vision than we can admit, and is unworthy of the attention paid to it by optical writers. They have been induced to take notice of it, because the means of correcting it in a considerable degree are attain­able, and afford an opportunity of exhibiting their know­ledge; whereas the indistinctness which accompanies a large field is a subject of most difficult discussion, and has hither­to baffled all their efforts to express it by any intelligible or manageable formulæ.

This subject must however be considered. The image at GF of a very remote object is not a plain surface per­pendicular to the axis of the telescope, but is nearly sphe­rical, having O for its centre. If a number of pencils of parallel rays crossing each other in I fall on the eye-glass, they will term a picture on the opposite side, in the focus **F.** But this picture will by no means be flat, nor nearly so, but very concave towards E. Its exact form is of most difficult investigation. The elements of it are given by Dr Barrow ; and we have given the chief of them in the article Optics, when considering the foci of infinitely slender pencils of oblique rays. Therefore it is impossible that the picture formed by the object-glass can be seen distinctly in all its parts by the eye-glass. Even if it were flat, the points G and II (fig. 16) are too far from the eye-glass when the middle F is at the proper distance for distinct vision. When, therefore, the telescope is so adjusted that **we** have distinct vision of the middle of the field, in order to see the margin distinctly we must push in the eye-glass : and having so done, the middle of the field becomes indis­tinct. When the field of vision exceeds twelve or fifteen degrees, it is not possible by any contrivance to make it tolerably distinct all over ; and we must turn the telescope successively to the different parts of the field that we may see them agreeably.

The cause of this indistinctness is, as we have already said, the shortness of the lateral foci of lateral and oblique pencils refracted by the eye-glass. The oblique pencil *bGa,* by which an eye placed at I sees the point G of the image, is a cone of light, having a circular base on the eye-glass, of which circle *ab* is one of the diameters. There is a diameter perpendicular to this, which, in this figure, is represented by the point o. Fig. 18 represents the base of the cone as seen by an eye placed in the axis of the telescope, with the object-glass as appearing behind it. The point *b* is formed by a ray which comes from the lowest point B of the object glass, and the point *a* is illuminated by a ray from A. The point *c* at the right hand of the circular base of this cone of light came from the point C on the left side of the object-glass; and the light comes to *d* from D. Now the laws of optics demonstrate, that the rays which come through the points *c* and *d* are more con­vergent after refraction than the rays which come through *a* and *b.* The analogies, therefore, which ascertain the foci of rays lying in planes passing through the axis, do not de­termine the foci of the others. Of this we may be sensible by looking through a lens to a figure on which are drawn concentric circles crossed by radii. When the telescope is so adjusted that we see distinctly the extremity of one of the radii, we shall not see distinctly the circumference which crosses the extremity with equal distinctness, and *vice versa.* This difference, however, between the foci of the rays which come through *a* and *b,* and those which come through c and *d,* is not considerable in the fields of vision which are otherwise admissible. But the same dif­ference of foci obtains also with respect to the dispersion of light, and is more remarkable. Both D’Alembert and Euler have attempted to introduce it into their formulæ ; but they have made them useless for any practical purpose by their inextricable complication.

This must serve ns *a* general indication of the difficul­ties which occur in the construction of telescopes, even al­though the object-glass were perfect, forming an image without the smallest confusion or distortion.

There is yet another difficulty or imperfection. The rays of the pencil *aGb* (fig. 16), when refracted through the eye-glass, are also separated into their component colours. The edge of the lens must evidently perform the office of a prism, and the white ray *Gb* will be so dispersed, that if *bi* be the path of its red ray, the violet ray, which makes an­other part of it, will take such a course *bn* that the angle *ibn* will be nearly 1/27th of *G'bi'.* The ray *Ga* passing through a part of the lens whose surfaces are less inclined to each other, will be less refracted, and will be less dispersed in the same proportion very nearly. Therefore the two violet rays will be very nearly parallel when the two red rays are rendered parallel.

Hence it must happen that the object will appear bor­dered with coloured fringes. A black line seen near the margin on a white ground, will have a ruddy and orange border on the outside, and a blue border within : and this confusion is altogether independent on the object-glass, and is so much the greater as the visual angle *b*IE is greater.

Such are the difficulties. They would be unsurmountable, were it not that some of them are so connected that, to a certain extent, the diminution of one is accompanied