AN
INTRODUCTION TO THE STUDY
OF THE
Optical Defects of the Eye,
AND
THEIR TREATMENT
BY THE
SCIENTIFIC USE OF SPECTACLES.

BY
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TORONTO.

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BY A. M. ROSEBRUGH, M.D.

(Read before the Canadian Institute, February 3rd, 1866.*)*

The following pages were written as an introduction to a course of lectures recently delivered by me on the diseases of the eye. I have not thought it necessary to alter the form, as I propose publishing them as a pamphlet, hoping that they may be useful, not only to the members of my ophthalmic class, but to Canadian medical students generally.

In their preparation, I must here acknowledge my indebtedness to the elaborate works of Mr. J. Z. Laurence and Mr. J. Soelberg Wells, of London, and especially to the very comprehensive treatise of Professor Donders, of Utrecht, published in 1864 by the New Sydenham Society.

CHAPTER I.—OPTICAL CONSIDERATIONS.

The eye is pre-eminently an optical instrument, and the phenomena of vision all depend upon the laws of optics. Hence, a knowledge of some, at least, of the elementary principles of light is essential to a correct appreciation of the physiology of the eye. The diagnosing of optical defects of the eye,—long and short sight, &c. &c., and their treatment with the scientific use of spectacles, require some knowledge of the laws of refraction, and the properties of convex and concave lenses.

The philosophy of the ophthalmoscope can hardly be understood unless the principles of both refraction and reflection are thoroughly mastered.

You will therefore, I hope, not consider the time ill spent if, before proceeding with the investigation of diseases of the eye—you review with me some of the elementary principles of optics which lie at the foundation of all ophthalmic science.

The *nature* of light is not known. I can no more tell you what light is, than your professor of physiology can tell you what life is. We know that the sun shines, but how it shines we cannot tell.

"Two different theories have been advanced of the more intimate nature of light." "One, the *Newtonian* (*corpuscular*) conceives that each luminous point is constantly giving off a succession of luminous corpuscles which follow each other in uninterrupted succession on an imaginary line or axis like a string of beads on a rigid thread."

The *undulatory* theory (Christian Huychens') on the other hand considers space as pervaded by a subtle gaseous fluid or ether; that luminous bodies have the power of communicating to this ether a wave motion which affects the retina the same as vibrations of the air affect the auditory nerve.

Sir John Herschel, speaking of the great ingenuity of the undulatory theory says, "if it is not true it deserves to be."

The sun is the great natural source of light; as it shines by its own light it is called *self-luminous.* The fixed stars are also self-luminous; so is a lighted lamp and bodies in a state of ignition. But most bodies by which we are surrounded, are seen only by reflected light The light from an object seen by moonlight is reflected twice before it reaches the eye. The moon reflects the light from the sun, and the object, the light which it receives from the moon.

Every luminous object gives off, or radiates, in every direction, an infinite number of straight lines of light. Each of these lines taken alone is called a *ray* of light. A bundle of rays is called a *beam* of light when the rays run *parellel* to each other. When the rays *diverge* from a luminous point or are made to *converge* to a focus they are called a *pencil* of rays, thus :

Fig. 1 represents a pencil of rays diverging from a flame F, after passing a convex lens they are rendered parallel and these parallel rays passing the second convex lens B, the rays are converged to the point (focus) P.

The parallel rays may be called a *parallel* pencil; the diverging rays a *divergent* pencil, and the convergent rays a *convergent* pencil. The point where rays of light meet is called the *focal* point or simply a *focus.*

Strictly speaking, there is no such thing in nature as parallel rays; the nearest approach we have to it are the rays of light we receive from the sun and the fixed stars. Practically, for our purpose however, we may consider rays of light parallel that are received by the pupil of the eye from objects that are twenty feet distant or any distance greater than that. Pencils of light from objects less than twenty feet distant are more decidedly divergent.

A good illustration of a divergent pencil can be obtained from a lighted lamp or candle in a dark room. If a piece of card board, with a small circular opening in it, be held near the lamp, you will have, upon the opposite wall, an illuminated spot of the same shape as the opening in the card, but very much larger.

This will prove not only that the rays *diverge*, but also that the rays proceed in straight lines.*

Convex lenses :—We shall now proceed to the consideration of convex lenses, which, for our purpose, is the most important part of the subject. Lenses are made of various transparent substances as amber, alum, quartz, glass, diamond, and even of ice. Those in ordinary use are made of glass. When the two surfaces of a convex lens have the same degree of curvature, the lens is said to be equi-convex. When one of the surfaces is flat or plane, the lens is called a plano-convex lens. Glass spectacles used by old persons for reading, &c., are commonly made double convex.

In order to simplify the subject as much as possible, let us confine our attention to lenses that are equi-convex.


FIG 2

In fig. 2 let A be the centre of the circle B, C, D, of which A, B, is the radius, and let E be the centre of the circle F, G, H, of which the radius E, F, is equal to the radius A, B. The circle F, G, H, will be equal to the circle B, C, D. The part D,H, common to both circles, represent a section of an equi-convex lens. The line A,E, is called the *axis* of the lens, and the line D, H is called the *diameter*. The centre of the diameter (where it is intersected by the axis) is the optical centre of the lens.

Reading glasses, and burning glasses, are examples of a double convex lens. Many of you have, doubtless, seen the experiment of

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(* Convergent pencils of light do not exist in nature. Parallel pencils or divergent pencils of rays can be rendered convergent by means of a convex lens. Thus in fig. 1, the rays diverging from F, are made to *converge* to P by the convex lenses, A. and B.)

setting fire to wood, paper, &c., by means of a burning or sun glass. The explanation of this is simply that the convex lens possesses the property of converging a portion of the sun's rays to a point called the focus.

In Fig. 3, P, P, represent a pencil of parallel rays converged to a focus at F by means of the double convex lens, L.

The focus for parallel rays is called the *principal* focus. It is always the same distance from the optical centre in the same lens. The length of the focus for parallel rays is, in equi-convex lenses, equal to the length of the radius of curvature.

The shorter the focus, the greater is the "power" or "strength" of the lens. A lens that can bring parallel rays to a focus at a distance of one inch from the optical centre of the lens, would be called a *one inch* lens. Another lens whose focus is two inches from the optical centre, is called a *two inch* lens, and so on. Convex lenses therefore receive their names according to the number of inches or fraction of an inch, the principal focus is distant from the centre of the lens. The strongest lenses used for spectacles are what are called cataract glasses; they are worn by patients who have had their crystaline lenses removed. Their strength ranges from 2 to 4 inches focal length. The weakest spectacles that are ordinarily used have a focus of 36 inches. Convex lenses having a focus of 36 inches do not enlarge the letters of a book at the ordinary reading distance.

Let us now see what practical application we can make of this principle of convex lenses.

Supposing that a person accustomed to using convex spectacles, gets one of the glasses broken, and applies to you to learn the strength of the glass that would be necessary to replace the broken one, or in other words—to learn the strength of the glass that is still whole. How would you proceed? One method is to use the lens as a sun glass, and ascertain by measurement, how far from the glass, the sun's rays are brought to a focus. If you find, for instance, that the focus is 10 inches from the lens, you will have ascertained that the person has been wearing glasses of 10 inch focus, or as they are sometimes called No. 10 convex, or simply + 10 (plus 10).

The method, however, that is usually adopted, depends upon a property of convex lenses that will be more fully explained further on.

If, for instance, you hold up a 10 inch convex lens at a distance of 10 inches from a white wall—the wall being about 20 feet from an open window, opposite—there will appear, behind the lens, upon the wall, an inverted, miniature picture of the window, and trees or buildings, &c., in front of the window. If the lens be held at a greater or less distance from the wall than the focal length of the lens, the inverted picture will be indistinct. Measuring the distance therefore that the lens must be held from the wall, to produce the sharpest picture, will give the focal length of the lens.

Suppose, now, that we bring the lens to within, say 5 feet of the window, and hold a sheet of white paper at the principal focal distance behind the lens, viz., at ten inches, we will find a change in the inverted picture, there will still appear distant buildings, trees, &c. but the sash of the window will be very indistinct. If, however, we move the sheet of paper 12 inches from the lens—that is, two inches farther from the lens, we will again see the image of the sash but scarcely any trace of the buildings, trees, &c. This experiment is an illustration of the fact that the nearer an object approaches the front of a convex lens, the farther will be its image behind the lens; thus, when an object is 5 feet or rather 60 inches from the front of a 10 inch convex lens, the inverted image is found to be 12 inches behind the lens; when 30 inches, it will be 15 in.; when 20, that is, double the length of the focus, the image will be double the length of the focus behind the lens; viz., 20 inches; when 15 inches, the image behind the lens will be removed to 30 inches. As the object approaches the principal focal distance of the lens the image recedes much more rapidly; thus when at 12 inches, the image will be 60 inches; when at 11, the image will be 110 inches behind the lens. When however we bring the object to within 10 inches of the lens—that is, at its principal focus there will be no image formed behind the lens, as the rays after passing the lens will be parallel.

(I would strongly urge you, gentlemen, to perform all these experiments for yourselves, as in that way only can you become familiar with these important principles. These latter experiments can be performed best in a dark room—taking for an object the flame of lamp or candle).

From the above we can easily understand the principle, [illegible], that the *less* divergent the rays of a pencil (that is, the nearer they approach parallel rays,) incident or falling upon a convex lens, the nearer will the focus of the convergent pencil be to the principal focus of the lens. 2nd. The *more* divergent the incident pencil, the less convergent (the more nearly parallel) will be the refracted pencil, and the more distant will its focus be from the principal focus of the lens.

Questions of the following nature very often arise in optics, viz., the length of the principal focus of a convex lens being given, and the distance a certain object is in front of it;—to find how far behind the lens will be the inverted image of the object. Or to express it more technically, the length of the principal focus of a convex lens being given and the length of the divergent incident pencil, to find the length of the focus of convergent refracted pencil. Thus: Suppose you had the following question: A 10 inch lens is 60 inches from an object; how far behind the lens will be the inverted image?

This could be solved immediately, by actual trial, and measurement, but this is not always practical.

The rule given in some text books on optics is as follows: multiply the length of the divergent incident pencil, that is, the distance the object is from the lens, by the focal length of the lens, and divide by the difference; thus: $60\times10=600$, $60-10=50$, 600 divided by $50=12$; or $\frac{60\times10}{60-10}=\frac{600}{50}=12=$ the distance behind the lens.

There is another property of convex lenses which I must not omit to mention; namely, what is called it magnifying power.

When a convex lens is placed between the eye and an object,—the object being at a less distance from the lens than its principle focus, the object will appear enlarged or magnified. The shorter the focus of the lens, the greater is its magnifying power. Thus, a 4 inch lens has a greater magnifying power than an 8 inch lens; a 2 inch lens greater than a 4, and a 1 inch greater than a 2 inch lens. The 1 inch lens has, in fact, double the magnifying power of a 2 inch lens; a 2, double that of 4 inch; a 4 inch, double that of an 8 inch, &c.

The "power" of a lens is therefore inversely proportional to its focal length. For this reason a different form is used in expressing the "power" or strength of a lens. A 1 inch lens is taken as unity, and as a 2 inch lens is just half the strength, it is simply expresed $\frac{1}{2}$, and as a 3 inch lens has just one-third the strength of a 1 inch, it is written $\frac{1}{3}$; a 4 inch is $\frac{1}{4}$ &c. We will find that this nomenclature is not only very convenient, but scientifically correct.

For example, suppose we have two lenses of 4 inch focus each, and we wish to know their combined "power" when used as one lens; we simply add their reciprocals thus $\frac{1}{4}+\frac{1}{4}=\frac{2}{4}=\frac{1}{2}$. The two lenses have, therefore, the magnifying power of $\frac{1}{2}$, which is the reciprocal of 2, and are consequently, together, equal to a 2 inch lens, which can be proved by actual measurement. Again, suppose we have a 6 inch lens, and a 12 inch lens, and we wish to know their combined strength, $\frac{1}{6}+\frac{1}{12}=\frac{3}{12}=\frac{1}{4}$ which represents the power of a 4 inch lens; the 6 and the 12 inch lenses taken together being equal to one lens having a focus of 4 inches.

To save repetition, I may here state that when a *concave* lens enters into combination with a *convex* lens, it has a neutralizing effect upon the convex lens. If we have a convex 6 and a concave 6 the one would neutralize the other,—thus $\frac{1}{6}-\frac{1}{6}=0$. But if the convex lens has the higher power, the concave lens simply weakens it—that is, lengthens its focus—thus, if we have a convex 6 and a concave 9 the result will be $\frac{1}{6}-\frac{1}{9}=\frac{3}{18}-\frac{2}{18}=\frac{1}{18}$, which represents the strength of one lens having a focus of 18 inches. If, however, the concave lens has the higher "power" it will simply be weakened by the concave lens,—the combination will be equal to a concave lens having a lower "power," or a longer focus than the concave lens taken,—thus reversing the last example, suppose we have a *concave* 6 and a *convex* 9, we will then have $-\frac{1}{6}+\frac{1}{9}$ or simply $\frac{1}{9}-\frac{1}{6}=\frac{2}{18}-\frac{3}{18}=-\frac{1}{18}$, which represents the strength of a *concave* lens having a focus of 18 inches.

This fractional nomenclature (taking 1 for numerator and the focal length of the lens for denominator) will assist us also in understanding the principle of the formation of images at different distances behind a convex lens, according to the distance of objects in front of it.

Let me remind you that when an object, for instance the flame of a candle, is placed in the focus of a convex lens, the diverging rays of light from the object are rendered parallel by the lens. Thus, a lens having a focus of 20 inches will render parallel pencils of light diverging from an object 20 inches from the lens. Bearing this in mind let us again try the solution of the following question, pro-

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pounded not long since, viz.:—When an object is 60 inches in front of a 10 inch convex lens, how far behind the lens will be the inverted image of the object? Or, to express it differently, when a divergent pencil of light emanates from a point 60 inches from a 10 inch convex lens, at what distance behind the lens will the pencil be converged to a focus?

Now, we know that a lens of 60 inches focus, placed in the position of the 10 inch lens, would render the rays parallel that fall upon it from the object 60 inches distant. Were it possible, therefore, to divide the 10 inch lens into two lenses, one having a focus of 60 inches to render the rays parallel, the remaining portion would bring these parallel rays to a focus at its principle focus. Deducting then $\frac{1}{60}$ from $\frac{1}{10}$ will give the strength of the remaining portion of the lens $\frac{1}{10}-\frac{1}{60}=\frac{5}{60}=\frac{1}{12}$; the two parts then $\frac{1}{60}$ and $\frac{1}{12}$ are equal to the one lens $\frac{1}{10}$. And, as the $\frac{1}{60}$ will render the rays parallel from the object 60 inches distant, and these parallel rays falling upon the other part $\frac{1}{12}$, they will be brought to a focus at the principle focus of this part, viz: at 12 inches from the lens. Let us illustrate this with another example. Suppose that an object is 30 inches in front of a convex lens of 10 inch focus, and we wish to know how far behind the lens will be the focus of a pencil of rays diverging from a point in the object. We will have $\frac{1}{15}-\frac{1}{30}=\frac{2}{30}=\frac{1}{15}$; this $\frac{1}{15}$ represents the power of a 15 inch lens, which we know will bring the parallel rays to a focus at 15 inches behind the lens.

FIG. 1.

Fig. 4 illustrates this; O represents an object 30 inches from a ten inch convex lens, the lens supposed to be divided into two parts, one having a focus of 30 inches, and the other a focus of 15 inches. The 30 inch lens refracts the rays of the divergent pencil d, d, d, d, so as to render them parallel, as shown at P, P, P, P, P. These parallel rays, meeting the 15 inch lens, are again refracted and are converged to a focus at F, which is the principle focus of the lens, viz., at 15 inches.

Fig. 1, page 3, represents a 10 inch lens, at a distance of 20 inches from an object, F. The lens is supposed to be divided into two equal parts, of 20 inch focus each: the first half renders the diverging pencil parallel, and the second half converges the parallel pencil to a focus, at 20 inches from the lens; $\frac{1}{10}-\frac{1}{20}=\frac{1}{20}$.

(Dr. Giraud-Teulon, of Paris, has ascribed the origination of the above theory to Mr. J. Z. Laurence, of London, to whom we are very much indebted, for his praiseworthy efforts to popularize this hitherto neglected, field of Physiological and Pathological Optics.)

Let me next direct your attention to certain optical considerations which have a most important application, in the treatment of optical defects of the eye.

You may remember that in a former experiment, a 10 inch lens was held ten inches from a white wall, so as to show the miniature inverted picture of the window, &c., 20 ft. distant; and that when the lens was brought to a distance of 60 inches from the window, it was found that the image of the window was formed 12 inches behind the lens, instead of 10 inches, and that at 10 inches, the image was so indistinct as to be scarcely recognizable.

Now suppose that a 12 inch lens be immovably fixed 12 inches from the same wall, it will then be in a proper position to bring parallel rays to a focus on the wall, where it will form an inverted picture of the window, and objects at a distance beyond the window.

If we now bring the flame of a lamp, for instance, to a distance of 60 inches from the lens, no distinctly defined image of the flame will appear upon the wall; but if, by any means, we can render the pencil parallel that diverges from the flame, the 12 inch lens will then converge it accurately to a focus upon the wall, where we will have an inverted image of the flame.

From the knowledge that we have now obtained, we know that a 60 inch lens placed in front of the 12 inch lens will render these rays parallel. All that we have to do then is to combine a 60 inch lens with the 12 inch lens: the 60 inch lens to render the rays parallel that diverge from the flame, 60 inches distant, and the 12 inch lens to converge these rays to a focus, at the principal focal length of the lens. This is exactly what we do in supplying old people with convex spectacles. Their eyes are constructed to bring parallel rays to a focus, on the retina; but the rays from near objects are too divergent to be focussed upon the retina without artificial aid; this deficiency is what we supply with suitable glasses.

Before leaving the consideration of optical lenses, there is one subject to which I wish to direct your attention; namely, the formation of an inverted image behind a convex lens.

Many of you are, probably, familiar with the fact, that when light is admitted into a darkened room, through a small orifice, there appears upon the opposite wall of the room, an inverted, dim, shadowy picture of buildings, trees, &c., in front of the aperture. This can also be seen, on a smaller scale, by holding a sheet of white paper a few inches from the key-hole of a darkened hall.

The philosophy of this is seen in Fig. 5.

Let A, B, represent the position of a flame of a lamp that is a short distance in front of an aperture of a darkened box. Pencils of divergent rays of light radiate from the apex of the flame in every direction; one of these pencils is represented in the figure to illuminate the end of the box, and one of the rays escaping through the small orifice *c*; this ray passes in a straight line to the back of the box, and strikes the point *a*, which it illuminates.

Rays of light diverge from the lower part of the flame, also; one of these rays is shown to enter the aperture *c*, and to pass to the back of the box at *b*. In a similar way it might be illustrated that pencils of light radiate from every point in the flame A, B, and that one ray from each point passes into the box and illuminates a portion of the back. In this way we get an illuminated spot at the back of the box, which is an exact counterpart of the flame in front of the box, but *inverted*, the apex of the flame pointing downwards. The reason that the picture is reversed is that, as rays of light (in the same medium) pass in straight lines, a ray from the top of the flame, after passing the aperture, must necessarily pass to the lower part of the back of the box; and a ray from the lower part of the flame must necessarily (in moving in a straight line) pass to the upper part of the back of the box. You will observe, also, that the size of the image depends upon its distance behind the apertur if the image is as far behind the aperture, as the object is in fro the image will be of the same size as the object, if half the distan half the size, as seen at f, g.

If, in the above experiment, the aperture be enlarged, it will found that the image at the back of the box will become much l distinct; the more the aperture is enlarged, the more indistinct w be the image. The reason of this indistinctness in the image is th when the aperture is enlarged, a number of diverging rays from e point in the flame pass through the aperture, and each one repe the image, so that the parts of the image overlap each other.

This is shown in Fig. 6. A, B, represents the flame of the la and C, E, D, F, the image behind an aperture. The aperture supposed to be just large enough to admit two divergent rays, ea of these rays produces a separate image; thus, the point A is peated twice at D and F, and the point B is repeated at C and The larger the aperture, the more light is admitted, but the m indistinct is the image.

If now, a convex lens be inserted in the enlarged aperture, th divergent rays that enter the aperture (from every point of object) are converged to a focus; thus in

Fig. 7.

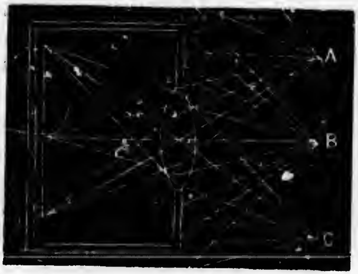

Fig. 7. A C represents an object in front of a convex lens, and *a c* the inverted image behind the lens. Rays diverging from the point A and falling upon the lens L are brought to a focus at *a;* rays from B are similarly focussed at *b*, and so on. In a similar manner, diverging rays from every point in the object A C that enter the lens are brought to a focus in the image between *a* and *c.* We will then have in the position of *a c* a distinct inverted image of the object A C. If this image is received upon a sheet of white paper we can see it only upon its front surface; but if it is received upon thin oiled paper, or upon ground glass, we can see it from behind; and if, while viewing the image from behind, the ground glass be removed, we can still see the inverted image (or at least a portion) occupying the same position as the ground glass just occupied—being suspended, as it were, in the air, and forming what is called an ærial image. In order to see this ærial image under favourable circumstances, one eye only should be used, and should be in a line with the lens and the object, and should be at least ten inches behind the position of the inverted lens.

Chapter II.—Optics of Normal Eye.

The human eye, from before backwards, is about one inch in diameter. Its transparent media are the cornea, aqueous humour, crystaline lens, and vitreous humour. This combination, with the convexity of the cornea, is equal to a convex lens having a focus of about one inch (more accurately $\frac{18}{20}$ of an inch.)

When a normal eye is directed to a distant object (*i. e.* in a state of rest), parallel rays of light are brought to a focus upon the retina, and a very minute inverted picture of the object is sharply defined upon that membrane. If the sclerotic coat be removed from the back of the eye of an ox, and the eye be placed in an aperture of a darkened room, with the cornea looking, for instance, towards the opposite side of the street, an inverted image of the buildings, &c., in front of the aperture will be seen at the back of the eye.

The impression that objects make upon the retina, is conveyed through the optic nerve to the brain, but in what manner this communicates to the mind a knowledge of the appearance of objects, is more than we can tell. We can simply say with Potterfield, that "God has willed it so."

We are aware, however, that although the eye may be free from disease, and the connection between the retina and brain in eve way perfect, if the optical mechanism of the eye be in any way defe tive so as to produce ill defined images upon the retina,—vision w be indistinct, and that the distinctness or indistinctness of visi will be in exact proportion to the distinctness or indistinctness of t inverted picture. Hence the necessity of understanding the opti of the eye in order to comprehend the pathology and treatment the numerous optical defects to which it is liable.

CASE 1. Let me here take an example. A few weeks ago a ph sician of this city sent a patient for my advice, fearing that he w losing the sight of his left eye. Upon examination, I found that had what we call "paralysis of accommodation" of that eye.

He could see distant objects with perfect distinctness, but ne objects he was unable to define; he could not read large type unl the letters were very large, and several feet from the eye. The e was, in fact, simply passive, like a convex lens, or a camera-obsc with the screen to receive the image immovably fixed at the princi focus of the lens, and could only bring parallel rays to a focus the retina.

I found that by rendering the diverging rays parallel, by mean a convex lens, he could see near objects distinctly; by placing a inch convex lens before that eye, he could read fine type at six inch with a 10 inch lens at ten inches, with an 18 inch lens at eight inches, &c. &c. The 6 inch lens rendered the rays parallel t diverged from the letters six inches distant, and these parallel r falling upon the eye were brought to a focus upon the retina. 6 inch lens does not increase the apparent size of letters one-h whereas this patient could not see letters ten times the ordinary s at six inches, or any distance less than about two feet from the ey The 10 inch lens rendered the rays parallel from objects ten inc distant, and the 18 inch lens from objects eighteen inches distant

The eye was unable to bring diverging rays to a focus upon retina; in other words it had lost the power of "accommodatio (We can temporarily paralyse the accommodation of the eye by app ing a strong solution of Atropine.)

A normal eye differs from the glass lenses we have been describ in the fact that it can, not only focus parallel rays upon the retina, also rays that diverge from objects as near as from four to six or ei inches from the eye. When parallel rays fall upon a 1 inch con lens, they are brought to a focus one inch behind the lens, but if an object, for instance the flame of a lamp, be brought to within four inches of the lens, we know that the focus will fall farther than one inch behind the lens. If we wish to receive the inverted image of the lamp upon a screen, the screen must be held one inch and a third behind the lens.

Now when an object is brought to within, say four inches of the eye, it has no power to move the retina backwards to receive the image that would be formed behind that membrane, but, what answers the same purpose, it has the property of so far increasing its refractive power, as to be able not only to render parallel, these diverging rays, but also to focus them upon the retina. This increase in the power of the eye, is equal to the addition of a 4 inch lens in front of an eye that has its "accommodation" paralysed, as a 4 inch lens renders rays parallel that diverge from objects four inches distant.

FIG.

Fig. 8 represents the section of a normal eye. When it is accommodated for distant objects parallel rays P, P, are focussed upon the retina at F, while diverging rays from O, would form a focus at *fd.* When, however, the eye is accommodated for the near object O, these diverging rays are focussed upon the retina at F.

The manner in which this increase in the refractive power of the eye s effected is still a disputed point. Most physiologists however are now inclined to the theory that it is caused by an increase in the curvature,—a thickening from before backwards, of the crystaline lens.*

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* The accommodotion of the eye was at one time believed to be produced by he external muscles, but it is now ascertained that the accommodation can remain perfect with all the external muscles paralysed.

The iris was thought, by others, to have the power of increasing the refractive power of the eye, but it was proved by a case that occurred in Dr. Von Graefe's practice that accommodation can still be effected with entire absence of the iris. Helmholtz and Cramer have proved by means of the opthalmometre, that when he eye is accommodated for a near object it undergoes the following changes:—

The "near" and "far" point.—The nearest point to which objects can be brought to an eye and be seen with perfect distinctness, is called the "near" point, and the farthest point of distinct vision is called the "far" point.

In a normal eye the "near" point is about seven inches from the front of the cornea, and the "far" point is at an unlimited distance. In childhood, however, the "near" point is about 3½ inches from the eye and recedes as age advances. At the age of forty the "near" point of a normal eye is nearly eight inches from the eye.

When the "near" point recedes to a greater distance than eight inches from the eye it becomes inconvenient; such an eye is called *presbyopic* or long-sighted.

When the "far" point is not unlimited, but is at a definite distance from the eye, as for instance from six inches to four or five feet from the eye—such an eye is called *myopic* or short-sighted.

Range of Accommodation.—The distance between the "near" and "far" point in any eye, is called the "range of accommodation." If a person can read distinctly very fine type at four inches from the eye, and can also see clearly at an infinite distance the range of accommodation would be said to equal ¼ because, when such an eye is directed to objects at an infinite distance, (accommodated for parallel rays) in order to see clearly objects only four inches distant, it is necessary to increase the curvature of the crystaline lens, or in other words the "power" of the eye to an extent equal to the addition of a 4 inch convex lens; the power of which is expressed by ¼. If a person's "near" point is at eight inches from the eye, and his "far" point at an infinite distance. his range of accommodation would be said to equal ⅛.

If the "near" point of a myopic eye be 3 inches, and the "far" point be 12 inches, we get the range of accommodation by the equation $\frac{1}{3}-\frac{1}{12}=\frac{1}{4}$.

CHAPTER III.—MYOPIA.

CONCAVE LENSES.—Before proceeding to the consideration of Myopia, it will be well for us to glance at some of the properties of concave lenses; and, in order to simplify the subject, we will confine

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1st. The pupil contracts; 2nd. The pupillary edge of the iris moves forward; 3rd. The peripheral portion of the iris moves backwards; 4th. The anterior surface of the lens becomes more convex (arched); 5th. The lens does not change its position; 6th. The cornea retains the same degree of curvature.

ourselves to equi-concave lenses. An equi-concave lens is bounded by two surfaces, which are portions of the concave side of two circles which have equal radii.

Fig. 9. A, B, one of the concave surfaces of the lens. C is the centre of curvature, and C, R the radius of curvature. When parallel rays, P, P, strike one surface of the lens, they have a divergence upon leaving the second surface of the lens, as if they proceeded from the centre of curvature, C, which, in an equi-concave lens, is also the principal focus of the lens. C, R, is the focal length of the lens. In a convex lens, the focus is measured *behind* the lens; in a concave lens, it is measured *in front* of it. If we call the focus of the convex lens positive, we must call the focus of the concave lens negative. When parallel rays of light fall upon a convex lens, they are converged to a focus. When they fall upon a concave lens, they are made to diverge. A convex lens enlarges, and a concave diminishes the apparent size of objects. The focal length of a convex lens is measured behind; and that of a concave lens, in front of the lens. They are, therefore, entirely opposite in all their properties; and, for this reason, a convex lens is called a positive lens; and a concave one, a negative lens. Or, shorter still, they are indicated by the plus (+) and minus (—), algebraic symbols; thus, + 5, and — 5; or, + $\frac{1}{5}$, and — $\frac{1}{5}$. To ascertain the focal length of a concave lens, we ascertain what convex lens it will neutralize.

1. In a myopic eye, parallel rays, as well as those that have a certain degree of divergence, are focussed *in front* of the retina; and, the inverted image of distant objects being formed in the same position, the picture upon the retina will be ill-defined, and vision for distant object consequently indistinct.

Patients with myopia complain that, although their vision for near objects is perfect, they cannot see objects at a distance with any distinctness. They can read the smallest type, when brought near th eyes, even better than persons with normal vision, but they are n able to recognize their friends at a distance of fifteen or twenty fe

In order to enable such persons to see distinctly at a distance, it necessary for them to wear concave spectacles of such a strength, th the parallel rays from distant objects may have such a degree of dive gence, that, falling upon the myopic eye, they may form a focus up the retina. Theoretically, we should prescribe concave glasses such a strength that their focus will correspond with the patien "far" point. Thus, if the "far" point be at 12 inches, we shou prescribe — 12, as a twelve inch concave lens, placed before such eye, will give parallel rays from distant objects the same degree divergence as if they proceeded from the "far" point of the ey namely, at 12 inches from the eye. Thus, in Fig. 9, P. P. represe parallel rays falling upon the concave lens, A. B.; they are made diverge, as if coming from the focus, C., and falling upon the e divergingly, they are focussed upon the retina at F. Practically, ho ever, we would find that — 12 would be rather too strong, and that 15, or — 16 would probably answer better. As a rule, the weak glasses should be worn that will enable the patient to see dist objects with distinctness.

In testing the degree of myopia, we use a series of test types th are so constructed that No. I (smallest) can be distinctly seen and re by a person having normal vision, at a distance of 1 foot; No. II, 2 feet; No. V, at 5 feet; No. XX, at 20 feet; and so on. A spe men of these types will be annexed to this paper. The types also used in testing the acuteness of vision in Presbyopia, Hyperm tropia, Amblyopia, &c.

2. In determining the degree of myopia in any case, we ascert the greatest distance at which No. I test types can be read distinct if at 10 inches, the "far" point will be at 10 inches, and the myo would be called $\frac{1}{10}$; if at 6 inches, the myopia would be called From this we can, as stated above, get a proximate knowledge of strength of the concave lens necessary to relieve the myopia.

3. A myopic eye, when in a state of rest, is adjusted for diverg rays. To enable such an eye to see distant objects, that is, to br parallel rays to a focus on the retina, it is necessary to give th parallel rays a preliminary degree of divergence by the interposit of the proper concave lens.

4. Myopia can be distinguished from every other defect of vision, by the fact that concave glasses improve vision for distant objects. If we have no concave glasses convenient, we can diagnose it from Amphyopia, (insensibility of the retina) by the following ready method:—A person with normal vision can read distinctly, No. I test type at 12 inches, and even a little farther. We will suppose that a patient's vision is so impaired, that he can only read No. II at 6 inches; if he is *not* also myopic, he can also read No. IV at 12 inches, or No. LX at 180 inches—that is at 15 feet. However impaired then a person's vision may be, unless he be also myopic, he can see as well proportionately, at one distance as at another. On the contrary, a person with myopia, say $\frac{1}{6}$, can see the smallest type (much smaller than No. I,) at 6 inches, but he cannot see No. II, or even No. V, at 12 inches.

This disease is often hereditary. Over exertion of the eyes upon near objects at the age of puberty, (about 14 or 15) is a very frequent cause of myopia.

Short-sighted persons often inquire if we would advise the use of spectacles. There can be no objection to wearing glasses that will enable them to see distant objects; for their eyes are thus changed to normal ones, but as most persons use their eyes much more frequently upon near than upon distant objects; the glasses should be no stronger than necessary. Some contend, however, that short-sighted persons should dispense with glasses for reading, writing, &c. Prof. Donders, however, recommends their use for this purpose, for the following reasons:—

1st. "Because strong convergence of the optic axes is necessarily paired with tension of the accommodation. The latter is an associated action, not arising from the mechanism of the convergence, but existing within the eye itself, and may consequently easily lead to an increase of the myopia. Besides this, the pressure of the muscles upon the eye ball appears to be greater when the optic axes are convergent, than when they are parallel, and this increase of pressure cannot but tend to give rise to the development of posterior staphyloma.

2d. "On account of the habit which short-sighted persons have of bending their head forwards during reading or writing. This must cause an increased flow of blood to the eye, and an increased tension within the eye itself. Owing to this development of sclerotico—choroiditis posterior, effusions of blood and detachment of the retina which are so apt to occur in short-sighted persons, are undoubted greatly promoted. For this reason, we should always tell the patients to read with their head well thrown back, and to write at sloping desk. But it may, on the other hand, be urged that it just in looking at near objects that myopic persons have an adva tage, for they can see them remarkably distinctly. And the gre danger is, that after reading for a short time with spectacles, t patient, on getting somewhat fatigued will, instead of laying the bo aside, approach it nearer to the eye, in order to gain greater reti images, and thus strain and tax his power of accommodation t much. If we, for instance, give a patient whose far point lies a inches, a pair of spectacles which enable him to read at 12 inches, will, if not very careful, after a short time almost insensibly bri the book nearer to his eyes, and thus have to make use of a grea amount of accommodation. If he does this frequently, he will so increase his myopia. The greater the range of accommodation t less harm will spectacles do, and *vice versâ*. Spectacles may also used for near objects in those cases of myopia in which astheno (depending upon insufficiency of the internal recti muscles) sh itself as soon as the patient has read or worked at near objects fo short time. Whilst these forms of myopia may be furnished w spectacles for near objects, it is very dangerous to permit their in patients whose range of accommodation is very limited, and w moreover, suffer perhaps from such an amount of amblyopia (ge rally depending upon sclerotico—choroiditis posterior) that t cannot read No. 4 or 5 Jäger even with the most accurately cho glasses. Such patients will bring the object very close to the e in order to obtain large retinal images, the accommodation will greatly strained, the intra-ocular tension be increased, and gr mischief will be sure to ensue. If there is much amblyopia, spec cles should not be permitted at all for near objects."*

In cases where the myopia is extreme, there usually co-exists p terior staphyloma of the sclerotic. Von Graefe says it is present all cases of myopia where the "far" point is less than five inch the myopia being less than $\frac{1}{5}$. Out of sixty cases of myopia ex ined by J. Z. Laurence, forty-four had posterior staphyloma.

The presence of this disease can be easily diagnosed with t ophthalmoscope. (See Hulke or Zander on the ophthalmoscop

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*Mr. J. Z. Laurence, of London, recommends that deeply concave lenses be tint order to obviate their "dazzling" effect.—(Med. Times and Gazette, Oct. 22nd, 1864.)

Posterior staphyloma is a serious complication in myopia, as the sensibility of the retina becomes more or less impaired in the position of the bulging of the sclerotic, and in some cases the retina becomes detached from the choroid. It is the existence of this disease that prevents improvement in cases of myopia, as the eye becomes flattened with advancing age.

Donders considers that in myopia, the antero-posterior diameter is alone at fault; that is, it is too much elongated, and that the cornea and crystaline lens have usually a normal curvature.

The characteristics of a myopic eye, are*

1st. Parallel rays are focussed in front of the retina.

2nd. The "far" point is at a definite distance and positive.

3rd. When the eye is in a state of rest it is adapted for divergent rays.

4th. Concave glasses improve vision.

CHAPTER IV.—HYPERMETROPIA.

You will remember that when a normal eye is in a state of rest, and directed to a distant object, parallel rays are brought to a focus upon the retina, and that when a myopic eye is in a state of rest, parallel rays are brought to a focus in front of the retina. When, however, a hyperemtropic eye is in a state of rest, parallel rays would (if continued) form a focus behind the retina. Hypermetropia is, therefore, the reverse of myopia. In myopia, the refractive power of the eye is excessive, and in hypermetropia it is not strong enough. When the accommodation of a myopic eye is paralysed, it has the power of focussing none but diverging rays upon the retina, but a hypermetropic eye under the same circumstances can focus only converging rays upon the retina. The "far" point of a myopic eye is at a definite distance and positive, but the "far" point of a hypermetropic eye is at a definite distance and negative. Concave glasses improve the vision for a myopic eye, and convex for a hypermotropic one.

This is an affection which has received very little attention until within the last ten years. It was indeed noticed by Dr. McKenzie of Glasgow, in 1841, but it was not until about five years ago that

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* From Donders' system of classification.

Prof. Donders, of Utrecht, from his elaborate researches on this subject, first pointed out how common this affection is, and how frequently it is the sole cause of that peculiar weakness of sight (formerly so little understood) called asthenopia.

Donders believes that this condition of the eye depends more upon a shortening of the antero-posterior diameter of the eye, than upon a too low degree of its refractive power; that the cornea and crystaline lens have a normal degree of curvature, and that parallel rays would form a focus at the normal distance behind the lens, were the retina far enough back to receive it.

A very good illustration of a hypermetropic eye is one in which the crystaline lens has been removed in the operation for cataract. To enable such an eye to see distinctly, even distant objects, it is necessary to place in front of it a strong convex lens of about four inches focus, called a cataract glass. The eye having too low a refractive power to converge rays to a focus, on the retina, it is necessary to give rays falling upon the eye, a preliminary degree of convergence; the eye having sufficient power to complete their refraction to a point upon the retina. We do the same thing in relieving cases of hypermetrophia.

FIG. 10.

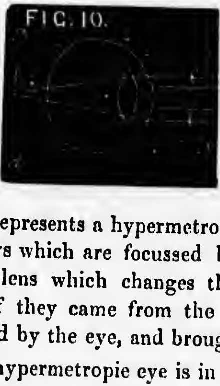

FIG. 11.

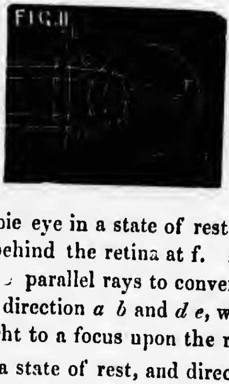

Fig. 10 represents a hypermetropic eye in a state of rest. P P are parallel rays which are focussed behind the retina at f. L, Fig. 11, is a convex lens which changes the parallel rays to convergent ones, at c, c, as if they came from the direction *a b* and *d e*, which again are refracted by the eye, and brought to a focus upon the retina at F.

When a hypermetropic eye is in a state of rest, and directed to distant objects, it is adjusted for convergent rays; images upon the retina will consequently be ill defined, and vision will be indistinct. To remedy this, it is necessary for the eye to increase its refractive power by increasing the antero-posterio diameter of the crystaline lens, so as to bring parallel rays to a focus on the retina.

When a person with hypermetropia, attempts to read or write, or accommodate his eyes to short distances, it is necessary for him to tax his accommodation to its utmost extent, in order to bring the diverging rays to a focus on the retina. This excessive effort at accommodating the eye for short distances, can not be kept up for more than a few minutes, when the ciliary muscle begins to relax,—the "near" point commences to receed, and (if he is reading) the letters become indistinct. The eye also feels fatigued, and other symptoms arise which will be referred to when speaking of Asthenopia.

Diagnosis.—When we suspect a patient has hypermetropia, we test his eyes as follows :—We place a series of test-types, No. xv., xx., xxx., &c., at a distance of about 20 feet. If he can read No. xv. or xx. at this distance, his acuteness of vision is normal. We then try his vision with weak convex glasses, say No. 50, and if he can read the same type, at the same distance, we try successively No. 40, 36, 30, 24, &c., until we reach the glasses that render the test type indistinct at that distance. Some persons may possibly be able to relax their accommodation so as to see as well at a distance, with convex 50 lenses, as without them; and not be hypermetropic; it would, however, be very strong presumptive evidence of its presence; and if, in addition, the patient complain of the symptoms of Asthenopia, we would be generally safe in pronouncing it a case of hypermetropia. The shorter the focus of the lens he can use, the stronger is the presumptive evidence of the disease.

Again, if another patient be tested with the same type, at the same distance, and we find that he can not read a smaller type than No. xl. at 20 feet without spectacles, and that he can read No. xv. or xx. with convex glasses, say + 10 or + 12, his would be called a case of hypermetropia *absolute.*

In order, however, to test accurately the degree of hypermetropia in any case, it is necessary to neutralize one element in the refractive power of the eye; namely, the power of accommodation. In most cases of hypermetropia, particularly in young subjects, the accommodation of the eye is so constantly exercised, even when directed to distant objects, that it is quite impossible for them, by any effort of their own, to completely relax that accommodation. I related in a former chapter, the case of a patient who had lost the power of accommodating his eye to different distances. As the refraction of his eye was normal, parallel rays were brought to a focus upon the retina, and vision for distant objects remained perfect.

Had his eye been hypermetropic, parallel rays would not have bee sufficiently converged by the refractive power of the eye, to form focus upon the retina; vision would, consequently, have been indi tinct. By placing, however, the proper convex lens in front of su an eye, the requisite preliminary convergence would be given to t rays, to enable the eye, with its low refractive power, to focus the rays upon the retina, and thus render vision distinct.

The lens used in such a case would indicate the degree of hyp metropia. If the lens were a + 15 inch, the hypermetropia wou equal $\frac{1}{15}$ if a + 10, the hypermetropia would be $\frac{1}{10}$, and so forth.

We have, however, the means of temporarily producing this co dition of the eye by artificial means. By applying a four gr solution of atropine to the eye, within two hours the action of t ciliary muscle will be completely paralysed. A solution of one g of atropine to an ounce of pure water (also a solution of the extr of belladonna) will dilate the pupil widely, and in some cases, w render the eye slightly presbyopic, but it will not paralyse the acco modation.

If we test, in this manner, the case of suspected hypermetro mentioned above, and find that after his accommodation is pa lysed, he is not able to read No. xxx. even with + 50, and t the only glass with which he can read No. xv. and No. xx. 20 feet is + 20; his hypermetropia is therefore $\frac{1}{20}$. But as could see as well with + 50 as without them, before his acco modation was paralysed; he had a manifest hypermetropia of, The difference between his total hypermetropia and his mani hypermetropia will give the amount of the *latent* hypermetrop which he overcame with the exercise of his accommodation, name $\frac{1}{33\frac{1}{3}}$, thus $\frac{1}{20} - \frac{1}{50} = \frac{1}{33\frac{1}{3}}$.*

Asthenopia, according to Donders, depends almost invariably hypermetropia. He describes it as follows: "The power of vision usually acute,—and nevertheless, in reading, writing, and other cl work, especially by artificial light, or in a gloomy place, the obje after a short time, become indistinct and confused, and a feeling fatigue and tension comes on in, and especially above the eyes, nec sitating a suspension of work. The person affected now often inv untarily closes his eyes, and rubs his hand over the forehead a

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* Hypermetropia can easily be diagnosed with the ophthalmoscope.

eyelids. After some moments rest, he once more sees distinctly, but the same phenomena are again developed more rapidly than before."

According to my own experience with these cases, the above description corresponds very closely with the description that most patients give of their symptoms. Some give more prominence to the neuralgic pains which they experience in and around the eye, and in some cases extending to the back of the head. I was consulted, about a year ago, by a lady from the town of Simcoe, C.W., who had all these symptoms in the most aggravated form. If she attempted to read even one line, it gave her so much pain in her eyes and forehead that, for several years, she had scarcely dared to even raise the lid of a book. She was unable to keep her eyes upon any one object for more than an instant at a time, without causing her pain. Others, again, do not speak of any pain or fatigue of the eye ; but that, after reading a short time, the letters become indistinct, so that they are obliged to stop or look away at something distant, or close the eyes for a short time, when they can again proceed, the same symptoms recurring.

In regard to the *prognosis* in hypermitropia, Donders thinks that when it is once developed it never gives way. All the inconvenience of the accompanying Asthenopia can be relieved by wearing the proper glasses to relieve the hypermetropia ; but the cause, namely (in most cases), a congenital flattening of the eye-ball from before, backwards, will probably remain through life.

As age advances, the "near" point recedes from the eye, as in a normal eye, so that in time it becomes complicated with presbyopia.

Treatment.—In order to correct this optical defect, it is necessary for the patient to wear a pair of convex spectacles of sufficient strength to enable him to see distant objects distinctly, without any effort of the accomodation. In cases where the hypermetropia is absolute, and the patients are not able to see distinctly at any distance, they can, approximately, by trial, select the glasses that will remedy the low degree of refraction of their eyes. But, in all other cases, it is necessary to paralyse the accomodation, and test with lenses of different strength, in order accurately to ascertain the degree of hypermetropia. When we ascertain this fact, we also know the number of the glasses that we must prescribe for them. The effect of the atropine usually lasts about a week, after which the patient can commence wearing glasses. Before, however, he use the spectacles that he is to wear permanently, his accomodation must first be gradually relaxed by th use of weaker lenses. Donders' rule is to prescribe first that gla that will neutralize his manifest hypermetropia, and $\frac{1}{4}$ of his late hypermetropia, and every two or three weeks change them for stronger pair, as he becomes accustomed to their use, until the glass are reached that we found to be necessary to correct his hypermetr pia. Thus, if a patient has a total amount of hypermetropia equ to $\frac{1}{10}$, and a manifest hypermetropia of $\frac{1}{30}$, his latent hypermetrop ($\frac{1}{10} - \frac{1}{30} = \frac{1}{15}$), would equal $\frac{1}{15}$; one fourth of $\frac{1}{15}$ is $\frac{1}{60}$; thi added to $\frac{1}{30}$ ($\frac{1}{30} + \frac{1}{60} = \frac{3}{60} = \frac{1}{20}$), equals $\frac{1}{20}$. We would therefor prescribe, at first, 20 inch convex spectacles, which we would after wards change successively for + 18, + 16, + 14, &c., until he has s relaxed his accomodation that he can, with ease, wear + 10. I will not be until he becomes accustomed to this last pair that all hi symptoms of Asthenopia will disappear.

Strabismus.—Prof Donders was the first to direct attentlon to th fact, that nearly all cases of convergent strabismus arise from th presence of hypermetropia. We know that when both eyes ar directed to a near object, they are very much converged,—the opti axes cross at the point to which they are directed. If one eye b covered, and the opposite eye be accommodated for its " near " point the convered eye will be found to be very decidedly converged toward the nose,—to have, in fact, a temporary convergent squint. Thi arises from the constant association of the act of accommodating th eye for short distances, with the act of contracting the internal rec muscles. The hypermetropic, however, being obliged to exert th accommodation of their eyes, even when looking at distant objects, i is easy to understand that they would be inclined to contract thei internal recti-muscles unduly, so as to increase this power of accommodation. This converges the eyes to a point at a nearer distanc than the object looked at, and causes one of the eyes to turn inwards while the other is fixed upon the object. When, therefore, they wis to see distinctly with one eye, they instinctively turn in the other At first the convergent strabismus is seen occasionally only, and i this stage may be prevented by using the proper spectacles to correc the hypermetrophia. After the squint has existed sometime, i becomes confirmed and cannot be cured without an operation.

If the convergence exceeds three lines, a partial tenotomy, upo each eye, should be performed, and the effect controlled by a conjunc tival suture, by which means we have the power of regulating our operation, in proportion to the effect we wish to produce.

When Strabismus shows itself in childhood, it should be treated without delay, for, if not corrected, the vision of the "cross-eye" will very soon become impaired.

To get the full benefit of spectacles, in cases of hypermetropia, they should be used both on the street, and at church, as well as when reading or writing,—in fact whenever the eyes are used.

The characteristics of a hypermetropic eye then are :

1st. Parallel rays form a focus behind the retina.

2nd. The "far" point is at an definite distance and negative.

3rd. The eye, in a state of rest, is adjusted for convergent rays.

4th. Convex glasses improve vision.

5th. This affection is usually accompanied by symptoms of Asthenopia and Amblyopia, and frequently by convergent strabismus.

CHAPTER V.—PRESBYOPIA.

This affection usually develops itself between the ages of 40 and 45. Most persons at this age, although previously enjoying excellent vision, complain that their sight, particularly in the evening, is beginning to fail for near objects, as small print, &c., although they can see distant objects as well as ever.

In reading they will hold the book or paper at nearly arm's length and perhaps bring the lamp almost between their eyes and the page. Reading in this manner soon fatigues them, and they are obliged frequently to rest,—or to resort to spectacles.

In childhood, when the vision is normal, the "near" point is from 3½ to 4 inches from the eye, and the "far" point at an unlimited distance ; that is, we can see objects distinctly as near as from 3½ to 4 inches from the eye, and we can see objects clearly (the size being in proportion to the distance) from that to an indefinite distance. As age advances the "near" point recedes. At the age of 40 the "near" point is about eight inches from the eyes. When the "near" point recedes to a greater distance than 8 inches, Donders calls it a case of presbyopia ; Laurence, however, thinks that it should not be called presbyopia unless the "near" point is at least 10 inches from the eye.

Presbyopia, then, is not an optical defect of the nature of myopi or hypermetropia, but is simply a lessening of the accommodativ power of the eye.

It is supposed to depend upon, or to be caused by, the crystalin lens becoming hardened as age advances, so that it does not yiel sufficiently to the contraction of the ciliary muscle.

In a case of pure presbyopia where, for instance, the "near" poi is 12 inches from the eye, vision will remain normal for all point beyond that distance. When the "near" point is 12 inches distan and the "far" point at an infinite distance, the accommodation i only $\frac{1}{12}$. Taking eight inches as the normal "near" point, $\frac{1}{8}$ woul represent the normal accommodation. Deducting $\frac{1}{12}$ from $\frac{1}{8}$ give the degree of presbyopia thus: $\frac{1}{8} - \frac{1}{12} = \frac{1}{24}$. The degree o presbyopia in this case would then be $\frac{1}{24}$. This fraction $\frac{1}{24}$ also r presents the strength of the glasses necessary to correct the presb opia, namely 24 inch convex. Practically, we would probab find that a pair of 30 inch convex would answer better, as th weakest glass that can be worn with comfort, is the one that shoul be prescribed. Again, if a person's "near" point be at 16 inches, h presbyopia ($\frac{1}{8} - \frac{1}{16} = \frac{1}{16}$) will be $\frac{1}{16}$, and a 16 inch convex lens woul enable him to read at 8 inches.

"There can be no question as to the advisability and necessity affording far-sighted persons the use of spectacles. They should b furnished with them as soon as they are in the slightest degre annoyed or inconvenienced by the presbyopia. Some medical me think that presbyopic patients should do without spectacles as lo as possible, for fear the eye should, even at an early period, get used to them as soon to find them indispensable. This is, howeve an error, for if such persons are permitted to work without glasse we observe that the presbyopia soon rapidly increases."*

If, however, we call all cases presbyopia, where the "near" poi recedes to a greater distance than eight inches from the eye, it w follow that we may have presbyopia in cases of myopia and hyp metropia. If a person's far point be at 20 inches from the eye h would be called *near-sighted* and if his near point recedes to inches from the eye, he would be also *far-sighted.*

In some persons, as age advances, the "far" point also recedes

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* J. Soelberg Wells.

as to render the person hypermetropic; this form of hypermetropia seldom exceeds $\frac{1}{24}$. When a person has both hypermetropia and prebyopia, it is necessary for him to use a stronger pair of glasses for reading, &c., than for ordinary use. If a person for instance, wears a pair of 18 inch convex spectacles to correct a hypermetropia of $\frac{1}{18}$, and as age advances his "near" point recedes to 12 inches, even with the addition of his glasses, it will be necessary for him to wear, for reading, a pair of glasses having a focus of about 10½ inches. Thus $\frac{1}{8} - \frac{1}{12} = \frac{1}{24} =$ presbyopia, this added to the lens to correct his hypermetropia, ($\frac{1}{18} + \frac{1}{24} = \frac{1}{10\frac{1}{2}}$ nearly) equals 10½ nearly.

In the very aged, it is necessary to prescribe glasses, that will enable them to read at 5 or 7 inches from the eye, as their vision is usually somewhat impaired.

The following table constructed by Dr. Kitchener may give a general idea of the glasses required at different periods of life when the presbyopia is unaccompanied by hypermetropia or amblyopia.

At 40	years,—	36	inch	focus.	At 70	years,—	12	inch	focus.
" 45	"	30	"	"	" 75	"	10	"	"
" 50	"	24	"	"	" 80	"	9	"	"
" 55	"	20	"	"	" 85	"	8	"	"
" 58	"	18	"	"	" 90	"	7	"	"
" 60	"	16	"	"	"100	"	6	"	"
" 65	"	14	"	"					

Prof. Donders thinks that when there is no hypermetropia present we should generally advise those glasses to be worn that will enable the person to read distinctly No. I (smallest) test type at a distance of 12 inches.

There is an optical defect of the eye that is occasionally met with called astigmatism (from *a* and *στίγμα*) in which horizontal and vertical lines are not brought to a focus at the same distance behind the crystaline lens. It is relieved by glasses specially ground for each case, these glasses are cylindrical. I have seen but one case of astigmatism.

A very comprehensive article on this subject appears in the Medical Times and Gazette, Nov., 1864, from the pen of J. Zachariah Laurence, M.B., of London.

The paralysis of the accommodation of the eye I have already referred to in a case on page 14.

SPECIMENS OF JÄGER'S TEST TYPES.

No. I.—Brilliant, omitted for want of type.

No. II.—Pearl.

A person with normal vision should be able to read No. II at any distance from eight inches to two feet the eyes.

temperance was virtue. They wrought with cheerfulness on days of labour; but observed festivals as intern
of idleness and pleasure. They kept up the Christmas carol, sent true-love knots on Valentine morning,
pancakes on Shrove-tide, shewed their wit on the first of April, and religiously cracked nuts on Michaelmus

No. III.—Nonpareil.

Being apprised of our approach, the whole neighbourhood came out to meet their ministe
dressed in their fine cloths, and preceded by a pipe and tabor; a feast also was provided
our reception, at which we sat cheerfully down; and what the conversation wanted in

No. VI.—Bourgeois.

was made up in laughter. Our little habitation was situated at the
of a sloping hill, sheltered with a beautiful underwood behind, and prat

No. VIII.—Small Pica.

ling river before; on one side a meadow, on the other a green
My farm consisted of about twenty acres of excellent land,

No. X.—Pica.

having given a hundred pounds for my predecessor's
good will. Nothing could exceed the neatness of my

No. XII.—Great Primer.

little enclosure; the elms and hedge-
rows appearing with an inexpressible

No. XVI.—2-line Great Primer.

and was covered with

Cannon. No. XX.—Snellen.

thatch, which

4-line Roman. No. XXX.—Snellen.

gave it an

8-line Roman. No. XL.—Snellen.

air of