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 coiners, and the ſtraight lines are all changed into curves, as is repreſented in fig. 13.

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 cor­rection; 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 by any intelligible or manageable formula:..

*Quaeque tractata nitescere poſſe*

*Deſperat relinquit.*

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 form 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 H (fig. II.) 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 fee 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 12 or 15 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. We have ſhown (in Optics, n⁰ 252) how to determine theſe in all the cases which occur. But the determination is not complete, and relates only to thoſe rays which are in a plane passing through the axis of the lens. But the oblique pencil *b*G*a,* 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.* 12. repreſents the baſe of the cone as ſeen by an eye placed in the axis of the teleſeope, 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 thro' 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 teleſeope 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 as 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 aG*b,* 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 G*b* 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 i'*bn w*ill be nearly 1/27th of G*b'i'.* 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 contuſion 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 by a diminution of the other. Our readers will recollect, that in the article Optics we gave ſome account of what are called the *Caustic curves* (Optics n⁰ 252), and ſhowed that theſe curves are the geometrical loci of the foci of infinitely ſlen­der pencils. Conſequently the point G is very nearly in the cauſtic formed by a beam of light consiſting of rays pa­rallel to Io*,* and occupying the whole ſurface of the eye- glass, becauſe the pencil of rays which are collected at G is very ſmall. Any thing therefore that diminiſhes the mutual inclination of the adjoining rays, puts their concourſe farther off. Now this is preciſely what we want : for the point G of the image formed by the object glaſs is already beyond the focus of the oblique ſlender pencil of parallel rays ia and i*b* ; and, therefore, if we could make this focus go a little farther from *a* and *b,* we ſhall bring it nearer to G, and ob­tain more diſtinct viſion of this point of the object. Now