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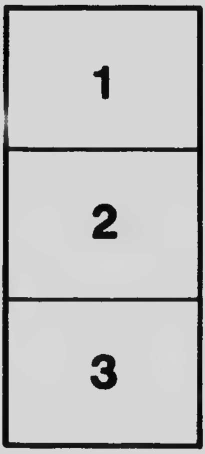

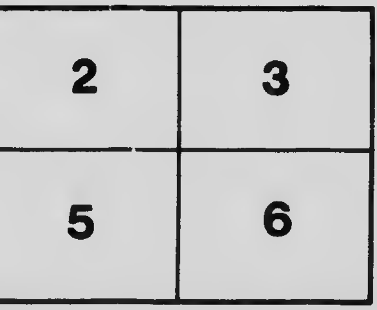

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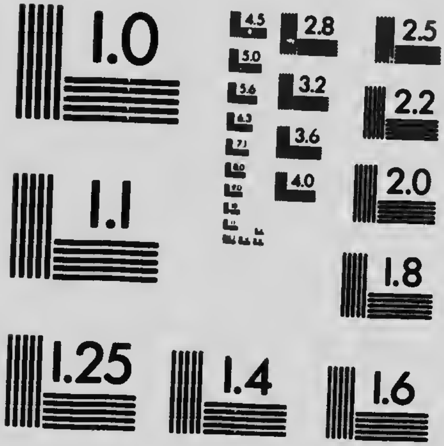

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INTRODUCTION

THIS brief sketch is in no way intended as a text book on muscular anomalies, and in it I have not even attempted to discuss thoroughly any considerable portion of muscular insuffiencies, as the insurmountable objection to any scheme of education in this branch of optics lies in the fact that it is deluged with theories and starved for facts. It is a fairyland of speculation and only the most bigoted writer would insist upon his particular dogma being unreservedly accepted as the correct one.

I do not even claim the merit of originality, the theories and deduction being largely selected from the most conservative of modern authorities, and all that has been attempted is a classification and condensation in order to bring the subject within the scope of the average optician of to-day, most of whom in Canada are generally uninformed upon this important section of optometry, and who have but little time or opportunity to sort out the facts for themselves, even when they possess the necessary material to work on.

A judicious application of the doctrines enunciated, I feel sure will furnish the correct solution to many optical conundrums remaining unanswered in the pages of the record book, and will enable the inteligent optician to approach his work in the future with greater confidence and even if it extended no further, would in this alone produce better results and a higher degree of satisfaction to both the refractor and the refracted.

OCCULAR MYOTONY

Emetropia and ametropia have been discussed from the standpoint of the optician to such an extent, and the instruments for diagnosis have been so perfected in recent years that the measurements of refractive errors has become almost a question of arithmetic.

The better qualified refracting opticians while duly recognizing this fact, are, however, the very first to realize that the theory of refraction as applied to human sight together with the laws laid down by the highest authorities for measuring, calculating and correcting its errors do not invariably give the expected results even when applied under the most favored conditions. and the inevitable conclusion is that the absolute truth about refraction, its errors and correction is not the whole truth, and these higher truths are to be sought for outside the scope of refraction pure and simple, but are inseparable in their results, and must be applied in conjunction.

That an intimate relation exists between the motor muscles and the dioptrics of the eye, is inevitable, and has long been recognized, but limitations of the effects have never yet been fixed, and as a consequence all efforts at diagnosis of muscular anomalies have hitherto in the main been rather of a desultory nature, and have not had any recognized basis upon which to work, and in consequence have not been generally satisfactory in results.

The prime cause for the existence of this condition is undoubtedly to be found in the fact that the study of muscular anomalies has not yet got beyond the experimental stage, and to the existence of several theories not yet completely harmonized, but the fact remains that we have some established position to work from, and it is possible to work intelligently and with success, over a large range of actual cases, and to produce results which are impossible when muscular considerations are excluded.

I purpose, therefore, in these articles to consider the question of muscular balance in its relation to the physiology of vision from a conservative standpoint treating the question of muscular errors and its correction from the viewpoint of the optician, and excluding as far as possible that seductive tract of research which would follow muscular imbalance to its sequence in nervous diseases of various forms, as being outside the scope of this article as well as of those for whom it is intended, although I may before concluding quote from the best of those who have investigated along these lines, not with a view to inducing the optician to forsake his own particular field, but merely as an illustration of the magnitude of the work of which we are engaged in the elementary stages and which must become a work of greatest care and study when the extent of its branches comes to be generally realized.

The eye ball is merely a globular formed object deposited in the receptacle prepared for it in the skull and attached to the skull by the motor muscles. The muscles are six in number, four of them being straight and two oblique.

The recti or straight muscles are the superior, inferior, external and internal; while the obliques are known as superior and inferior.

The particular function of each of the recti muscles is apparent, the superior being attached above, and in contracting turns the eyes upward; the inferior being attached below and turn them downward, while the internals attached at the inner side are used in converging, and are opposed by the externals which pull the eyes back to the normal position or acting with one of the internals turn the eyes to the right or left.

The obliques are attached above and below, but instead of passing straight backward to their attachment to the skull, they are wrapped around the ball like the coil of a watch spring, and are used in rotating the ball on its antero--posterior axis.

It is understood with this arrangement of muscles controlling the eye ball, that if the recti muscles are of normal length and correctly attached to the ball, that with all of them at rest the eye will be directed to infinity, and in the effort to look in any other direction, one or more of these muscles must contract, and in so doing the ball in rotating places the tension on the opposing muscle which when the contracting muscle relaxes, returns the ball to its normal position with its axis directed to infinity, and all muscles at rest.

Supposing now that owing to a defect, one of the muscles—say the internal—is attached to the ball further forward than its opposing muscles, it is very evident that it will predominate over the exteriors, and in a state of rest will exert a "pull" on the ball which would induce it to turn inwards, unless held in check by a contraction of the externals.

Again we find under certain conditions of ametropia that certain muscles are used to an unnatural extent, the result of which is a development in thickness of that muscle at the expense of its length. Here again we would find the eye turning toward the shortened muscle and prevented from so doing by its opponent.

The term orthophoria is used to denote a condition of perfect muscular balance, and as applied to the muscles is synonymous with emetropia as applied to the refraction.

Any condition in which this muscular balance is disturbed, and one or more muscles over-balancing their opponents is known as heterophoria.

Heterophoria being a condition of imbalance between the motor muscles, it naturally partakes of different forms in accordance with the particular muscles affected.

A preponderance on the part of the external recti producing a tendency in the eye ball to deviate outward is known as exophoria, while an inward tendency is called essophoria.

A predominancy of the superior rectus of the right eye over that of the left eye would be right hyperphoria, and the left superior being in excess would be left hyperphoria.

Formerly the upper and lower balance of the muscles was known as hyperphoria, nd cataphoria, but as any predominancy in one upper muscle is only comparative with that of the opposite eye, right hyperphoria and left cataphoria are, of course, synonymous, and latterly it has been customary to use only the term hyperphoria in reference to vertical balance and designate right and left hyperphoria to indicate which superior muscle predominates.

Having briefly referred to the conditions under which the eye ball is rotated under normal conditions, and the principal terms under which the various imperfections are known, let us consider these conditions individually, their effect upon the vision and comfort, and the best known means of diagnosing them.

Heterphoria is a debatable question with optical writers and considerable difference of opinion exists as to its cause no less than as to the best means of relief.

Savage says in referring to this point.—"One view is that there is a congenital weakness of one muscle as compared to its opposing muscle, this weakness being due either to the fewness of the muscular fibres entering into its formation or to its faulty attachment to the schlera, this in the weak muscle being abnormally far from the point of attachment, or to a want of proper inervation."

Other writers oppose this theory and deny that heterophoria is congenital and attribute all conditions of heterphoria to a spasm in one of a pair of muscles, and thus excites action in it in excess of its opponent.

Still another theory is that the seat of the trouble does not lie in the muscle at all, but in the masculae, which it is claimed do not occupy corresponding positions on the two retinæ, and thus demand a constant muscular action to maintain single vision, and this theory goes still farther and claims that a further cause of heterophoria is to be found in a malconstruction of the features by which one eye is located higher than the other.

No one can gainsay the possibility of any or all of these theories working out to produce heterophoria, but the fact that we often find essophoria at distance and exophoria at near point would exclude two of them in all such cases. However, from the optician's point of view —which does not contemplate operating for relief—the theory as to its cause is not so important as the fact of its existence and the safest methods of diagnosis and relief.

In examinations made for heterophoria, it is important that the full correction for any error of refraction should be worn.

Several appliances are used for the purpose of measuring the muscular balance, but it is probable that the Maddox Rod is the simplest and most reliable, but is of little value in the ordinary trial frame method owing to the utter impossbility of knowing when it is exactly vertical, and horizontal, and any measure of the error by the use of prisms is only guess work from the same cause as the exact position of the base is almost impossible to locate so that some such instrument as the Stevena phorometer is desirable to ensure accurate results.

The effect of the Maddox Rod, which is worn over one eye while the other is uncovered, is to convert the image of the object looked at into such a changed form that it no longer represents the object at all, and so far as the sense of sight is concerned, is practically another object altogether. The result of this is that the necessity of maintaining single vison is removed as the possibility of it is destroyed when we change the appearance of the image in one eye.

With the Maddox Rod over one eye and the other eye exposed, the attention is directed to a small flame located at infinity, which is seen normally with the uncovered eye, but seen through the rod appears as a bar of light running at right angles to the direction in which the rod is placed. The effect will be more pronounced if a rod composed of red glass is used.

To thoroughly appreciate the philosophy of this test, it must be borne in mind, when both eyes are directed to infinity, the muscles will in orthophoria be entirely at rest and in heterophoria, the only hindrance to a state of rest is the fact that both eyes not fixing one point normally they have to be directed to it by the muscles or else diplopia ensues; but with the Maddox Rod there is no incentive to maintain single vision as the rod itself produces two separate images, one of them seen as the flame and the other as a bar of light, consequently the only incentive to a muscular action is removed and the muscles relax and the eye ball is rotated to a positon permitted by the relaxed muscles.

If there is no heterophoria present the muscles will all be relaxed when the eyes are directed to the distant flame, and consequently the interposition of the rod over one eye will have no effect upon the muscles or the direction of fixation line and the two objects—the flame and the bar of light—will occupy the same position, or in other words the bar will be seen to pass directly through the flame, but if a condition of imbalance exists, the instant the rod is placed in position, single vision, no matter how much muscular effort is expended, is impossible, and the muscles relaxing carrying with them the eye ball and the bar and the flame are seen in different places, the relative position determining the amount and kind of heterophoria.

To test the lateral muscles, place the rod horizontally over the left eye and direct the attention to the flame which will now appear normally with the long bar of light running vertically through its centre if the muscles are orthophoric. If the bar is seen to the right of the flame, it indicates that the eyes have moved outward indicating a predominance of the externals, exophoria, and if seen to the left, they have converged, and essophoria is assured.

To find the amount of error, the phorometer is placed in position in front of the rod and the prisms rotated until the bar passes through the flame when the kind and degree of the error is read from the scale.

In testing the vertical muscles, the rod is placed vertically and the consequent bar of light is seen horizontally, passing through the flame if orthophoria, and above it in left hyperphoria, and below in right hyperphoria.

The amount and kind is shown with the phorometer in just the same way as in examining the lateral muscles.

Although I have already pointed out the unreliability of all tests made with instruments not accurately adjusted, I think it as well to give a description of the various appliances used for diagnosis, merely repeating the caution already given, that any error in the level or position of the particular disc used or in fitting of the trial frame will render valueless any results achieved by the examination.

I have already described the Maddox Rod which may be single or composed of several; the appearance in both cases is similar and the results calculated in the same manner.

It is important when a spherical correction of any considerable magnitude is worn that the centreing be accurate; especially should there be a considerable difference between the correction used for each eye as in the event of decentreing the prismatic effect would be unequal with the two different lenses and an apparent muscular imbalance created thereby.

The Savage Double Prism furnishes an excellent corroborative test, and can be used with very little additional expense.

The double prism consists of an ordinary trial ring containing two six degree prisms placed with their bases together in the manner of a split bifocal, so that in placing it in the trial frame, the base line will bisect the centre of vision.

With the double prism placed in the trial frame with the apices vertical and the other eye covered, the flame is doubled vertically. The covering being removed from the other eye, a third flame is seen between the two already seen with the opposite eye.

With perfect muscular balance the third flame is in the same plane as the first two and exactly midway between them.

The presence of imbalance will be indicated by the irregular position of the three images as the deviation of the eyes as a result of the disassociation of the two images will permit the eye balls to rotate to the position in which the muscles are all at rest.

If the middle image is to the left of the other two it indicates exophoria, and to the right essophoria. If the middle image is seen nearer the lower flame, it shows right hyperphoria, and if closer to the upper flame, left hyperphoria.

The prism placed in front of the exposed eye that will restore the middle flame to its normal position equal distance from the upper and lower flames, and in a line vertically with them is the measure of the muscular error.

The advantage claimed for this test is that it shows vertical and lateral error simultaneously as a displacement upwards, and outwards indicates hyperphoria, exophoria combined, but it is probable that the maddox rod and phorometer is more accurate, and if carefully applied the results are more reliable, and the few moments extra time necessary to test each muscle separately is of no acount as compared with the importance of having absolute accuracy.

What is known as the "dot and line" test is also made in conjunction with the double prism in examining the condition of the muscles for close work.

To make this test the double prism is placed over the right eye with the base line horizontal and accurately bisecting the vision and a plain disc covering the left eye.

The attention is directed to a card held at sixteen inches distance on which is drawn a plain black line with a dot in the centre, and which, of course, with the prism in position is seen doubled vertically, and upon uncovering the left eye, a third line is seen between the other two.

Previous to removing the covering of the other eye, it is well to adjust the card until the two images of the dot and line are equally distinct and the dots exactly in line.

With both eyes exposed, the three images are seen, the upper and lower with the right eye through th double prism and the middle one with the left eye unaided excepting by any correction which may be necessary for any error of refraction.

In orthophoria the lines will be equally distant, and the dots in a vertical line.

In exophoria the central dot will be to the left of the other two and in exophoria it will have moved to the right.

Hyperphoria in the right eye will be indicated by the approach of the central line to the lower one and left hyperphoria by the approach of the central and upper line.

The measurement of the error is made with a prism over the free eye with its apex in the direction it is desired to move the central line. For instance, in hyperphoria a prism base down of sufficient power to bring the line to a central position would be the measure of the error, while in exophoria the base would be inwards and in essophoria outwards.

The process of measurement for nearpoint is practically the same for distance, but the results frequently are unlike. It frequently happens that where a distance test has shown essophoria, a near test will show a less amount and in some instances will disclose exophoria, as although the externals may be at a disadvantage where the eyes are directed to a distant point owing to a preponderance of power in internals, this preponderance diminishes or possibly disappears entirely at nearpoint where convergence is required, and a considerably increased amount of power demanded from the internal muscles to sustain the necessary convergence.

It is quite common to find cases which are orthophoric for distance and exophoric for near work.

In some cases where the double prism is used, only two images are seen; this will happen when the error is just six degrees which will have the effect of throwing the middle line exactly over one of the others. When only two lines are seen, change the opaque disc to the eye having the prism before it which will have but one line and upon uncovering again the position will more easily be disclosed as in changing the cover rapidly from one eye to the other it can be noticed which line disappears, and a weak prism placed base vertical will instantly bring the third line into view.

Savage's method of applying what he calls the "strength test" is useful as being corroborative of the tests already given.

The "strength test" is made with a maddox double prism and is applied to the superior and inferior muscles. It consists in placing the double prism before one eye with the other eye covered, and the prism is depressed until the eye looks through the upper section only in which the base is downward, and the flame is seen doubled vertically, and if a scale in inches is placed behind the flame it is easy for the patient to state the distance separating the two images of the flame; the prism is raised until the flame is seen only through the lower section in which the base is up and the distance separating the two images again noted, and this being the same under both conditions, shows perfect balance of the opposing muscles, but if through the upper prism the images are closer together than through the lower one, shows preponderance in the superior muscle, or hyperphoria in the eye which has been subjected to the test.

It will be noticed that the basis of all the tests for heterophoria is the disassociation of the images of the two eyes, or, in other words, the prevention of binocular vision as the efforts being constantly made to maintain it would prevent us from measuring the true condition just as any effort at accommodation in hyperopia would invalidate the results.

In the tests described, the effects of the Maddox Rod is so tremendous and the resulting image so totally unlike that of the opposite eye that no possibility exists of securing binocular vision, but other means can be employed, which, while producing a certain difference in the two images, does not positively destroy binocular vision in all cases, but only in those of higher degree of heterophoria where the muscles already over-balance, but maintain a parallelism of the visual axes by a supreme effort are unable to withstand even the smallest additional burden.

A plain red glass disc placed over one eye will in some cases produce diplopia and it is used by some authorities to decide as to whether the muscular imbalance is of such a degree as to demand an operation for its relief. The claim being, that if diplopia is produced by the use of the red glass, the muscular error is of such a degree that no hope of permanent relief is to be expected from the use of prisms, while if single vision is maintained with it in use, the case offers a fair prospect of relief and improvement by their aid.

In the foregoing I have briefly described the conditions known as heterophoria and its sub-divisions, together with the best known methods of diagnosing the amount and kind, but the important point from the practicing optician's point of view is, of course, the means employed to correct the error and correct all cases of muscular imbalance to a condition of orthophoria. Just how, is where the stumbling block to consistently successful muscle work has always been.

In refracting it is generally fair to assume that when we find a certain amount of manifest hyperopia or astigmatism, and nearly always with myopia, that the proper thing is to supply the lens that will correct it, confidently expecting the result to be satisfactory.

Not so, however, with muscular error; we do not on finding 4 degrees of essophoria supply 4 degrees prism base out and consider the case finished, but the closest investigation becomes necessary to realize clearly the connection between any existing error of refraction and the muscular error, and the possible effect of such error in producing it, as well as to note the effect of the correction of the ametropia in possibly producing an apparent muscular error.

This condition of apparent imbalance produced by existing or corrected errors of refraction is known as "pseudo" heterophoria to distinguish it from "true" heterophoria. Just as we have simulative myopia in which the actual condition of the refraction is hyperopic, but by reason of a spasm, which is merely an involuntary spasmodic action of the ciliary, over-correcting the want of refraction and accepting a concave glass to restore the vision to normal.

Savage, from whom I quote frequently in these articles, uses the two terms "Pseudo" and "True" in opposition to describe those conditions of real and apparent heterophoria, although it must be remembered that temporarily at least in either case, muscular imbalance exists, but in one instance the imbalance does not proceed from any inherent error in the construction or development of the muscle, but from an involuntary spasmodic action in one muscle which, while in this condition, or while the causes which produce it remain, is practically heterophoric, but when the cause is removed, assume voluntarily a condition of balance, while in the other there is an actual difference in the lifting power value of a set of opposing muscles which cannot be remedied until the unequality is corrected.

Essophoria particularly is subjected to this equivocation between true and false error, and cases have been known where both conditions are present together.

In true essophoria the fixed condition is one of preponderance of the internal either by reason of an over-development of the internals or a partial paralysis or want of power in the externals.

In addition to the generally recognized cause of true essophoria, viz., the abnormal power of one or both internals or a faulty attachment of the same it is contended that an over-development of the nerve centres which supply the motive power to operate these muscles, will result in an excessive nerve stimulation producing excessive action on the part of the muscles.

The optician or even the oculist cannot by means of subjective examinations form any conclusion as to which particular cause true essophoria is attributable, and it is only in operating that a tense or flabby muscle can be detected. The condition of the nerve centres, of course, is mere speculation.

Another feature that must not be lost sight of in this connection is the variation in the width between the eyes as two subjects in which the muscular development was alike, one having a P.D. of excessive amount, and the other abnormally narrow, it is obvious that the one with the wide P.D. will have to exert more convergence to fix a given close point than will one with a shorter distance between the eyes.

This point is easily illustrated by taking two points, say 4 inches apart and draw a line from each to another point, say 6 inches away, and midway between them and perform the same operation from two points three inches apart, and the same distance from the third point, it will be seen that the angle in the first diagram is much larger than in the second, and as it represents the angle of convergence, every additional degree represents additional nerve force.

PSEUDO or simulative essophoria is purely a question of false pretenses: the internals under test show varying degrees of preponderance and the young operator stands aghast at the results recorded and if a hasty correction by prisms is made, he is joined by his patient in his feelings of surprise.

This condition is closely akin to the spasm of the ciliary muscle and in fact are often co-existent.

It is a condition of contraction produced by the sympathetic action of the nerve centres controlling the ciliary and internal recti muscles. The close connection between these two muscles and their nerve centres is easily comprehended when we remember that the one operates the convergence while the other controls accommodation. two functions designed to work together in an equal degree so that any condition demanding abnormal accommodation such hyperopia would, in the act of stimulating ciliary action upon it at the same time, have a tendency to stimulate the convergence.

Sometimes it has been found in emetropia with a debilitated condition of the ciliary, possibly as a result of illness, that the excessive effort necessary to produce the required accommodation creates an over-plus of nerve force for the convergence and an eye examined under these conditions would show essophoria, while such conditions of stimulation lasted.

The importance and frequency of pseudo essophoria may be approximately estimated if we calculate upon the harmonious action of the two nerve centres controlling the convergence and accommodation and apply this calculation to all cases of uncorrected hyperopia.

Even the elementary student knows, of course, that under normal conditions equal amounts of convergence and accommodation are used, the one being measured in metre angles, and the other in diopters, so that in fixing a point at 10 inches, the emetropia would expand 4 diopters of accommodation and 4 metre angles of convergence, but if the same calculations are applied to a hyperopic of 2 diopters, the accommodation demanded to fix a point at 10 inches is 6 diopters, and the convergence acting in unison the eyes would fix a point at 6 1-2 inches, which would render the object of vision which is located at 10 inches, indistinct, and possibly doubled, so that a repressing action on the part of the externals is required to restrain the extra convergence, and as the nerve force is utilized for 6 1-2 inches, there is in addition the force necessary to hold the eyes fixed at 10 inches so that in making a test of muscular balance in a case of 2D. hyperopia uncorrected one would invariably find essophoria produced by the stimulation incidental to the accommodative effort necessary to see the flame used in the test, even though placed at infinity.

Savage insists that any examination with the view to ascertaining the condition of the muscular balance are totally unreliable if the eye is at all under the influence of atropine. He claims to have established the fact that an eye so examined will disclose less exophoria and more essophoria than the actual condition when no myduatic is used.

The reason suggested is in accordance with the theory of the sympathetic action of the converging and ciliary muscles and in paralyzing the ciliary by means of the myduatic its effect extends to the nerve centres controlling the internal muscles and this lessens the converging power for the time being, and causing a test to show lack of convergence—that is exophoria.

ESSOPHORIA is disclosed by any of the regular tests previously enumerated, but as the Maddox Rod is probably the simplest and is certainly as accurate as any other method, I will confine the description to that, while the reader in practice can extend his experiments to various contrivances as suit the fancy.

If used over the left eye, essophoria is disclosed by means of the Maddox Rod, when the bar of light seen through the rod is apparently to the left of the flame seen by the right eye. If the phoroptmeter is used, the amount of the error is registered on the scale when the prisms are revolved, which place the bar in the centre of the flame.

If prisms from the trial case are used, they should be placed in front of the right eye, base out, and the amount of the error is indicated by the strength of prism necessary to bring the images of the flame and line together.

The duction test should be made by means of the rotary prism to ascertain whether the lifting power of the lateral muscles is normal.

The term "duction" is applied and a prefix attached to indicate each muscle; adduction refers to the power of the external muscle to fuse double images produced by prism displacement.

Everyone knows that theoretically the weakest possible prism in front of one eye would produce diplopia, as a result of the displacement of the image in that eye to a point on the retina not corresponding to that of the other eye, but we know that the weakest prism does not in fact produce diplopia, that various amounts are required for each muscle, and for different cases and that diplopia is avoided when the prism is worn by reason of the muscle rotating the eye ball so that the images harmonize, but when the displacement is above a certain amount as a result of increasing the strength of the prism, the muscle can no longer rotate the eye ball sufficiently to produce single vision.

It is this power to fuse doubled images that is termed duction, and as it practically means the lifting power of a muscle, and as we have as the result of experiment and comparison, acquired a standard for each muscle, the duction test merely indicates whether each muscle possesses the normal amount of power.

Adduction. the lifting power of the externals, is considered normal when it can overcome a prism of 7 degrees. Inability to fuse more than 6 degrees is subnormal and 8 degrees or over is abnormal.

Addiction refers to the internals and is considered normal between 18 and 25 degrees.

Superduction refers to the power of the superior rectus, and is considered normal at 2 to 3 degrees.

Subduction, or lifting power of the inferior rectus, and is also normal at 2 or 3 degrees.

This digression was rendered necessary to the understanding of the tests for essophoria and is equally applicable to tests for other forms of muscular error, and it will not be necessary to more than refer to it in describing them.

In essophoria then we test the lifting power of the external muscle by means of a prism base in which being 6 to 8 degrees without producing diplopia, the adduction would be considered to be normal, but more would be abnormal and unless we found the adduction equally abnormal would point to imbalance at once.

If the duction test showed a lack of power in the external recti it is evident that outside of the question of balance between the internals that fatigue is natural in using the muscle and an increase in its power is desirable.

If imbalance is present in favor of the internals, a development of the externals will solve both difficulties.

Pseudo essophoria is distinguished from true essophoria by examining the condition of refraction and if found hyperopic and without the correction essophoric and with the correction orthophoric or nearly so, the muscular error is manifestly not real, but is a part of the refractive error and with its correction disappears.

In correcting hyperopia where essophoria has been shown to be present, each diopter of correction will correct about 2 degrees of essophoria, and in hyperopic astigmatism the amounts are about one half of this so that a case of 2d. hyperopia with 3 1-2d. of essophoria would usually be corrected in refractive and muscular error by 2d. sphere and conversely if the refractive error be myopic with essophoric imbalance, the correction of the former will add to the latter similar proportions to those enumerated and such a complication would render any correction for the error of vision practically impossible until the muscular balance was restored, and glasses supplied without so doing will be troublesome, and cause complaint of strain and fatigue if worn for n[illegible]r work.

The means of relief in essophoria are of two kinds, not including operative treatment, and consist of prisms worn constantly with base out and what is known as prism rythmical exercise for developing the weakly externals.

In supplying prisms for constant wear, the base is always over the weak muscle, and the object of it is to deflect the ray of light so as to render unnecessary wholly or in part the rotation of the eye ball, and as a general rule, one half the total amount of the error in the form of a prism will give relief.

The objection to this method of treatment is that it is at best, but temporizing, and it in no way aims to remove the cause and merely relieves the strain, and renders possible a further deviation of the unworthy muscle by removing the necessity of exercise.

The amount of the prismatic correction in mose cases of essophoria may be divided between the two eyes or worn entirely before one. The general rule where no spherical correction is combined is to divide the prismatic correction between the two eyes, but when other corrections are combined, the whole of the prisms is attached to one eye, where it is a small amount, say not more than 2d., but if more, it is divided in order to equally distribute the weight.

The rythmic exercise is performed by means of prisms base in sufficiently strong as to just produce diplopia which is overcome, and the two images fused by a determined muscle effort, thus bringing into violent exercise the undeveloped externals. Immediately the objects are fused the glasses are lifted—and the muscles relax, and the glasses being lowered again, the diplopia is again present, and again fused. The exercise is continued for a period of 5 to 10 minutes and repeated daily, and the development of the externals will be indicated each day in the increased strength of prism which is required to produce diplopia.

In exophoria either the external muscles are shortened, or in some instances attached to the eye-balls further forward than their opposing internals or possibly exophoria is produced by an over-plus of nerve energy supplied to the external muscles, although this latter condition is known as pseudo exophoria to distinguish it from intrinsic or real exophoria when the conditions of the mscles or their attachments are faulty.

Naturally if uncorrected the above conditions would produce an outward squint which is prevented by an abnormal use of the internal recti muscles to counteract it.

In intrinsic exophoria, the preponderance of course is relative; either the externals may be abnormally developed or the internals are puny and undeveloped; the result is the same, the balance is disturbed.

Savage states that intrinsic exophoria is also caused by the unequal supply of nerve force to the opposing muscles, but this theory is combatted by other writers who claim that this form should be classed as pseudo.

Savage also claims that intrinsic exophoria can exist without a state of imbalance between the externals and internals, and points to the obliques as the cause pointing out that their attachment makes them powerful abvertors, and aid in exerting force outward.

And again the superior and inferior may be attached nearer the temporal or outside margin and thus in elevating or depressing the ball would create a tendency to outward squint.

The same fact confronts the optician in almost all forms of heterophoria and fixes a limit to his successful efforts at relief. It is the fact that among the causes connected are always to be found conditions of faulty construction or abnormal development of the nerve cells in the brain and which of course cannot yield to treatment along mechanical lines, nor probably any other kind, and successful treatment is confined to pseudo forms and intrinsic only when the relative power or length of opposing muscles is disturbed but in nearly all cases relief can be obtained by prism correction which removes the strain from the over-burdened muscle.

It must be clearly understood that the fatigue which is inseparable from heterophoria is the expression of overwork suffered by the muscle that is working at a disadvantage.

It is the internal in exophoria and the external in essophoria, and the burden is simply the task of working incessantly preventing a deviation of the visual axis toward the preponderating muscle—the external in exophoria, and the internal in essophoria, so that in supplying a prism base over the less powerful muscle, the eyeball is allowed to deviate and the visual image is properly aligned preventing diplopia by means of the prism.

In distinguishing between intrinsic and pseudo exophoria, we have to look at the condition of the refraction and compare the muscular balance for far and near.

Emetropia and exophoria increased at near point as compared with distant test can only be accounted for by excessive development of the ciliary muscle requiring consequently less effort and of course less nerve energy for a given close point than normal and a consequent effort of repression of accommodation carrying with it nerve energy to the externals.

In myopia we of course expect to find exophoria for close work and result of entirely suppressing ciliary action.

A normal muscular condition according to Savage would be 1.8 degrees of exophoria for every diopter of myopia in testing at 16 inches. This shows the importance of accuracy in ametropic corrections in connection with muscular tests.

In testing for exophoria if we find the conditions orthophoric at distance and exophoric for near the condition is pseudo and is produced either by myopia or abnormal development of the ciliary muscle.

In testing the muscular balance exophoria is indicated when with Maddox Rod over the left eye the bar of light created by it will be seen to the right of the flame seen by the other eye, and the prism required to bring them together represents the amount of exophoria.

It is very important that the near test, as well as the distant test, should be made, as when complaint of asthenopia has led to the muscular investigation, if the test ceases at distance when orthophoria has been found, the trouble will still continue if exophoria for near work is present, as it is the use of the eyes at near points that produces all the fatigue in this form of heterophoria by reason of the excessive strain required in convergence.

The lifting power of the muscles should also be ascertained by means of the rotary prism with which the phoroptometer is usually fitted, having in mind the normal lifting power of each muscle.

To operate the Risley prism, the attachment is swung into position with the handle horizontal and the white line on the prism exactly vertical and opposite the zero mark on the scale. In this position the bases of the two prisms are in opposite directions and the power of both is thereby neutralized.

If the thumb-screw is now turned to the left, the index pointer on the outer prism will revolve to the right over the various numbers of the scale and indicate that prismatic power represented by the number on the scale to which the indicator points is before the eye with its base inwards over the internal muscle, and the lifting strain is thus placed over the external. In a like manner, if the thumb-screw be turned to the right the indicator will rotate to the left toward the temple, and the base will then be over the externals and the strain on the internals.

To test the vertical muscle, the thumb-screw is placed in a vertical position, with the index at zero, and by turning it to the right the index points upward and the strain is on the inferiors, and if turned to the left the superiors are under strain.

To measure the lifting power of each muscle, the prism is adjusted at zero, with the thumb-screw horizontal for the lateral muscles, and turning the screw slowly to the right the strain on the inte al is gradually increased, while the attention is fixed on the distant flame, and immediately this appears to double, the rotating prism is stopped, and the duction or lifting power of the internals is read from the scale. The same operation is repeated with the externals by reversing the direction of the rotating prism.

The vertical muscles come under examination by shifting the thumb-screw to a vertical position and rotating the prisms over each muscle in succession and reading the amount from the scale in the same manner as in the case of the lateral muscles.

In the case of the external muscle the normal power is 6 to 8 diopters, and if less than the minimum amount the exophoric error is caused by partial paresis or arrested development of the interni, but if over 8 diopters an over-development of the externi is the cause.

The technical terms for these two conditions is sthenic and asthenic, a point which, while of general interest only to opticians, is important only when an operation is contemplated.

Exophoria in addition to the general complaint of asthenopia or fatigue will usually produce a blurring of the type in reading for any length of time, much the same as in presbyopia, but in the latter it is owing to the difficulty in maintaining the eyes focussed at the point at which vision is desired, while in the former it is through the inability to maintain the visual axes of both eyes at the point of fixation, the convergence being deficient.

Sleepiness always prevails owing to the muscular insufficiency extending to the eyelids causing them to droop and close and a condition of the trouble while making prolonged efforts to use the eyes for close work will usually produce inflammation and a drawing sensation at the nasal side of the eyes.

Relief is found in prisms with the base in.

If the condition is pseudo with myopia no relief is possible unless the full correction for the myopia is sworn for near work, and in those cases when it is found impossible to wear this the muscular condition will have to be relieved by prisms base in.

Exophoric people who are hyperopic cannot possibly wear the correction for the refractive error while muscular imbalance remains as the correction, but adds to the burden of convergence.

Savage maintains that if the hyperopia be less than 2.00 diopters and the exophoria for near point more than 4.00 no correction should be given, and further states that even when the muscular error is caused by exercise, that an under correction of one half diopter is best.

The same writer gives two methods of developing the interii in exophoria—the candle test and the prism gymnastics.

The candle test is simplicity itself, and the outfit consists of an ordinary candle.

The candle exercise is conducted by means of a lighted candle held by the patient at arm's length on a level with the eyes.

The vision is fixed upon the flame and it is slowly approached towards the face continuing to fix it with the eyes until a point seven inches away is reached, where it is held.

The eyes are then closed and the candle removed and the process again repeated.

This method simply exercises the internals in the most natural manner in order to see the flame singly and the continuation of it from day to day produces the development sought for.

By means of prism base out and commencing with weak prisms they should be gradually increased until it is possible to see singly through 8 degree prism.

With the prism in position a flame at 15 or 20 feet should be fixed intently, and then the frames containing the prisms should be raised allowing the muscles to relax, and the alternate raising and lowering continued for five minutes at a time. This procedure continued for a week ought to show definite progress in the process of muscle building.

It is of course important that a record of the exact muscular condition be kept and re-examinations made frequently to ascertain the degree of development accomplished. If possible a slight over-development of the internal is desirable.

HYPEROPHORIA

Is a condition in which the visual aves of the two eyes is not in the same horizontal plane, or in other words, the eyes in a state of rest fix separate points, one higher than the other.

It is generally described as a condition in which the inferior muscle is insufficient, while the term cataphoria refers in a like manner to the superior, but this condition has really to do with the comparative balance of the two eyes; a right hyperphoria is really equivalent to left cataphoria, and vice versa, so that the term cataphoria has fallen into disuse, and the condition is described as right or left hyperphoria.

If the right superior predominates so that the point of fixation of that eye is above that of the left, right hyperphoria exists, while if the fixing point of the left eye is above, it is left hyperphoria

Unlike essophoria and exophoria, hperphoria cannot have its cause in defective refraction, and may be caused by a malformation of the orbit or a faulty attachment, or in the over-development of either the superior or inferior rectus muscle.

In some cases hyperphoria is undoubtedly owing to a faulty action of the oblique muscle, which will cause the elevation of the visual axis of one eye in excess of the other. Unlike errors in the lateral muscles, it rarely happens that the vertical muscles exist in a state of imbalance without producing more or less discomfort and frequently a very slight amount of imbalance will cause an excessive degree of pain and discomfort, although doubtless owing to the fact that it does not depend at all upon errors or refraction, it is not nearly as prevalent as lateral imbalance.

The methods of testing are similar to those used for essophoria and exophoria, but it is well for the student to clearly realize that nothing but the most accurately constructed instruments are of any use in measuring it, and the use of the prisms from the trial case in the trial frame are totally unreliable, and time spent in the attempt is wasted if accurate results are desired.

It is utterly impossible to place the prism absolutely accurate in reference to the horizontal plane, and consequently vertical error will generally be produced where none exists.

The Maddox Rod in the trial frame is permissible as a means of practice, but for actual work, nothing can take the place of the phoroptometer.

The "UNIVERSAL PHOROPTOMETER" is the most desirable owing to its many improvements, and ease of manipulation. In this instrument the colored Maddox Rod is attached to the left side so that it may be swung in front of the left eye, and the method in which it is pivoted to the frame makes it absolutely certain that when in position, the rod is positively horizontal, providing the instrument is level, and as it is fitted with spirit level it is an easy matter to verify this point.

A candle or small flame located at twenty feet distance, and on a level with the eyes of the patient, is used as a fixing point, and with the Maddox Rod in front of the left eye, the flame appears as a horizontal bar of red flame, which, if it cut the centre of the candle flame, indicates a condition of balance, but if seen above the flame, it indicates that the left eye has rotated downward below the point which the right eye is fixing, and consequently showing the presence of a preponderating inferior in the left eye as compared with that of the right eye—a condition known as right hyperphoria—while if the bar is seen above the flame, left hyperphoria is indicated.

The amount of error is disclosed on the scale of the phoroptometer when the prism lever is adjusted so as to bring the bar and the flame into the same plane.

In high degrees, simply placing a red glass before the eye will destroy binocular vision, and cause diplopia, and the kind of error will be shown by the position of the red light in reference to the white one.

An important detail in connection with the test is the position of the head, which should be perfectly upright, and the eyes directed straight to the point. If the light is located above, or below, the test will be more or less unreliable.

The symptoms of hyperphoria are similar to those of errors in the lateral muscle, with the additional peculiarity in the position of the head which is frequently carried in such a position as will afford the greatest ease to the afflicted muscles. A certain tilting of the head is often noticed and is sometimes confused with the prominent symptoms of astigmatism.

The complaints are those generally incidental to fatigue of the motor muscles, and in extreme cases produce alarming results, affecting the health to a serious degree.

The treatment of hyperphoria by prism exercise is the usual method of permanently relieving the condition of imbalance,, and it must be remembered that the apex of the prism is to be placed over the weak muscle and the exercise continued until it is developed if possible slightly in excess of its opponent.

When prisms are prescribed for constant use, the base is placed over the weak muscle, and the tension is thus relieved.

It is customary to prescribe for constant wear about one half the amount of the error.

Many cases of muscular imbalance will not yield to prism exercise, and show practically no improvement under their use. These cases are usually those in which the muscles are incorrectly attached, and relief is only possible through the medium of an operation.

CYCLOPHORIA.

In addition to the disturbances of the recti muscles already enumerated in the foregoing pages, the question of balance of the oblique muscles has to be considered.

The superior and inferior oblique are attached above and below, and coil around the ball like folds of a main-spring in a watch. A contraction of either of these muscles gives a rotatory motion to the ball, and they of course pull in opposite directions.

In a state of perfect balance with both relaxed the ball assumes its normal position without muscular effort, but in the case of over-development in one, the involuntary rotation of the ball is prevented by the continued action of the other.

The principal causes of muscular imbalance of the obliques which Savage terms Cyclophoria, is in the attachment of the muscle being too far back, as it can easily be seen by the aid of the simplest knowledge of mechanics that if one muscle is attached farther forward than the other, the one farther back is describing a greater circle, or mechanically speaking, is operating over a larger pulley than the other, and reaps the advantage of power in proportion.

Oblique astigmatism undoubtedly is a prolific cause of oblique muscular disturbances, although it may possibly be contended that this form is not real cyclophoria, and disappears with the correction of the astigmatism, but whether real or psuedo from an operator's point of view, it is distinctly real to the optician, and is not always relieved by the amet opic correction, and frequently does not disappear for a considerable time after the glasses have been worn.

The complication of the oblique muscles in oblique astigmatism is undoubtedly one of the prime causes of the difficulties met with in securing a comfortable correction for the astigmatic error.

These complications are peculiar to non-symmetrical oblique axes, and are accounted for in the effect produced on the retinal image by the astigmatic cornea.

In looking at an upright line with an obliquely astigmatic eye, the image is formed on the retina in an oblique position tilted over towards the meridan of greatest curvature, and if the axes of the two eyes be in different directions, the two retinal images will occupy different position on the two retinae, which of course would produce diplopia, with its attendant feelings of discomfort, and an eye so affected will necessarily make every possible effort to overcome it in order to secure any degree of comfort.

This condition is remedied by a contraction of one set of obliques which, revolving the eyeballs in the sockets, brings them into such a position that both images are upright.

The condition of fatigue caused by this constant contraction may well come under the heading of heterophoria, and it is probably far more in evidence as a factor in asthemopia attendant upon uncorrected astigmatism of this nature than the strain caused by the imperfect vision. If, however ,the asthenopic symptoms subsided upon applying correcting cylinders, we might well omit all mention of it in discussing heterophoria, but we frequently find upon supplying the proper cylinders restoring normal vision that the asthenopia is greatly increased, and the lenses produce distortion of the object, and in many instances are absolutely refused as impossible.

That the cylinders are approximately correct is evidenced by the fact that vision is improved thereby, and similar amount of improvement is not possible by any other means, so that we have the phenomenon presented of greater discomfort with correct lens than without.

The explanation in the light of what has gone before is simple. The eye has gone uncorrected for years; the obliquely tilted images have been rectified by a constant contraction of one of the obliques, which has become developed and shortened in excess of its opponent, and when the correcting cylinder is applied, the image is no longer tilted, and the oblique is no longer required to rotate the eyeball, but as a result of its development, it is impossible for it, even relaxed to its utmost, to permit the eye to go to its normal position unless the opposing oblique is called into action to pull it over.

This condition produces one of two results: If the opposing oblique possesses sufficient power and stamina to overpull the shortened muscle, good vision is assured, but the fatigue sure to attack the constantly contracted oblique will produce discomfort of even more pronounced form than that felt in the effort to see previous to the correction being worn, and the glasses, if not utterly unacceptable, will certainly be unsatisfactory at best, and if the opposing oblique be unequal to the task, the glasses will be totally unacceptable, objects will be distorted, and diplopia is inevitable.

In the absence of any knowledge of muscular dynamics, it has been customary to try and get the patient to persevere with the glasses in the hope that the eyes "will come" to them, as it is called, but the most common practice is to supply a partial correction only. Cylinders have been supplied for gymnastic purposes with a view to developing the oblique that is laboring at a disadvantage. By this method, round cylinders are used so that they may be adjusted at varying degrees, and the practice consists in prescribing them at such an angle that the weak oblique is forced to contract violently to prevent diplopia, and thus develop by exercise as in the case of prism exercises.

I am not in a position to state what results may be counted on by this method, but in the absence of any unauthenticated facts, I think it will be found safer to humor the muscular error at the expense of a part of the vision secured, and place the axis of the cylinder from 5 to 10 degrees away from its proper degree, thus producing a false muscular balance, but a greater degree of comfort than is possible with a perfect correction of the vision.

A simple test for real cyclophoria is by means of the double prism and a line. The prism is placed over one eye with base line horizontal, and the other eye covered, and the attention directed to a straight line drawn on a card or paper held sixteen inches away. The effect of the double prism is to double the object so that two lines are seen parallel to each other, and upon the other eye being uncovered, a third line will appear midway between the two first seen, and in orthophoria, parallel to them.

If, with the prism before the right eye, right end of the middle line approaches the lower line, the left superior oblique is defective. If the middle line approaches the upper line, at the right end, the left inferior is at fault. Similar appearances at the left end of the lines indicate similar troubles existing in the right obliques.

In addition to muscular complication incidental to hyperopia and myopia already referred to, there is that of presbyopia, and it is just here that opticians generally fail on what to them appears the simplest form of refracting.

Presbyopia in theory seems so easy of understanding, and so simple in correction that even the best posted opticians in ordinary refraction but ignorant of muscular philosophy have been at a loss to account for many cases which have proved entirely unsatisfactory under what appears to be a perfect correction. A careful examination with the phoroptometer will show in these cases exophoria at near point, and of course the correction of the presbyopia by convex spheres bringing the near point closer will still further tax the already insufficient convergence.

There is no doubt also that from the apparent simplicity of presbyopia and its correction, that many corrections are carelessly made, and in many instances an over-correction is supplied without a just appreciation of its effect upon the muscular balance.

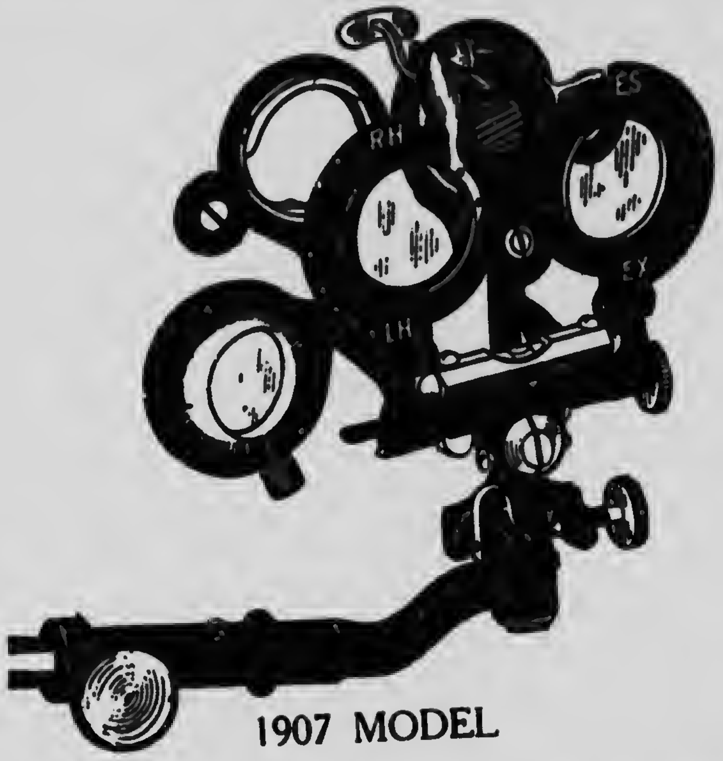
Even in Orthophoria where the internal recti is fully equipped to sustain the burden of convergence, discomfort and inconvenience is more or less in evidence if the presbyopia correction be unnecessarily strong, a condition which will be intensified when exophoria is present.

The only safe plan to follow is to combine muscular examinations with every examination for refractive errors, and in presbyopia, particularly where exophoria is shown, the spherical correction must be reduced to the weakest possible quantity consistent with close vision, and where no correction is tolerated on account of the muscular strain thereby produced, the internals will have to be strengthened by rythmic exercises or prisms to the amount of half the muscular error with the base supplied in conjunction with the spherical correction.

It is generally a safe plan to have reading glasses decentred inwards, thus relieving in part the strain on the convergence.

For the purpose of exercising the motor muscles, a set of prisms and a special frame for holding them should always be used, for which purpose the universal hetrophoric set is preferable, as the frame is of an improved form, much easier of manipulation than the old style, and the prisms being round, can be used for any form of error and their bases set in any desired direction.

Universal Phoroptometer



1907 MODEL

The "Universal" combines in one instrument a 3 cell trial frame with patent revolving cylinder cells; 1 Risely Rotary Prism; 1 Multipe Maddox Muscle test; 1 Stevens' Phorometer.

When used as a trial frame, the Phoroptometer attachments are instantly swung out of sight, and the 3 cells left clear to receive the trial lenses.

The rotating cells holding the cylinders are revolved by means of a geared thumb wheel and are instantly controlled by a touch of the finger.

The Risely Prism is used for measuring high degrees of error, also for rythmic exercise as well as for testing the lifting power of each muscle.

The near test is used not only for muscular defects but is the most accurate and simple means of measuring the Presbyopia.