$+\frac{1}{10}$ and $+\frac{1}{15}$ lens measures the deficiency in the refractive power between the emmetropic eye and the eye affected with H.; consequently

$$H = \frac{1}{10} - \frac{1}{15} = \frac{1}{30}$$

and a $+\frac{1}{30}$ lens should enable the patient to overcome the defect in the refractive power of the eye from which he suffers.

Atropine not always necessary.

In cases where the amount of H. is small, it may not be necessary to overcome the latent H.: we may be able by means of the test above described to discover the degree of manifest hypermetropia as compared with that of an emmetropic eye, and having neutralized this defect in its refractive power by means of a convex lens, the patient's sight, with the aid of his glasses, will be perfectly good for all practical purposes.

Test types.

I have already referred to the diagnosis of the degree of H. by means of test types; I have only to allude therefore to that of the ophthalmoscope as an instrument by which we can not only determine the existence of H., but also form an idea of its degree.

Ophthalmic test of degree of H.

The difficulty in this case, as in that of M., arises from the fact that the observer must, while looking at a near object, prevent his ciliary muscle from acting—that is, he must, while examining the H. eye, prevent his eye from accommodating itself for a near object. The reflected rays of light from the fundus of an hypermetropic eye are divergent according to the degree of hypermetropia, and an emmetropic eye with its accommodation suspended can only obtain a clear image from parallel rays;* but if we place a convex lens behind the sight-hole of the ophthalmoscope, so as to render these divergent rays parallel, provided we can prevent our ciliary muscle from acting, the parallel rays reflected from the fundus of an hypermetropic eye will be brought to a focus on our retina, and enable us to obtain an erect image of any small vessel in the region of the yellow spot; the power of the convex lens, which converts the divergent into parallel rays, will under these circumstances give us an idea of the degree of H. existing in the case under examination.

Selection of Glasses in Cases of H.—I have

* "A Practical Treatise on Diseases of the Eye." By R. Brudenell Carter, F.R.C.S. Macmillan, 1875. Page 550.

Selection of glasses.

already referred to the means by which we ascertain the degree of H. and the power of the lens necessary to overcome the diminution in the refractive power of the eye; but in practice we shall find that from long-continued action, it is difficult to prevent the ciliary muscle from exerting itself too powerfully on the lens, so that in order to ascertain the glasses necessary to correct the defect of vision in a case of hypermetropia, the patient should be directed to read No. 20 of Snellen's test types at a distance of twenty feet; this he will probably be unable to do without the aid of convex glasses. Supposing that with No. 30 he reads this sized print clearly, it will then be necessary to destroy his accommodating power with atropine, and this having been done, we find, perhaps, that he now requires No. 20 convex glasses to define the same letters; but as he cannot overcome the habit of over-using his ciliary muscle, we must make allowance for this, and strike the difference between the lenses necessary to overcome the M.H. and the L.H., and supply our patient with No. 24 or No. 26 convex glasses. We may further test their defining power, by placing first a convex and then a concave glass in front of his spectacles.

Danger of retinal hyperæmia.

We sometimes meet with cases of hypermetropia, in which there is considerable hyperæmia of the retina, induced by constantly overstraining the eye; and if this condition has lasted for some time, the nervous apparatus will be more or less damaged, and imperfect vision must be a permanent result. The patient's sight, however, may be considerably relieved by the use of convex glasses, unless irreparable damage has been done to the nervous tissue.

Glasses always to be worn.

Whatever glasses we may order, it is necessary that the hypermetropic patient should wear these constantly, otherwise it is impossible to overcome the tonic contraction of the ciliary muscle: at first he may find the spectacles inconvenient, but we must insist on their being worn from morning till night; and it matters not what the age of the patient may be, so soon as we discover that he suffers from H., our course of action is clear, for properly-adjusted convex glasses can alone overcome the defect of vision from which he suffers.

H. in cases of extraction of lens.

Hypermetropia, as I have before remarked, is found to an extreme degree after the removal of the lens, the

condition called "aphakial" existing; in fact, the power of accommodation is destroyed, and we must supply our patient with glasses for seeing near and far distant objects. As a rule, a + $3\frac{1}{2}$ or + 4 lens will best enable such a person to see distant objects, and he may require a + 3 or perhaps + $2\frac{1}{2}$ lens to define letters with. In consequence of the weight of these powerful lenses, plano-convex glasses are often useful; and we can only determine the power of the lens required by trying glasses of various strength, and noting the ones with which the patient sees best. The smaller the pupil after extraction, the better as a rule will be the defining power of the patient, and the power he has of judging of distance accurately: I have seen a person after the operation of extraction has been performed on both eyes, play a very good game of billiards with + 3 glasses, the pupils being not larger than they would have been when extremely contracted in the healthy eye.

Small pupil desirable.

The distinctions between the various affections of the eye I have been considering, are well shown in the following table, taken from Mr. J. Z. Laurence's work on the *Optical Defects of the Eye*, p. 30.

Tabular view of optical defects.

The Eye in a State of Rest (=Crystalline at its Minimum Curvature; Optic Axes Parallel).

1. Eye:—	2. Parallel rays are focussed:	3. Far point:	4. Eye in a state of rest adapted for:	5. Effect of glasses for distant objects:
I. Normal.	*On* the retina.	At an infinite distance.	Parallel rays.	Convexes and concaves deteriorate vision.
II. Myopia.	In *front* of the retina.	At a definite distance and positive.	Divergent rays.	Concaves improve vision.
III. Hypermetropic.	*Behind* the retina.	At a definite distance and negative.	Convergent rays.	Convexes improve vision.

PRESBYOPIA.—Presbyopia consists in a defect in the accommodating power of the eye, arising from alterations in the fibrous structures of the lens, which prevent the convexity of its anterior surface from becoming increased in correspondence with the contractile power exercised by the ciliary muscle; and, in consequence, the near point of sight for small objects is removed to a distance of not less than eight inches from the cornea: while rays from distant objects are still brought to a focus on the retina. Presbyopia may be brought about by glaucoma, in consequence of changes in those parts of the eye which influence the act of accommodation; but in an uncomplicated instance of presbyopia, the focal error is completely corrected by applying a suitable convex lens in front of the eye, so as to compensate for the loss of refractive power in the eye caused by changes in the lens.

PRESBYOPIA.

Failure of accommodation.

The alterations which result in presbyopia may be said to commence from the age of twenty years, when the near point begins to recede. At five-and-forty, its distance from the cornea is usually upwards of eight inches; the eye is then pronounced to be presbyopic, and as the patient experiences, for the first time, some little inconvenience in reading and writing, he probably applies for relief. His far point, however, remains unaffected; for, as I have repeatedly stated, the lens and ciliary muscle are passive when objects at a distance of twenty feet or upwards are under examination.

Near point recedes with age.

Far point unaltered.

Presbyopia, as I have before remarked, may be completely neutralized by proper lenses, and we should invariably insist on those suffering from this defect of vision using convex glasses, which will enable them to read No. 1 of Snellen's test types at twelve inches from their eyes without fatigue. The spectacles should be worn so that the patient may look over them when using his eyes for distant objects; and as a general rule the weakest glasses which enable a patient to read No. 1 type at twelve inches distance from his eyes should be given. In the majority of cases No. 36 or 40 convex glass will be strong enough to overcome the presbyopia in its early stages: as the patient grows older he will require to increase the focal power of his spectacles.

Convex glasses for.

Presbyopia may exist with myopia, but will not be perceptible so early in life as it would be in the case

of an emmetropic eye; and if the M. amounts to $\frac{1}{8}$, the presbyopia cannot exist, because the near point cannot be removed beyond 8″ from the eye. But if the M. is only slight, then as age advances the patient may require concave glasses to enable him to see distant objects, but he will also require convex glasses to enable him to overcome the deficiency of the accommodation necessary to make out small objects near the eye.

Presbyopia and myopia.

Presbyopia again may be present with H., and although the latter affection may have been overcome by means of proper glasses, nevertheless as the hypermetropic patient advances in age he can no longer accommodate for near objects such as in reading and writing, and we must therefore add such power to the lenses as will enable them to overcome this want of action in the lens. Thus a person who has worn $+\frac{1}{12}$ glasses to overcome his H. will probably at forty-five years of age require a $+\frac{1}{30}$ lens added to his $\frac{1}{12}$ to enable him to read with comfort $(\frac{1}{12}+\frac{1}{30})=\frac{1}{9}$ or a $+\frac{1}{9}$ lens; but on leaving off his reading he would require the $\frac{1}{12}$ lens for distant objects. To obviate the necessity for constantly changing his spectacles, Franklin devised the plan of putting two half-lens in each ring of the spectacle frame: the upper half being the weaker, for distance, the lower half the stronger, for reading. Glasses of this kind are useful in cases such as that above noticed.

Franklin's plan of lenses.

Astigmatism.

Astigmatism.—By astigmatism is meant, a condition of the dioptric media, such that the refractive power of the eye varies in its different meridians, so that in one plane it may be emmetropic or hypermetropic, and in another plane myopic, and so on; the consequence is, that rays emanating from one point, are not reunited into one point after traversing the eye, and thus a very imperfect image of any object under observation is formed on the patient's retina: under these circumstances a person complains of the letters or words he may be reading being indistinct; in the effort which he makes to accommodate, first for one meridian and then for the other in order to obtain clear vision, the ciliary muscle becomes strained and asthenopia is the result.

Unequal refraction in different meridians.

Near vision confused.

Symptoms.

It is obvious that the more widely dilated the pupil is, the greater will be the fault in the refraction of the rays of light passing through the dioptric media of an

eye affected with astigmatism: but the acuteness of vision, as I have before remarked, for both near and distant objects is lessened, so that in reading the letters appear blurred, the difficulty of defining the print increasing after the eye has been exercised for some time, in consequence of failure in the ciliary muscle to act on the lens. Objects at a distance of ten or fifteen feet, such as the woodwork of a window-frame, is distorted, the horizontal bars being more clearly defined than the vertical ones, or *vice versâ*. It is in fact easy to understand the deformity which must arise in the outline of all figures, when looked at through a cornea in which the rays of light passing through the horizontal, are refracted differently from those passing through its vertical meridian.

Objects blurred.

Ill-defined.

Astigmatism is frequently a congenital affection, the curvature of one meridian of the cornea being greater than that of another meridian. But inflammatory changes in the cornea may induce similar results; and there can be no doubt that inequalities in the curvature of the anterior surface of the lens, as well as structural changes in the cortical walls of the lens, may cause astigmatism.

Causes.

Donders has divided astigmatism into three kinds:—

Three varieties of astigmatism.

I. *Simple astigmatism*, in which the principal meridian is emmetropic, the other being myopic or hypermetropic.

II. *Compound astigmatism*; either myopia or hypermetropia existing in both of the principal meridians, but differing in degree in each.

III. *Mixed astigmatism*, in which one of the meridians is myopic while the other is hypermetropic.

Diagnosis.—Neither concave nor convex spherical lens will materially remedy the defective vision caused by astigmatism.

Diagnosis.

Probably the most simple and effective method of diagnosing cases of astigmatism is by means of Snellen's half circle of radiating lines, together with a combination of + and − spherical glasses. A patient comes to us with suspected astigmatism; we place him with his back to the light and with Snellen's fan of radiating lines, hung at 20″ in front of, and on the same level as his eyes. Each eye must be examined separately. We find that with the right eye he can see the vertical lines of the fan clearly, the

By test lines.

Example.

inclined lines only dimly, and the horizontal lines hardly at all. On placing a $-\frac{1}{24}$ spherical lens before the eye the horizontal lines become clear, but the vertical rays are thus rendered indistinct. Evidently in this case the vertical meridian of the eye was emmetropic, but the horizontal meridian was myopic to the extent of $\frac{1}{24}$.

In the left eye with a $-\frac{1}{9}$ lens the inclined ray of the test fan, 70°, which was previously dim, came out quite clearly, and with a $-\frac{1}{36}$ placed in front of the $-\frac{1}{9}$ the line $-20°$, previously dim, was clearly defined, so that the corneal meridian corresponding to line 70° in the fan is myopic to the extent of $-\frac{1}{9}$, and the meridian of line $-20°$ is myopic to the extent of $\left(\frac{1}{9}+\frac{1}{36}\right)=\frac{5}{30}=\frac{1}{7\frac{1}{5}}$.

In fact, having by means of Snellen's radiating lines discovered that the meridians of the eye differ in their refractive power, we must set ourselves to work to discover if + or − glasses overcome the defect in the acuteness of vision in the affected meridian. It may be as in the example given above (the right eye) that one meridian is emmetropic, and the other myopic (myopic astigmatism), or as in the left eye that the degree of M. differed in different meridians (compound myopia astigmatism), M. H. may be found in one meridian and emmetropia in another (hypermetropic astigmatism), the degree of H. is noted, and so on. But in cases of A. H. it will often be necessary as in simple H. to paralyse the ciliary muscle before we can properly determine the deficiency in the refractive power of the eye.

Tests of astigmatism. The ophthalmoscope.

Several very ingenious methods have been invented to test the amount of astigmatism in any particular case; among these the ophthalmoscope holds a prominent position, and it affords the means not only of detecting astigmatism, but also of determining its degree, and the plane in which it is situated. A concave mirror of thirty inches focus should be employed, the fundus of the eye being illuminated at a distance of five feet, the accommodation of the eye under observation having been paralysed with atropine. The patient should then be directed to follow the movement of the surgeon's finger in a horizontal and vertical direction; an inverted or an erect image becoming alternately

visible according as the observer views the fundus of the eye through the meridian of the greatest or least curvature.

Chromatic test.

If a person whose eye is healthy, be directed to look through a plate of violet-coloured glass, fixed in a black screen, the glass will appear to be surrounded with a red rim; this is accounted for by the different refrangibility of the rays of light. In the case of astigmatics, the refraction seems to be completely altered: for if the above experiment be repeated upon a patient suffering from this form of disease, the vertical meridian being myopic and the horizontal hypermetropic, the opening in the screen will appear surrounded above and below by a blue rim, and on either side by a red one.

Distortion of visual images.

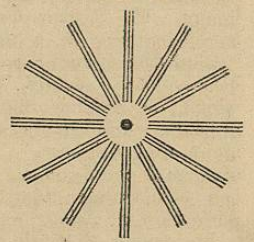
Another method of ascertaining the existence of astigmatism, is to place the patient at a distance of 12 or 16 feet from a bright spot of light, upon which he is directed to keep his eye steadily fixed, looking at it through a round hole in a screen; if the eye under examination is astigmatic the bright spot will appear to be elongated, according as the light is nearer or further off than the point for which the eye is accommodated.

If the eye is accommodated for a further point and the maximum curvature of the cornea coincides with the vertical meridian, the luminous spot will appear horizontal, but vertical if the eye is accommodated for a near point.

Green's test.

Dr. Green's method of testing an eye for astigmatism is as follows. A figure such as that here depicted is drawn, each line being equal in thickness to those employed to form the letters of Snellen's No. 20 test types. This test is placed 20 feet from the patient's eyes, and while he fixes his eye on the central spot, if he be astigmatic, the radiating lines in one meridian only will be distinctly seen, those corresponding to the meridian of lowest refraction being dimly if at all distinguishable. We may further, by means of this figure, ascertain the degree and nature of the astigmatism

FIG. 52.



by cylindrical glasses of a certain power rendering the whole figure distinctly visible, in fact overcoming the defective refractive power of the cornea.

It has been stated that the inverted image of the optic disc of an astigmatic eye, viewed by the ophthalmoscope, is elongated, so that the long axis corresponds to the meridian of least refraction. Dr. Hay shows that this is not uniformly true; that the form of the nerve-image depends on the distance at which the objective lens is held from the eye. If we suppose the lens to be of three inches' focus, and held about three inches from the eye, the nerve will appear circular notwithstanding the astigmatism; that if the lens be held nearer than three inches, the image will be oval, and the long axis correspond to the meridian of least refraction; if the lens be held farther than three inches, the image will be oval, and its long axis correspond to the meridian of greatest refraction.

If a minute hole be drilled in a piece of metal, and held close to an emmetropic eye, accommodated for distant vision, the spot, instead of appearing round, looks as if it were star-shaped; that this is due to the lens, is proved by the fact, that when the lens is removed no such appearance is produced, and if the cornea be neutralized by holding the eye open in a small vessel of water, bounded by a convex glass side, the hole appears still to be star-shaped, provided the lens is *in situ*.

Different sectors of lens give different images.

Donders explains this fact by reference to the anatomy of the lens, which is divided into sectors by its fibrous bands, each sector forming a separate image. He further demonstrates it by moving a small opening in a metallic plate before the eye; "when the opening comes in front of the boundary between two sectors, two faint images appear, of which, on further displacement, the first seen disappears, while the one which has supervened remains alone and brighter." If, therefore, there be any abnormal condition in these sectors of the lens, we can readily understand that it must interfere with the perfection of vision; more particularly as the rays of light passing through each sector are subject to the laws of spherical aberration.

Treatment.—Astigmatism may be corrected by properly adapted *cylindrical lenses*. Mr. J. Z. Laurence remarks that "A spherical lens is a segment of a sphere, and refracts the incident rays of light equally in all planes of the segment; a cylindrical lens is the segment of a cylinder, and refracts rays of light most in a plane at right angles to the axis of the cylinder of which it is a segment, whilst those rays of light which strike it in the plane of the axis, undergo no refraction whatever. For the sake of simplicity we may therefore restrict our consideration to these two directions—that of the axis and that of the transverse diameter. A 6-inch convex cylindrical lens means one which refracts a pencil of parallel rays thus: (1) those which strike it parallel to the transverse diameter of the cylinder are focussed at six inches from the surface of the lens; (2) those which strike it parallel to the axis of the cylinder are not focussed at all by the lens, but pass through it refracted not more than they would have been by passing through a piece of plain glass."*

Cylindrical glasses.

Refract unequally in different planes.

To counteract, therefore, defective vision induced by astigmatism, in which the principal meridian is normal, the other being myopic or hypermetropic, a cylindrical lens is employed; the rays passing through its axis undergo no change, while those passing through a plane at right angles to this, should undergo the amount of refraction necessary to neutralize the abnormal condition of the corresponding meridian of the cornea; and the same principle applies to the other forms of astigmatism.†

Hence may neutralize astigmatism.

Having, therefore, in the first instance, discovered the exact nature of the changes that have occurred in the curvature of the cornea, cylindrical glasses must be adapted to counteract the abnormal refraction. A considerable amount of study and experience is required, to enable one to master difficult and complicated cases of this kind; but having once overcome them, one of the greatest triumphs in the practical application of ophthalmic science is achieved—namely, the adaptation of cylindrical glasses to correct the impairment of vision caused by astigmatism.

Must be adapted to individual cases.

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* "Optical Defects of the Eye," by J. Z. Laurence, p. 65.

† *Vide* S. Wells' "Lectures," p. 192.

Illustrative case from Donders.

As an example I may give one of Donders' cases as illustrating the method by means of which we may select glasses for a patient suffering from astigmatism:

Mr. V., aged fifty-nine years. The *right* eye is nearly emmetropic: improvement of vision at a distance by convex $\frac{1}{60}$ is doubtful; concave $\frac{1}{60}$ acts injuriously.

From youth the patient has been unable to use his *left* eye; however, there exists neither obscurity nor organic change in the fundus oculi. Positive and negative spherical glasses produce no improvement. The reflected images of the cornea had suggested the idea of asymmetry. Examination with the ophthalmoscope afforded the proof of it: in the non-inverted image, I, as an emmetrope, saw, with some tension of my accommodation, vertical vessels of the retina perfectly acutely; horizontal vessels, on the contrary, appeared, on tension of accommodation, very faint, and on perfect relaxation were not well defined. I hence inferred the existence of myopia in the vertical, and of hypermetropia in the horizontal meridian. On examination with the point of light, the principal meridians seemed to deviate little from the vertical and horizontal planes; the most slender vertical line was seen with convex $\frac{1}{45}$, the most slender horizontal with concave $\frac{1}{30}$. The diagnosis was: mixed astigmatism $=\frac{1}{18}$ composed of

$$\text{Myopia } \tfrac{1}{30} + \text{Hypermetropia } \tfrac{1}{45}.$$

The cornea more than fully accounted for this: the radius of curvature in the visual line amounted, in the horizontal plane, to 8·29 mm., in the vertical=7·69,—indicating an astigmatism of 1 : 11·67. While (at least by the method with the point of light) only a mixed astigmatism $\frac{1}{18}$ was found, the crystalline lens appeared to compensate in part for the astigmatism of the cornea.

Quite in accordance with the ametropia in both principal meridians, the left eye sees at a distance vertical lines a little better than horizontal. With convex $\frac{1}{45}$ horizontal lines are still more indistinctly visible, while vertical lines are acutely seen. *Vice versâ*, with concave $\frac{1}{30}$ horizontal lines are very well

seen, vertical lines, on the contrary, are only faintly perceptible. . . . . .

For distance, a flat glass was prescribed for the right eye; for the left a bi-cylindrical glass of $\frac{1}{45}\ c\ \Gamma - \frac{1}{30}\ c$. For close work, I was anxious, the acuteness of vision not being perfect, to bring the far point to 12″. This was effected by means of a spherico-cylindrical glass of $\frac{1}{20}\ s \subset \frac{1}{18}\ c$: with $\frac{1}{20}$, in fact, the far point in the vertical meridian $(\frac{1}{30}+\frac{1}{20}=\frac{1}{12})$ becomes=12″, and with $\frac{1}{18}\ c$, the far point in the horizontal is made equal to the far point in the vertical. Hereby the right eye now acquired simply $\frac{1}{12}\ s$. The images were of nearly equal magnitude, and the vision was with both eyes at the same time very pleasant. Vision with the left eye was more acute than with the right.*

Artificial pupil.

Should the astigmatism have been induced by ulceration of the cornea, it will often be necessary to make an artificial pupil, and then, with the aid of cylindrical glasses, the patient's sight will probably be vastly improved.

Asthenopia.

Asthenopia.

Asthenopia, or feebleness of vision arising from defective or irregular muscular action, the internal rectus being at fault in motor asthenopia, and the ciliary muscle in the accommodatory form of the disease.

1. Motor variety.

1. *Motor Asthenopia.*—If a ruler, or any other object, be held at a distance of some twenty feet from a person's face, and he be directed to keep his eyes steadily fixed on it, as it is gradually brought nearer to him, we notice that his eyes converge upon it; and, when the object is brought within four inches of them, they will be inverted in a marked manner. This inward movement of the eyes is symmetrical in healthy vision, so that the rays of light proceeding from the object under observation, fall upon precisely corresponding spots on both retinæ (the maculæ luteæ). If, however, from any cause, the power of the internal rectus in one or both eyes becomes weakened, so that

* Moore's Translation of Donders, p. 530.

Failure of internal rectus;

when the patient is engaged in looking at a near object, as for instance in reading, the muscle can no longer contract sufficiently to counteract its antagonistic muscle; under these circumstances, the eye, in place of being inverted, will be more or less everted by the external rectus, and the rays from the object under examination not falling upon exactly similar points of the retinæ in both eyes, diplopia results (Fig. 47). It is this condition which constitutes motor asthenopia.

from over-straining in near sight.

In the case of a person suffering from myopia, it is evident that, as he reads or writes with the book or paper close to his eyes, the internal recti must be kept constantly contracted; and from being thus overstrained, in course of time the muscle becomes exhausted, and the person being no longer able to maintain the effort necessary to invert the eyes, the external rectus asserts its superiority, and the globe is turned outwards. This is often increased by the peculiar conformation of the eyeball, which being elongated in the antero-posterior axis its centre of motion becomes altered, necessitating increased action of the internal rectus to converge the eye upon near objects; and thus the tendency to motor asthenopia, from overstraining of the internal rectus, is augmented.

Causes divergence.

Effect on vision. Words run together.

If a change of this kind in the direction of the eye takes place while the patient is reading, the words appear to run into one another, and become very indistinct, and he is obliged to rest his eyes for a time till the exhausted muscle can recover itself. Should the patient, however, in place of discontinuing his work, endeavour by an increased effort to go on with it, he may possibly be able to do so for a short time; but the eyes then begin to give him pain from congestion of the choroid, and headache supervenes, so that he is ultimately compelled to take rest.

Headache.

Common in myopia.

Motor asthenopia, therefore, is seldom met with, unless among myopes, or those engaged in work which necessitates their bringing the object upon which they may be employed very close to the eye; in either case the overstraining of the internal rectus is the origin of the disease.

The symptoms of this affection are those I have above described: the patient complains that, after writing or reading for a time, the words or letters appear to run into one another; and if he persists in using his eyes, he suffers from pain in them, extending to the eyebrow and side of the head. After resting for an hour or so, these symptoms disappear, and he can again continue his employment for a longer or shorter period.

Relieved by rest.

Diagnosis.

The simplest way of detecting the existence of this form of asthenopia, is to place a ruler or some such object in front of the patient, and direct him to look at it steadily while you slowly bring it nearer to within half a foot of his face. If motor asthenopia exist, we shall notice, in the course of a few minutes, that one of the patient's eyes will begin to quiver, and then gradually become everted, and he will at once tell you he can no longer see the object distinctly.

V. Graefe's prism test.

Von Graefe has devised a very simple means of detecting not only the existence but also the degree of motor asthenopia. A black spot, about the size of a split pea, is to be made on a sheet of white paper, and through this spot a perpendicular line must be drawn. The patient is then directed to look steadily at the figure, and a prismatic glass, with its base turned upwards, is to be placed before first one eye, and then the other. If he be emmetropic, the prism will simply cause two spots to appear on the paper, one above the other; but if asthenopia should exist in either eye, one of the spots will be seen in its real position, and the other above it, and to the right or left of the perpendicular line. Now, in order to discover the degree of diplopia, which is the cause of this deviation of the spot from the perpendicular line, all that is necessary is, to put a second prism, with its base outwards or inwards as the deviation of the spot may indicate, in front of the first one. The angle of the prism, required to restore the spot to its position on the perpendicular line, will indicate the amount of existing diplopia.

The degree of divergence ascertained.

Treatment.

The Treatment of motor asthenopia may either be palliative by means of glasses, or complete, by division of the muscle antagonistic to the weakened one.* If

* Donders remarks that "Von Graefe has established the indications for tenotomy with great accuracy. The condition for the operation is this, that under the attempt at single vision, a sufficient divergence of visual lines should appear to be pos-

By concave lenses.

the former plan of treatment be adopted, the use of concave lenses, by preventing the necessity of the patient's bringing objects very close to his face, as in reading and writing, saves the constant strain which would otherwise be exerted on the internal rectus; and by husbanding the strength of this muscle, enables it to contract when called on to do so, and to converge the optic axes upon an object close before the eyes.

Prisms.

Or we may, by the use of proper prisms, correct the diplopia by bending the rays of light upon the macula lutea of the everted eye, in this way reproducing binocular vision.

Division of external rectus.

In very slight cases these means may prove effectual; but in the majority of instances it will be necessary to do more than this, and to cut through the tendon of the external rectus. Great care, however, is necessary to divide only so much of the muscle as will prevent it from overcoming the contractile power of the internal rectus, otherwise we shall simply complicate matters by converting the external into an internal strabismus. If the operation be properly performed, and the muscle antagonistic to the overstrained one, whichever that may be, is carefully divided, motor asthenopia cannot, of course, exist (*vide* Chap. XIV.).

2. Accommodatory asthenopia.

2. *Accommodatory Asthenopia.*—The symptoms of this form of disease are very much akin to those described as characteristic of motor asthenopia, except that the patient's eye is not everted after being used for a time. Patients suffering from accommodatory asthenopia, have often very good long and short sight; they simply complain of the words or letters they may be reading appearing confused, and running into one another after a few hours' work. If,

No eversion.

Words run together.

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sible. This should be tried (after neutralization of the myopia by concave glasses placed at a proper distance from each other) with prismatic glasses; we should investigate with what prismatic glasses, held with the refracting angle outwards before the eyes, single distant vision is still attainable. The strongest glasses then which can still be overcome give the measure of the possible divergence. It is allowable now so to perform tenotomy that this possible divergence shall be completely removed. If the strabismus is evident without prisms, there can be no doubt of the propriety of dividing the internal rectus."—Moore's Translation of Donders, p. 428.

in spite of this, an effort is made to continue reading, the eyes become painful and weary, and it is then absolutely necessary to rest them for a time; but in ten minutes or a quarter of an hour the patient can resume his employment.

From fatigue of ciliary muscle.

These symptoms arise from inability on the part of the ciliary muscle to keep up the accommodative effort, which is necessary for bringing divergent rays to a focus on the retina. The muscle, from being overworked, or from general debility, soon becomes fatigued, and being no longer able to contract, it gives way: the anterior surface of the lens then recedes, so that parallel rays of light are alone correctly focussed on the bacillar layer. The patient can therefore see objects at a distance, although the words he may be reading or writing appear indistinct. A little rest speedily restores the power of the ciliary muscle, and he can again set to work for a time.

Ophthalmoscope in diagnosis.

The ophthalmoscope may be useful in these cases, to enable us to ascertain that no positive disease exists, either in the dioptric media or the fundus of the eye. Hyperæmia of the retina, it is true, will generally be detected; and, as I have before observed, this should never be regarded as a small matter, although in this instance it may not indicate any serious derangement of nutrition, being merely an effect of the prolonged strain to which the apparatus of the eye has been exposed in the effort to maintain the necessary accommodation.

Hypermetropia a cause.

The majority of cases of accommodatory asthenopia depend upon hypermetropia, and when this is corrected with proper convex glasses, the ciliary muscle, being no longer overstrained, will be able to maintain the necessary convexity of the lens to focus divergent rays, and the symptoms of asthenopia will disappear. But a long residence in the tropics, severe illness, and, in fact, any cause which impairs the tone of muscular fibres of the ciliary, together with that of the other muscles of the body, may produce accommodatory asthenopia. Under any circumstances, a pair of weak convex glasses, by increasing the refractive power of the eye, will obviate the necessity for any great alteration in the convexity of the lens for

Corrected by convex glasses.

Rest and tonics.

near objects, and thus relieve the ciliary muscle; but the patient should be enjoined to rest the eye as much as possible, and very often a tonic plan of treatment is called for. I have known several cases of this kind, in which the asthenopia had apparently been brought on by general derangement of the health, and a change to Europe entirely removed the troublesome symptoms from which the patients were suffering.

Should the asthenopia depend on H., we must discover the degree of defect which exists in the refractive power of the eye, and supply this deficiency by means of proper convex glasses.

CHAPTER XVI.

CONGENITAL MALFORMATIONS AND DISEASES OF THE EYE.

Congenital Affections.

A few remarks on this subject may be useful, although, with one or two exceptions, these cases are similar to those already described in the foregoing pages. The fœtus is doubtless subject to diseases of the eye *in utero*, the results of which may be apparent at birth in the form of opacities of the cornea or synechia, especially if the parents have suffered from syphilis. The congenital malformations and diseases of the eye, however, may be briefly passed in review in the same order as that I have adopted throughout this work.

Epicanthus.

Malformations of the Eyelids and other Appendages.— Epicanthus consists of a deep fold of skin along the side of the root of the nose, overlapping the inner angle of the eye and completely hiding the caruncle. A modification of this condition is common to all the Burmese and Chinese races: their flat nasal bones and the loose fold of skin covering the inner angle of the eye are peculiar to these people, and as they advance in life present the appearance of an epicanthus.

Ptosis.

Ptosis is at times a congenital affection, and when occurring under these circumstances, usually depends upon a defect of the levator palpebræ muscle, and is, therefore, almost hopelessly irremediable.

Malpositions of the lids.

Ectropium, entropium, and trichiasis have been met with in the new-born infant, following, in all probability, inflammatory affections of the conjunctiva during the child's fœtal state.*

Union.

Mr. Travers mentions an instance of a child having been born with the eyelids united (anchyloblepharon).

* Mr. Wilde on "Malformations and Congenital Diseases of the Organs of Vision," p. 12.