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THE HARMONIOUS SYMMETRICAL ACTION OF THE OBLIQUE MUSCLES IN ALL CASES OF OBLIQUE ASTIGMATISM.

Read before the Nashville Academy of Medicine, January 15, 1891.

BY G. C. SAVAGE, M. D.,

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More than four years ago I became convinced, from observation, that a revolution of the eyes, on their antero-posterior axes of rotation, occurs in all cases of oblique astigmatism, for the improvement of vision. This conviction led me to develop a theory of revolution which I made public, for the first time, in a paper entitled "The Function of the Oblique Muscles in Certain Cases of Astigmatism," read before the Section of Ophthalmology of the American Medical Association, at its Chicago meeting in 1887. A year later I wrote a second paper in reply to a paper on "Binocular Astigmatism," read by Dr.

H. Culbertson before the Section of Ophthalmology, at the Cincinnati meeting of the American Medical Association, in which I advocated the same theory of rotation as set forth in my first paper, and by it accounted for all the phenomena referred to in Dr. C's paper, viz., loss of parallelism of the sides of a rectangle, slanting of a level surface, etc.

In developing my theory of rotation I believed the teaching to be true that, under all circumstances, the naturally vertical meridians of the corneæ must be kept parallel or double vision would result. I, therefore, reasoned that, in rotating, both eyes must roll in the same direction. This could be effected only by the superior oblique of one eye acting with the inferior oblique of the other; and this action I termed "Harmonious non-symmetrical."

At that time the condition necessitating this revolving of the eyes was not clear to me. I contented myself by believing that the retinal image was thereby sharpened. That oblique astigmatism involves the necessity of abnormal action on the part of the oblique muscles I will be able to prove in this paper, thus taking the rotation of the eyes on their antero-posterior "axes of rotation" out of the domain of theory and placing it in that of fact.

What is astigmatism? I cannot hope to answer this question more clearly than it is answered in many of the books on the eye. But many of you, not being Ophthalmic Surgeons, possibly have never read the chapter on astigmatism. An astigmatic eye is one whose cornea has not the same radius of curvature for all its parts. That part of the cornea having the shortest radius is the most rapidly curved, while the part with the longest radius is the least rapidly curved These two parts are always at right angles the one with the other. As a rule the meridian of greatest curvature is in the vertical or nearly so, while the meridian of least curvature is horizontal or nearly. As we go from the meridian of greatest, towards the meridian of least, curvature, we find every meridian less rapidly curved, hence each having a longer radius than the one preceding it.

The law of refraction by curved surfaces I will illustrate by supposing that we have before us two spheres of crown glass, one having a radius of two inches, the other a radius of one inch. Parallel rays of light, on entering either of these spheres, will undergo such a bend at the points of entrance, as will bring them to a focus at the opposite extremity of the diameter of the sphere. The larger sphere, having a diameter of four inches, has, therefore, a focal power of four inches; the smaller sphere, having a diameter of two inches, has a focal power of two inches. The density of the one sphere being the same as the density of the other, the difference in focal power is due solely to the want of similarity in curvature. The more rapidly curved surface has the shorter focus, the least rapidly curved surface, the longer focus.

As already defined Astigmatism is due to a want of similarity of curvature of the different parts of the cornea.

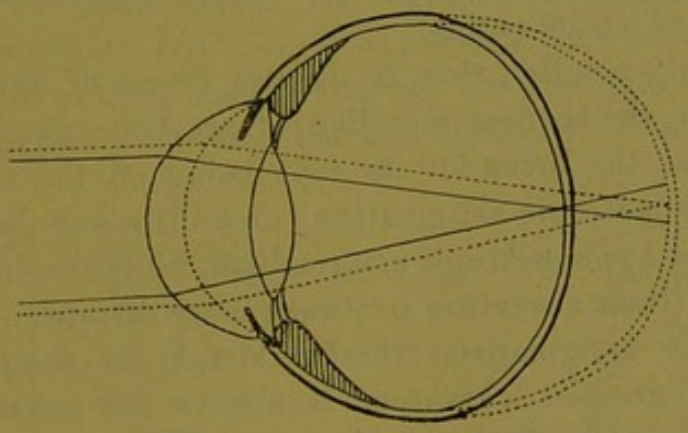

Figure A.

Figure A is intended to represent an astigmatic eye. The continuous and dotted curved lines to the left represent the meridians of greatest and least curvature of the cornea, known in ophthalmology as the two principal meridians. These must be considered as at right angles with each other. The continuous line being the more rapidly curved, we will consider as the vertical meridian of the cornea, and as such is destined to refract the rays of light entering the eye in the vertical plane. The two continuous parallel lines represent this plane of rays,

and these, as shown in the figure, are so bent by this curved surface as to be brought to a focus on the retina, represented by the continuous curved line to the right. The broken curved line to the left, representing the horizontal meridian of the cornea, is less rapidly curved, and, therefore, so refracts the rays of light entering the eye in a horizontal plane (these are represented by the two broken parallel lines) as to give them a longer focal distance. You see them brought to a focus on the dotted curved line to the right, some distance behind the continuous line representing the retina. This difference in focalizing power affects alike both divergent and parallel rays of light.

To have a perfect image of any external object formed on the retina, all the rays emenating from any one point of the object must be brought to one point on the retina. For this to be, the cornea must be a section of a perfect sphere—all the meridians having the same radius of curvature. It is clear then that an unaided astigmatic eye cannot have a well defined image of any object formed on its retina.

I need only mention that, in the two forms of hypermetropic astigmatism, the corneal meridian of greatest curvature is the *best* meridian, the focus for its rays being on the retina, as in simple hypermetropic astigmatism, or a little way behind it, as in compound hypermetropic astigmatism, while the focus for the meridian of least curvature is always more distant.

In myopic astigmatism, whether simple or compound, the meridian of greatest curvature is always the *worst* meridian. In the fifth and last form, mixed astigmatism, the most rapidly curved meridian is the myopic, the least rapidly curved the hypermetropic.

If you were all Ophthalmic Surgeons it would be superfluous for me to add that regular astigmatism, which includes the five kinds just mentioned, is congenital in its origin and its duration is commensurate with the life-time of the individual. While there are opinions to the contrary it is the conviction of the author of this paper that, so long as the astigmatic cornea remains free from pathological changes, the kind and quantity of the astigmatism remains invariable. That is to say, the radii

of curvature of the two principal meridians bear at all times the same relationship to each other.

What effect has astigmatism on the retinal image? Suppose the object looked at to be a line occupying a position at right angles to the meridian of best curvature; its image will be more or less sharp, depending on the quantity of astigmatism, except at its two extremities which will be blurred. If the line correspond to the best meridian, the whole image is marred so that the line is not well seen. If the two principal meridians are respectively vertical and horizontal, the retinal image of any external object is unaffected except in sharpness of outline as indicated above.

In all cases of oblique astigmatism there is something more than a simple blurring of the image. In eyes free from astigmatism, and even in astigmatic eyes when the principal meridians are vertical and horizontal, the object and the retinal image are always in the same plane. In oblique astigmatism, be the obliquity much or little, it is a physical impossibility for the object and its retinal image to occupy the same plane. There is, therefore, not only blurring but also obliquity of the image.

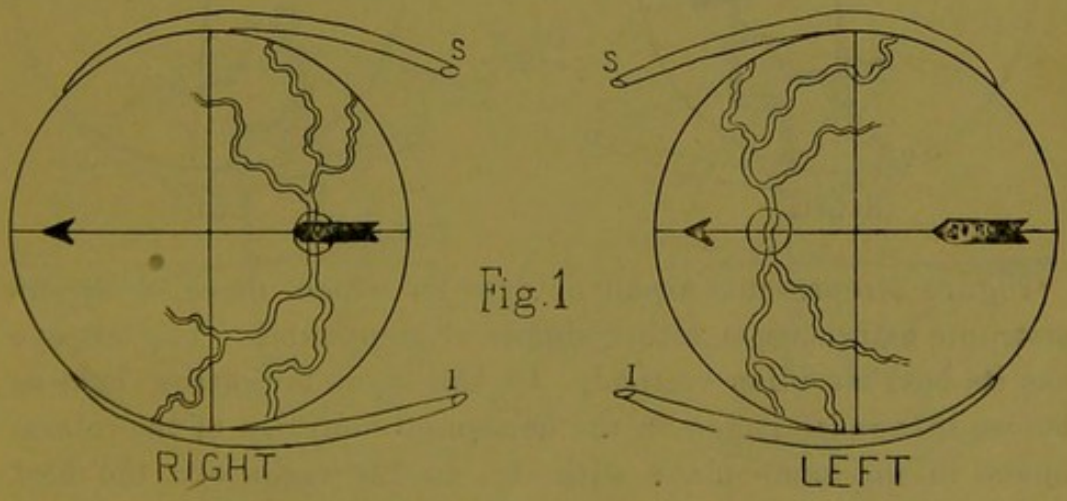

Fig. 1

Figure 1 represents a pair of eyes in which the two principal meridians are vertical and horizontal (they can also represent eyes that are non-astigmatic). If, before these eyes an arrow, or the picture of an arrow, be held horizontally the arrow-head

towards the patient's left, it will throw a reversed image on each retina and the two images will be in the same plane with the object. The two images being horizontal fall on parts of the two retinæ that act together, hence but one object is seen.

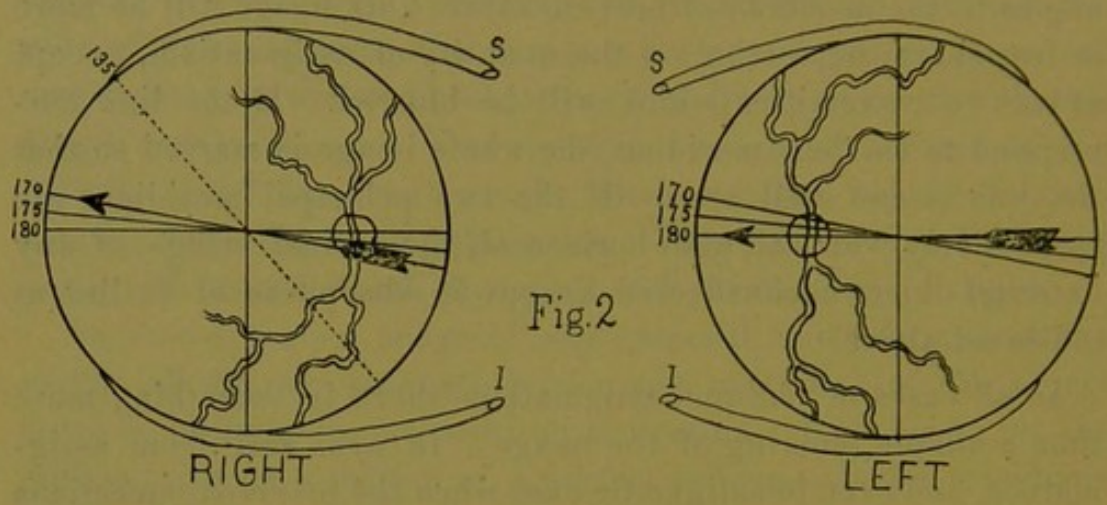

Fig.2

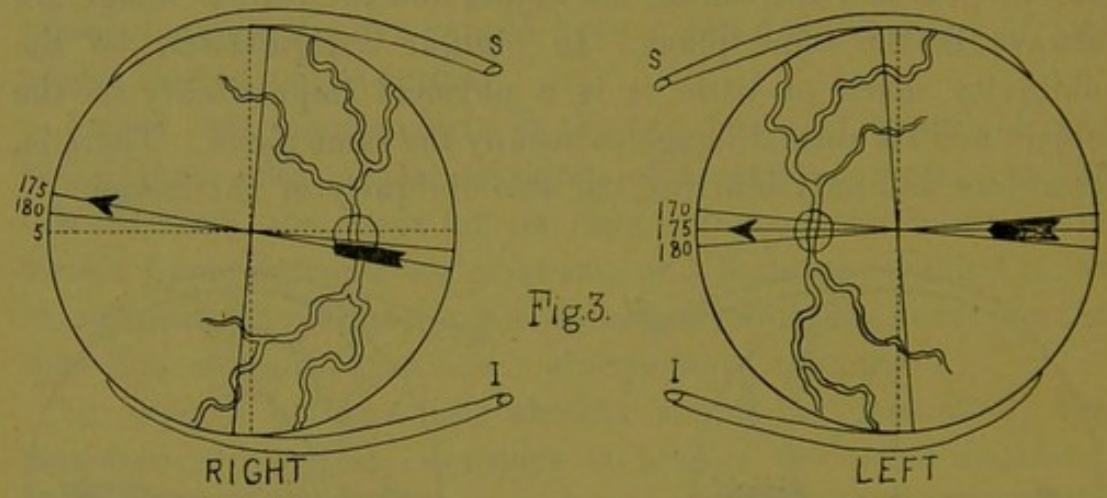

Fig.3.

Figure 2 represents a pair of eyes in which there is hypermetropic astigmatism, either simple or compound. The left eye has its best meridian vertical. In this eye, the arrow held as before throws its image on the horizontal meridian of the retina, hence in the same plane with it. In the right eye the best meridian is at 135°, as shown by the dotted line. In obedience to the well known law of refraction by curved surfaces, the image of the same arrow must be oblique in this eye, and hence not in the same plane with the object. The obliquity of the image will be greater or less depending on the quantity of the

astigmatism. I represent it as falling on meridian 170° of the retina. The horizontal image in the left eye and the oblique image in the right eye, do not fall on parts of the two retinæ that harmonize. The direction of either image in relation to the other cannot be changed except by artificial means—a proper cylindrical lens. This being true, the pair of unaided astigmatic eyes represented by figure 2 must see the arrow double as shown in figure 8, unless something is done by the eyes themselves for the purpose of harmonizing the images. What is done will be shown later.

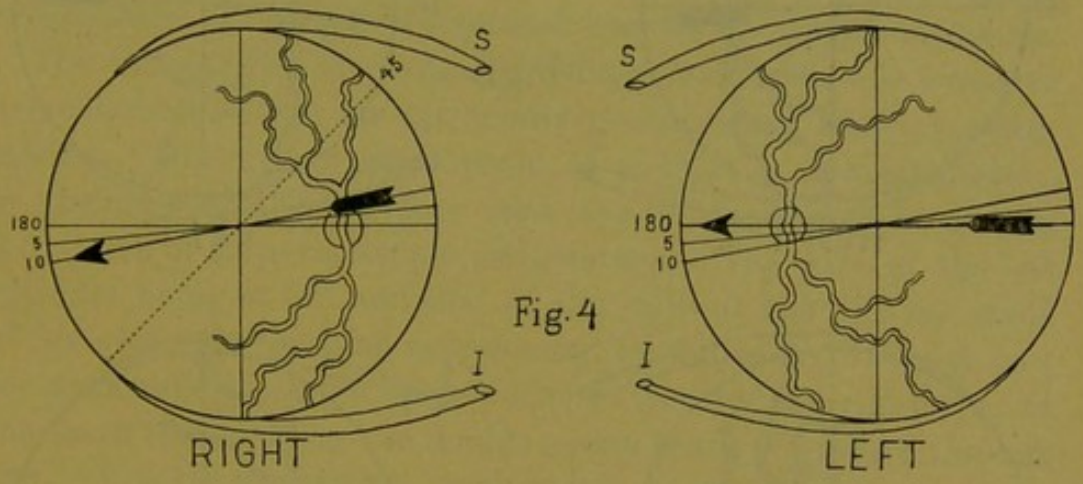

Fig. 4

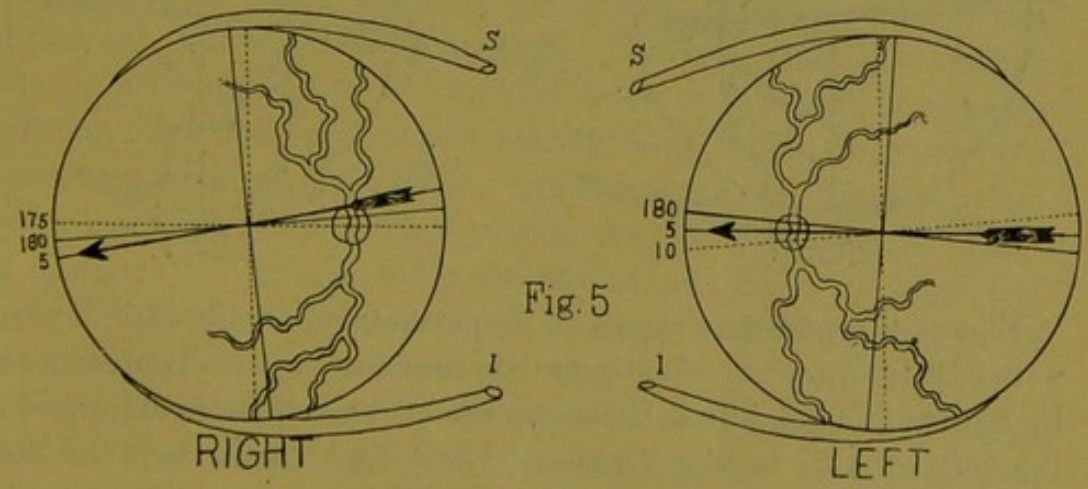

Fig. 5

Figure 4 represents a pair of hypermetropic astigmatic eyes, the left one having its best meridian vertical, and the right one having its best meridian at 45°. In these eyes there is a left horizontal image (image and arrow in same plane) and a right

oblique image, this time on retinal meridian 10°. Nothing but artificial means will change the relative directions of these images; and there must be double vision, unless the oblique image can be made to fall on a portion of the retina that will harmonize with the portion of the other retina, on which the harizontal image may fall.

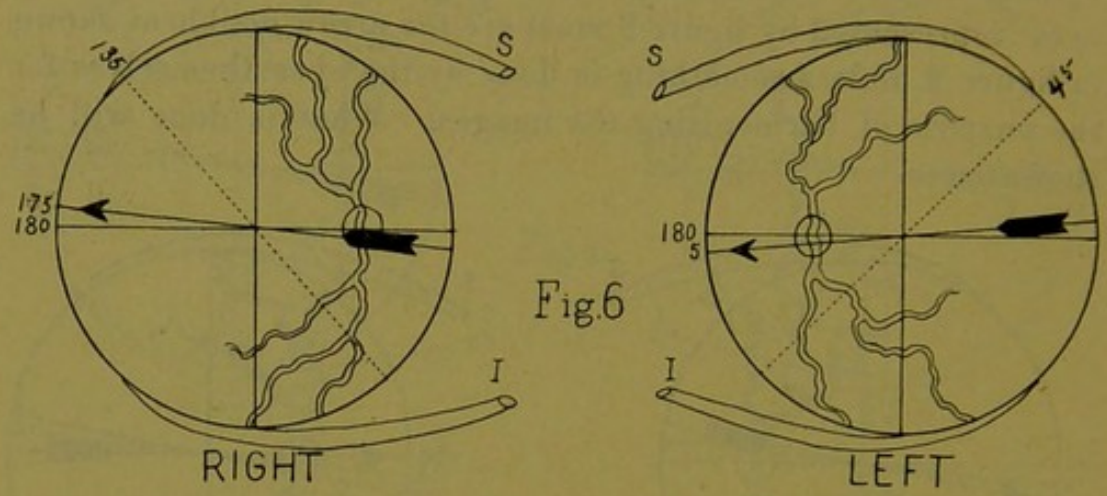

Fig.6

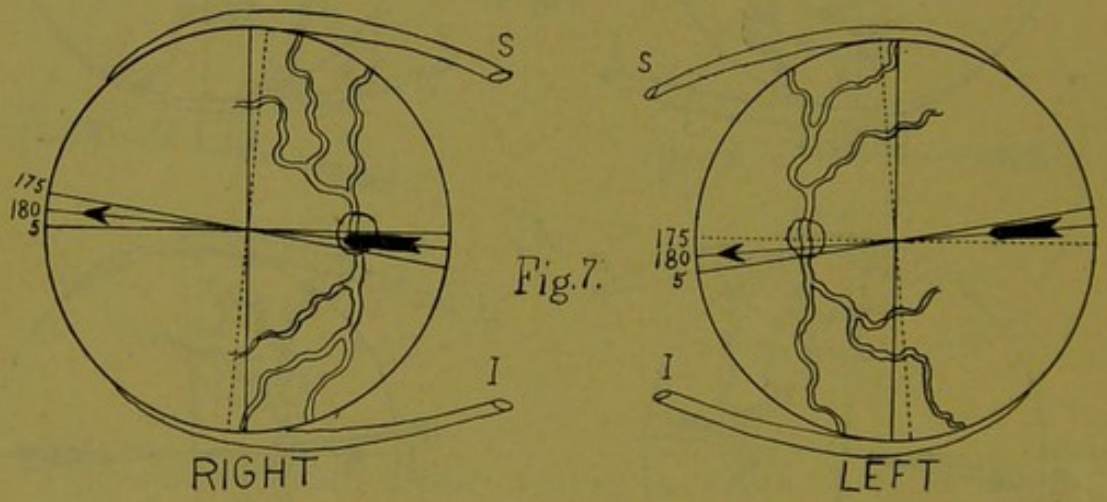

Fig.7.

Figure 6 represents a pair of hypermetropic astigmatic eyes, with half the quantity of astigmatism found in the eyes represented by figures 2 and 4, but in both eyes the best meridian is oblique, in the left at 45°, in the right at 135°. An arrow held in the horizontal position before these eyes will throw an oblique image on each retina, the one in the left eye, on the meridian 5°, the one in the right, on meridian 175°. Without some change double vision, as shown in figure 8, will be inevitable.

Figure 8.

In the same way I could demonstrate the obliquity of retinal images in oblique myopic astigmatism. The rule in oblique astigmatism, without a single exception, is this:—*the retinal image is displaced towards the meridian of greatest curvature, therefore, in oblique hypermetropic astigmatism the image is displaced towards the meridian of best curvature; in myopic astigmatism, from the meridian of best curvature, and in oblique mixed astigmatism, the image is displaced towards the myopic meridian.*

The obliquity of the image in oblique astigmatism is a matter demonstrable. One can artificially produce any kind of astigmatism. One who is emmetropic, or at least is non-astigmatic, by placing a—3 D cyl. before each eye in trial frames, he creates 3 dioptres of hypermetropic astigmatism. The axis of the left cylinder being at 90° and that of the right at 135°, he has made of his own eyes the kind represented by figure 2. He may now for a moment place the opaque disc in front of his right eye, at the same time placing the double prism (each 6°) before the left eye. A horizontal arrow, head to left, having been drawn on a card board, he looks through his double prism and sees two horizontal, hence parallel, arrows. On removing the opaque disc from the right side of the trial frame a third arrow appears between the other two but not parallel with them—it is oblique down and to the patient's left. On removing the double prism two arrows are at once readily seen, the one crossing the other, as in figure 8. In a moment the two arrows begin to shut and open like the blades of a pair of scissors, and finally they are merged indefinitely into one.

What efforts are made by the eyes for the correction of astigmatism? In some forms of astigmatism the ciliary muscle labors to improve the state of vision—to sharpen the retinal image. When the rays of light come to the eye parallel, no form of ciliary strain can improve the vision in myopic astigmatism, simple or compound. For divergent rays, in low

degrees of myopic astigmatism, regular ciliary contraction may so act on the lens as to cause the focal interval to fall on the retina, whereby a sharper retinal image is formed.

In hypermetropic astigmatism, the rays of light being either parallel or divergent, regular ciliary contraction can so act on the lens as to make the focal interval fall on the retina, and thus sharpen vision.

In myopic astigmatism, the best meridian being either in the horizontal or the vertical, there can be no strain in distant seeing, for no kind of strain would improve the vision, but there may be ciliary strain in near vision. In hypermetropic astigmatism, non-oblique, there is ciliary strain both for distant and near seeing.

Sectional contraction of the ciliary muscle for the partial or complete correction of astigmatism has its advocates. Martin developed the theory. The ciliary muscle is supposed to act in two opposite sections, while the balance of this circular muscle remains quiet or is in a slighter state of action. The parts in greatest action are supposed to coincide with the corneal meridian of least curvature. It is argued that, in this way, lenticular astigmatism is produced, of the same kind as, but at right angles to, the corneal astigmatism. If this be true, then in non-oblique myopic astigmatism, distant seeing is not attended by sectional ciliary contraction, since it would make vision worse and not better—distant vision in simple myopic astigmatism of 1 D is better than when there is 1 D of simple myopia. The object of all eye-strain is to improve vision and when this cannot be effected the strain is not instituted. In myopic astigmatism near vision would be greatly improved by sectional ciliary strain.

In hypermetropic astigmatism, sectional ciliary contraction could sharpen both distant and near vision. Granting that there may be, now and then, a case of "masked" hypermetropic astigmatism which would point to the correctness of Martin's theory of sectional ciliary contraction, the great mass of evidence gathered from daily observations by whomsoever made goes to prove that there is no truth in his theory.

In all cases of oblique astigmatism, unless the obliquity is in the same direction in the two eyes, and the astigmatism the same in kind and quantity, something must be done in order to prevent double vision, as represented in figure 8. There are but two ways of accounting for the absence of this peculiar kind of double vision, in such forms of astigmatism as that represented in figures 2 and 4. Sectional ciliary contraction would account for it. If it were possible for the ciliary muscle thus to act, one can readily understand how the curvature of the lens could be so changed as to result in lenticular astigmatism equal, but at right-angles, to the corneal astigmatism. If such ciliary action were to take place in the right eye of either figure 2 or 4, the retinal image would not only be made as sharp as if in an emmetropic eye, but it would also be made to lose its obliquity and thus double vision would be prevented. As beautifully as this sectional ciliary action would account for the absence of double vision in cases of oblique astigmatism, it is certainly a false theory, since, when all ciliary power has been suspended by atropine or age, the eyes are still able to do something by means of which the double vision represented by figure 8 is prevented.

If sectional ciliary contraction does not occur, then the two eyes represented by figure 2 or 4 have no inherent power by means of which the relative directions of the two retinal images can be changed, hence there must be double vision, unless the oblique image in the right eye and the horizontal image in the left can be made to occupy corresponding parts of the two retinæ. This can be effected alone by the *harmonious symmetrical action of the oblique muscles.*

Figure 3 shows how the eyes represented by figure 2 act in order to have the images fall on corresponding parts of the retinæ. The superior oblique muscle of the right eye has so revolved it as to bring meridian 175° of the retina in position to receive the impress of the oblique image, while, at the same moment, the superior oblique muscle of the left eye has so revolved it as to bring meridian 175° to the horizontal, hence in position to receive the horizontal image. The oblique and

horizontal images being now on harmonizing portions of the retinæ there is no double vision.

The double vision that would exist in astigmatic eyes represented in figure 4 is prevented by the harmonious action of the inferior oblique muscles, as shown by figure 5, the inferior oblique of the right eye bringing meridian 5° under the oblique image, while the inferior oblique of the left eyes causes meridian 5° to come under the horizontal image. Thus the two images are made to fall on corresponding parts of the two retinæ.

In the oblique astigmatism of the two eyes represented by fig. 6, the two oblique images are made to fall on corresponding parts of the retinæ, by the harmonius action of the two superior oblique muscles, as shown in fig. 7.

The obliquity of the image, and the consequent strain on the oblique muscles, fully account for the greater trouble attending oblique astigmatism than is found connected with astigmatism in the vertical or horizontal. As has already been shown in this paper, non-oblique myopic astigmatism is unattended by any sort of strain, in distant vision.

In oblique myopic astigmatism, there is strain on either the two superior or two inferior oblique muscles in both distant and near seeing. In all other forms of oblique astigmatism there is, likewise, strain on the oblique muscles.

In all kinds of non-oblique astigmatism, also in simple hypermetropia, the time comes when all nervous phenomena caused by their existence pass away; their disappearance, being gradual but finally complete, coincides with the failure and final loss of ciliary power, brought about by advancing age. The symptoms caused by oblique astigmatism may be modified by old age putting at rest the ciliary muscles, but they cannot be made to vanish, for the oblique muscles are forced to continue to act in age, as in youth, so as to harmonize the images on the two retinæ.

It is easy to account for the little suffering endured by one person with a certain quantity of astigmatism oblique in a certain direction, while another person with the same condition of refraction is a greater sufferer. Let us suppose two persons

having eyes represented by figure 2. The necessity for over-action, or abnormal action, is on the superior oblique muscles. In the case of the one who suffers but little the superior obliques are powerful and can bear the necessary strain without generating a train of nervous phenomena; in the other patient the superior oblique muscles are feeble and the necessary over-work is attended by periodical waves of suffering.

The propriety—I may say the necessity—of correcting non-oblique astigmatism by means of cylindrical lenses is now universally acknowledged. Such a lens sharpens the retinal image, thus making the object clear and distinct, and at the same time removes the necessity for abnormal ciliary strain. In youth, headaches and other symptoms whose existence depends on this strain, vanish as if by magic when the correct cylindrical lenses are worn. Otherwise old age alone would relieve the sufferer without being able to sharpen the image.

In oblique astigmatism the correcting lens both sharpens the retinal image and causes it to lose its obliquity, thus, at one stroke, destroying the necessity for abnormal ciliary strain and for overaction on the part of the oblique muscles. The one set of symptoms whose existence is lost in advancing age, and the other set whose duration is commensurate with the length of life, are made to disappear by the power of the cylindrical lens.

In the several cuts showing the effect of oblique astigmatism on the retinal image of a horizontal arrow, the best meridian is 45° either out or in from the vertical. This position for the meridian of greatest curvature was chosen because, for any given quantity of astigmatism, the obliquity of the retinal image is greatest here. If there are several cases of hypermetropic astigmatism of 3 D each, one of these having its best meridian at 100° (or 80°) will have a retinal image only slightly oblique, another with its best meridian at 110° (or 70°) will have more obliquity of its retinal image, and so on until the case is reached in which the best meridian is at 135° (or 45°), and now the maximum of obliquity of the image is reached. In the remaining cases the best meridians are between 135° (or 45°) and the horizontal, and the nearer these are to the

horizontal the less oblique are the images. What is true of hypermetropic astigmatism is also true of the myopic and mixed forms of astigmatism. The obliquity of the image varies not only with the difference in position of the meridian of greatest curvature, but also with varying quantities of astigmatism. The image will not be so oblique if there is 1 D of astigmatism, with its best meridian at 135° (or 45°), as when there are 2 D, in the same direction. The amount of obliquity of the retinal image of any horizontal object varies, in any given quantity of astigmatism, with the more or less remote position of the meridian of greatest curvature from the vertical or horizontal up to 45°; also with the quantity of astigmatism, the best meridian being at some fixed angle between the vertical and horizontal. In small degrees of astigmatism the obliquity of the image can be but a few minutes, while in the higher degrees the obliquity is 5° or more. In some of the figs. used illustrating this paper the obliquity of the image is represented as being as much as 10°, only for convenience of illustration.

All errors of refraction should be corrected by the examination of only one eye at a time, an opaque disc being placed in front of the other eye, and the eyes should be under the influence of a mydriatic, unless ciliary strain has been suspended by age; especially should this be the plan of procedure in all cases of oblique astigmatism. It is in cases of oblique astigmatism only that oculists find trouble in locating the axis of the cylinder, at one moment the patient indicating that it should be at a certain angle, and at the next moment 5° or more removed from this point. Enough time should be spent and sufficient care exercised to enable the operator to determine the natural location of the best meridian, and at this angle the axis of the cylinder should always be placed. If the best meridian in hypermetropic astigmatism is in the temporal quadrant and there is doubt as to whether the axis of the cylinder should be placed at a certain angle or 5° nearer the horizontal the latter should be chosen, for in such a case the superior oblique from long habit wants to continue to revolve the eye in an abnormal, but, without the proper cylinder, necessary, position. The point to be chosen,

in myopic astigmatism, for the location of the axis of the cylinder is always the reverse of that for hypermetropic astigmatism—I mean where there is doubt between any two points.

Each of the two eyes in which there is oblique astigmatism having thus been carefully corrected the proper glasses are ordered. When the patient begins to wear them his binocular single vision is nearly always disturbed by an apparently changed codition of objects, a rectangle no longer appearing to be such, and a level surface seems to incline. Some times the changes are so marked as to make the patient very uncomfortable. This metamorphopsia (so termed by Dr. Lippincott, of Pittsburg,) may continue a few hours, a day, a week or a month, but in the end is certain to disappear. It is due to a continuation of the old habit of rotation, when both eyes are used, and a consequent loss of coincidence of the best meridians and the axes of the cylinders. Whenever this now unnecessary habit of rotation is broken, be it soon or late, sudden or gradual, the metamorphopsia ceases. The different forms of metamorphopsia can be demonstrated artificially.

Four years ago I said that in cases of oblique astigmatism the eyes were made to rotate by means of the oblique muscles; I repeat the assertion to-day with emphasis, but with this modification: I then thought the rotation was effected by the *harmonious non-symmetrical* action of the abliques, but in this paper I have demonstrated that the rotation is brought about by the *harmonious symmetrical* action of the obliques and, too, have shown why the rotation is necessary.

The only papers ever published, touching this question, so far as I know, except my own already referred to, are: one on "Binocular Astigmatism" by Dr. H. Culbertson, in the Journal of the Association, Nov. 3, 1888; and one on "Metamorphopsia" by Dr. J. A. Lippincott, in the Archives of Ophthalmology, March, 1889. The latter is a valuable paper and shows the Doctor to be a close observer as well as a ready writer. In his paper he incidentally refers to the obliquity of the retinal image in oblique astigmatism but does not advocate the doctrine of rotation.

INSUFFICIENCIES OF THE OBLIQUE MUSCLES AND HOW TO CORRECT THEM.*

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In the Archives of Ophthalmology, Vol. XX, No. 1, 1891, I announced my discovery of "Insufficiency of the Oblique Muscles." I closed that paper by saying of the nervous symptoms brought about by this state "I can see no hope of prevention or cure." On the 17th day of May, 1892, while a patient was before me whom I had known to be a sufferer from this condition for two years, and to whom I had often said "There is not now, nor can I see how there ever can be, any relief for this trouble," a thought of the proper means of correction dawned upon me. I at once applied the newly thought-of principle in this case and with the most gratifying results. Of this case I shall have more to say before closing this paper.

Before setting forth the treatment I will refer to the condition itself, and the proper means of detecting it. In doing this, since I cannot do better, I quote from my paper published in the Archives: "Every ophthalmic surgeon, however skilled in correcting errors of refraction and in operating for the different known forms of heterophoria, has had cases of eye-strain for which he could do but little. In investigating a few such cases during the last six months I have found the cause to be a want of equilibrium on the part of the *oblique muscles*. The detection of this condition is easy. I place a double prism (my modification of the Maddox prism) before one eye, the other for the moment being covered, and ask the patient to look at a horizontal line on a card held eighteen inches away. The effect of the double prism (each 6°, bases in), so placed that the axis

*Reprint from the *Ophthalmic Record* Vol. II, No. 1, Nashville, Tenn.

is vertical, is to make the line appear to be two, each parallel with the other. The other eye is now uncovered, and a third line is seen between the other two, with which it should be perfectly parallel.

"While a change of the position of the axis of the double prism from the vertical towards the horizontal will alter the distance between the lines, their direction will be unchanged, hence no loss of parallelism. This fact admits of a little carelessness in the placing of the prism in the trial frames, though the axis should be vertical so as to give the maximum distance between the two extreme lines.

"If there is a want of harmony on the part of the oblique muscles this test will show it at once in a want of parallelism of the middle with the two other lines, the right end of the middle line pointing towards the bottom and the left end towards the top line, or *vice versa*, depending on the nature the of individual case.

Fig. 1.

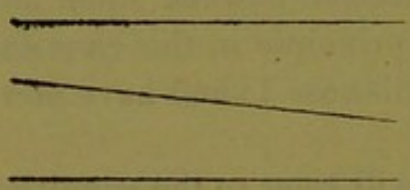


Fig. 3.

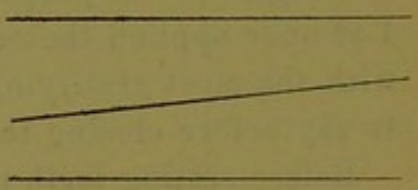


Fig. 2.

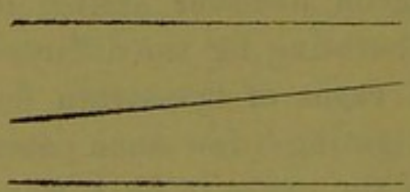


Fig. 4

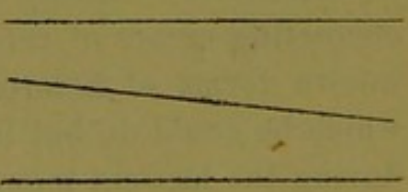
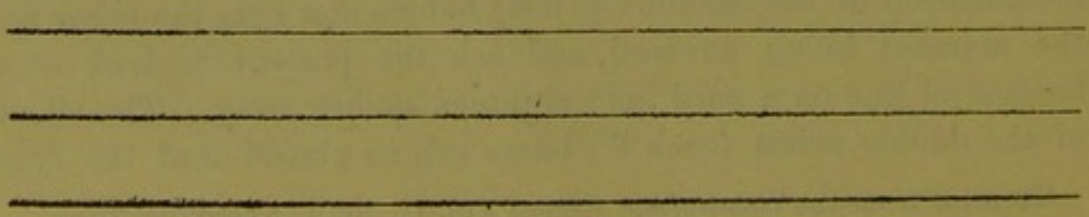


Fig. 5.



"In my investigations I have always considered the eye before which no prism is held as the one under test. With the double prism before the right eye the patient is asked about the position and the direction of the middle line. It may be nearer the bottom, thus showing left hyperphoria; or again, it may extend farther to the right than the other two and not so far to the left, thus showing exophoria, or vice versa, showing esophoria.

"If the right ends of the middle and bottom lines converge while the left ends diverge, the superior oblique of the left eye is at once shown to be in a state of underaction. Fig. 1 represents such a test of the left eye. Fig. 2 shows a test of the left eye when the inferior oblique is the too weak muscle. Fig. 3 represents a test of the right eye, the loss of the parallelism between the lines being due to underaction of its superior oblique, and Fig. 4 the same condition of the inferior oblique of the right eye. Fig. 5 represents a test of both eyes when there is perfect equilibrium of the oblique muscles.

"As is well known, the function of the oblique muscles is to keep the naturally vertical meridians of the two corneæ parallel even when not vertical, [except in cases of uncorrected oblique astigmatism, as shown in Vol. 1, No. 1 of the *Ophthalmic Record*]. This must be, or a troublesome form of double vision will result. If there is perfect equilibrium of the obliques, this parallelism of the meridians named is maintained without trouble; but if the superior oblique of either eye be too strong for its inferior, or vice versa, the parallelism of the vertical meridians is preserved, and double vision prevented, only by excessive work on the part of the weaker muscle. This condition of the oblique muscles brings on, at longer or shorter intervals, a train of nervous symptoms for which, at present, I can see no hope of prevention or cure."

As can be readily seen the condition described then was *symmetrical insufficiency of the obliques.* Up to that time I had not seen, nor had I heard of, a case of *non-symmetrical insufficiency of the obliques.*

Dr. Moulton, however, reported such a case in a letter* to the

*See *Ophthalmic Record*, Vol. 1, No. 4, 1891.

editor of the *Ophthalmic Record.* I had reasoned that such a condition would not give trouble, since the strong muscles would be allowed to act, thus revolving the two eyes in the same direction, but causing no disturbance of vision. I still believe this reasoning correct except in cases of corrected astigmatism. Such a case Dr. Moulton reported, asking for an explanation of the fact that it became necessary for him to rotate his 1.00 D. cylinders from 90° to 100°, in order that the patient might have comfort, when several examinations under atropia had shown that the axis of each cylinder should be at 90°. My explanation, published in connection with his letter, was that there was insufficiency of the superior oblique of her right eye and the inferior oblique of her left eye; that these weak muscles, at the times of the several examinations, exerted their full amount of power and thus kept the best meridians at 90°; that these muscles at other times, because of fatigue, could not exert the necessary amount of power, and thus allowed their stronger opposing muscles (the inferior oblique of right and superior oblique of left) to change these meridians from 90° to 100°. It was at such a time as this that the Doctor learned that the axes of his cylinders should be placed at 100°. Comfort came to, and remained with, his patient as a result of this little proceedure. It was good practice and should be followed in all cases of astigmatism where there is *non-symmetrical insufficiency of the obliques.*

In *symmetrical insufficiency of the obliques* the case is very different both in principle and practice. It is for this latter condition that I am now able to point out the remedy.

To illustrate clearly the principle and practice I will take up for study the case of J. B M., age thirty-five, whose case I was studying the moment the thought of the cure came to me. Two years ago he came to cousult me about a headache that for a long time had troubled him, and which was growing more severe. He had been advised that it was probably due to eye-strain and if so, it could be cured by properly adjusted lenses. A preliminary examination showed only a slight error of refraction. This he consented to have corrected, hoping that he would get

relief, other means having failed. Under homatropine the following correction was given:

O. D. V. = $\frac{20}{XX}$ with + .25 ⌓ + .25 cyl. ax. 155°.

O. S. V. = $\frac{20}{XX}$ with + .25 ⌓ + .50 cyl. ax. 90°.

It was determined at the same time that he had $\frac{1}{2}^{\circ}$ left hyperphoria. It was also determined that he had insufficiency of both right and left superior obliques. He was told that all but the latter could be corrected; that he would get some, but not complete, relief by wearing his sphero-cylindrical lenses, the left ground on a prism of $\frac{1}{2}^{\circ}$ base down; that, at times, the insufficiency of the obliques would give him trouble for there was nothing that could be done for this condition. I did tell him, that, if, when engaged in near work, he felt a headache coming on, he might cover one eye with a flap thus doing away with the strain necessary for harmonious action of the muscles of the two eyes. This he tried occasionally, but found it very inconvenient to work with one eye only. His attacks of suffering were greatly lessened in both frequency and severity for some months, as a result of the elimination of some of the factors formerly constituting the cause of his suffering.

He wore his spectacles continually, but after a while his headaches began to return. They grew more frequent and more severe untill he became an almost daily sufferer. Not infrequently on going home from his office his wife would have to put him to bed like a child. He would occasionally take medicines prescribed by his family physician to relieve the severity of the attack.

At intervals, during the whole time, he would consult me. When complaining I would tell him that I believed that the then-active cause was the insufficiency of his superior obliques, and that I was powerless to do more than I had already advised. A few months ago I made a second examination of his eyes under the influence of homatropine, but only to find that the result of my former examination was correct. I did not have to urge him to wear his glasses, because he had learned that he was more comfortable with than without them.

On the 13th of May, 1882, he came to me and said that I must do something more for him; that he must have relief.

Reminding him that I had twice investigated his eyes and each time had found the same conditions and had corrected all that was correctable, I told him I was willing to try again, but that I was now as unable to correct the insufficiency of his obliques as I ever was. In the course of this conversation I told him if he had but one eye he would not be a sufferer. Deciding that it would be four days before he could return for another examination he went away. On the 17th at the hour appointed he came; and without hope of finding an additional means of relief, I under-took the investigation again. The results of former examinations as to lenses were confirmed.

My study of the recti muscles resulted as formerly in finding a left hyperphoria of $\frac{1}{2}°$. With the remark "we will now look into that incorrectable condition," I began to investigate the obliques. Placing the 6° double prism before his right eye, the left eye (the one under test) showed the middle line dipping unmistakably to the right, as in Fig. 1, thus showing insufficiency of the left superior oblique. Transferring the double prism to the left eye, the right eye showed the middle line dipping to the left, as in Fig. 3, thus showing insufficiency of the right superior oblique. Having stated again that nothing more could be done for him, in a moment the thought occurred to me that, if a cylinder was placed before the eye in such a way as to make the line incline still more in the same direction, on removing the double prism the weak obliques would have to act more than usual in binocular vision. I reasoned that this over-action being in the nature of gymnastic exercise, if conducted properly must develop the weak muscles, and thus be a source of relief to the patient. Leaving the double prism in front of the right eye I placed a + 2.00 cylinder before his left and revolving it so as to bring its axis to 135° the middle line was seen to dip very much more to the right. I then turned the axis back to 90° when the dipping was the same as when no cylinder was on. Turning the axis of this cylinder to 45° the middle line was made parallel with the other two (this little proceedure of placing the axis of a cylinder obliquely first in one direction then in the other, and watching the effect on the middle line will establish or disprove the correctness of the diagnosis). The diagnosis

made and positively confirmed, I at once commenced the gymnastic exercise by placing a + 2.00 cylinder before each eye, the axis of the right at 70° and the axis of the left at 110°. The patient was asked to fix his vision on a candle twenty feet distant (the double prism had been removed). In three minutes the axis of right cylinder was turned to 60° and that of the left to 120°; three minutes later the axis of right was placed at 50° and that of left at 130°; and again in three minutes the axes were changed, the right to 45° and the left to 135°. With each turning there was additional demand made on the superior obliques, the maximum being reached when the axes were respectively at 45° and 135°. With each turn the patient could feel additional strain. The cylinders were allowed to remain in this position of maximum effect three minutes when they were removed and the double prism test was applied. There was the slightest, if any, dipping of the middle line. Both patient and practitioner felt encouraged. He has returned daily for the *exercise* which has been conducted every time in the manner above described.

On the day after the first *exercise* he resumed his office work which requires almost continuous near use of his eyes, and has been absolutely comfortable up to this time—the end of the eleventh day—and not one dose of medicine has been taken. For the last three days before beginning the *exercise* the test when applied to either eye showed but little, if any, want of parallelism of the lines. His improvement has been rapid and remarkable.

I have now under the exercise treatment a little girl, age fifteen years, whose trouble is insufficiency of the inferior obliques. The dipping of the middle line is to the left in the left eye, and to the right in the right eye, just the contrary of what was found in the other case.

The *exercise* in her case is carried on by revolving spasmodically the axis of the right cylinder from 90° to 135° and that of left from 90° to 45°, the reverse of the plan in the first case. She does not bear the exercise so well as the first patient, but her improvement in five days is noticable.

My records for the past two years show a number of cases of *symmetrical insufficiency of the obliques*, to all of whom I stated: "for this condition I can do nothing."

The condition is real, the treatment is rational, and relief must follow. The condition is easy of detection and the insufficient muscle can be quickly located. The double prism before the right eye, the middle line is seen by the left (the one under test); if it dips towards the opposite (right) side the superior oblique is insufficient (see Fig. 1), if towards the same side the inferior oblique is insufficient (see Fig. 2). The same is true when the right eye is under test as is shown in Figs. 3 and 4. In the treatment either concave or convex cylinders can be used; if the concave are used and the insufficiency is in the superior obliques the axes must be placed in the lower nasal quadrant, if in the inferior obliques then the axes must be placed in the lower temporal quadrant. If for the exercise the convex cylinders are chosen the axes must be placed in the lower temporal quadrant for insufficiency of the superior obliques and in the lower nasal quadrant for insufficiency of the inferior obliques. In either case the effect is increased as the axis is made to move from the vertical to the point of maximum effect which is 45° from the vertical.

The exercise may be commenced with a .50 to a 1.00 D. cylinder, and increased each day a .50 D. up to 3.00 D. The cases will be very rare that will require a stronger exercise ~~prism~~ than the last named. The graduated exercise should be continued daily. Each eye being affected, the exercise cylinders should be placed before both.