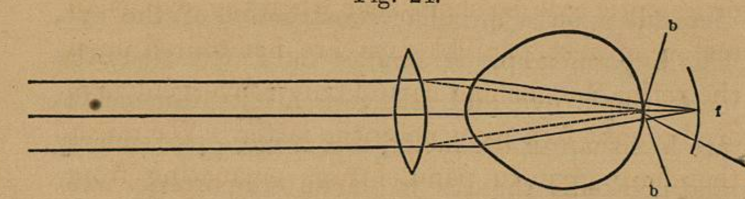
too long, so that when the eye is in a state of rest the focus of the dioptric system lies in front of the retina, and parallel rays (emanating from objects at an infinite distance) are brought to a focus before the retina, and only more or less divergent rays are united upon the latter, Fig. 11, p. 27.

Now, in hypermetropia we have just the reverse of this. The refractive power of the eye is so low, or its optic axis so short, that when the eye is in a state of rest, parallel rays are not united upon the retina, but behind it, and only convergent rays are brought to a focus upon the latter. We must, therefore, give to parallel rays emanating from distant objects a convergent direction by means of a convex glass, and the reader will now see how it is that a hypermetropic eye requires convex glasses for seeing distant objects. The patient may require perhaps even a stronger pair for near objects. The consequence of this low refractive power of the eye is, that whereas the normal eye unites parallel rays upon its retina without any accommodative effort, the hypermetropic eye has already, in order to do so, to exert its accommodation more or less considerably, according to the amount of hypermetropia. This exertion increases, of course, in direct ratio with the proximity of the object. If the degree of

hypermetropia is moderate, and the power of accommodation good, no particular annoyance is perhaps experienced, even in reading or writing. If, however, the hypermetropia is absolute, the patient will not be able to see well at any point.

Fig. 24 represents a hypermetropic eye, in which, either on account of its being too short in

Fig. 24.



the antero-posterior axis or its possessing too low a power of refraction, parallel rays are not brought to a focus upon the retina (r), but behind it at f; circles of diffusion (b b) are formed upon the retina, and the object consequently appears blurred and indistinct. To remedy this the eye undergoes a change in accommodation, so as to increase its power of refraction sufficiently to unite the parallel rays at r. The less the power of refraction of the hypermetropic eye, the greater must this effort of the accommodation be, and it must increase, of course, proportionately as the object is brought nearer to the eye. By placing a suitable convex lens before the eye, the parallel rays are rendered so convergent that they are united upon the retina (r) without any effort of accommodation, and we thus place the hypermetropic in the same condition as the normal eye, upon whose retina parallel rays are brought to a focus without any effort of accommodation.

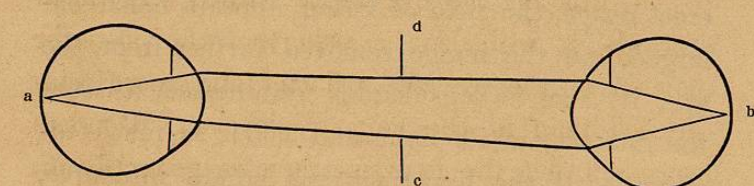
It will be found that this condition generally depends upon a peculiar construction of the eye. The hypermetropic is smaller and flatter than the emmetropic eye, and although all its dimensions are less than in the latter, this is more particularly and markedly the case in the antero-posterior axis. The eye does not appear to properly fill out the palpebral aperture, but a little space may be observed between the outer canthus and the eyeball. Upon directing the eye to be turned very much inwards, it will also be seen that the posterior portion of the eyeball is flatter and more compressed than in the emmetropic eye. Donders considers that the hypermetropic is generally an imperfectly developed eye, that the expansion of the retina is less, and that there is a smaller optic nerve with a less number of fibres. He thinks, moreover, that in hypermetropia there often exists a typical form of face, chiefly dependent upon the shallowness of the orbit, which lends a peculiar

flatness to the physiognomy. The hypermetropic construction of the eyeball is congenital, and often hereditary.

The ophthalmoscope also enables us to diagnose a hypermetropic eye, but in this case just the reverse obtains to what was seen in the myopic eye. (Page 68.)

I. The fundus may also in this case be seen in the erect image at a considerable distance, but we obtain an erect image of it (and not as in myopia a reverse image), for if we regard the optic nerve, or one of the retinal vessels, and move our head to one side, we find that the image *moves in the same direction.* For an explanation of this let us glance at Fig. 25.

Fig. 25.



Let a be the hypermetropic eye, b the eye of the observer; a is adjusted for its far point (convergent rays), and the rays reflected from its background will, consequently, emanate from it in a divergent direction, as if they came from a point behind the retina, and they must, therefore, also fall in a divergent direction upon the eye of the observer. If the latter is myopic (adjusted for divergent rays) the rays will be united upon his retina without the aid of any correcting lens behind the ophthalmoscope. But, if his eye is emmetropic (adjusted when in a state of rest, for parallel rays), he will either have to place a convex lens behind the mirror, or have to accommodate for a nearer point. The strongest convex lens with which the details of the fundus can still be seen in the erect image, affords us a relative estimate of the degree of existing hypermetropia.

The image of the observed eye will be erect, for *c* and *d* retain their relative positions.

II. On going closer, but still examining in the erect image, the field of vision appears much enlarged, and the image removed further from the eye, its size is considerably diminished, whereas the intensity of its light and colour is much increased. If the hypermetropia is high in degree, we can overlook at a glance not only the whole optic entrance, but also a considerable portion of the fundus around it. If our eye is emmetropic, we must, in order to gain a distinct image, either place a strong convex lens behind the mirror, or else we must accommodate for a nearer point.

In the indirect mode of examination the size of the optic disc will appear much larger than in the emmetropic eye, which is due to its image being formed further from the object lens.

The ophthalmoscopic diagnosis of hypermetropia is frequently of much service, especially in young children affected with strabismus, the state of whose refraction we wish to ascertain, but who are too young to read. Again, in spasm of the ciliary muscle dependent upon hypermetropia, the latter may be so completely masked that the patient can only see at a distance with slightly concave glasses, and not at all with convex ones. We hence, perhaps, believe it to be a case of myopia, but on ophthalmoscopic examination we find that the refraction is markedly hypermetropic. In such cases the patient should, however, look at some distant object or into vacant space, so that his accommodation may be quite relaxed. We may notice in such patients how the ophthalmoscopic appearances vary when the accommodation is relaxed, and when it is called into action by their regarding some near object.

We must distinguish various forms of hypermetropia, and in our classification of these we shall follow Donders' system.

We may, in the first place, divide hypermetropia into two primary classes, the original and the acquired.

The latter is met with in old persons in whom the eye has undergone senile changes. When speaking of presbyopia, we saw that the near point begins to recede from the eye at about the tenth year, and that this recession continues uninterruptedly to advanced age. The far point remains stationary till about the age of forty or forty-five, when it gradually recedes from the eye; at the age of fifty-five or sixty, this is distinctly evident in the emmetropic eye, for it has then become hypermetropic, and a convex glass is necessary for distinct vision of distant objects. This, however, varies greatly in different individuals. At seventy or eighty years of age, the hypermetropia often equals $\frac{1}{24}$. This recession of the far point—this diminution of the refractive power of the eye—is evidently due to senile changes in the structure of the lens, which, with advancing years, becomes firmer and more consistent, and its surface somewhat flatter.

Absence of the crystalline lens will also, of course, give rise to very considerable acquired hypermetropia.

Original hypermetropia may be subdivided into manifest (Hm) and latent (Hl).

In order to determine the presence of hypermetropia, we direct the patient to read No. XX at a distance of 20 feet. Let us suppose that he can do so with ease; we then find the strongest convex glass with which he can still see clearly and distinctly, and this gives us the degree of *manifest* hypermetropia. If convex 20 is the strongest glass with which he can read No. XX distinctly (convex 18 making the sight worse), $Hm = \frac{1}{20}$.

Each eye should be tried separately, as the degree of hypermetropia may vary. The patient is next directed to read very small print with this glass, and if we find that he can read No. 1 clearly and distinctly as close as 5″ to 6″ from the eye, we know that his range of accommodation is also good. The position of the near point, and the extent of the range of accommodation, will, of course, vary with the age of the patient.

But although convex 20 may be the strongest glass with which he can see at a distance, the degree of hypermetropia may in reality be very much higher than $\frac{1}{20}$. The fact being, that the patient has been so accustomed to exert his accommodation (even when regarding distant objects), that he cannot relax it all at once, even when there is no occasion for it, the malconstruction of the eye being compensated for by a convex lens. To find the real degree of hypermetropia, we must therefore paralyse his accommodation by a strong solution of atropine (gr. iv ad ℥j). This should be allowed to act for two or three hours. At the end of this time we again examine the patient, and now, perhaps, find that he cannot see No. 20 at all at 20′ without glasses, or even with convex 20. To do so distinctly he, perhaps, requires convex 8; and this difference in the power of the glasses required before and after the paralysis of the ciliary muscle, shows us to what an extent he exerted his accommodation before the application of the atropine. But this great difference only exists in young persons, with a good range of accommodation. The atropine should be only applied to one eye at a time. Its effect goes off in about six or seven days. But as it greatly dims the sight, it should only be applied in those cases in which it is of importance to know precisely the amount of latent hypermetropia. Slight degrees of hypermetropia are often unnoticed till the age of twenty or twenty-five, when symptoms of asthenopia begin to show themselves if the patient is obliged to work for any length of time at near objects. Our suspicion is aroused by these symptoms, and on placing a convex glass before his eyes, we find

that he can distinguish distant objects far better than without it. If the glasses be only momentarily held before the eyes, the existence of hypermetropia may escape us, for the patient has been so accustomed to exercise his power of accommodation even for distant objects, that he cannot at once relax it. But if he continues to look through the glasses for a few minutes, he gradually finds that the distant objects become more and more distinct, and clearly defined. In order to make sure to what degree the hypermetropia exists, and to what extent the person is obliged to exercise his accommodation in looking at distant objects, we must paralyse his power of accommodation by the instillation of a strong solution of atropine.

This brings us to Donders' next division of manifest hypermetropia, into the *facultative*, *relative*, and *absolute*.

In *facultative* hypermetropia, the patient is able to see well (with parallel optic axes) at an infinite distance with or without the aid of convex glasses, and his sight is generally sufficiently acute to enable him to read small print and to work at fine objects. We often find that such persons, whilst young, complain of no fatigue during work, but that presbyopia sets in more early than in emmetropia, and then symptoms of asthenopia soon manifest themselves. We must distinguish this form of facultative hypermetropia from that which was formerly distinguished by that name by Donders. We, namely, sometimes meet with emmetropic eyes which not only see perfectly near at hand and at a distance, but which are capable of relaxing their power of accommodation to such an extent, that they can unite convergent rays upon the retina, for they are able to see at a distance with slightly convex glasses.

In *relative* hypermetropia, the eye may also be able to accommodate itself either for parallel or for divergent rays, and see well both at a distance and near at hand; but it can only do so by converging the optic axes for a nearer point than that at which the object is situated; by acquiring, in fact, a periodic convergent squint. This is not of very frequent occurrence in childhood, but is more often met with after the age of puberty and in early manhood. The sight is always more or less affected, and the patient has a difficulty in finding the exact distance at which he can see best.

In *absolute hypermetropia* vision is indistinct both for infinite distance and for near objects; for the patient cannot unite the rays upon the retina even with the strongest effort of accommodation or with the strongest convergence of the optic

axes. The focus of both divergent and parallel rays remains situated behind the retina. It is not often met with in youthful individuals, as they generally possess a sufficiently strong power of accommodation to overcome it. In a superficial examination such a patient might be mistaken for a person suffering from myopia with amblyopia, for he will not be able to see distinctly at a distance without glasses, which may be erroneously attributed to myopia, nor will he be able to read very fine print, and this may be supposed to be due to amblyopia.

It is a curious fact, that when the hypermetropia is considerable, the patient can often read better when the print is only a short distance from the eye than when it is 10″ or 12″ off. Von Graefe thinks this is due partly to the diminution in the size of the pupil which takes place on looking at small objects, for the area of the pupil being smaller, some of the peripheral rays are cut off, and there is consequently a diminution in the circles of diffusion on the retina. He has also shown that on approximating an object to the eye, the circles of diffusion on the retina in a hypermetropic eye increase comparatively less in size than the size of the retinal images. In consequence of this, there is more chance of interspaces between the letters when the print is held at a distance of 5″ or 6″, than at 10″ or 12″. At the latter distance, there would not be so much difference between the size of the retinal images and the circles of diffusion, so that the letters would appear more confused and indistinct. But, besides these reasons, the greater amount of convergence, and consequent increase in the action of the power of accommodation, has most likely some influence in enabling the patient to see better at a distance of 5″ or 6″.

We have already seen that the near point recedes from the eye with advancing years, that at the age of forty-five it is about 9″ or 10″ from the eye, and we followed Donders in considering presbyopia to commence when the near point was removed further than 8″ from the eye. A hypermetropic eye may, therefore, at a certain age become presbyopic; or again, an originally normal eye may become presbyopic at the age of forty-five, and hypermetropic at fifty or sixty, so that we may have presbyopia and hypermetropia co-existing in the same eye. If, with the glasses which neutralise his hypermetropia, a hypermetropic patient cannot read very small print nearer than 12″ to 14″ from the eye, he is also presbyopic. He may, therefore, require a double set of glasses, one pair for distance and a stronger pair for reading.

The range of accommodation of a hypermetropic eye is easily found. We must first change it into a normal eye by furnishing it with that convex glass which will enable it to see distant objects distinctly without almost any exercise of the accommodation; and then, it still wearing this glass, find the nearest point at which it can read No. 1 distinctly and easily. If the patient requires for distant vision convex 20 before the instillation of atropine, and convex 10 after it, we should try his nearest point with a glass between the two—No. 16 for instance, for No. 10 would be too strong. He has been so accustomed to strain his accommodation that he cannot all at once really command his near point with convex 10.

Let us now suppose that with convex 16 his near point (p) lies at 7″; his far point (r) has been found to be at an infinite distance (∞); for he can see distant objects well with convex 16 without much effort, although convex 20 is best. The range of accommodation $\frac{1}{A}$ is to be found by the formula $\frac{1}{A}=\frac{1}{P}-\frac{1}{R}$. Now, $p = 7''$, $r = \infty$, hence $\frac{1}{A}=\frac{1}{7}-\frac{1}{\infty}=\frac{1}{7}$. The range of accommodation $=\frac{1}{7}$.