DONATED TO AOA LIBRARY BY:

Dr. Gordon C. Shivas
Madison Street
Pulaski, Tennessee
SUPPLEMENT TO
THE
OPTICIAN'S MANUAL
SUPPLEMENT TO

THE

OPTICIAN’S MANUAL.

CHAPTERS 11 AND 12.

A Treatise on the Science and Practice of Optics,

COMPILLED FROM THE SERIAL, WRITTEN BY

C. H. BROWN, M. D.,

Graduate University of Pennsylvania; Professor of Optics and Refraction; Formerly Physician of the Philadelphia Hospital; Member Philadelphia County, Pennsylvania State and American Medical Societies.

Published Exclusively in The Keystone, the Organ of the Jewelry and Optical Trades.

WITH ILLUSTRATIONS.

Published by

THE KEYS'TONE,

19TH AND BROWN STREETS, PHILADELPHIA, PA., U.S.A.

1899.
PREFACE.

THIS Supplement to "The Optician's Manual" has been compiled in response to repeated and urgent requests that we republish in book form the two chapters of The Keystone serial which covered the important subjects of Hypermetropia and Myopia. These two chapters are a direct continuation of the matter published in the Manual, and all who have read them concede that there is no book available to the optician in which Hypermetropia and Myopia have been treated so clearly and exhaustively. As in the case of "The Optician's Manual," the matter is written in such a way as to be readily intelligible to the beginner, while containing all the information needed by the experienced optician. In presenting this Supplement, we are happy in having the endorsement beforehand of the profession at large, including optical teachers, students and practitioners.
Chapter 11.

HYPERMETROPIA


Chapter 12.

MYOPIA

CHAPTER XI.

HYPERMETROPIA.

Having given a careful representation of the anatomy of the eye and the physiology of vision, as well as of the simpler laws of optics and the properties and uses of lenses, and having enumerated the outfit required and given minute directions as to the method of examination of a case of supposed optical defect, together with a detailed description of the loss of accommodation and the diagnosis and treatment of presbyopia and its complications, we pass on to the consideration of the various optical defects. The first one to be studied will be hypermetropia, as being perhaps the error of refraction with which the optician meets most frequently.

The word hypermetropia is made up of three Greek words, signifying in excess of the measure of the eye. It may be defined as that condition of the eye-ball, in which the antero-posterior (from in front backward) axis of the ball is too short; in other words, the globe of the eye is too flat, which is equivalent to its refracting power being insufficient, so that parallel rays of light entering the eye cannot be brought to a focus upon the retina when the accommodation is at rest, as it should be when we are looking at distant objects.

HISTORY OF HYPERMETROPIA.

Although hypermetropia had been mentioned and described by previous writers somewhat indefinitely, it was reserved for Donders to reduce the knowledge concerning it to
scientific accuracy; but it was not until 1848 (less than half a century ago) that he published his first description of this defect, and cleared the optical atmosphere surrounding it, which had perviously been cloudy and misty with speculation and error.

The elucidation of this hitherto mysterious defect was the magnificent result of many years of patient toil and systematic investigation of the subject, in the light of the knowledge concerning it which was at that time the property of the scientific men of the day, together with the added fruit of Donders' own research and discovery, just as many other great truths have been evolved by a similarly slow process but by a persistent application, such as has characterized the labors of many of the great minds of the age.

Previous to this time many affections of the eye were misunderstood, because of the imperfect knowledge of these matters available at that day, and were supposed to have their origin in the nervous system of the eye. In the light of our present knowledge, however, many of these cases were hypermetropic, and the distressing symptoms were caused by the strain imposed upon the accommodation in its unaided efforts to overcome the defect.

**DONDERS' OWN WORDS.**

"He who knows by experience how commonly hypermetropia occurs, how necessary a knowledge of it is to the correct diagnosis of the various defects of the eye, and how deeply it affects the whole treatment of the oculist, will come to the sad conviction that an incredible number of patients have been tormented with all sorts of remedies, and have been given over to painful anxiety, who would have found immediate relief and deliverance in suitable spectacles.

"It is a great satisfaction to be able to say that asthenopia need now no longer be an inconvenience to any one. In this we have an example, by what trifling means science sometimes obtains a triumph, blessing thousands in its results. The discovery of the simple fact that asthenopia is dependent on the hypermetropic structure of the eye, pointed out the way in which it was to be obviated."
PROF. DONDELS

Is one of the best-known men connected with the ophthalmology of the preceding generation, and his name is a familiar one to every optical student of the present day. His death was an irreparable loss to ophthalmology and to optics, which is shared and felt by every individual practitioner and worker in this field. But it has been truthfully said by one of his biographers that "we do not lose the master, since his works remain and will always remain, forming the life, the soul of ophthalmology."

Prof. Donders.

Donners pursued a medical course, and at the early age of twenty-two years occupied a teacher's chair, followed two years later by his elevation to the professorship of anatomy and physiology in the University of Utrecht, from which he had so recently graduated, and in which he continued during all of his active professional life, building up an international reputation that was limited only by the size of the world, and making of this little city of Utrecht a scientific center that emitted its radiance in every direction, and attracted the attention of learned men of every clime. Donders was indeed a foremost representative of Holland in the noble galaxy of savants that were cultivating the fertile fields of science.

Donders did not confine his researches to any one portion of the field, but his labors extended over the whole domain of
science, in which are found everywhere the evidences and results of his indefatigable investigations. But to us, as opticians, he is best known and most revered for having enriched our science as no man before or since has done, and particularly through the medium of his great work on the accommodation and refraction of the eye, the fountain of knowledge from which every writer and teacher on the subject draws his inspiration.

Donders's preference in his work was always for teaching, and he is said to have possessed in an eminent degree all those essential qualities which go to make up the perfect professor. "An erudition as profound as extensive; an excellent memory; an intelligence capable of adapting itself to his audience; a wit which colors abstract matters; a rich flow of language; a voice sonorous and flexible; gesture noble and significant; something sublime emanated from the man; physically grand and beautiful, something at once imposing, captivating and sympathetic; great knowledge and great desire to impart it."

DONDERS' MODESTY.

It seems as if Donders' learning was equaled only by his modesty, and the latter quality is scarcely less an element of greatness than the former; it certainly increases one's admiration for the man. Several instances exemplifying this trait of his character are related, and they are so distinctive of the man as to bear repetition.

On one occasion an admirer was felicitating him on the discovery of astigmatism, when he made the following magnificent reply: "Pardon me, my friend, astigmatism was known a long time before my day; I only discovered astigmatic people."

When the time came for Donders, on account of the limitations which age imposed upon him, to retire from the professor's chair, which he had honored for so many years, it was made an occasion of paying special homage to his merits by his countrymen, pupils and admirers. His modest response to all the glory which was sought to be showered upon him was, "Talk not to me of my merits, but congratulate me on my lucky star."
HYPERMETROPIA.

CHARACTERISTICS OF A HYPERMETROPIC EYE.

Hypermetropia may be looked upon as a congenital defect, in fact the statement has been made that all babies are born hypermetropic. It is supposed to be due to an arrested development in the formation of the eye-ball, which may vary from the slightest degree to an extreme condition of smallness.

The hypermetropic eye differs somewhat from an emmetropic eye, and the following have been enumerated as some of the characteristic points of an eye suffering from this defect. The eye is said to look smaller, but this is a change that is not always noticeable, although as a matter of fact the ball is smaller than the normal eye in all of its dimensions, but particularly antero-posteriorly. The lens and iris advance forward, which makes the anterior chamber shallower. The pupil is small and contracted.

The ciliary muscle, by reason of its action on the accommodation, upon which the eye depends for whatever clear vision it may enjoy, is much larger and more fully developed than in emmetropia, this development being particularly noticeable in the anterior portion, which is composed chiefly of circular fibers, and is due to the constant strain imposed on the accommodation by the hypermetropia.

On account of the constant relation existing between the accommodation and the convergence (as has been fully explained in the previous chapters) this excessive accommodation is apt to cause an excessive convergence, the result being a case of convergent strabismus.

In hypermetropia of high degree, the optic nerve is diminished in size and contains a less number of fibers, which accounts for the lessened acuteness of vision so often found in these cases.

In this defect the face is said to have a characteristic flat appearance, the nose depressed, orbits shallow, and the distance between the eyes to be increased. It should be remarked, however, to the optician that these points are often absent, and that there may be no distinctive features apparent in the face.
It is not unusual to find a hypermetropic eye disposed to astigmatism.

HYPERMETROPIA HEREDITARY.

It is not an infrequent occurrence to find many members of the same family affected with hypermetropia. This is so commonly the case that when the diagnosis of hypermetropia is reached in the examination of a patient, the question naturally presents itself in the examiner’s mind as to whether some other members of the family are not similarly affected; and when this question is put to the patient, the answer generally corroborates the assumption, at least to the extent of admitting that one or both parents commenced to wear convex glasses for reading at a very early age. (Hypermetropia in some cases first shows itself as an early presbyopia, as remarked in the last chapter.)

Cases will sometimes be met with in which one eye is emmetropic, and the other eye hypermetropic; and in such cases there may be a very marked difference in the form of the bones on the two sides of the face, thus illustrating the shallowness of the orbits and the flatness of the face with the diminished prominence of the nose, which so often accompanies and indicates hypermetropia. A writer relates a case of this kind, the patient being a young lady who presented herself for treatment of stricture of the nasal duct. The lack of symmetry between the two sides of the face and in the size of the eyeballs was strikingly noticeable, and an examination showed the presence of hypermetropia in one eye.

It will be remembered that the normal or emmetropic eye, when the accommodation is at rest, is accurately adapted for parallel rays, which come to a focus on the retina, forming on this membrane sharply defined images of distant objects, from which these rays emanate. This is accomplished without any action of the accommodation, which is left unrestricted for its normal purpose of adjusting the dioptric apparatus of the eye for the divergent rays issuing from objects close at hand.

In hypermetropia, on the contrary, we find the dioptric system of the eye, when the accommodation is suspended (this is a supposed condition, however, and one that seldom occurs,
because in this defect the accommodation is in active and continuous use), on account of the shallowness of the ball, arranged for the refraction of convergent rays, as no other form of rays can be united on the retina in the production of a clearly defined image. Now it is a well-known fact that in nature all rays of light are either parallel or divergent, and hence the hypermetropic eye, being conformed for convergent rays, is adapted for a condition which does not naturally exist.

**THE FAR POINT IN HYPERMETROPIA.**

In emmetropia the far point of distinct vision is situated at infinity, or at any distance far enough removed from the eye that the rays proceeding from it shall be parallel. While in hypermetropia, on account of the adaptation of the eye for the unnatural convergent rays, the far point is negative, or may be said to be situated beyond infinity, if such a condition can be imagined.

In emmetropia the parallel rays are united on the retina, and distinct vision is the result; in hypermetropia these same parallel rays strike the retina before they have converged to a focal point, which renders distinct vision an impossibility, because each point of the image is surrounded by diffusion circles, and these circles from points of the image close together overlap each other.

**DEFINITION OF HYPERMETROPIA.**

Hypermetropia may then be defined as that condition of the eye in which there is a shortening of the antero-posterior diameter of the ball, or the positive refracting power of the eye is deficient, and the result in either case is that the focus is behind the retina. Or, in other words, the diameter or length of the eye-ball is less than the focal length of its dioptric apparatus.

**THE DIFFICULTIES OF HYPERMETROPIA PRACTICALLY DEMONSTRATED.**

A concave lens is a negative lens and diminishes refraction; a hypermetropic eye is one in which there is naturally a deficiency of refraction. Now if we consider these two facts
together, it follows that a concave lens placed before an emmetropic eye will lessen its refraction, and to that extent will make it equivalent to, and place it in the same optical condition as, a hypermetropic eye. Therefore if any one enjoying emmetropic eyes desires to experience a practical demonstration of the difficulties and hindrances which are ever present to annoy and harass the hypermetrope, he can very easily place his own eyes in the same condition by making them artificially hypermetropic by the use of concave lenses.

If he tries first weak lenses, and by changing them gradually increases their strength, he will in the beginning find that by the exercise of his accommodation he is able to neutralize and overcome the diminishing effect of the concave lenses.

![Outline of a Hypermetropic Eye, Showing the Focus of Parallel Rays to be Back of Retina.](image)

As, however, he gets into the higher numbers, it becomes a more and more difficult task for the accommodation to counterbalance these increasing negative lenses.

If, in spite of these warnings that the accommodation has reached the extreme limit of its powers, and its greatest effort is required to preserve vision clear through the concave lenses, a step farther be taken with stronger glasses, it would entirely drain all the resources of the ciliary muscles, and they would be no longer equal to the task of supplying the necessary refractive power, and vision would become blurred, and the eyes would be in a condition of absolute hypermetropia.

Convex lenses sufficiently strong placed before the concave ones, would supplement the exhausted accommodation, and would partly or wholly nullify the diminishing effect of the concave lenses, and distant vision would again be restored clear and distinct.
HYPERMETROPIA.

FORMS OF HYPERMETROPIA.

Hypermetropia may be classified as original and acquired.

In the acquired form the eye was primarily emmetropic, but on account of the lessening of its refraction, toward which all its senile changes tend, the focus for parallel rays falls behind the retina, and the refraction of the eye passes over from a condition of emmetropia to that of hypermetropia. The changes that take place in the eye with the advance of years, more especially as to the loss of accommodation, and the rationale of the appearance of hypermetropia in old age, have been fully described in the chapter on presbyopia.

Original hypermetropia may be either congenital, or developed at a very early age by an interruption in the growth of the eye, especially in its antero-posterior diameter. The weight of authority seems to favor the opinion that the eyes of new-born babes are hypermetropic, which condition may soon develop into emmetropia, and then pass over into myopia; and when once these changes have occurred by a lengthening of the axis of the eye-ball, they become permanent, and the eye cannot again return to its original hypermetropic condition. This would indicate a tendency for the eye-ball to elongate, and the natural inference would be that myopia is apt to increase, while hypermetropia seldom grows greater, but frequently diminishes.

DIVISIONS OF HYPERMETROPIA.

Original hypermetropia may be divided into manifest and latent, and in order to ascertain the total hypermetropia it is necessary to add the manifest to the latent.
In hypermetropia of not too high a degree, it is usually found that the distant vision is quite up to the standard, and the sight is apparently that of an emmetropic eye. This is accomplished by means of the accommodation, which increases the convexity of the crystalline lens and adds to the refractive power of the eye, and thus bends parallel rays so as to advance their focus from behind the retina on to this structure. It is the same effect that is produced by a convex lens placed in front of the eye; and the amount of accommodation required, which can be expressed by a certain number of convex lens, will represent the degree of hypermetropia present.

The division of hypermetropia into manifest and latent depends on the action of the accommodation; manifest hypermetropia is possible only with a suspended accommodation, while the latent form is that which is concealed by the contraction of the ciliary muscle. Hence it follows that the more passive the accommodation, the greater the manifest hypermetropia; and the more active the accommodation, the greater the latent hypermetropia.

The manifest hypermetropia is usually apparent without a mydriatic, and is measured by the strongest convex glass that will be accepted for distant vision. The latent defect can be made manifest, or can be detected, only by the use of a mydriatic. As the person advances in life and the power of accommodation weakens, in the same proportion the latent defect decreases and passes over into manifest, until finally there remains no more latent trouble, but it has all become manifest.

The manifest hypermetropia is, for the purposes of convenience, written Hm, the latent hypermetropia Hl, and the total hypermetropia Ht.

ILLUSTRATIONS OF THE DIVISIONS OF HYPERMETROPIA.

Perhaps this subject can be made more clear by the exemplification of a case of hypermetropia tested at a distance of twenty feet with Snellen's test types. Possibly the eye can distinguish only the larger letters, and the vision would be recorded as follows: \[ V = \frac{20}{60} \]. If now there is placed before
the eye a convex lens of 2 D, the vision is raised to normal, and \( V = \frac{2}{30} \). In this case the accommodation is supposed to be at rest, and the total hypermetropia (Ht) is 2 D.

If, however, the eye would call into action a portion of its accommodative power, the hypermetropia would be corrected thereby and the vision raised to \( \frac{2}{30} \) without the employment of a convex lens, and this is usually the state of affairs as it is found in young hypermetropes. If now the eyes are tested with convex lenses, the vision remains the same, so that we find \( V = \frac{2}{30} \) either with or without convex lenses. This illustrates manifest hypermetropia, and the strongest convex lens through which vision still remains \( \frac{2}{30} \) would represent the degree of manifest hypermetropia (Hm).

The record of this case would read \( V = \frac{2}{30} \), Hm. = + 1 D. That is to say, vision is normal or \( \frac{2}{30} \), and remains as good when a convex lens of 1 D is placed before the eye. Now in this case we presume that a certain amount of the defect is latent or concealed by the action of the accommodation, because the patient is unable to completely relax it.

In this imaginary case we have a total hypermetropia of 2 D., and a manifest hypermetropia of 1 D., and therefore the difference between the two would indicate a latent hypermetropia of 1 D.

The latent hypermetropia can seldom be revealed except by the use of atropine, and we would remark in passing that this is not always necessary for the following reason: we can scarcely ever give a glass to do more than correct the manifest hypermetropia, which can be measured without the use of the drug; why then should it be considered essential to determine the latent defect, which after all will not bear correction?

**THEORY OF THE CORRECTION OF HYPERMETROPIA.**

It would be theoretically correct to place before hypermetropic eyes, convex glasses of such strength as to completely neutralize the error of refraction and correct the total hypermetropia, thus giving to parallel rays the degree of convergence for which the refractive media are adapted, and in this manner obviating the necessity for calling into action any part of the accommodation for vision of distant objects, so as
to leave the entire accommodative power unimpaired for the necessary adjustment of the eye for the divergent rays proceeding from small objects close at hand. This would be the ideal method of correction of this oftentimes distressing defect.

Although it would seem to be the proper thing in hypermetropia to prescribe such glasses as would completely correct the defect, yet practically such a method of procedure has been found not to answer, except in but few cases, and even then not until after repeated trials with glasses, and not until the eyes have adapted themselves to their use.

THE OBSTACLE IN THE WAY OF THE COMPLETE CORRECTION OF HYPERMETROPIA.

The hypermetropic eye, ever since it commenced to fulfill its function in looking at the lettered blocks and picture books of childhood has been accustomed to associate with the act of vision a certain amount of muscular action, or, in other words, a definite contraction of the ciliary muscle to overcome the defect, for only by this means is the hypermetropic eye able to enjoy clear and distinct vision; and as the natural instinct of the eye impels it to produce well-defined vision if within the range of its possibility, this effort of the muscle of accommodation is purely an automatic and involuntary one, and is ever present, from the time the dawn of morning opens the eyelids and allows the rays of light to enter through the refractive media, until they are closed in sleep.

It has been said that man is a creature of habit, which becomes to him a second nature, and from which it is difficult and oftentimes impossible for him to break away. The habit thus acquired, of contraction of the ciliary muscle coincident with the act of vision, is hard to abandon entirely, even after the error of refraction is fully corrected by convex glasses placed before the eyes and all necessity for the use of the accommodation thus removed.

Hence it follows if there is a correction (either partial or entire) of the hypermetropia by means of the accommodation, and in addition there is a correction of the same defect by means of convex glasses, there is evidently a surplus of correc-
tion, and the glasses appear to be too strong and cannot be worn.

In other words, we are able to correct, by the employment of glasses, only that portion of the hypermetropia which the accommodation by its relaxation will permit us to do, or which we can coax the accommodation not to correct, and this brings us back to the point from which we started and which we emphasized in the last issue, that we can scarcely ever give a glass to do more than correct the manifest hypermetropia.

BLURRING OF IMAGES DUE TO THE SCREEN BEING TOO CLOSE TO THE REFRACTIVE MEDIUM.

In hypermetropia the focus of parallel rays is behind the retina, and hence the rays strike the retina before they have been united in a focal point, the reason being that the retina (or the screen on which the images are formed) is closer to the crystalline lens than the focal distance of the dioptric media of the eye.

Any student of optics who is sufficiently interested in these matters, can take a strong convex lens from his trial case and see for himself how the images of objects will be blurred when the screen on which they are formed is closer than the focal distance of the lens.

The student will stand in front of a window and hold the lens in such a position that the light coming from the outside will fall upon it and pass through it. A sheet of white paper is to be used for a screen and placed at the focal distance of the lens. If the strength of the latter is 5 D., the sheet of paper will be placed eight inches from it, and small and distinct images of external objects, such as trees and houses, will be formed upon it; every detail of the objects; every leaf and branch of the tree, all the doors and windows of the house, will be clearly defined, and form a beautiful (though diminished and inverted) picture. This illustrates the formation of distinct images on the yellow spot of the emmetropic eye, the retina being at the exact focal distance of the dioptric system of the eyes, which may then be said to be in measure.

If now the screen of white paper be moved slightly, so as to bring it closer to the lens, the sharpness of the images is
at once destroyed; the trees may still be seen in blurred outlines and the shape of the house be discerned, but none of the fine details can be perceived. If the screen be moved still nearer, the trees will gradually fade out of sight, and even the outlines of the house will be lost. This illustrates the formation of the indistinct images on the yellow spot of the hypermetropic eye, the eye-ball being flat and the retina too close to the crystalline lens, which may then be described as an eye out of measure. The flatter the eye, the closer the retina to the crystalline lens, and the higher the degree of hypermetropia, the more blurred will be the images formed in the eye, and the less satisfactory the vision.
RESTORATION OF THE CLEARNESS OF THE IMPERFECT IMAGES.

When the screen of paper is moved up to seven inches, the images are noticeably blurred, and when it is moved to six inches there is no distinct definition of objects. If at this distance a second convex lens of 1.50 D. be placed before the first lens of 5 D., an instantaneous and marvelous effect is produced in the restoration of the images to perfect clearness and distinct definition, a stepping, as it were, from twilight to mid-day.

The student who performs this experiment for himself will be the better able to understand and appreciate the effect of convex glasses in the correction of hypermetropia, and how they produce distinct images on the retina without any accommodative effort.
PRACTICAL ILLUSTRATIONS OF THE DISTINCT IMAGES OF EMMETROPIA AND THE INDISTINCT IMAGES OF HYPERMETROPIA.

In order to emphasize these points, and to afford a practical illustration of the marked difference in the clearness of the images formed in the emmetropic and hypermetropic eyes, as well as to show the difficulties under which the hypermetrope labors, we present on page 24 a cut of the title page of a holiday number of The Keystone as its image would appear when formed on the yellow spot of the emmetropic eye, which the reader can compare with the image of the same object formed in the hypermetropic eye on page 25.

The first cut was made with the dioptric apparatus of the photographic camera in perfect adjustment, so that the rays proceeding from the title page were accurately focused on the screen. In making the second cut, the screen was moved closer to the condensing lens of the camera, thus stimulating the relative positions of the retina and crystalline lens in the hypermetropic eye, and in this case the rays struck the screen before they were united in a focus, and, as a consequence, the image there formed is imperfect and indistinct.

These illustrations have reference to the refractive condition of the emmetropic and hypermetropic eyes, that is, with the eyes in a state of rest and the function of accommodation in a passive condition. The student knows that if the accommodation is brought actively into play, the results obtained will be entirely different.

The hypermetrope, if the degree of defect be not too high, by the exercise of his accommodative power is able to supplement and increase the refractive strength of his eye, and in this way bring the focus of parallel rays forward so as to coincide with the retina, and thus counteract the disturbing influence caused by the nearness of the retina to the lens.

This would clear up the retinal image and give the hypermetrope perfect vision, but it would be accomplished only at the expense of a constant strain on the accommodation, which Nature will not sanction, as she expects distant vision to be entirely devoid of accommodative effort.
SUB-DIVISIONS OF HYPERMETROPIA.

Manifest hypermetropia has been further divided into facultative, relative and absolute. We do not attach very much practical value to these sub-divisions, but we feel that our readers should not be entirely ignorant of them.

Facultative hypermetropia is the term applied to those cases of hypermetropia in which distant objects can be clearly seen, either without or with convex glasses. In these cases the accommodation is sufficiently strong to overcome the defect and afford perfect vision; and at the same time it is obliging enough, when convex glasses are placed before the eyes, to subside and retire from the field, and allow the convex lenses to do its work.

Relative hypermetropia is the term applied to those cases of hypermetropia in which, by the addition of the entire accommodative force to the natural refractive condition, the eye still does not possess sufficient power to bring the parallel rays of distant vision, much less the divergent rays of near vision, to a focus on the retina, except by an over-convergence of the visual axes, or, in other words, by squinting.

Absolute hypermetropia is the term applied to those cases where distinct vision is impossible without artificial assistance. The entire refractive and accommodative power of the eye, reinforced by the strongest effort of convergence, is insufficient to bring parallel rays of light to a focus on the retina, much less the divergent rays proceeding from near objects. Such an eye is entirely dependent upon convex glasses for any vision at all.

The facultative form of hypermetropia is most common in youth, when the accommodation is vigorous and able to overcome the defect. The relative form occurs a little later in life, when the accommodation weakens and no longer suffices to correct the defect without the added assistance of the convergence. In old age the accommodation has become entirely exhausted, and then the hypermetropia becomes absolute.

From the very nature of it, acquired hypermetropia can never occur in the latent form, but it is always manifest. Neither can it come under the head of facultative, but it may-
possibly be relative, although it is more apt to be absolute. All this becomes clear and easily explained when it is remembered that acquired hypermetropia is due to a natural diminution of refraction, and occurs only after the accommodation has been shorn of its strength by age, and when all that remains of it is memory.

Facultative hypermetropia is almost the same as manifest hypermetropia; although we consider the latter term preferable because it is more expressive, the word itself indicating that it is not concealed, but that it is easy of detection, by the ready acceptance of a convex lens.

CAUSES OF HYPERMETROPIA.

As has already been shown, the essential condition in hypermetropia is that the retina is too close to the dioptric apparatus, so that the rays of light strike this membrane in diffusion circles before they have had the opportunity to unite in a focus. This condition may be dependent upon several different causes, which we will enumerate as follows:

1. Axial hypermetropia, in which the dioptric system may measure up to the same standard as an emmetropic eye, but the eye is flat and there is a lessening of the antero-posterior diameter of the globe of the eye, and a consequent shortening of its axis. This is by far the most common cause, and it has been illustrated in the earlier part of the chapter.

The axial form of hypermetropia is congenital, and is due to an arrest of development of the eye in its growth, particularly noticeable in the antero-posterior diameter. Such eyes are distinguished by their smallness and mobility, the diminution in size being oftentimes a noticeable feature.

2. The length or depth of the eye-ball may be the same as an emmetropic eye, but the refractive power of the dioptric apparatus may be too feeble to bring the rays of light to a focus on the retina, which they strike in un-united circles, producing the same effect as the axial form.

This deficiency of refractive power may be due to several different causes: there may be a depression of the cornea or a lessening of its convexity, as the result of inflammation or disease; or it may normally be lacking in convexity; there
may also be a diminution in the natural convexity of the crystalline lens; and there may also be a reduction in the index of refraction of the refracting media, the aqueous humor, the crystalline lens and the vitreous humor.

3. Aphakia, or the absence of the crystalline lens either naturally or artificially, is a cause of the most pronounced hypermetropia. In such cases there is an absence of all refractive power and the eye becomes intensely hypermetropic.

AMOUNT OF SHORTENING IN AXIAL HYPERMETROPIA.

The following table (after Donders) shows the amount of shortening of the axis of the eye-ball for the various degrees of hypermetropia:

<table>
<thead>
<tr>
<th>Degree of Hypermetropia</th>
<th>Diminution of Axial Line</th>
</tr>
</thead>
<tbody>
<tr>
<td>.50 D.</td>
<td>.16 mm.</td>
</tr>
<tr>
<td>1 D.</td>
<td>.31 mm.</td>
</tr>
<tr>
<td>1.50 D.</td>
<td>.47 mm.</td>
</tr>
<tr>
<td>2 D.</td>
<td>.62 mm.</td>
</tr>
<tr>
<td>2.50 D.</td>
<td>.77 mm.</td>
</tr>
<tr>
<td>3 D.</td>
<td>.92 mm.</td>
</tr>
<tr>
<td>3.50 D.</td>
<td>1.06 mm.</td>
</tr>
<tr>
<td>4 D.</td>
<td>1.22 mm.</td>
</tr>
<tr>
<td>4.50 D.</td>
<td>1.4 mm.</td>
</tr>
<tr>
<td>5 D.</td>
<td>1.6 mm.</td>
</tr>
<tr>
<td>6 D.</td>
<td>1.9 mm.</td>
</tr>
<tr>
<td>7 D.</td>
<td>2.2 mm.</td>
</tr>
<tr>
<td>8 D.</td>
<td>2.6 mm.</td>
</tr>
<tr>
<td>9 D.</td>
<td>2.9 mm.</td>
</tr>
<tr>
<td>10 D.</td>
<td>3.2 mm.</td>
</tr>
<tr>
<td>11 D.</td>
<td>3.5 mm.</td>
</tr>
<tr>
<td>12 D.</td>
<td>3.8 mm.</td>
</tr>
<tr>
<td>13 D.</td>
<td>4.1 mm.</td>
</tr>
<tr>
<td>14 D.</td>
<td>4.4 mm.</td>
</tr>
<tr>
<td>15 D.</td>
<td>4.7 mm.</td>
</tr>
<tr>
<td>16 D.</td>
<td>4.9 mm.</td>
</tr>
<tr>
<td>17 D.</td>
<td>5.2 mm.</td>
</tr>
<tr>
<td>18 D.</td>
<td>5.5 mm.</td>
</tr>
<tr>
<td>19 D.</td>
<td>5.8 mm.</td>
</tr>
<tr>
<td>20 D.</td>
<td>6.1 mm.</td>
</tr>
</tbody>
</table>

The axial line of the emmetropic eye is nearly \( \frac{2}{3} \) of an inch; in 3.50 D. of hypermetropia this would be reduced to \( \frac{2}{3} \) of an inch; in 7 D. of hypermetropia to \( \frac{2}{5} \), and in 10 D. of hypermetropia to \( \frac{3}{5} \) of an inch. This shows in the latter grade of the defect a shortening of \( \frac{1}{5} \) inch, which is quite a considerable amount.
Hypermetropia is the predominant error of refraction. Babies in the majority of cases are born hypermetropic (perhaps in all cases), although this condition may afterward develop into emmetropia, and finally pass over into myopia. The reason why infants are almost invariably hypermetropic is undoubtedly due to the fact that at birth the eye has scarce reached its full development.

Various animals, such as frogs, rabbits, cats and dogs, have been examined with the ophthalmoscope to determine their refraction, and all have been found to be hypermetropic, sometimes as much as 3 D. or 4 D. The ciliary muscle in these animals is but poorly developed, the hypermetropia therefore existing in a manifest form; in view of which their near vision must be very indistinct. This, however, is a matter of no inconvenience to them, as they are not called upon to use their eyes in near vision for those employments which so much tax the human eye, reading, writing and sewing.

**DEGREE OF HYPERMETROPIA.**

Ordinarily the degree of hypermetropia may be expressed by the convex lens that is required to correct it. In *axial* hypermetropia it depends upon the flatness of the eye, or the distance of the retina from the focus of the refracting media.

In *refractive* hypermetropia it depends upon the deficiency of refractive power, or the amount to which this falls below the normal standard.

In emmetropia the distance of the retina and the location of the principal focus exactly coincide, and the extent of their departure from each other in hypermetropia would indicate its degree, and the greater this departure the higher the degree of defect. In one case we reckon the distance from the nodal point to the focus of the hypermetropic eye, and the distance from the nodal point to the retina of the same eye, and then compare the two, and the difference between them will denote the hypermetropic deficiency.

In the table given we can see the amount of diminution of the axial line for every dioptric of hypermetropia, and
conversely a certain diminution in the axial line implies a certain degree of hypermetropia, and each increases in equal proportion. A convex lens corresponding to the grade of the defect will bring forward the focus to the position of the retina, and thus tend to counterbalance the diminution in the axial line. While in refractive hypermetropia, the convex lens directly supplies the deficiency in refractive power, and at the same time reveals its extent and expresses it in definite terms of refraction.

A good idea of the difference in shape between the emmetropic eye and the hypermetropic eye may be obtained by comparing a round apple with a flat turnip. The round apple represents the normal or emmetropic eye, and the turnip the flat or hypermetropic eye, and a comparison of them will convey to the mind a well-defined conception of the difference in shape between emmetropia and hypermetropia.

SYMPTOMS OF HYPERMETROPIA.

When a child complains of headache and pain in the eyes, and is taken from school and charged with stupidity, or punished for idleness, and the family physician advises abstinence from study or change of occupation, and puts the patient through a course of powerful medicines or (puts a course of medicines through him) for an imaginary nervous trouble, the intelligent optician will recognize these as symptoms of hypermetropia; and he knows (and why shouldn't the family physician know?) that medicines are worse than useless in such a case, but that a pair of properly adjusted convex glasses will remove the headache and pain in the eyes (when nothing else can), and will, perhaps, make the child as bright and studious as any of his companions. Otherwise if the cause of the trouble is not recognized and rectified, the child's prospects are blighted for life.

The hypermetrope (if the defect is not of too high degree) usually sees well at a distance, but the presence of the defect is made known even in early life, by the pain and symptoms of fatigue that follow any close use of the eyes. By a tension of the accommodation the hypermetrope may be able to read well for awhile, but sooner or later the constant effort to contract
the muscle of accommodation sufficiently for near work causes fatigue and exhaustion of the muscle, and the accommodative effort can be maintained only by the greatest difficulty, and the patient is reminded that he has eyes and that they are weak and painful ones.

The eyes feel strained and painful, the letters run together and become blurred, and there is an instinctive desire to rest the eyes by closing them for a moment or two and compressing them. After this a fresh start can be made, only to break down in a little while as before. In short, the symptoms of hypermetropia may be said to consist of pain and discomfort on using the eyes, and an indistinctness of the letters on a printed page.

**SELF CORRECTION OF HYPERMETROPIA.**

The condition of every hypermetrope would be a sorry one indeed, if he could not alter and increase the refraction of his eye, and make vision clear and distinct by bringing the focus of rays forward to the retina. While a hypermetrope with no inherent power over the defect would see nothing clearly at any distance, fortunately he possesses in his accommodation a means by which he can increase his refraction and overcome his trouble. While it is possible for distinct vision to be thus purchased by the hypermetrope, it is accomplished only at the expense of a constant strain upon the accommodation, the amount of strain depending on the degree of hypermetropia.

Since hypermetropia can be thus corrected by the individual himself by the use of his accommodation, no ill effects may be noticed for some time, and indeed the presence of the defect may not even be suspected. At length there comes a time when the accommodation breaks down, and it is no longer equal to long-sustained efforts required by reading and near work.

Anything that weakens the accommodation will precipitate this breakdown, hence it is especially liable to show itself after a protracted illness, or if the patient's system has been run down from overwork or anxiety. It also becomes apparent as the patient approaches the presbyopic period of
life, when the accommodation fails from the natural changes in the eye.

The illustration previously given, showing the outline of a hypermetropic eye, represents it as refracting parallel rays of light, or those proceeding from a distance of twenty feet or more, in which case the focus is behind the retina and vision is more or less indistinct. As has just been described, this focus is advanced to the retina and vision made clear by the action of the accommodation, which is thus kept on a constant strain.

But when the rays proceed from close objects or from those nearer than twenty feet, they became divergent, and the nearer the object is brought to the eye, the more divergent the rays that proceed from it to enter the eye. Now it does not require much reasoning to show that when divergent rays are refracted by a lens, the resulting focus cannot be at the same place as that of parallel rays, but it will be farther removed; or if it is desired to keep the focus at the same place, it is equally evident that more power is necessary in a lens to focus divergent rays at that point than is required to bring parallel rays to a focus at the same distance.

\textbf{THE ACCOMMODATION IN HYPERMETROPIA.}

Hence when we apply these principles to the hypermetropic eye, we find that the focus of divergent rays is back of that of parallel rays, or still further removed from the retina, when the accommodation that is in force for distance remains unchanged. Therefore the accommodation of the hypermetrope, which must be constantly exerted even for distance, is put to a still greater strain for near vision.

As a consequence, it follows in reading, writing or sewing, to which the emmetrope comes with fresh and strong eyes, that in the case of the hypermetrope, who is compelled to use some of his accommodation for distant vision, and whose ciliary muscle is in the harness (as it were) from the time the eyes are opened in the morning until they are closed in sleep at night, the start is made with that much of a deficit from the normal strength of the eyes, and near vision is maintained and continued only by calling into action the reserve of accommo-
THE RESERVE MUST NOT BE IMPAIRED.

Just as the use of its reserve will impoverish a bank or an insurance company, so the use of its reserve accommodative power will exhaust an eye and cause it to break down; for it must be remembered that a tension of only a portion of the accommodation can be sustained for any length of time. Therefore in the case of the hypermetrope, who is compelled to use a part of his accommodation for distance and the balance of it for reading, there soon appear pain and fatigue of the eyes and general symptoms of asthenopia, which gradually increase and become so pronounced as to compel a frequent interruption of the strain on the accommodation by closing the eyes and resting them for a moment or two.

The laws of State prohibit the officers of a bank or an insurance company from touching the reserve fund, which must be kept intact, under heavy penalties; but not more so than do physical laws forbid any encroachment on the reserve of accommodative power, else equally severe punishment may follow. As a rule, banks and insurance companies are so conservatively managed that not only is the reserve not infringed upon, but, on the other hand, it is from time to time increased, and to that extent is the institution inherently strengthened and raised in public estimation. Rectitude of character, as well as fear of the law, averts any violation of the reserve in banks and insurance companies, except in rare instances, when the offender is forced to pay the penalty for his crimes. But no high sense of duty to one's self, nor even the fear of the suffering that is sure to follow, prevents violation of the laws of health, as is noticeably evidenced on every hand by the abuse of the eyes and of the stomach. The hypermetropic eye is urged to the full extent of its accommodative power, until it breaks down from sheer exhaustion, while the stomach is overloaded at all hours of the day and night with rich and indigestible food, until it finally rebels and is unable to perform its functions.
IIVPERMETROPIA.

FAR-SIGHTEDNESS.

The popular term for hypermetropia is far-sightedness or long-sightedness, and the use of these words has led the laity to believe that such eyes can see better at a distance than emmetropic eyes; but these terms are misnomers and are misleading, because a hypermetropic eye cannot see any better at a distance than an emmetropic eye, and besides, what it does see is only at the expense of an unnatural use of the accommodation. The student who understands the shape of the hypermetropic eye, and the difficulties under which it labors, will realize that it is far from being as good an eye as the normal. Then, too, it frequently happens that hypermetropia, if of high degree, very much diminishes the acuteness of vision.

CONFUSED WITH MYOPIA.

On account of this impairment of vision, hypermetropia is sometimes mistaken, even by the patient himself, for myopia. These are cases of hypermetropia of high degree, in which the person finds that he is able to materially improve his reading vision by holding his book close, which increases the size of the retinal image, intensifies the illumination, and by contracting the pupil cuts off some of the circles of diffusion. Is it any wonder under these circumstances that the case is looked upon as one of myopia? These matters can perhaps be best emphasized by a few illustrative cases taken from the writer's record-book.

A CASE OF HYPERMETROPIA SIMULATING MYOPIA.

WILLIAM F. Aged ten years. School-boy. Comes to me with the statement that he has always been near-sighted, and that of late his eyes are getting worse. They hurt when he reads, and vision is quite indistinct, so much so that he is compelled to almost close his lids in order to see. There is also a convergent squint, which alternates between the two eyes. R. V. = \( \frac{10}{9} \), L. V. = \( \frac{5}{9} \). Reads Jaeger No. 9, 2 in. to 5 in.

A history such as this, with so imperfect near and distant vision, is very apt to mislead the average optician into sup-
posing that he had a case of myopia to deal with; and really, to any but a skilled refractionist, this would be a most natural error, for is not the boy compelled to hold his book very close to his eyes, and is not his distant vision imperfect and indistinct, and does he not half close his eyelids, as all myopes are apt to do?

In testing his eyes with convex lenses, I soon found it was a case of high hypermetropia, but vision was scarcely satisfactory even with the best glasses I could give him. As this was an unusual case, and as he desired the removal of the strabismus, I instilled atropine in his eyes for a week, during which time I operated on his eye for the correction of the strabismus. I kept him under observation for two weeks, and then ordered the following glasses:

\[ \begin{align*}
    \text{R.} & \quad \frac{1}{3} D. \\
    \text{L.} & \quad \frac{1}{3} D. \\
\end{align*} \]

for constant wear.

Some three weeks later he reports eyes as comfortable, able to read and study with satisfaction, and does not have to hold book so near, nor half close lids, in reading, as formerly.

ANOTHER CASE OF HYPERMETROPIA, IN WHICH AN OPTICIAN PREScribes CONCAVE GLASSES.

Annie F. Aged seventeen years. A sister of the boy in case above narrated. She comes with nearly the same history as her brother. She says she has always been near-sighted, but does not have much pain in her eyes unless she uses them for too long a time. Some months ago she purchased a pair of glasses from an optician (which she showed me, and which I found on examination to be \(-3.50\) D.), but they have been of no benefit to her and she has used them but little. \( R. \) V. \( = \frac{3}{100} \), L. V. \( = \frac{5}{200} \). Refraction = manifest hypermetropia of \( 3.50 \) D. Reads Jaeger No. 9, 2 in. to 7 in. With \( +3.50 \) D. can read the same print out to 11 in. Prescribed for her

\[ \begin{align*}
    \text{R.} & \quad \frac{1}{3} D. \\
    \text{L.} & \quad \frac{1}{3} D. \\
\end{align*} \]

for constant wear.

Two months later she reports that her sight has improved very much, and that she can see better than she ever could, and is now able to use her eyes a great deal, without pain or discomfort.
THE MORAL OF THESE CASES.

One lesson to be learned from the above cases is that too much reliance should not be placed on the patient's statements. Both the boy and the girl called themselves near-sighted, and they both accepted concave glasses when placed before their eyes. Under these circumstances nothing is more natural to the unskilled optician than to regard these as cases of myopia, and hence every man should be constantly on his guard to avoid falling into such a grievous error.

The reader of these pages, even though he possesses only a moderate amount of knowledge and experience, is aware that to give concave glasses to either of the above cases would not only fail to relieve them, but would make their eyes infinitely worse than to wear no glasses at all, it would, in fact, only be adding fuel to the fire.

In the boy's case he came to me at first hand, and I was able to correctly diagnose the trouble and prescribe the proper glasses, and hence he suffered no injury to his eyes from improper lenses. But the girl ran a great risk of ruining her eyes with the concave glasses that were prescribed for her, and she escaped only because the glasses were of no benefit and she did not wear them.

Another interesting point that impresses us in the study of these cases is the occurrence of two such marked cases of hypermetropia in the same family.

ANOTHER CASE OF HYPERMETROPIA SIMULATING MYOPIA.

MARY H. Aged fifteen years. About a year ago her eyes commenced to trouble her. She consulted an oculist, who told her it was necessary to drop atropine into her eyes, to which she and her parents objected. She was then taken to another oculist, who said she didn't need any glasses.

She comes to me with the statement that she has always held her book close to her eyes, but recently is compelled to hold it closer than ever. Complains of a great deal of headache, and of a dull, heavy pain over eyes, which is much worse after reading.
HYPERMETROPIA.

\[ V = \frac{1}{2} \]  
\[ \text{Hm.} = +1.25 \text{ D.}, \text{with which } V = \frac{1}{2} \]  
Reads Jaeger 3, 2½ in. to 9 in. With the +1.25 glasses the range of accommodation is from 3 in. to 33 in. Ordered

\[ \text{R.} = +1.25 \text{ D.} \]  
for constant wear.

Three years later she reports that glasses have given the greatest satisfaction in every particular, and she wants them put into a gold frame.

One interesting point about this case is the limited range of accommodation for so small a degree of hypermetropia, and the wonderful effect of the glasses in increasing her reading limit from nine inches to thirty-three inches. Cases like this are afforded untold benefit from the proper glasses, while at the same time they are a source of great satisfaction to the prescribing optician.

The distance of the far point in this case (nine inches) would point toward myopia, although with an acuteness of vision of \( \frac{1}{2} \), but a slight degree would be possible.

ANOTHER SIMILAR CASE.

Mrs. Sarah K. Aged thirty-eight years. Says she has been near-sighted all her life, but has never been able to get glasses to suit her eyes.

\[ V = \frac{1}{2} \]  
\[ \text{Hm.} = +5.50 \text{ D.}, \text{with which } V = \frac{1}{2} \]  
Can read only large size print, and can read no farther off than seven inches. With the +5.50 D. lenses can read out to twelve inches. As these glasses correct only her manifest hypermetropia, and as she is approaching the presbyopic period, she will consequently need a stronger pair for reading. After testing her eyes for reading I ordered \( R. + L. = 8 \text{ D.} \), which afforded her the greatest satisfaction.

The point of interest in this case is that this woman should have reached thirty-eight years of age without having been able to obtain suitable glasses, which can be explained on one of two grounds: Either the optician gave her concave glasses because she said she was near-sighted, which would only hinder her eyes instead of helping them; or he did not know how to properly test her eyes for hypermetropia, and hence gave her only a weak convex glass of not sufficient strength.
to afford her relief, because he was afraid he might injure her eyes by giving her too strong a glass.

ANOTHER CASE OF HYPERMETROPIA, CLASSED AS ONE OF MYOPIA.

Lizzie H. Aged twenty-eight years. Says she has always been near-sighted, and when attending school the teacher allowed her to go close to the windows in order to be able to see to read. On examination I found her vision $\frac{1}{2}$, and with the unassisted eye was unable to read even the largest size print on the reading test card. A pair of $+8$ D. enabled her to read ordinary print with ease and comfort, and gave her good distant vision.

A CASE OF HYPERMETROPIA TREATED WITH CONCAVE GLASSES.

Susan G. Aged ten years. Complains of a great deal of pain in eyes, and headache. She showed me a pair of $-4$ D. glasses which an optician had given her, but which she had not been able to wear. She cannot see at a distance with them, nor can she read with them; neither can she read without them, as her eyes have gotten into such a weak and irritable condition. An examination showed her vision equals $\frac{1}{2}$, and a manifest hypermetropia of $+1.25$ D. Is able to read newspaper print no farther away than nine inches.

As the girl was young it seemed best to commence with weak lenses, and hence she was ordered $+0.75$ D. for constant wear. A week later she returned to have the glasses set in a gold frame, and her report was that they had given the greatest satisfaction; she can see well with them both far and near, with entire relief from the pain in her head and eyes.

The error of the optician in giving this young girl a concave lens of $4$ D. is a most inexcusable one. It is difficult to understand how such a mistake could have been made by an optician of any intelligence, except on the supposition that it was looked upon as a case of myopia, and the concave glasses were prescribed according to the rule in myopia that the distance of the far point expresses the degree of defect and at the same time the correcting glass.
If the optician had examined her distant vision, he could hardly have made such an error, because a vision of \( \frac{3}{8} \) is not compatible with a myopia of 4 D.; and besides, if he had measured her refraction according to the methods laid down in The Manual, he would certainly have found some evidence of the existence of hypermetropia; at least nothing to lead him to prescribe a — 4 D. glass. A grievous error of this kind would permanently injure the eyes if the patient continued to wear the glasses, and when discovered it brings reproach on opticians as a class.

A FINAL CASE OF HYPERMETROPIA IN WHICH CONCAVE GLASSES WERE PRESCRIBED.

Mrs. K. G. Aged twenty-three years. Had been having trouble with her eyes for some time previously, and about three months ago consulted an optician, who gave her a pair of — 1 D. glasses. She has tried to wear these glasses, but they cause her eyes to ache, and she is unable to thread a needle with them.

A careful examination was made with the following result: R. E., vision \( \frac{1}{2} \); with + 1 D. = \( \frac{1}{8} \). L. E., vision = \( \frac{1}{3} \), with a manifest hypermetropia of .75 D. Is able to read Jaeger No. 4 only, 6 in. to 11 in. The above lenses increase the reading far point to sixteen inches. Ordered R. E. + 1, L. E. + .75, for constant wear, and these afforded the greatest comfort and satisfaction.

MORAL OF THESE CASES.

The writer could give the history of a great many more similar cases from his own case-books, but sufficient have probably been narrated to call attention to, and to emphasize, this most important point, that is, the great danger to the eye when concave glasses are prescribed in cases of hypermetropia. Of course it is a natural error, into which the optician may easily be misled by the patient’s statements that he is near-sighted, and by his answers when test lenses are placed before his eyes; but it is to be hoped that no reader of The Manual will ever allow himself to fall into such an error, and he cer-
HYPERMETROPIA.

...will not if he carefully follows the directions given in this chapter and in the chapter on Method of Examination.

Too much stress cannot be laid on the importance of the proper differential diagnosis between hypermetropia and myopia, and at the risk of repetition (which, after all, serves as the best means of fixing a fact in the student's mind) we will repeat the rule as follows: In testing the refraction of an eye always commence with convex lenses, and if these make vision clearer, or if they are accepted at all, it is prima facie evidence of the existence of hypermetropia; for the diagnosis of hypermetropia, in testing with the trial case, depends upon the acceptance of a convex lens for distance, and in such a case concave lenses should not be used, else they too be accepted, and then the optician becomes mixed and the diagnosis is in doubt. For it should be remembered that weak concave glasses are accepted for distance by almost every eye, and rarely fail to cause some slight improvement in vision; and hence if they are tried first and at once accepted, the optician may too hastily jump to the conclusion that the case is one of myopia, and may be led to commit the unpardonable error of prescribing concave glasses in a case of hypermetropia.

LATENT HYPERMETROPIA.

The optician will sometimes meet with cases of suspected hypermetropia that will not accept convex lenses; their vision is \( \frac{2}{5} \), and all convex lenses blur it. In spite of this all the symptoms may point to hypermetropia, and the optician may be able to detect its presence by the retinoscope and by other means which will be described later on. Such patients are unable to relax their long-contracted ciliary muscles in the slightest degree; and in these cases the total hypermetropia is all latent. This condition of non-relaxation of the muscle of accommodation is most frequently found in young persons, in whom it is strong and vigorous. In some cases where convex lenses are thus rejected when each eye is tested separately, it may be possible to secure their acceptance by trying the eyes together in binocular vision, when the accommodation relaxes more readily.
THE OPHTHALMOSCOPE IN HYPERMETROPIA.

It has been stated that the hypermetropic eye, when at rest, is adapted for convergent rays, and hence when the eye is strongly illuminated, the emergent rays will follow the same course in returning, and as a consequence will diverge from the surface of the cornea. During the ophthalmoscopic examination of the hypermetropic eye by the direct method, the instrument is held very close to the eye under observation, and the optician rotates behind the mirror, and into its aperture, a convex lens of sufficient refractive power to render parallel the divergent rays issuing from the patient's eye, when an erect, virtual, magnified image of the retina of this eye will become visible to the observer. The focal power of the convex lens necessary to make the divergent rays parallel will represent the degree of the hypermetropia.

This method of determining the refraction does not always yield accurate results, and should not be relied upon to the exclusion of the test by trial lenses; but in cases where the answers are unsatisfactory with the trial case, and particularly in children, it suffices to give a very satisfactory clue to the condition of the refraction and the degree of defect. With the improved ophthalmoscopes of the present day, the proper correcting lens can be found by simply rotating the disk until the strongest convex lens is reached that does not blur the retinal picture.

FAR-SIGHTEDNESS.

The common term in use among the laity for hypermetropia is "far-sightedness," in contradistinction to nearsightedness, the common name for myopia. As this term would indicate, the idea generally prevails that the hypermetropic eye can see at a greater distance and can see better far off than an emmetropic eye. This is a great mistake: nothing can be better for vision than a normal or emmetropic eye. Instead of being more advantageous, the hypermetropic eye is an undeveloped eye, and because of this incompleteness there is apt to be an insufficiency in the layer of rods and cones of the retina, as well as of the optic nerve fibers, and therefore
the vision can scarcely measure up to the normal standard of distinctness for distant objects, much less for near ones.

COURSE OF HYPERMETROPIA.

While myopia inclines to increase in proportion to the close use of the eyes and in consequence thereof, hypermetropia, on the other hand, rarely increases, but rather tends to decrease. It has been shown that the hypermetropic eye possesses a larger ciliary muscle than the myopic or the emmetropic eye, and that its circular fibers particularly are more highly developed, few or none of which are found in the myopic eye. The statement is also made that the yellow spot is situated farther toward the temporal side than is the case in the emmetropic eye, thus increasing the distance between the disk and the macula.

VISION IN HYPERMETROPIA.

In the lower grades of hypermetropia during adolescence, vision usually equals $\frac{2}{3}$, and the defect is almost or altogether latent, and is therefore difficult of detection; but in the higher grades of the defect vision is more or less impaired, even when the hypermetropia is completely neutralized by the proper convex lenses.

This deficiency of sight depends partly on the insufficiency of the rods and cones of the retina as mentioned above, but more perhaps on the nearness of the retina to the nodal point, which causes the size of the retinal images to be smaller than in emmetropic eyes, and being smaller they are able to impress fewer of the perceptive nervous elements. Even when the size of the images is increased by the magnifying effect of convex lenses, the vision is not always raised to normal, which tends to prove the scarcity of the rods and cones.

For these reasons persons with a marked degree of hypermetropia cannot see well at night or in dimly-lighted rooms. Such persons fall into the habit of partially closing their lids, and bringing small objects well illuminated quite close to the eyes, where for a short time they can be seen distinctly. The holding of objects close to the eyes is so contrary to the popu-
lar ideas about far-sightedness, that an explanation of this phenomenon would not be out of order. As the object approaches the eye the size of the retinal image increases to a much greater extent than the circles of diffusion. The strong illumination which is necessary to enable the objects to be seen causes a contraction of the pupil, which shuts out the circumferential rays and diminishes the diffusion circles, in which it is aided by the half-closed lids. At the same time the hypermetrope learns to suppress the impressions of any un-united rays that fall upon the retina. In this way these hypermetropes are sometimes able to do fine work and read small print even without the aid of glasses, a fact that is almost incredible. Is it any wonder then that these cases are sometimes confounded with myopia? They can, however, see distant objects with convex glasses, which would be quite impossible in myopia.

The ability to read so close to the eyes requires a very strong supply of light, not only to illuminate the letters, but also to contract the pupil to its smallest size, which, assisted by the partially closed lids, acts as a stenopaic apparatus, very much on the same principle as the improvement in vision caused by the pin-hole disk; we consider a single ray as emanating from each point of an object, and passing through the dioptric media and forming an image on the retina.

**ESTIMATION OF THE TOTAL HYPERMETROPIA.**

The total hypermetropia can be determined upon by paralyzing the accommodation by a strong solution of atropine (or one of the other mydriatics) and then selecting the glass that affords the best distant vision. The total hypermetropia as thus ascertained is oftentimes very much greater than the manifest error. The writer has seen many cases where the manifest hypermetropia was less than 1 D., and some in which there was no evidence even of any manifest defect, where he found the total hypermetropia, as revealed by the mydriatic, to be 3 D. or 4 D. and even more.
THE USE OF ATROPINE DISCOUNTENANCED.

But the employment of atropine belongs largely to the province of the physician or oculist, and we advise against its use by the optician. It produces a most alarming disturbance of vision in hypermetropic eyes, which in some cases has so frightened the individual, even where he was advised in advance of its probable effect, that he has refused to submit to a second instillation of the drug, and either tried to get along without glasses or sought them elsewhere.

Many persons have consulted the writer, who have attributed (whether justly or unjustly) much of their trouble to the atropine that had been dropped in their eyes, and have declared with the greatest positiveness that their sight has never been as good since the drug was used, as it had been before. In view of the possibility of such an experience, it would scarcely be policy for the optician to run the risk of injuring his reputation in this way.

Nor indeed is it really necessary in a majority of cases; for even though the total hypermetropia is ascertained by the use of the mydriatic, the patient would be unable to wear glasses strong enough to correct it all. In fact, the custom of the writer is to advise his students to correct only the manifest error, and in almost all cases it will be found that such glasses are about as strong as the patient can wear. This is particularly true of young persons, in whom the accommodation is strong and active. As the person grows older, and the accommodation lessens and weakens, more and more of the latent defect becomes manifest, and stronger and stronger glasses can be borne and are called for.

We repeat the statement that almost any case of hypermetropia can be corrected without the use of atropine, at least temporarily. The writer does not employ the drug nearly so much as he did in the earlier years of his practice. He has frequently found that the glasses that were indicated by the preliminary examination, were the same glasses that were prescribed after repeated examinations under atropine, because his experience had taught him that the total error could not all be neutralized; and this experience has occurred so often
that he was led to look upon atropine as almost superfluous in the detection and correction of the majority of cases of optical defect, because the result of a careful examination without atropine indicates glasses about as strong as they can be borne even after the use of the drug.

While atropine is used and the glasses are prescribed while the eyes are still under its influence, such glasses usually prove to be too strong, so much so as to prohibit their use, because the attempt is made to correct too much of the latent defect. We will cite a case in illustration, in which there is only a slight manifest error, but probably a marked degree of latent defect. Atropine had previously been used by another physician, which developed the latent hypermetropia and the glasses had been prescribed accordingly, with the result, as so often happens, that they could not be worn.

**CASE OF HYPERMETROPIA CORRECTED UNDER ATROPINE IN WHICH THE GLASSES WERE NOT SATISFACTORY.**

J. L. B. Aged eighteen years. Always had weak eyes and has suffered a great deal with neuralgia in eyes. About two years ago was given a pair of glasses, which were fitted after repeated examinations under atropine, but they have never been of any benefit to her, and in fact she not been able to wear them. Vision of both eyes is $\frac{10}{10}$, and she accepts $+ .25$ C. axis $90^\circ$. Reads Jaeger No. 4, $4\frac{1}{2}$ inches to 36 inches. These cylinders were ordered for constant wear; they afforded her the greatest satisfaction and relieved all the unpleasant symptoms of which she complained.

There is possibly some latent hypermetropia in this case in connection with the slight hypermetropic astigmatism, but which would not bear correction, as evidenced by the trouble with the glasses first prescribed.

**LATENT HYPERMETROPIA VS. MANIFEST.**

In some cases the hypermetropia may be almost entirely latent, and a casual examination would show very little, if any, manifest error. In other cases the hypermetropia may be almost entirely manifest, and an examination under atropine would reveal very little, if any, latent defect. Another point
with which the optician should be familiar, is the fact that the amount of discomfort is not always proportionate to the degree of hypermetropia.

These points are well illustrated in the two following cases, both of whom happened to be under my care at the same time:

A CASE IN WHICH THE HYPERMETROPIA IS ALMOST ENTIRELY MANIFEST.

Mrs. J. M. H. Aged forty-two years. About eight years ago eyes first commenced to trouble her, but they have been getting worse during the past two or three years. Has had her glasses changed frequently, but to no advantage. Her present glasses, which were given her for reading only, are $-1.50$ D., besides which she also has a pair of $+2$ D. Complaints of frequent attacks of neuralgia. Unable to read or sew more than five minutes at a time, when she begins to feel sick and dizzy. V. $= \frac{1}{10}$; Hm. $= +2.50$ D., with which V. $= \frac{1}{2}$. Can't see to read without glasses; with $+3.50$ D. reads Jaeger No. 4, 8 to 32 inches.

Under atropine, V. $= \frac{1}{2} \frac{5}{10}$. Ht. $= +3.50$ D. with which V. $= \frac{3}{12}$.

Ordered $+2.50$ D. for distance, and $+4$ D. for reading. These glasses relieved the neuralgia and enabled her to use her eyes with comfort.

The optician who fitted this case with $+2$ D. for reading evidently did not or could not test her refraction to determine if she was hypermetropic or if any other error existed. He mistook it for a case of early presbyopia, and as she was not very far advanced in years, he was afraid of giving her glasses too strong; they were not sufficient to correct the manifest hypermetropia, much less to enable her to read or sew with any degree of comfort.

A CASE IN WHICH THE HYPERMETROPIA IS ALMOST ENTIRELY LATENT.

Mrs. Dr. G. A. K. Aged thirty-one years. Has been wearing glasses more or less for reading and sewing for the past eleven years. Her reading glasses are $+1.50$ D., which she uses without much discomfort. Her eyes trouble her most
when from any cause her system is run down, while the
annoy her but little when she enjoys her usual health. She
has no particular difficulty with her eyes at present, but her
husband, being a physician, advises her to have her eyes ex-
amined.

\[ V. = \frac{1}{2}. \quad \text{Hm.} = + .75 \text{ D.} \quad \text{Reads Jaeger No. 3.} \quad \text{Ht.} = + 4 \text{ D.} \quad \text{Under atropine} \ V. = \frac{1}{4} \frac{1}{2} \ . \quad \text{Ht.} = + 4 \text{ D.} \quad \text{with} \ \text{which} \ V. = \frac{1}{2}. \quad \text{Ordered} + 2.50 \text{ D. for reading, but she com-
plained that these were too strong, and not entirely com-
fortable in spite of the degree of hypermetropia present, and I was}
compelled to reduce them to + 1.50 D. for reading, the same
number she had been using. As her distant vision was unim-
paired, and she had no trouble with her eyes, glasses for con-
stant wear seemed unnecessary.

THESE CASES COMPARED.

A careful study and comparison of these two cases will
amply repay the practical optician, and to assist him we will
make mention of a few of the important points. In the first
place, Mrs. H., with a total hypermetropia of 3.50, suffers
greatly with neuralgia and inability to use her eyes, while Mrs.
\[ K., \quad \text{with a total error of} \ 4 \text{ D.}, \quad \text{has no pain and uses her eyes}
with comparative comfort.\]

In the next place, Mrs. H. shows a manifest defect of 2.50
D., while Mrs. K., whose total defect is .50 D. greater than
Mrs. H., reveals a manifest error of only .75 D. This ac-
counts for the difference in the glasses prescribed for each lady,
and explains why Mrs. K. needs no glasses for distance, and
why such weak glasses suffice for her for reading. Of course
the difference in the age of these patients is the reason for the
variance in the symptoms referred to. In the first case the
accommodation is weakened by age and is unable to overcome
the defect, and in the second case it still retains the vigor of
youth and suffices to keep the refractive power of the eye up to
the necessary degree.

HISTORY OF HYPERMETROPIA.

The slighter degrees of hypermetropia occasion but little
inconvenience until the individual reaches the thirties, when
HYPERMETROPIA

49

...it manifests itself chiefly as an early presbyopia. In cases where the defect is a little more marked (from 1 D. to 3 D.), it usually causes the condition of convergent strabismus. In still higher degrees of hypermetropia, strabismus may be absent, but a group of symptoms known as "asthenopia" may be produced. This is a pen picture of the effects of the several degrees of hypermetropia, varying in different cases according to the peculiarities of each individual (his muscular power and nervous susceptibility). Sometimes a very slight degree of hypermetropia may be the cause of much distress; in other cases a much higher amount of refractive error produces but little discomfort.

The asthenopic symptoms of hypermetropia are especially liable to manifest themselves after an illness, or if the health of the patient is impaired from overwork, anxiety or other causes.

Distant objects are seen by the emmetropic eye without any effort of accommodation, consequently its whole power is free for use in near vision. But in hypermetropia, on the contrary, there is no distinct vision of any object even at a distance, without more or less effort of accommodation. Hence there is a deficiency of accommodation to start with, or in other words an extra weight to carry, and as a matter of course under such circumstances the accommodation gives out much sooner than it otherwise would. The less the degree of hypermetropia, all other things being equal, the longer the eyes can be used before the annoying symptoms supervene. Therefore it becomes evident that the length of time the tension of the accommodation can be kept up is to a great extent dependent upon the degree of defect, or the amount of extra weight the ciliary muscle has to carry.

In the earlier years the soft and yielding crystalline lens and the strong and well-developed ciliary muscle enable the eyes to do their work without much complaint even in the face of a high degree of hypermetropia. But as years pass on and the lens becomes firmer and the muscles weaker, then the troublesome symptoms manifest themselves and become very annoying.
HYPERMETROPIA IN CHILDREN.

The eye strain that is caused by hypermetropia cannot fail to have an effect upon the character and natural disposition of children, and frequently tends to render them peevish and fretful, as well as desponding and lacking in self-reliance. The constant effort required for vision retards the quickness of perception and comprehension, and the exhaustion that is sure to follow this continued straining of the eyes interferes with the concentration of the attention; for these reasons the child unconsciously and without knowing the reason why, acquires a distaste for books.

An hypermetropic boy sits down to study his lessons full of the enthusiasm of youth and with a determination to perform his task. Sooner or later a feeling of uneasiness creeps over him and makes him restless. He thinks he needs more light and he moves near to the window or close to the lamp. Then the glare of the increased light irritates the eyes, and they begin to feel heavy, and the face becomes flushed. He makes effort after effort to continue his work, but he finds it is of no use; his head droops over the table, and he finally falls asleep.

This struggle is repeated day after day, and the naturally bright boy becomes backward and stupid. He gradually loses his desire for study, and he continues through life without the habit of application and the power of concentration, which are so essential to success, and all on account of a neglected optical defect, which should have been corrected at the commencement of his education.

DETERMINATION OF HYPERMETROPIA.

The optician will be able to determine the existence of hypermetropia when any one of the following conditions is found to be present:

1. When distant vision is improved by a convex lens, or when the acuteness of vision equals \( \frac{9}{10} \) and is just as good with a convex lens as without.

2. When a patient is able to read fine print through a convex glass at a greater distance than the focal length of the lens.
3. When the near point lies at a greater distance from the eye than is proper for the age, or when the amplitude of accommodation falls below the normal standard. A reference to the tables in the Chapter on Presbyopia will show the distance of the near point and the amount of amplitude of accommodation at the various ages, a departure from which can be readily detected.

4. When with the ophthalmoscope the fundus of the eye can be distinctly seen with a convex lens in the aperture of the instrument.

The presence of any or all of these conditions indicates the existence of hypermetropia, which is then to be measured and corrected by the means to be described.

AMOUNT OF HYPERMETROPIA.

The amount of hypermetropia may vary from a fraction of a dioptric to fifteen dioptries; when it exceeds 6 D. it is looked upon as a case of high hypermetropia. When the defect is under 4 D. in young persons with a good accommodation, the acuteness of vision as a rule is normal and equals $\frac{20}{20}$. Such patients may accept weak convex lenses, but without any improvement in vision, which has not fallen below the normal standard, the defect existing in the latent form. When the degree of hypermetropia is greater than 4 D., the vision is apt to be more or less impaired, which in moderate degrees is raised to normal by the proper convex lenses. In extreme cases of high hypermetropia it is impossible to secure normal vision by the most carefully adjusted glasses.

SIGNS OF HYPERMETROPIA.

The presence of hypermetropia makes it a matter of more or less difficulty to maintain distinct vision of small objects for any great length of time. The vision begins to blur and the patient is compelled to stop reading and rub his eyes. This for the moment seems to clear up the vision, and the book is again taken up and a fresh start is made; but the blurring occurs again and again until finally the accommodation becomes entirely exhausted, and the reading must be discontinued.
The book is often held in a very strong light, which serves to contract the pupil and thus render vision clearer. At the same time many hypermetropic persons fall into the habit of holding the book quite close to their eyes, thus increasing the size of the visual angle, when vision is also assisted by the half-closed lids acting as a stenopaic apparatus.

**PAIN IN HYPERMETROPIA.**

One of the principal subjective symptoms of which the hypermetropic patient complains is pain, which varies very much as to its character and location. Sometimes it is in the eye-ball, sometimes over the brow and through the temple, sometimes on the top of the head, sometimes in the back of the head and nape of the neck, and in extreme cases the pain may be accompanied by nausea and vomiting. Headache is a very common symptom, and is often described under the French term *migraine*.

**TESTING HYPERMETROPIA.**

If the symptoms have indicated the existence of hypermetropia, and the preliminary examination has confirmed this, the eyes must then be carefully tested to determine the degree of defect. Each eye should be tested separately, noting first its visual acuteness, and then commencing the test with weak convex lenses.

If a mild convex glass is accepted, the diagnosis of hypermetropia is assured, and then stronger and stronger glasses are placed before the eye in rapid succession, until the strongest convex lens is reached with which the patient is able to read \( \frac{3}{6} \); or if it is impossible to raise the acuteness of vision to normal, then the strongest convex lens that affords the best sight in looking at the card hanging twenty feet away. This is the measure of the *manifest hypermetropia*.

If the acuity of vision is not raised to normal by a convex spherical lens, there is a possibility of the existence of an astigmatic element in the case, for which a careful examination should be made. If, however, vision equals \( \frac{2}{6} \) with the spherical lens, it is hardly likely that any astigmatism is present, but still every case should be tested with
a view of its detection if it exists. If none is present, the convex lens is all that is necessary to correct the ametropia. In order to insure accuracy, this examination should be repeated two or three times on as many different days.

In cases where vision is found to be exactly alike in the two eyes, and if spasm of the accommodation is suspected, the two eyes may be tested together, when more suitable glasses can oftentimes be obtained in this way by the acceptance of stronger glasses, than when one eye is excluded from the act of vision, because with parallel axes the accommodation is more apt to relax.

THE METHOD BY OVER-CORRECTION.

In cases where the hypermetropia exists largely in a latent form, and where there is consequently difficulty in having the patient accept convex lenses, the following “method by over-correction” will often yield satisfactory results.

Place in the trial frame a stronger convex lens than is required, that is, one strong enough to greatly over-correct the defect. This, of course, blurs the vision, but at the same time it encourages the accommodation to relax, as the more the relaxation of the accommodation the greater the improvement in vision.

Then place in the trial frame, in front of this convex lens, a weak concave lens, which at once causes an improvement in vision. Then try successively stronger and stronger concave lenses until the weakest one is found that affords a vision of \( \frac{3}{4} \), and then the difference between the two lenses will be the measure of the manifest hypermetropia.

For instance, a + 6 D. lens is placed in the trial frame, with which perhaps vision is only equal to \( \frac{3}{4} \). Concave lenses improve this vision, and it is found a - 4 D. enables the patient to read \( \frac{3}{4} \), in which case + 2 D. is the measure of the manifest hypermetropia.

LATENT HYPERMETROPIA BECOMES MANIFEST.

As age advances and the vigor of accommodation lessens, if there is any latent hypermetropia it gradually becomes manifest. A person may have 6 D. of latent hypermetropia at
ten years of age, when the defect is difficult of detection, or perhaps its existence may not even be suspected. At thirty-five years of age half of it (3 D.) may have become manifest and is easily discovered by the usual tests, and after middle age the whole of it becomes manifest and complicates and augments the natural condition of presbyopia, and then the total hypermetropia and the manifest hypermetropia are synonymous terms.

A HYPERMETROPIC EYE CHANGING ITS REFRACTION.

The normal condition of refraction in childhood is one of hypermetropia, as has been stated; some persons retain this condition all through life, a considerable number become emmetropic as they grow older, while a certain percentage pass over into a condition of myopia. In all these changes, from hypermetropia to emmetropia and from emmetropia to myopia, there is a gradual lengthening in the antero-posterior diameter of the eye-ball, and the rapidity of the changes and the degree of myopia finally attained will depend on the amount of lengthening and the recession of the retina from the focus of the parallel rays.

When these changes occur they usually take place before adult age is reached. In childhood and youth the membranes and tissues of the eye are soft and yielding, and can offer but little resistance to the causes that tend to elongate the ball. After twenty years of age the tunics of the eye, and especially the sclerotic, become tough and firm, after which there is little danger of these morbid changes taking place, or if they have already commenced, their progress is now checked.

SPASM OF ACCOMMODATION.

On account of the persistent contraction of the ciliary muscle which is necessary to overcome the error of refraction and render vision distinct, hypermetropia often gives rise to a condition which has been termed spasm of the accommodation. This simulates myopia in all of its symptoms, the resemblance being particularly noticeable in the impairment of distant vision and the confirmed habit of holding the book close to the eyes. In these cases concave lenses are often accepted
and may cause a great improvement in distant vision; but it need hardly be said that no well-informed optician would order them, as they would only aggravate the trouble and impose a greater strain on the accommodation.

This state of spasm is apt to occur in persons whose nervous system is in a low state of vitality, and, strange to say, it seems to bear no relation to the vigor of the accommodation. It is almost incredible that persons with a weak accommodation should suffer with constant contraction of the ciliary muscle; but such is really the case. It might be well to remark in passing that spasm of accommodation may occur in conditions of refraction other than hypermetropia.

**TREATMENT OF HYPERMETROPIA.**

In absolute hypermetropia vision is indistinct at all distances. The accommodation is not equal to the task of uniting even parallel rays (those from a distance) in a focus on the retina, much less divergent rays (those from near objects). In such cases the rays must be rendered convergent before they enter the eye; and this changing of parallel and diverging rays into a convergent form is accomplished by means of convex lenses.

The treatment, then, of hypermetropia consists in the application of a convex lens of such strength as will impart to parallel rays sufficient convergence to make them focus upon the retina without any effort of the accommodation.

Diagram of a passive hypermetropic eye, the focus of parallel rays lying behind the retina, as shown by the dotted lines. A convex lens placed in front of the eye converges the rays to a focus on the retina, as shown by the plain lines, the accommodation all the while being quiescent.
TWO PAIRS OF GLASSES MAY BE REQUIRED.

In many cases two pairs of glasses may be required: one pair to enable distant objects to be distinctly seen, and another pair to permit of fine print being easily read at the ordinary reading distance. Two pairs of glasses become a necessity under one of two conditions: in high degrees of hypermetropia and in hypermetropia complicated with presbyopia.

When the range of accommodation is much diminished, this deficiency may be compensated for by a change in the position of the glasses. If very strong convex glasses are worn, a slight alteration in their distance from the eyes is equivalent to a change for those of a greater or lesser power, as may be needed to make objects distinctly seen at different distances, thus supplementing the use of the accommodation and obviating the necessity for glasses of an intermediate focus. Therefore great care should be taken to see that such glasses are properly adjusted and centered. As these glasses are usually required for near vision, where a marked convergence of the visual axes is called for, the centers of the lenses should be slightly approximated, so that the visual lines may pass through them. If this precaution be overlooked and the rays of light pass through the peripheral portions of the lenses, their prismatic effect is called into play, which may cause a disturbance of the close relation which should exist between the functions of accommodation and convergence, and this may be followed by a train of symptoms making up the condition of asthenopia.

In facultative hypermetropia where both near and distant vision is good, and the use of the accommodation can be continued without fatigue almost as long as may be desired, no glasses are necessary until the near point has receded beyond eight or nine inches. This occurs much earlier than in the normal eye, and such persons are required to wear glasses for close work in many cases when only twenty-five or thirty years old.

AN UNNATURAL USE OF THE ACCOMMODATION.

In hypermetropia, as has already been shown, either on account of the faulty formation of the eye-ball or of a de-
iciency of refractive and accommodative power, an excessive amount of muscular power is required to adjust the dioptric apparatus of the eye for near vision. Now, the placing of a convex lens before such an eye does away with the necessity for a certain amount of muscular effort, and, therefore, the lens represents, or is equivalent to, the expenditure of a certain amount of muscular force. In other words, the convex lens lifts a load from the shoulders of the overburdened muscle, which is then called upon to perform only its legitimate work.

In hypermetropia the brain abhors the circles of diffusion that would naturally be formed on the retina and the blurred vision that would result therefrom, and instinctively turns to the function of accommodation and appeals to it to bring the focus of rays forward to the retina and thus restore clearness of vision.

In giving the hint to the nerve centers that control the accommodation as to what is expected of it, and while notifying it when the time arrives for action, the brain despatches sufficient nerve force (no more and no less) to the ciliary muscle to accomplish the purpose of clear vision. The most wonderful thing about this whole matter is the accuracy with which the brain measures the work that is to be accomplished, and the nicety with which it sends forth just the amount of force required.

This is an unjust use to which the accommodation is put, but it must be continued until the necessary glasses are supplied. Transgression on any of Nature's laws is sure to be followed by punishment sooner or later, and the breaking of this law proves no exception to the rule, as is shown by the torture which some of these hypermetropic and asthenopic patients are compelled to suffer.

WHAT GLASSES TO PRESCRIBE.

In the correction of hypermetropia by convex lenses in the light of the above statements, the important question naturally arises as to what shall be the power of the glass required in each individual case? This brings up the subject of the total amount of error, and what proportion of the latent
portion it is advisable to attempt to correct. The total hyper-
metropia is made up of the sum of the manifest and the latent,
the divisions between which are plainly marked.

The former can be easily measured, but the latter can be
detected only by the employment of atropine, the use of which
by the optician has been discountenanced on these pages on
every occasion. But, for the sake of argument, suppose the
drug had been used and the total error determined in this way.
Theoretically it would seem to be the proper thing to at once
and completely neutralize it, but practically such glasses are
found to be much too strong.

Previously there had been an excessive and unnatural
contraction of the ciliary muscle, by means of which a por-
tion of the defect had been rendered latent. When the total
neutralizing glasses are placed before the eyes, the muscle
should completely relax and allow the defect, which it had
rendered latent, to now become manifest and correctible by
glasses; but instead of this, the contraction of the muscle still
continues, which, with the action of the convex lens, supplies
an excess of refractive power, which may result in an aggra-
vation of the very symptoms it was intended to relieve. Hence
the rule has been formulated not to attempt to correct the total
amount of hypermetropia at the first fitting of glasses.

**CORRECTION OF TOTAL HYPERMETROPIA.**

When a hypermetropic eye is under the influence of
atropine, vision at all distances is blurred and indistinct. The
full correction of the defect is necessary to clear up distant
vision, and a lens 4 D. or 5 D. stronger will enable the patient
to see at reading distance. As soon as the effects of the drug
have worn off (which may not be for a week) and the accom-
modation is again allowed to exercise its function, then dis-
tant vision is dimmed when the same glasses are placed before
the eyes, and this haziness, which envelopes all distant objects,
continues until the glasses are taken off. The tension of the
accommodation, which is the disturbing feature in this prob-
lem, is a variable quantity in different individuals, some few
persons bearing almost or quite the full correction with little
discomfort, while a great many others will tolerate but a small part of the correction.

Oculists who are accustomed to employ atropine in the correction of hypermetropia, use different methods in dealing with this difficulty. Sometimes the full correction is ordered and placed before the eyes while still under the influence of the mydriatic, and the patient is instructed to wear them constantly all the while that the influence of the drug is wearing off and the accommodation is returning to its normal state. In this way it is hoped to coax the eyes to accept the glasses.

It might be well at this point to remind the optician that when the glasses are fitted at fifteen feet (and even at twenty feet), there is really an over-correction of about .25 D., because the rays proceeding from these distances are not strictly parallel, and hence the lens that is required to focus them perfectly on the retina is a little too strong to exactly focus parallel rays. Therefore, even when it is desired to order a full correction, the glass which affords the best vision under atropine at fifteen or twenty feet should be weakened by .25 D. This is a slight step in the direction of enabling patients to wear a full correction.

The full correction may need to be reduced.

In other cases the oculist may employ a different method, as follows: the effect of the atropine is allowed to wear off and the eyes regain their full power of accommodation, after which an interval of one or two weeks is permitted to pass before the eyes are given their final trial for the glasses which are to be prescribed.

The full correction as found by the atropine is then placed before the eyes, and the effect on the distant letters is noted. If they afford a normal acuteness of vision (which unfortunately is rarely the case) the oculist would be justified in ordering them. If, however, as is usually the case, the acuteness of vision is impaired by these full strength glasses, they are gradually reduced little by little until the lens is arrived at that permits a vision of \( \frac{2}{9} \). This may require a reduction of one-fourth, one-third, or even one-half of the full amount, and these weakened glasses are the ones that are then ordered.
HYPERMETROPIA.

WHY THEN USE ATROPINE?

This practically amounts to a correction of the manifest hypermetropia only, and now the question naturally arises, "Of what benefit is the use of atropine to determine the total error (which will not bear neutralization), when only the manifest defect is after all corrected, the amount of which can be just as well determined without the use of the mydriatic?" This question carries its own answer.

Exophoria may act as a frequent cause of the inability to wear the full correction of convex glasses in hypermetropia, on account of its accompanying insufficiency of the internal recti muscles. In this condition an extra supply of nervous force is required by these muscles in order to maintain parallelism of the visual axes, which implies a corresponding stimulation of the muscle of accommodation. It therefore follows that in the face of this constant incentive to action on the part of the accommodation, it can hardly be expected to relax to any appreciable extent to admit of the acceptance of a convex lens. A displacement of the optical centers of these glasses inward may be of some benefit, as this will assist the overtaxed convergence, and in like manner will tend to diminish the accommodation.

A PRACTICAL ILLUSTRATION.

The writer of these lines has seen many cases of hypermetropia coming from the hospitals and dispensaries of this city who were unable to wear the glasses given them. The rule in these institutions is to use atropine and correct the total error, the refracting being done by assistants and beginners. If the patient returns with any complaint, he is assured the glasses are made according to the prescription, and that the latter is correct, and he is advised to persevere in their use. If the luckless patient ventures to return again to find further fault with the glasses, he is given the scant courtesy that is so common in charitable institutions, and is dismissed with the statement that nothing more can be done for him.

He finally drifts into the office of some oculist or falls into the hands of some optician, who hears his story and quickly
perceives the cause of his trouble, and, by reducing the strength of his glasses, gives him immediate comfort. This is a very common occurrence, and hence we feel safe in making the statement that the optician, in the great majority of cases, if he exercises the proper care, will be able to fit his cases of hypermetropia as satisfactorily as the oculist who uses atropine. Therefore, the practical optician will have to do only with the manifest hypermetropia, which he is able to measure and correct by the methods set forth in this chapter.

After the glasses have been worn for awhile, some additional portion of the latent hypermetropia becomes manifest, when the glasses may be advantageously changed for those a little stronger. After a time another change may be made in the same way, and finally in some cases the latent error becomes almost or entirely manifest, when glasses corresponding to the degree of the total hypermetropia are the proper ones to prescribe, and no further changes are likely to be necessary until the presbyopic period of life arrives.

SHOULD THE GLASSES BE WORN CONSTANTLY?

This is a question that frequently arises, and it is one which the optician will be called upon to answer, which can only be done by taking into account all the peculiarities of each individual case, with special reference to these three points: the age of the patient, the degree of the hypermetropia, and the symptoms of which he complains.

If the degree of the defect is not high, and the patient is young and in vigorous health, and the eyes are strong with distant vision perfect, there would scarcely seem to be any real necessity for their constant use. When such a person is engaged in long-continued sight-seeing, as at a theatre or at an exposition, symptoms of fatigue of the eyes may appear, when recourse should be had to the glasses. Even when glasses are not worn for customary distant wear, there is every reason why they should be brought into use on such special occasions, in order to assist the ciliary muscle and lessen the strain on the eye.
WHY GLASSES SHOULD BE WORN.

In many cases where the optician may find it necessary to advise his patient to wear the glasses constantly, the latter will sometimes protest and say that he can see perfectly well at a distance without them, and that therefore he does not need them. Under such circumstances the optician must take the trouble to explain the reason why the glasses are to be worn for distance, and that they are intended not so much to improve vision as to enable the patient to see with less strain and to assist the ciliary muscle, which is overtaxed.

If the patient is no longer young, if the degree of hypermetropia is marked, or if there is much pain in the eyes, and headache and symptoms of asthenopia, then in any or all of these cases the use of glasses for constant wear is no longer a question or a matter of fancy, but becomes an actual necessity. In any case where the distant vision is impaired and where it is raised to the normal standard by the glasses, there is sufficient reason why the glasses should be used for constant wear.

The fact is that when hypermetropia exists in any marked degree, no amount of resting the eyes nor the observance of any fixed rules can possibly prevent such eyes from becoming weak and painful in the absence of convex glasses, which will, when regularly made use of, do much to render them more useful and comfortable.

In the prescribing of glasses two objects must be kept in view: to select that glass which will afford the greatest acuteness of vision, which results only when the rays of light are sharply focused on the retina, thus producing a distinct image. This sharp focus may be effected by the accommodation alone, by a convex lens alone (as in an eye under atropine), or by a combination of action of a convex lens and the accommodation; and hence the optician must make the effort to so associate the glasses and the accommodation that this clearly defined focus may be maintained. In the second place, that glass should be chosen which will enable the eyes to perform their functions with the greatest ease and comfort.
A COMMON COMPLAINT.

It frequently happens that when convex glasses are first given to a hypermetropic person for constant wear, they will make objects appear magnified, and, therefore, closer than they really are. Such a person may return to the optician with the complaint that the pavement seems to approach him, and therefore he feels as if he was walking up-hill or taking a step upward. It may be well for the optician to make a re-examination, so as to be sure that the glasses that have been prescribed are not at fault, and then the patient should be assured that if he will persist in their use these annoying appearances will speedily pass away and the sight will become so natural that he will scarcely be conscious of having glasses before his eyes.

RULES FOR DETERMINING THE GLASSES.

Some authorities, instead of prescribing the strongest convex lenses with which the patient retains his full acuteness of vision, think it best to order a lens somewhat weaker, perhaps .50 D. to .75 D. less, and in this way they feel confident the eyes will at once take kindly to the glasses, and will begin to reap the benefit to be derived from their use at the start, whereas the stronger ones would probably annoy the eyes at first and might require some time before they became habituated to them.

In cases where atropine has been applied, Donders advised the prescribing of a glass that would correct all the manifest hypermetropia and one-fourth of the latent. Another author recommends a convex lens equal in strength to one-half the sum of the manifest and the total error. For example, if the manifest error was 2 D. and the total error 4 D., the sum of the two would equal 6 D., and the glasses ordered would be +3 D. This last rule can scarcely be considered a scientific one, and, in fact, neither of these rules appeals to the optician, as they are both based on measurements made under atropine. We repeat, then, and would emphasize the advice, that the optician should not attempt to do more than correct the manifest error.
Donders' Words.

"He who knows by experience how commonly hypermetropia occurs, how necessary a knowledge of it is to the correct diagnosis of the various defects of the eye, and how deeply it affects the whole treatment of the oculist, will come to the sad conviction that an incredible number of patients have been tormented with all sorts of remedies, and have been given over to painful anxiety, who would have found immediate relief and deliverance in suitable spectacles."

These words are as true now as when first uttered by our distinguished teacher, and they have been verified by the experience of many persons who have had this defect from childhood and who have suffered greatly while attending school, but who did not understand the cause of their distress until they grew up and learned the nature of hypermetropia.

Before Hypermetropia Was Understood.

Such persons were unable to use their eyes for any length of time, and therefore failed to complete their studies, and in this way fell behind their classmates and appeared to be stupid. If they complained of pain in the eyes or headache, it was regarded as an excuse to get away from their books. Occasionally such a child would chance upon a pair of grandfather's discarded spectacles, and, with childlike curiosity, would try them on, when it found to its amazement that it could read with comfort, and the print seemed large and plain. Of course, as soon as it was discovered in this presumptuous use of the old spectacles, the latter were taken away and the child warned never to touch them again under penalty of losing its sight and becoming blind. While the parents acted entirely for the best interests of the child according to their own limited knowledge, yet to us of this day, who are so familiar with the symptoms of hypermetropia and its method of correction by convex glasses, this deprivation of the child of the only means of relief seems little short of barbarous.

In former years many ambitious young men, with a fondness for study and high hopes for professional distinction, have had their anticipations nipped in the bud by increasing
difficulties experienced in continued near vision, and have been advised not to wear glasses, but to abandon all their chosen plans and go to the country and seek some occupation that does not call for any close use of the eyes. Could any disappointment be greater?

There are many pupils attending school at the present time who cannot use their eyes in study without pain and headache and irritation of the eyes, especially noticeable when they are used by artificial light, due to a hypermetropia, the correction of which by properly adjusted convex glasses would cause these annoying symptoms to vanish as rapidly as the morning dew before the rising sun. The frequency with which these cases are met with by parents and educators emphasizes the importance of an early recognition of the cause, in order that it may be removed before permanent injury is done to the sight, and that the complaints of children and their apparent stupidity may receive due allowance, and not be met with undeserved punishment.

Formerly there existed a great prejudice against the wearing of convex glasses by children, which doomed them to a continuance of suffering and handicapped them in the acquirement of an education. The prevailing idea was that convex lenses were suitable only for aged persons and that children were debarred from their use.

A TYPICAL CASE OF HYPERMETROPIA.

In order to point the moral for the preceding remarks, we will relate the history of a typical case, which was originally reported by Dr. Fenner.

A young man of sixteen years comes for advice, with the statement that his eyes are weak; they are small, prominent, and set widely apart, and present no external appearance of disease. The pupils act quickly and freely to the stimulus of light. On inquiring into the family history it is learned that he has a brother who suffers like himself, but to a less degree, a sister who has convergent strabismus, and his father was compelled to wear glasses at the age of thirty.

The patient's health is good; he attends school and is inclined to be studious, but, after reading or writing for a short
time, his eyes grow tired and the letters become indistinct. He moves the book further from his eyes, which enables him to see better for a little while, but soon the letters begin to blur again; another change in the position of the book affords a temporary improvement, which, however, is soon lost, and any further changes are futile. The eyes become more and more fatigued, there is a slight watering accompanied by a sensation of smarting and supra-orbital pain, the print pales and the borders and angles of the letters widen out so that they appear as confused, irregular spots on the paper, and he is compelled to discontinue his reading. He closes his eyes, rubs and presses the lids with his fingers for a few moments, when he is able to look around and see distant objects distinctly. After a few minutes of rest in this way he is again able to take up the book and see the letters with their original clearness, but the eyes give out sooner than before, and he goes through the same process of closing his eyes and compressing the lids. The pain over his eyes increases and develops into a severe headache, the conjunctiva becomes blood-shot, and if he persists in reading he becomes nauseated.

Thus he worries along through the day, and if he attempts to study at night all the symptoms are intensified, because his eyes are sensitive to strong artificial light, which produces a painful dazzling and causes a sensation of scratching and roughness as if sand was under the lids. When he awakes in the morning he finds his eye-lids somewhat adherent, but after washing his face and bathing his eyes, he feels all right again, and starts in with his studies with all the vim and enthusiasm of an ambitious youth; soon the well-known symptoms return and he goes through the experience of the previous day. A Sunday's rest invigorates his eyes, and on Monday he has less trouble than on any other day, and during a vacation he experiences no difficulty whatever. He says he has been under the treatment of a physician, who told him he had an "affection of the optic nerve," gave him medicines, blistered his temples, and dropped "eye-water" into his eyes.

On examination his vision is found to equal $\frac{29}{30}$. Convex lenses were tried, commencing with + .50 D., and increas-
ing to $+1.75\, D.$, which were the strongest accepted; $+2\, D.$ blurred the letters. Hence, his manifest hypermetropia is $+1.75\, D.$ His reading vision is now tried and his amplitude of accommodation measured. He is able to bring the print as close as six inches, but says it requires an appreciable effort; he gradually moves the book farther away as he reads, and by the time he has finished the paragraph it is out as far as fourteen inches. His near point of six inches represents an amplitude of accommodation of $6.50\, D.$, and, as the normal amplitude at this age is $+1\, D.$, there is presumptive evidence of the existence of $+4.50\, D.$ of hypermetropia, and, as the manifest error was $1.75\, D.$, the balance exists as latent hypermetropia.

Glasses of $+2\, D.$ are ordered for him, and he remarks, "Why, doctor, you don't want me to wear spectacles, do you?" "Certainly," the oculist answers, "or at least I wish you to try them." He then said, "I used to wear my grandmother's spectacles at night to get my lessons and I could see as well as ever, but when I told our doctor he said I must not use any more, for they would ruin my eyes and make me blind." Notwithstanding his doctor's advice he takes the glasses, returns to school, and has no further trouble with his eyes.

While ignorance of these matters might be excused in the laity, it is reprehensible in a physician; but now, since the nature of the defect and the proper means of correcting it are well understood, it is hoped, by the diffusion of knowledge, to overcome the prejudice which has so widely existed in the public mind against the wearing of convex glasses by children.

TWO PAIRS OF GLASSES.

In the higher degrees of hypermetropia, and in hypermetropia of persons approaching the presbyopic period of life, two pairs of glasses are required—one pair for distant vision, and the other pair to enable fine print to be easily read at the customary distance.

PROPER FITTING OF GLASSES.

It should be remembered that when strong convex glasses are worn, the removal of the lenses a little farther from the
eyes increases their power and makes them equivalent to glasses of a higher number; and, as this is sometimes not desirable, it would not be out of place for the optician to instruct his patient just how they should be worn.

Another point that should not be overlooked in the fitting of such glasses is to see that they are close enough together that the patient looks through the centers of the lenses when converging his eyes for near work, as otherwise, if the line of vision was through the edges of the lenses, the rays of light would be refracted as by prisms with curved surfaces; and, while this might not be undesirable in selected cases, unless it is specially indicated, and particularly if the decentering is outward, it might destroy the harmony between the functions of accommodation and convergence and be productive of asthenopic symptoms.

THE PROPER GLASSES.

It has been stated on a previous page that the hypermetropic eye is unable to see any object distinctly, not even the most remote, without an effort of accommodation, and the closer the object the more the strain. Consequently, in hypermetropic eyes the accommodation is in a state of constant tension.

When convex glasses are placed before the hypermetropic eye it is found that the ciliary muscle, which has been in a state of contraction for so long a time, cannot wholly relax; there still remains a certain amount of involuntary contraction of the muscle, but this is an element that cannot be measured (except by atropine, which is out of the question), and varies in different individuals.

Hence, in fitting such eyes with convex lenses, the strongest they will bear without blurring distant vision is just equal to the amount of relaxation of the muscle of accommodation, and this is known as the manifest hypermetropia. The degree of involuntary contraction of the muscle that remains, is the measure of the latent hypermetropia, with which the optician need not concern himself, as he will have done his whole duty in correcting the manifest error.

Sometimes there is no manifest hypermetropia, it is all
latent, which is particularly the case in young persons. At about twenty years of age some of it becomes manifest, the proportion of which increases with advancing years, the latent decreasing in the same ratio, until, finally, in middle life it has entirely disappeared, and all of the hypermetropia is then manifest.

A CASE OF MANIFEST HYPERMETROPIA IN WHICH THE LATENT PORTION IS REVEALED BY THE DIMINISHED AMPLITUDE OF ACCOMMODATION.

Joseph F. Aged twenty-one years.

Has no trouble in using his eyes in daytime, but complains of inability to read at night. He went to an optician, who gave him a pair of +.50 D. glasses, but they have not been of much benefit to him. On examination his vision is found to equal 1/6 and a manifest hypermetropia of .50 D. A test of his reading vision showed a range of accommodation of eight inches to thirty-three inches.

A near point of eight inches indicates an amplitude of accommodation of only 5 D., whereas the normal amplitude of a person at this age is at least 9.50 D., and hence we are justified in assuming the existence of 4.50 D. of total hypermetropia; and as the test showed only .50 D. of manifest error, there remains 4 D. of latent defect. It was not deemed advisable to correct the total error, and hence his reading vision was tested with the following results:

With 1 D., range of accommodation 7 in. to 33 in.
" 1.50 D., " " 3/2 " 33 "
" 2 D., " " 5 " 32 "
+ 2 D. glasses were ordered for reading, and gave the most perfect satisfaction.

A CASE OF SLIGHT MANIFEST AND MARKED LATENT HYPERMETROPIA.

Mrs. S. M. R. Aged thirty-eight years.

Eyes have been failing for the past year. Has constant headache and a great deal of pain and smarting in eyes. Complains that she can't see to thread a needle. Vision = 1/3. Manifest Hy. = .50 D. The near point has receded to sixteen inches, which implies an amplitude of accommodation of
2.50 D., and, as the normal amplitude at this age is about 5 D., we have evidence of 2.50 D. of hypermetropia.

It is a curious coincidence that if we calculate the reading glasses according to the rules given under Presbyopia the same result is obtained. Subtract the glass representing the receded near point (16 in. = 2.50 D.) from the glass representing the point which we wish to make the near point (8 in. = 5 D.), which leaves + 2.50 D. as the glass required.

One would expect at this age that more of the latent portion would become manifest, and that it has not indicates an exceptionally vigorous condition of the accommodation. Glasses of + 2.50 D. were ordered for reading, and for distance + .75 D. will answer at present, although stronger ones will soon be needed, as the latent trouble becomes manifest.

A CASE OF HYPERMETROPIA IN WHICH READING GLASSES FAILED TO GIVE SATISFACTION UNTIL DISTANCE GLASSES WERE WORN.

Mrs. J. H. S. Aged fifty-nine years.

Her eyes have been troubling her for past fifteen years, and she has great difficulty in getting glasses to suit. Has been compelled to change glasses frequently, those for reading at present being + 4 D., with which she can see fairly well, but in spite of this they do not give her satisfaction. Vision = 1/6. With + 1.50 D. = 1/6. Ordered + 1.50 D. for distance and constant wear, and advised her to continue the + 4 D. glasses for reading.

In this case the uncorrected hypermetropia kept the eyes on a constant strain, and consequently when the patient desired to read she commenced the task with eyes already fatigued, and, therefore, her reading glasses did not seem suitable, even though they were accurately adjusted for their purpose. But, now that her reading glasses are supplemented by distance ones, the constant strain will be relieved, and when she begins to read her eyes will be fresh and the reading glasses prove all that can be desired.

There has been a marked change of late years in the attitude of the public in regard to the wearing of convex glasses, and when their use is imperatively demanded for the rectifica-
tion of some optical defect, there is at least no stubborn protest; but there is still room for improvement, and instead of this placid acquiescence in their employment we would like to see such a sentiment prevail as would recognize their worth and demand their use wherever and whenever indicated.

CARE IN THE WEARING OF GLASSES.

When glasses are prescribed for the correction of hypermetropia, whether for constant wear or only for reading, the optician should give his patient definite instructions that he wear them always for the purpose for which they are given. If they are laid aside at intervals, a return of the old symptoms is apt to follow, and in this way little progress can be made in relieving the eyes and freeing them from irritation. Whereas, if the glasses are worn persistently, comfort is at once experienced and the eyes become better and stronger, so much so, in some cases, that the glasses may be dispensed with for general wear and used only for reading.

In young persons, whose eyes are strong enough to easily overcome the hypermetropia, whose distant vision is good, and who experience no trouble except in reading, the glasses may be given with the distinct understanding that they need be worn only for close use. As the patient grows toward the presbyopic period of life, these glasses will need to be exchanged for those of a higher power, and then the old pair will suffice for distant vision and should be used for that purpose.

In the case of intelligent persons who are desirous to be properly fitted the use of the trial case is the decisive method, and the test that is sufficiently trustworthy is the patient's own statement that such or such a lens does not blur the sight, or makes vision clearest, or feels the most comfortable to his eyes.

But in the case of stupid persons, or of children, where definite answers can only be obtained with the greatest difficulty, or where it is desired to verify the statements made, the optician should have recourse to his ophthalmoscope and retinoscope, the latter especially affording an inexpensive and satisfactory method of determining the state of the refraction. Even with the assistance afforded by these additional methods,
some cases will still be obscure, and the optician must fall back on his own experience and be guided by general principles, always endeavoring to press the patient to the most satisfactory answers obtainable.

There is no limit of age as regards the wearing of convex glasses for hypermetropia (or in using the proper glasses for the correction of any other optical defect). They may be placed before the eyes of a child as soon as he is old enough to understand that they are not playthings, that being about the age when the child commences to go to school. In those cases of hypermetropia which tend to produce squint, the persistent wearing of convex glasses will usually prevent this tendency from being developed. For the same reasons, they should be worn after an operation for strabismus, as a preventive of a return of the defect.

THE PUNCTUM REMOTUM IN HYPERMETROPIA.

The emmetropic eye, when at rest, has been shown to be adapted for parallel rays, or those proceeding from infinite distance, consequently its punctum remotum is said to lie at infinity. The hypermetropic eye, on the other hand, is adapted only for convergent rays; but there are no convergent rays in nature, and consequently such an eye is adjusted for a condition that does not exist. The focus of parallel rays lies behind the retina, and the punctum remotum becomes a negative quantity in hypermetropia.

The position of this negative point can be found by (or, in other words, the distance of the punctum remotum behind the eye will be equal to) the focus of the convex lens which is required to correct the hypermetropia. The writer finds that this subject is not clearly comprehended by the optical student, and a glance at the various standard text-books shows such conflicting and ambiguous statements that there is no wonder the reader is puzzled and confused and unable to gather a proper understanding of it. And as it is a matter of considerable theoretical importance, we will endeavor to describe it so clearly that the beginner of the study cannot fail to understand.
HYPERMETROPIA.

This illustration shows the punctum remotum of the hypermetropic eye and the lenses that give to parallel rays sufficient convergence to meet upon its retina.

The location of the far point behind the eye is the spot to which rays must converge before entering the eye, in order that they may be focused upon the retina. From this statement we are enabled to formulate the following corollary: The hypermetropic eye, when its accommodation is at rest and its refractive power at a minimum, is adjusted for rays converging to its far point, and such converging rays exactly meet upon its retina.

The focus of a convex lens is at a certain definite distance depending upon the refractive power of the lens, and therefore the convex lens that is needed to give to the rays the proper convergence, so that if continued they would meet at the punctum proximum, which holds a conjugate relation to the retina, must be a lens whose focal distance exactly corresponds to this point.

In the diagram of the hypermetropic eye, given above, the position of the focus of parallel rays is at \( F \), which is a certain distance behind the retina, and the convex lens immediately below it brings parallel rays also to a focus at \( F \), which is a corresponding point. If now this convex lens be raised to a position just in front of the diagramatic eye, and almost touching the cornea, it is evident that the rays that pass
through it and enter the eye will possess just the proper convergence to be focused on the retina of the eye, and hence this lens will be the proper one to correct the hypermetropia.

If the lens was placed farther from the eye a weaker one would suffice, because, the punctum remotum remaining at the same point, the farther the lens is removed from it the less refractive power it needs to focus parallel rays at this point. This fact is well illustrated in the diagram, where the second lens is removed from the eye, and although of weaker power has its focus at the corresponding point \( F \). Therefore, when the convex correcting lens is to be worn a definite distance in front of the eye, it must be of a certain strength; if it is approached closer to the eye its strength must be increased; if it is removed farther from the eye a weaker lens will answer.

**FAULTY CONCEPTIONS OF HYPERMETROPIA.**

So much has been written of late years as to the growing prevalence of myopia and its direct causation by the increased use of the eyes for reading and writing that is required by our habits of civilization, that we are almost unconsciously led to regard it as the most common error of refraction. This impression is heightened by the fact that myopia can with difficulty be concealed, and we readily recognize it by the stooping position, by the nearness with which the book is held, and by the well-known nipping of the eyelids together. But the fact is that hypermetropia is the most frequent defect, although it is not patent to others, and even the individual himself for a long time may not be aware of it until an impaired condition of health, or a severe attack of illness, or the approach of the presbyopic period of life makes it manifest by an unmistakable train of symptoms.

When these evidences of the defect become noticeable, as they are especially apt to do after a prolonged use of the eyes, it seems natural to place them in the relation of cause and effect; the one follows the other, and would seem to be directly produced by it. While this may be said of myopia, it is not true of hypermetropia; no amount of abuse or overtaxing the eyes can result in the production of hypermetropia, or can in-
crease it when already present. Of course, any immoderate use of the eyes will aggravate the symptoms and render the eye apparently weaker, but it cannot originate the essential condition of hypermetropia, an undeveloped or flat eye-ball, which is a congenital condition.

Another error that has crept in and gained credence, is the supposition that hypermetropia is better for distant vision than emmetropia. The fact that its far point is negative and that the hypermetropic eye is adapted for a point beyond infinity, shows that its accommodation is under a constant strain, and therefore its distant vision suffers from the disadvantage of being accomplished only at this expense. Whereas the emmetropic eye by nature is adjusted for the parallel rays of distant vision, and no other form of eye can be better than this.

No well-read optician should fall into the error of supposing that a person must be myopic simply because he holds his book close. Attention has already been called in the earlier part of this chapter to the fact that in high degrees of hypermetropia the book is sometimes approached quite near to the eyes, and the caution was given not to mistake hypermetropia for myopia, and a number of cases illustrative of this point were narrated. This matter is of such great importance as to call for a repetition at this place, while mentioning some false conceptions about hypermetropia.

**Sequel of Hypermetropia or Its Deleterious Consequences.**

All the defects of the optical construction of the eye, and especially those that impose an unnatural tax upon the accommodation, are not only accompanied by a certain train of symptoms, but are liable to lead to the production of other troubles. The evil effects flowing from hypermetropia may be enumerated as follows:

1. Headache and neuralgia.
2. Spasm of accommodation.
3. Blepharitis, styes, etc.
5. Cataract.
7. Asthenopia.
8. Convergent strabismus.
9. Retinitis and neuritis.

I. HEADACHE AND NEURALGIA.

These forms of paroxysmal pain are very common, and there is scarcely a family but can disclose one or more sufferers. There is usually no direct evidence of actual disease of the affected nerves or brain, or even of any of the vital organs of the body, and yet there must be some underlying cause in every case of intractable headache or neuralgia. These ailments may be classified under several different headings, but by far the most common form, and the one in which the optician is particularly interested, is the reflex.

Under this head (of reflex troubles) may be mentioned the headaches and neuralgias that result from a decayed tooth, hardened wax in the ear, disease or obstruction of the nasal cavities, some obscure rectal or pelvic irritation, and lastly, and most important from our standpoint, those that are caused by some error of refraction or some anomaly of the ocular muscles. No one can deny that remarkable cures of headache and neuralgia have been accomplished solely by the removal of one of the causes mentioned above, and without the use of drugs.

Therefore, in any case of intractable headache and neuralgia, the condition of the refraction of the eye and of its muscular equilibrium should be carefully inquired into; and when the family physician has such a case under his care and does not himself possess the skill or the instruments required to make the necessary examination, he should refer his patient to a skilled optician in whom he has confidence, in order that this source of suffering may be removed.

Many cases of headache have been treated by the physician on the presumption of cerebral congestion or cerebral anaemia, by the remedies that are ordinarily useful in such conditions, without benefit; and, finally, after every other hope of
HYPERMETROPIA.

relief had failed, the thought has occurred that perhaps the
eyes were at fault, and recovery immediately followed the
proper correction of any existing anomaly.

The literature on this subject of headaches and neuralgia
due to eye-strain is very extensive, and within the last few
years there has been a large amount of additional testimony
to prove the importance of a thorough examination of the
eyes in all cases of headache. It is proper to state that cor-
rection of the ocular anomaly does not always cure the pain
in the head immediately; sometimes the relief comes gradu-
ally, and again a course of constitutional treatment may be
necessary in addition.

2. SPASM OF ACCOMMODATION.

The constant contraction of the ciliary muscle in hyper-
metropia that is necessary to overcome the refractive error and
afford clear vision, often gives rise to the condition known as
"spasm of the accommodation," which is simply a high tension
and persistent contraction of the affected muscle. Such spasm
is apt to occur in persons of a nervous temperament, and,
strange to say, it bears no direct relation to the vigor of the
accommodation; that is, persons with a strong and vigorous
accommodation may never be troubled in this way, whereas
patients with a relatively feeble accommodation may suffer
with a marked cramp of the ciliary muscle.

The symptoms of spasm of the accommodation are photo-
phobia (dread of light), lachrymation (excessive watering of
the eyes), pain, contracted pupils and congestion of the eye.
In addition to these symptoms, distant vision is impaired and
there is a condition of false or simulated myopia, so marked
that concave glasses have been ordered on account of the im-
provement they afford in distant vision; this, however, is a
grievous error that should not be committed by any well-
formed optician. The cause of spasm of the accommodation
is not limited to hypermetropia.

3. BLEPHARITIS, STYES, ETC.

The constant strain under which the hypermetropic eye
labors causes an increased flow of blood to the organ, which
results in a congestion of some of the structures of the eye and a subsequent inflammation. In this way the edges of the lids become red and swollen, with the formation of scales and crusts, and the dropping out of the lashes, which are sometimes not reproduced. The statement has been made by competent authorities that "chronically inflamed eye-lids are almost always dependent upon hypermetropia or hypermetropic astigmatism."

This congestion may result in a localized inflammation, and there are few diseases of the lids more common or more annoying than styes, oftentimes one following another in quick succession, seeming to come without any apparent cause. The inflammation is seated in and around the bulb of an eyelash, and rapidly results in the formation of pus, which breaks naturally or is discharged by a small incision made in the apex of the tumor. The cause is usually to be found in some ocular anomaly, principally hypermetropia, and the treatment consists in the correction of the error by properly adjusted glasses.

4. GLAUCOMA.

This is a disease characterized by abnormally increased intra-ocular tension, which gradually advances to blindness. The majority of the cases of this dreaded disease occurs in hypermetropic eyes, and hence the value of correcting glasses becomes evident as a means of prevention. In one of the latest text-books on diseases of the eye, the statement is made that "overuse of the eyes, especially with improperly corrected refractive error, has a distinct tendency, by causing ocular congestion, to bring on glaucoma in an eye predisposed to the disorders by changes in the ciliary region."

5. CATARACT.

Investigations by competent authorities show that the majority of cataractous eyes are hypermetropic, and it follows that the use of the proper correcting glasses must be looked upon as an important preventive measure.

6. MYOPIA.

Hypermetropia is the prevalent condition of refraction in childhood, and the strain caused by this defect in the use
of the eyes during these tender years, for reading and studying for long periods of time and under unfavorable conditions, results in an elongation of the eye-ball and the development of myopia. This has been proven by abundant statistics.

7. **Asthenopia.**

This term means weak sight, and may be defined as a lack of sufficient muscular strength to maintain for any length of time the adjustment of the dioptric apparatus required for near vision. It may be divided into *muscular* and *accommodative*, the latter being the form which occurs as the result of hypermetropia, for the reason that a portion of the accommodation is diverted from its legitimate purposes of focusing the eye for near vision and used for uniting the parallel rays from distant sources, thus leaving a corresponding deficiency in the power of adjustment for close use, and requiring an unnatural tension of the muscle of accommodation for the latter purpose. The result is that the muscles become exhausted and symptoms of asthenopia make their appearance.

Asthenopia does not usually manifest itself in young persons, because their accommodation is sufficiently vigorous to overcome the hypermetropia without feeling the strain, and because they are seldom required to use their eyes for any considerable length of time in looking at small objects. But after the age of ten years, when the accommodation naturally begins to gradually fail, and when more and longer use of the eyes is required for reading, writing and studying, then the symptoms of asthenopia begin to be apparent, cause much annoyance and suffering, and even give rise to painful forebodings of future blindness.

In asthenopia there may be comfortable vision for a short time, but the necessary effort of accommodation required for close vision cannot be long maintained, and, notwithstanding an increased nervous impulse is transmitted to the eye to compensate for the unnatural tension that is called for, there are soon a feeling of fatigue within the eyes, pain in and around them, excessive irritability, and a blood-shot appearance of the conjunctiva. Vision becomes blurred, and the constant straining of the accommodation to form clear images aggravates
all the symptoms, renders the eye sensitive to light, particularly if it be artificial, causes a painful dazzling and a sensation of smarting and roughness as if there was sand beneath the lids; there is often a resulting conjunctivitis with swelling of the lids and sometimes a mucous discharge, which dries during sleep and causes the edges of the lids to adhere.

The patient is inclined to close his lids and rub his eyes or press them with his fingers, and, after a short period of rest, all the symptoms disappear; but they return with increased violence after another attempt to use the eyes in close vision, until, finally, the pain and irritation become so great that reading, writing, sewing and all fine work have to be abandoned, and some occupation sought that does not call for use of the eyes in sharp vision of small objects.

The treatment of asthenopia is the removal of the cause by the correction of the hypermetropia.

8. CONVERGENT STRABISMUS.

In this form of strabismus the visual line of one eye is directed to the object looked at, while the visual line of the other eye is deviated inward, and in four-fifths of all cases it is caused by (or at least it is associated with) hypermetropia; and therefore it is fair to presume that this condition of squint might have been corrected by the timely use of glasses.

When convergent strabismus is due to hypermetropia, it usually makes its appearance about five or six years of age, at the time when pictures, letters of the alphabet, and small objects are first noticed. Sometimes it does not show itself until after the child has been attending school for a time, when the close use of the eyes is more pronounced and more persistent. There is scarcely any ailment that may befall a child that will cause more alarm to the anxious mother than the appearance of strabismus; and a cross-eyed child in a family is something to be greatly dreaded, not only on account of the impairment of vision in the squinting eye, but also because of the unpleasant disfigurement.

The explanation of the production of convergent strabismus by hypermetropia is as follows: The presence of this error of refraction in an eye imposes upon its accommodation a
constant strain to maintain distinct vision. It has been found that by convergence of the visual axes an increase in the power of accommodation will be gained, and the greater the degree of convergence the more the resulting power of accommodation. In this way the visual lines are made to cross each other at a point nearer than that of binocular fixation, and while an increase in the force of accommodation is thus gained, it is at the expense of binocular vision, which gives way to diplopia or, perhaps, to monocular vision because the image cannot be formed on the yellow spot of each eye.

The visual line of one eye fixes the object looked at, and its image is formed on the yellow spot, while the visual line of the other eye is directed to another point, the eye itself being placed in such a position with reference to the object fixed by the straight eye, that its image is formed on the retina at a distance from the yellow spot. These two images therefore being formed on parts of the retina, which are not identical, cannot be fused into one, and double vision is the result.

This diplopia, while very annoying at first, does not last very long, for the following reason: the image of the object which is desired to be seen is received in the fixing eye and formed on the most sensitive portion of its retina, and hence the impression carried to the brain is clear and distinct; whereas the corresponding image in the deviating eye is formed on a portion of the retina which is much less sensitive, and hence the impression carried to the brain is not of a perfect image.

Under such circumstances (in cases of diplopia where one image is much clearer than the other) the sharp image of the straight eye commands the brain a more distinct recognition, which is only disturbed and confused by the feeble impression received from the squinting eye, and hence the effort is made by the percipient elements to suppress the recognition of the latter in order that monocular vision may be secured and prove satisfactory.

The hypermetropic child, when he begins to use his eyes for close vision, finds that he cannot see distinctly except by a considerable effort, of which he is conscious, and he soon finds, as if by instinct, that if he allows one eye to turn inward
he receives a clearer image in the other eye, and with less apparent effort of accommodation. Hence, when he desires to see distinctly at a close range, he unconsciously fixes the object with one eye, while the visual axis of the other eye converges and crosses the first visual line at a point nearer than the object.

As soon as the gaze is removed from close objects and fixed on those more remote, the squint disappears and the eyes assume their normal parallel condition, and continue so until again called upon to adjust the vision to a near point, when the strabismus returns. The natural instinct of the child (if it may be termed such), or some guiding impulse, leads the child to prefer clear monocular vision to blurred or strained binocular vision.

At this stage the squint is periodical, manifesting itself whenever the eyes are under the strain of close vision and vanishing with every relaxation of the accommodation. With the growth of the child and his advance in school, the eyes are used more and more in close vision, and consequently the condition of the squint is present for a greater length of time, and there is less tendency for the eyes to resume their normal position, the turning inward of one eye lasting even after the accommodation is passive, until finally the strabismus becomes fixed and permanent and binocular vision is forever lost.

**Impairment of Vision in the Squinting Eye.**

In some cases the squint appears first in one eye and then in the other, and under such conditions, when each eye shares alternately in the act of vision, the sharpness of sight is equally retained in both of them. But it usually happens that one eye is preferred for vision and is always used, and then the squinting eye, constantly receiving its image on a non-sensitive portion of the retina gradually loses its powers of perception and its acuteness of vision is very much impaired. There may be no organic change in the retina that can be detected by the ophthalmoscope, but from non-participation in the act of vision the nervous sensibility becomes blunted, and the eye is said to be amblyopic.
If an operation be performed early and the muscular equilibrium be restored, resulting in a return of binocular vision and the action of the two eyes in harmony, the sensibility of the retina may again be raised to normal, in which case it may become necessary, in order to hasten the improvement, to exclude the good eye and exercise the other for a few minutes each day in reading with a convex lens. In those cases where the strabismus has lasted for many years, the impairment of vision becomes permanent, and no operation or any amount of exercise of vision will avail in restoring the sight.

WHY DOES NOT STRABISMUS OCCUR IN EVERY CASE OF HYPERMETROPIA?

We have classed convergent strabismus as one of the evil effects that may result from hypermetropia, but in reading the rationale of its production the query may logically arise in the student's mind, why does not strabismus occur in every case of hypermetropia? While this question is perhaps easier asked than answered, still we have some very good reasons for its non-occurrence in every case.

In the normal eye there is a constant natural desire for single vision, which holds equally good in hypermetropia, and it becomes the duty of the ocular muscles to maintain binocular vision if at all possible. This results in a struggle between two contending impulses: in the first case binocular vision is preserved at the expense of clearness of sight; in the second case a more distinct perception is enjoyed, but with a sacrifice of single vision. In the former condition the brain, in its abhorrence of double vision, strives to obtain the clearest possible image and still retain single vision; in the latter predicament the endeavor to secure perfect vision, which can be accomplished only by the use of one eye, induces the brain to suppress the image formed on the retina (but not on the yellow spot) of the squinting eye.

In this contest between these struggling influences, the abhorrence of double images and the desire for single vision are in many cases the most powerful, resulting in the maintenance of binocular vision and the prevention of squint.
In addition to this, the theory has been advanced that some hypermetropes may pass through childhood without discovering that they are able to secure clear and distinct images by an over-convergence; but this proposition we are not altogether prepared to accept, because this is a natural instinct, and on account of the close relation existing between accommodation and convergence the youthful hypermetrope will as naturally learn to increase his power of accommodation by an excessive convergence, as he will to use his legs in walking.

In absolute hypermetropia, where the entire refractive and accommodative power of the eye, even when assisted by the strongest effort of convergence, is insufficient to form a clear image on the retina, there is no motive for excessive convergence because there is nothing to be gained by it, and hence, in such cases, strabismus is not likely to occur.

**Prevention of Strabismus by Convex Lenses.**

Inasmuch as convergent strabismus is one of the results of hypermetropia, on account of the strain imposed upon the accommodation, it naturally follows that the correction of the defect and the removal of the strain would be an important measure of preventive treatment, in the shape of properly adjusted convex lenses. When a suggestion of this kind is made to the mother she is horrified at the thought of her child wearing glasses; and if perchance her scruples are overcome and her consent given, there is constant difficulty in coaxing and persuading a child of five or six years of age to wear them.

The child is too young to appreciate the useful purpose for which they are given, nor is he inclined to accept them as playthings given for his amusement; and hence they do not appeal to him in any language that he can understand. Consequently there is a constant strife between parent and child in the endeavor to control the inclination of the latter to remove the glasses and to prevent their being broken. After this struggle continues for a while the parents become annoyed and disgusted, and their duty in this respect becomes so irksome that they neglect it, until finally the child has his own
way, the glasses are laid aside and lost, and the periodic squint becomes permanent.

**OCCURRENCE OF PERMANENT STRABISMUS.**

Even after the squint has become permanent, the duty of the parent does not cease, because by compelling the use of the eyes in alternation, the sight of both may be kept up to the normal standard. The usual tendency is for the child to use one and the same eye constantly for all purposes of vision, and then of course the sight of the other eye soon deteriorates. In order to obviate such a condition, the good eye should be covered with a handkerchief or a light bandage for an hour or two each day, thus compelling a use of the squinting eye and maintaining its visual powers unimpaired.

The advantages to be gained from such a practice are obvious; in fact, the patient retains two good eyes instead of one, and in such a case, if the sight of one is impaired or lost by injury or disease, the other at once becomes available for immediate and satisfactory use. Also if an operation be performed for the cure of the strabismus and the restoration of the natural position and movements of the eyes, there would be much more hope for a return of binocular vision if both eyes were of the same acuteness of vision.

**PREVENTION BETTER THAN CURE.**

However the prevention of the periodic squint from becoming permanent is of much more importance to the child than is an operation for its cure, for it is very doubtful if a strabismus operation, even though apparently successful, ever restores the ideal singleness of vision with two eyes—a perfect binocular vision. In many cases this is most likely due to the fact that the two eyes vary in their acuteness of vision, and this fact only serves to emphasize the advice given above, that the attempt should always be made to keep both eyes up to the normal standard by alternating their use.

The occurrence of convergent strabismus in a child just commencing to go to school almost certainly indicates the existence of hypermetropia, and should at once lead to a careful and skillful examination of the refraction, in order that the
defect may be quickly discovered and the remedy applied before the squint becomes fixed; because strabismus is never due, as is popularly supposed, to fright, imitation or naughtiness.

The statement has been made by some authorities that "the greater the degree of hypermetropia the greater, obviously, is its tendency to produce strabismus;" and while on first thought this seems like a reasonable assumption, yet it is a proposition from which we are compelled to dissent. In the higher degrees of hypermetropia, where the accommodation, with all the added assistance of convergence, is still not strong enough to overcome the refractive error, convergent strabismus can be of no advantage and does not occur. But it is in the moderate degrees of the defect (from 2 D. to 4 D.) that the accommodation is made equal to the task of neutralizing the defect by the assistance of the convergence, and here the strabismus is most commonly found.

The theory has been advanced by some authors that the amblyopia that is usually found in a squinting eye is not the result of the strabismus, but is the cause of it. They argue that the defective sensibility of the retina is congenital and thus leads to the production of strabismus; but they are able to present no convincing evidence in support of this theory, and the opinion of the writer is that the amblyopia is the direct result of the strabismus as explained in the foregoing.

9. RETINITIS AND NEURITIS.

Inflammations of the retina and of the optic nerve are oftentimes symptoms of grave constitutional diseases, as syphilis and Bright's disease, and yet there is abundant evidence to prove that these conditions may develop in patients who are entirely free from such maladies, and as the result of over-use of the eyes or the strain caused by hypermetropia; and an examination of a large number of cases of retinitis and neuritis has shown the existence of hypermetropia (perhaps in a latent form) in a great majority of the cases.

Of course it is quite possible that there may exist in these cases some underlying constitutional cause, some predisposition to these inflammatory conditions, and when the eyes
are thus rendered susceptible, it requires but a little strain or a trifling irritation to start up the disease.

10. NERVOUS DERANGEMENTS.

The strain imposed upon the eyes by an uncorrected hypermetropia has a decided effect upon the nervous system by a leakage of nerve force, and may lead to a train of evils far more extended that we are accustomed to suppose. When the various organs of the body perform their functions harmoniously, each receives its normal supply of nerve force, and there is no cause for irritation. But hypermetropia, by overtaxing the ciliary muscle and destroying the normal relation that should exist between accommodation and convergence, calls for an excessive supply of nervous energy and acts as an irritant to the central nervous system, with the final result of a breakdown and prostration of this important system, which not only causes misery and suffering, but statistics are not wanting to prove that the duration of life is materially shortened thereby.

Chorea. The clinical experience of hospital physicians has demonstrated most positively that there is a direct relationship between hypermetropia and chorea or St. Vitus’s dance; the percentage of this defect in choreic cases being placed as high as seventy per cent. Therefore it follows that such cases are rapidly cured by eye treatment alone, the correcting glasses stopping a leakage of nervous force that may have been going on for years.

Epilepsy is one of the most terrible diseases that can befall any human being, and its treatment by drugs alone is very unsatisfactory. Of late years specialists on nervous diseases have found that errors of refraction, and especially hypermetropia, bear a direct casual relation to the attacks, and that properly adjusted glasses are an indispensable adjunct to the treatment, if they do not even supersede all other methods of treatment.

Nervous Prostration and Insanity are very closely related, the former leading to the latter, and it does not require any stretch of the imagination to see how an uncorrected hypermetropia, by causing a leakage and excessive expenditure of
nerve force, may develop a nervous debility that leads to mental disturbance and ends in insanity.

TESTS FOR HYPERMETROPIA.

The outfit required by the optician for use in refraction tests has been described in the chapter devoted to that subject, and a repetition of the paraphernalia seems scarcely necessary at this place; but their use and the methods of making the practical tests will receive a detailed description.

The various tests for the detection and determination of hypermetropia may be enumerated as follows:

1. Trial Case.
2. Skiascopy.
3. Ophthalmoscopy.
4. Chromatic Test.
5. Scheiner's Test.
6. Amplitude of Accommodation.

THE TRIAL CASE.

The most reliable test for hypermetropia, and the most satisfactory on which to rely for the determination of the proper glasses, is by means of the test lenses from the trial case. The improvement of distant vision by convex lenses, or in cases of normal acuteness of vision where such a lens is accepted for distance, is regarded as proof positive of the existence of hypermetropia. From this fact it does not follow that the acceptance of a concave lens disproves it, as frequently a spasm of accommodation is an accompaniment of hypermetropia, and in such a case a concave lens improves distant vision and makes the case apparently myopic, when in fact it is hypermetropic.

ACUTENESS OF VISION.

The first step in the examination is the determination of the acuteness of vision, which is ascertained by means of the test card hanging twenty feet away. This may equal the normal standard of 20/20, or it may fall below it. The degree of acuteness of vision present does not throw much light on the existence or absence of hypermetropia.
If the visual acuteness is \( \frac{2}{5} \), the only certain deduction that can be drawn is that the case is not one of myopia, but it does not afford any information as to the presence of hypermetropia, because a normal vision may mean either emmetropia or hypermetropia.

On the other hand, if the vision is \( \frac{2}{3} \), or \( \frac{3}{5} \), the only undisputed inference that can be drawn is that the case is not one of emmetropia, but there is no knowledge afforded as to the existence of hypermetropia, because a lower visual acuteness may mean either hypermetropia, myopia or astigmatism.

**CONVEX LENSES THE TEST.**

How then is the presence of hypermetropia to be determined? By the acceptance or rejection of convex lenses for distant vision. A weak convex lens (usually \( +.50 \) D) is placed before the eye, the effect of which at once becomes apparent, one way or the other.

If the acuteness of vision is \( \frac{2}{3} \), and this convex lens blurs it, it is fair to presume that the eye is emmetropic; but if the convex lens is accepted, that is, if the vision remains just as good with the lens as without it, and if the No. 20 line can be just as clearly read, the case is proven to be one of hypermetropia. But the test does not end here, as the refraction has only been shown to be hypermetropic, the degree of which may be much greater than that represented by the \( +.50 \) D. lens. A +.75 D. lens is next placed in the trial frame, with which the No. 20 line is still clearly seen. But still the optician must not be satisfied, and he proceeds to use the next stronger and another stronger, continuing as long as the patient's vision remains \( \frac{2}{5} \), and the letters on this line are distinctly visible.

Finally a lens is reached that causes the patient to shake his head and say the letters are not quite as plain as they were before. He may be able to name them, because he has probably learned them by heart by this time, but he is conscious of the fact that their sharpness of outline is less marked, and some of the letters he is doubtful of. What has been determined now? The amount of the manifest hypermetropia has been
measured, by placing stronger and stronger convex lenses in front of the eye until the vision was made worse. In other words, the refraction of the eye was increased more and more by the addition of the convex lenses, until at last the focus of rays of light was formed in the vitreous humor in front of the retina, which simulated a condition of myopia, and distant vision was correspondingly impaired.

In that class of cases where the vision falls below \( \frac{20}{100} \), the test is commenced with convex lenses, which are not only accepted, but cause a marked improvement in vision. A \(+ .50\) D lens is tried first, and at once the patient notices that the letters are clearer and blacker, and perhaps he is enabled to read a few letters on the next line below. Then a \(+ .75\) lens is tried, and a \(+ 1\) D., with a noticeable improvement each time, and still stronger lenses until the acuteness of vision is raised to \( \frac{20}{16} \). But even when this point is reached the test does not stop, but is continued by the addition of still stronger lenses until the No. 20 line begins to be dimmed. Perhaps a \(+ .50\) D, or a \(+ .75\) D, lens stronger will be accepted than that which raises vision to normal; but as the amount of defect is not measured by the lens that first makes the No. 20 line readable, but by the strongest lens with which this line remains so, the test is not ended until this latter lens is reached.

NEVER TRY CONCAVE LENSES IN HYPERMETROPIA.

The optician should be cautioned always in cases of suspected hypermetropia to commence the test with convex lenses, and if they improve vision, or at least if they do not make it worse, the refraction is proven to be hypermetropic. Whereas if weak concave lenses are tried first, they will most likely be accepted on account of the spasm of accommodation which is generally present; and when once accepted they serve to stimulate the accommodation to still further contraction, and then if convex lenses are tried afterward, they will be promptly rejected; for the detection of hypermetropia by means of convex lenses depends upon a relaxation of the accommodation to the extent of the strength of the convex lenses used. In either case (with or without convex spherical lenses)
the rays of light are brought to a focus at the same place, and vision remains the same.

In the first case this was accomplished by the refractive power supplied by the crystalline lens of the eye, and in the second case by the convex lens in front of the eye. But when concave lenses are used first they excite the accommodation and cause convex lenses to be rejected, and in this way the diagnosis of the case becomes doubtful, and the optician may be led into serious error.

CAUTION IN CHANGING THE LENSES.

As the optician changes the test-lenses in front of the eye for stronger ones, he should not make too much of a jump or increase their strength too rapidly, else the ciliary muscle contract spasmodically and he fail to discover the hypermetropia. But he should increase only .25 D. at a time, leaving each lens in front of the eye for a short space of time, thus giving the ciliary muscle an opportunity to relax and encouraging it to do so, and by thus changing the lenses slowly and increasing their strength gradually, the test lenses will be used to the greatest possible advantage in developing and detecting hypermetropia.

THE METHOD BY OVER-CORRECTION, OR THE FOGGING SYSTEM.

After ascertaining the acuteness of vision, a strong convex lens is at once placed before the eye, about + 6 D. in ordinary cases, or even stronger if there is reason to suspect a marked degree of hypermetropia. This blurs the letters on the distance test card, and the patient involuntarily exclaims that he is unable to see with it. The optician encourages him to look quietly at the card for a moment or two without straining his eye, and after the eye recovers from the shock of suddenly placing such a strong lens before it, the vision may slightly improve.

The action of the convex lens is to induce a relaxation of the accommodation, as only in this way can the vision be made even slightly better. The natural tendency for the ciliary muscle is to contract, but a contraction of this muscle when a convex lens is before the eye instantly makes vision
very much worse. The eye is not slow to appreciate this fact, and then, as the natural instinct of the eye is for clear vision, the effort is made in the other direction, that is, in a relaxation of this muscle, which at once tends to slightly clear the vision, and thus a further relaxation is encouraged.

Now a weak concave lens (— .50 D.) is placed over this convex one, and by diminishing its strength improves vision quite noticeably and encourages a still further lessening of accommodation. After this lens remains a brief moment, it is replaced by a — 1 D. lens, which affords another improvement in vision and enables the patient to see more of the letters. Then — 1.50 D. is tried, followed by — 2 D., — 2.50 D. and — 3 D., with amelioration of vision each time until the normal standard is reached, and then the difference between the convex and the concave lens will be the measure of the hypermetropia.

AN ILLUSTRATION OF FOGGING.

A patient presents himself with all the symptoms of hypermetropia as they have been described in this chapter. On examination his acuteness of vision is found to be $\frac{20}{20}$. Each eye is tested separately with convex lenses, but only + .50 D. is accepted and a stronger lens blurs the vision. Then the eyes are tried together, and it is found in binocular vision that they will bear + 1 D., but nothing stronger.

If the optician desires to make his examination thorough, he will not stop here, but will make use of the fogging method. He places a + 6 D. lens in the trial frame, with which the patient is unable to read even the largest letter on the card at first, although after a moment he may be able to discern the form of the No. 200 letter. A — .50 D. lens is then placed in the front groove of the trial frame, which renders this letter clear and easily discerned. Then it is replaced by a — 1 D. lens, which brings out the No. 100 line. Next, a — 1.50 D. lens is tried with the effect of making clear the No. 70 line of letters; a — 2 D. clears up the No. 50 line, a — 2.50 D. the No. 40, and a — 3 D. brings into view the No. 30 line, and, finally, a — 3.50 D. brings the vision up to $\frac{20}{20}$ clearly and distinctly.
Now what has been done and what has been accomplished? The +6 D. lens first placed before the eye has been partially neutralized by the —3.50 D. lens and reduced to +2.50 D., with which vision is 2/3. In other words, the eye has been led to accept a +2.50 D. lens, with which the acuteness of vision is unimpaired, and hence this is the measure of the defect.

TEST FOR HYPERMETROPIA BY SKIASCOPY.

The essentials for the test by skiascopy are a darkened room, a bright light (either electric, gas or oil will answer), and a retinoscope, to which may be added the trial case.

The distance of the optician from the patient is a matter of considerable interest, for which, however, there is no fixed rule, each observer within certain limits selecting his own distance. The beginner may try the method at different distances, and then decide for himself at what distance he obtains the best results. When the plane mirror is used this is a comparatively simple matter, but with a concave mirror any great variation in the distance requires a corresponding variation in the focus of the mirror; the nearer the optician approaches his patient the shorter should be the focus of the mirror, and the greater the distance the longer the focus.

The preference of the writer is for a plane mirror and a distance of one meter, the advantages of this distance being that it is close enough to get a good view of the reflex and shadow, that a lens can be placed before the patient's eye and changed at will without requiring the optician to leave his seat, and that a uniform allowance of 1 D. is thus called for in the estimate.

The light should be steady, clear and white, and as bright as possible; the Welsbach light, the incandescent electric light or an Argand burner of either gas or oil will answer the purpose; and in order to obtain the brightest part of the flame, it is customary to use an asbestos chimney or screen with an aperture opposite the most brilliant part of the flame.

The room should be darkened by removing all sources of light except the one in use. It is not essential that the ceil-
The position of the light is varied by different authorities. Formerly, the advice was given to place the light in such a position above the head, and slightly behind, that the patient's eyes will be in the shadow, and that no light can fall on the trial lenses that may be placed in the frame. Or the light may be close to the observer, and thence reflected on the patient's eyes, the optician's eye, the light, and the patient's eye all being on the same plane. The closer the light is to the mirror, the brighter will be the reflected rays.

This drawing shows the mirror at a distance of one meter from the eye under examination, and the dark lines represent the reflected rays from the mirror, which illuminate the retina, and as in all hypermetropic eyes, focus behind the retina. The dotted lines indicate the diverging rays proceeding from the retina, and the convex lens of 3.50 D., which is placed in front of the eye, and which possesses just sufficient refractive power to bend these dotted diverging rays and bring them to a focus at the position of the mirror one meter away.

METHOD OF CONDUCTING THE TEST.

The patient and optician being seated at the proper distance, the latter takes his retinoscopic mirror, holds it in front of his own eye, looks through the sight hole, and reflects the light on the patient's pupil, which at once appears more or less brilliantly illuminated, according to the condition of the refraction of the eye, and the portion of the fundus which is being observed.

If the optic disk is in the direct line of view, the examination is more easily conducted; but as the refraction at the disk may possibly vary 1 D. or even 2 D. from that at the macula, the latter is really the proper part of the fundus to
be corrected, to obtain which the patient must look at the sight-hole of the mirror during the whole examination.

The reflection from the eye of a blonde is much brighter than from a brunette, on account of the greater amount of pigment in the eye-ground of the latter. The reflection is much brighter in cases of low refractive error than in high degrees of defect, where it is dull.

The shadow is the dark portion of the retina that immediately surrounds the illumination; they adjoin each other, and the contrast between them is most marked and more easily recognized when the illumination is the brightest. It is this combination of light and shadow that gives the "shadow test" its name. In a darkened room the retina is in darkness, except that portion which is illuminated by the light from the mirror. As the mirror is rotated, the retinal illumination moves and shadow takes its place. It is this change of place of the illumination followed by the shadow, that causes it to be spoken of as the movement of the shadow.

As the mirror is slowly and slightly rotated first one way and then the other, around an imaginary vertical axis, the light reflection moves with it across the face from right to left, and from left to right. Just here the beginner should know that the illumination of the patient's face always moves in the same direction as the mirror is rotated, but in the pupillary area it may move in the same or in the opposite direction, as it is affected by the condition of the refraction. Hence when the movement of the illumination is spoken of, it is that which is seen in the pupil and not on the face.

When the movement of the retinal illumination is the same as the movement of the light on the patient's face, the case is presumably one of emmetropia or hypermetropia, in the determination of which convex glasses must be used and placed before the eye. The trial frame is used on the patient's face with a + 1 D. lens over the eye under examination, and the light is again reflected on the pupil, and the direction of the movement is again observed. If this lens causes the light to travel in a direction the reverse of that on the face, the refraction is proven to be emmetropic. Whereas if the shadow still moves in the same direction as the light, the eye is hyper-
metropic, and the lens must be changed successively for stronger ones until finally a glass is reached which reverses the movement.

HOW TO MAKE THE NECESSARY CALCULATIONS.

When this glass is found it is compared with the previous lens, and the refraction of the eye is between the two. In other words, the number of the lens is found between the weakest glass which reverses the movement of the reflection and the strongest glass which does not reverse it. If when a $+3.25$ D. lens is placed in the trial frame, the illumination is diminished in size and very faint, appears to move rapidly and with the light on the face, the hypermetropia is still slightly uncorrected, and a stronger lens must be found. If a $+3.75$ lens is substituted for it, and the retinal illumination is then found to move opposite to the movement of the light on the face, the measure of the defect will be between the $+3.25$ D. and the $+3.75$ D., which is $+3.50$ D.

This lens has converged the emergent rays issuing from the patient’s eye and brought them to a focus in the optician’s eye, which is at a distance of one meter; and in so doing and fixing the far point at one meter, it has practically made the eye myopic to that extent, just one diopter. Therefore when the patient’s vision is tested with the letters at twenty feet, this 1 D. of artificial myopia partly neutralizes the 3.50 D. of hypermetropia, and the result of adding $-1$ D. to $+3.50$ D. gives 2.50 D. as the amount of the hypermetropia.

This $+2.50$ D. lens, when placed before a hypermetropic eye, suffices to render parallel the divergent rays proceeding from it, and conversely would so refract parallel rays of light entering the eye, as to exactly focus them upon the retina. But the additional $+1$ D. is necessary to refract the emergent rays still more in order to bring them to a focus at one meter.

The reader who follows these explanations carefully will readily understand why the correcting glass should be 1 D. less than that shown by the retinoscope, and the writer desires to draw especial attention to this point, as it is one that is more or less confused in the mind of the beginner in retinoscopy.
TEST FOR HYPERMETROPIA BY THE OPHTHALMOSCOPE.

The room should be darkened, and the same light can be used that was found available in the shadow test. It should be placed (by an adjustable bracket) on the same level as the eye that is to be examined, and on the same side of the head. Patient and optician sit facing each other and side by side. The pupil is then illuminated by reflecting the light from the concave mirror, and the red reflex is obtained. If there are any opacities in any of the refracting media, they at once become apparent by marring the clearness of the reflex.

Presuming there are none, the optician at once passes on to the direct method of the use of the ophthalmoscope, which is the one preferred for estimating the refraction. This gives an upright, enlarged picture, but only a very small portion of the fundus is visible at one time. The optician uses his right eye to examine the patient’s right, and approaches as close as possible, all the while keeping the pupil well illuminated. The beginner finds some difficulty in keeping the light on the pupil as he approaches, and as soon as it loses its bright red reflex he may know he is at fault with the position of his mirror.

In an emmetropic eye, parallel rays are brought to a focus exactly on the retina without any effort of accommodation. Conversely, the rays proceeding from the retina of such an eye are bent by its refracting media in such a way as to issue from the eye parallel.

THE OPTICAL PRINCIPLES INVOLVED IN THE OPHTHALMOSCOPIC TEST.

In hypermetropia the focus of parallel rays is behind the retina, and only convergent rays can be focused on the retina. As no such rays are present in nature, the hypermetropic eye is adapted for a condition that does not naturally exist. The rays proceeding from the retina of such an eye are bent by its refracting media, but as their power is less than normal, the rays emerge from the eye divergent, just as if they came from a point behind the eye. These diverging rays can be rendered parallel only by the interposition of a convex lens of the proper strength.
If the eye is viewed through the ophthalmoscope at a distance of twelve or fourteen inches, the condition of the refraction may be determined by the appearance and behavior of the blood-vessels as they are seen at the fundus of the eye, that is, the direction in which they will travel upon the moving of the head of the observer.

In hypermetropia a more or less clear view of the fundus can be obtained at this distance with the mirror alone. The image is enlarged, erect and virtual, and as the optician moves his head from side to side, the disk and blood-vessels will seem to move in the same direction.

In emmetropia the optician must approach much closer to the observed eye in order to get a distinct view of the disk and vessels, and then as he moves his head their behavior will be the same as in hypermetropia.

The power of accommodation in the eyes of both patient and optician is supposed to be at rest. In order to favor the relaxation of the accommodation in the patient's eye, the room is darkened and he is requested to turn his eyes in a distant direction, without, however, endeavoring to fix any one particular object in distinct vision. For the optician it is sometimes a difficult matter to place the accommodation at rest, because, in looking at the fundus of the patient's eye, he is inclined to adjust his accommodation as for a near object; whereas he should endeavor to relax his eye and place it in the condition for viewing distant objects. If the fundus be viewed as at a near point, the amount of accommodation brought into play will render the optician's eye practically myopic, and this is the reason why so many beginners can get a clearer view of the eye-ground by rotating a weak concave lens in the sight-hole of the ophthalmoscope. Therefore, it should be borne in mind that the improvement caused by a concave lens must not be considered as proof positive of the existence of myopia.

RELAXATION OF THE ACCOMMODATION.

The power to completely relax his ciliary muscle is a faculty that should be cultivated by the ophthalmoscopist; and as it is so essential in the determination of hypermetropia, the
HYPERMETROPIA.

following procedures will be found of benefit in assisting to
that end.

The optician looks upward and at the same time holds
above his eyes a white card on which there is a black spot. He then endeavors to relax his accommodation, and as soon
as he succeeds the spot will appear double; then the card is
to be lowered, the eyes following it, and as long as the spot
continues to appear double he will know that his accommoda-
tion is at rest.

Another exercise which is adapted for the same purpose,
is to hold a pen or pencil about ten inches in front of the face,
and if the ciliary muscle can be relaxed and the vision adjusted
for distance, the pencil will appear double, and will continue
so as long as the ciliary muscle can be kept quiescent.

Still another method of practicing the same thing is to
hold a book as close to the eyes as possible; then the observer
is to commence to read, and while thus engaged he endeavors
to look through the book or beyond it, when the letters will
run together and become obscured, because when the accom-
modation relaxes the letters are no longer focused upon the
retina; at the same time the optician will probably feel that the
act of convergence lessens and the eyes gradually turn out-
ward until their visual axes assume a parallel position.

By a frequent repetition of one or all of the above exer-
cises, the beginner can learn to approximate an object close
to his eyes, and at the same time keep his accommodation and
convergence in abeyance. Having thus secured control of
his accommodation, the optician will be in a position to esti-
mate by the use of the ophthalmoscope the amount of hyper-
metropia in any particular case.

WHAT TO LOOK FOR.

The optician should familiarize himself with the appear-
ance of the normal fundus; first by a careful study of the
colored plate given in a previous chapter, and then by actual
use of the ophthalmoscope with healthy eyes. The optic disk,
that is, the entrance of the optic nerve, is the object to be
looked for, it being circular in shape and much lighter than
the retina, which presents a bright, rose-red, granular appear-
HYPERMETROPIA.

ance. In brunettes there is more pigment matter in the retina, which brings out in strong contrast the difference in color of the disk and the retina.

The optician now endeavors to get a clear view of the details of the fundus, and if he and his patient are both emmetropic this is a comparatively simple matter. If the observer is not emmetropic, he must wear his correcting glasses. If he looks into an hypermetropic eye (of moderate degree) he will again see the features of the eye-ground clearly and distinctly, but by the involuntary use of his accommodation. A distinct picture being thus obtained in both emmetropia and hypermetropia, how can it be determined which condition is present? By the revolving of a convex lens into the sight-hole of the ophthalmoscope, and if the picture still continues as clear (or is made more distinct) the case is known to be one of hypermetropia. And the strongest convex lens with which the optician can get a clear view of the optic disk and the blood-vessels will be the measure of the defect, presuming that both persons have been able to relax their ciliary muscles.

In order to insure an exact measurement of the patient's refraction by means of the ophthalmoscope, the advice is given by some authorities to use the region of the yellow spot for the examination. But unless the eye is under the influence of a mydriatic, this is a difficult matter, because the pupil sharply contracts as soon as the yellow spot turns toward the mirror; and besides there is no marked feature here; such as a blood-vessel, which can be used for accurate focusing.

For all practical purposes the optic disk will be entirely satisfactory for this examination, and preferably the side of the disk toward the temple, because its margin here is generally well defined. The small blood-vessels as they pass over the edge of the disk are to be observed; this makes a delicate test, as the variation of but a fraction of a dioptric is sufficient to throw them in or out of focus.

The optic disk is seen if the patient turns his eye slightly inward toward the nose, while the yellow spot comes into view when he looks directly at the hole in the mirror, while the course of the main retinal vessels can be traced by the
optician moving his head, and directing the patient to turn his eye, in an appropriate direction as the course of each vessel is being followed.

**CHROMATIC TEST FOR HYPERMETROPIA.**

This test has been fully described and illustrated with colored plates in the chapter on "Method of Examination." It is a ready and convenient test for detecting hypermetropia, in which defect the retina, being farther front than normal, approaches the focus of the blue rays, causing the flame to appear with a blue center and a red border. The convex lens that neutralizes the flame and fuses it into a single color will be the measure of the defect.

In this illustration the rays are shown which emanate from the candle flame and pass through the perforations in the card, and, being bent by the refracting media of the eye, are focused on the retina of the emmetropic eye, which is shown by the dotted lines. The hypermetropic eye being flatter, its retina is farther forward, as shown by the black line, and the rays striking it before their union produce there two images of the flame, and therefore to such a person the flame is seen double.

**SCHEINER'S TEST.**

This test for hypermetropia is one that is not in common use, and yet it illustrates so beautifully certain optical principles that it is desirable the optician should be familiar with it. A card with two small holes, so close together that rays passing through them will enter the pupil, is placed in front of the eye to be examined. The patient looks through these holes at a candle flame twenty feet away, and if the eye is hypermetropic two flames are seen, instead of one as in emmetropia.

The explanation of this phenomenon is as follows: the rays of light proceeding from the candle flame travel in all directions and fall upon the card, a few of them passing
through the perforations; and if the eye is adapted to the flame, that is, if it be emmetropic, these two sets of rays will exactly meet on the retina, and form there a single image of the flame.

If, however, the eye be hypermetropic and the defect be not corrected by the accommodation, the two sets of rays will strike the retina before they have had the opportunity to meet, and each set will form an image of the flame. The greater the degree of the hypermetropia, the farther apart the two images will be. Convex lenses are then taken from the trial case and placed between the card and the eye, and that convex lens which causes the flame to be seen singly will be the measure of the defect.

DETECTION OF HYPERMETROPIA BY MEASURING THE AMPLITUDE OF ACkommodation.

The amplitude of accommodation is the power exerted by the eye to change its adjustment from a far point to the near point, and is measured by the closest point at which the patient is able to read the fine print. The lens whose refractive power corresponds to this focal distance will represent the amplitude of accommodation.

For instance, if twenty inches is found to be the distance of the near point, the amplitude of accommodation would be 2 D. If the near point is thirteen inches, the accommodation is equal to a lens of 3 D.; and if the near point is ten inches, the accommodation is 4 D.

In emmetropia the amount of amplitude of accommodation is a constant one for the different ages all through life, as shown by the following table:

<table>
<thead>
<tr>
<th>Years</th>
<th>Amplitude of Accommodation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>14 D.</td>
</tr>
<tr>
<td>15</td>
<td>12 D.</td>
</tr>
<tr>
<td>20</td>
<td>10 D.</td>
</tr>
<tr>
<td>25</td>
<td>9 D.</td>
</tr>
<tr>
<td>30</td>
<td>7 D.</td>
</tr>
<tr>
<td>35</td>
<td>6 D.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Years</th>
<th>Amplitude of Accommodation</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>4.50 D.</td>
</tr>
<tr>
<td>45</td>
<td>3.50 D.</td>
</tr>
<tr>
<td>50</td>
<td>2.50 D.</td>
</tr>
<tr>
<td>55</td>
<td>1.50 D.</td>
</tr>
<tr>
<td>60</td>
<td>.50 D.</td>
</tr>
</tbody>
</table>

This is the standard by which every case must be gauged, and any departure from which, at any certain age, can be readily detected.

A hypermetropic eye requires some of its accommodation for distant vision, and hence for close use there is a de-
ficiency of that amount; therefore the amplitude of accommodation present in a hypermetropic eye at a given age would be less than is indicated in the table for the same age; and the amount by which it is less would indicate the degree of defect.

For instance, if on examination a patient thirty years of age has a near point of eight inches, representing an amplitude of accommodation of 5 D., it is at once evident there is a deficiency of 2 D., and a presumption of the existence of a hypermetropia of that amount.

With the same amplitude of accommodation it is evident that the near point is farther away in hypermetropia than in emmetropia, as is shown in the above instance, where the near point is at eight inches instead of five and a half inches, the normal distance. In this way the existence of a latent hypermetropia can often be determined, that could not, perhaps, be detected by the usual test with trial lenses.

THE TESTS FOR HYPERMETROPIA COMPARED.

In considering the value of the tests that have been described for the determination of hypermetropia, the optician soon discovers that the two objective tests (ophthalmoscopy and retinoscopy) are somewhat difficult to learn. Of course he knows that the theories involved and phenomena observed are simple and easily understood, but it requires much time and practice to become an expert in the use of these methods. Therefore they may be considered subordinate to the test by the trial lenses, which is really the decisive one. And then, finally, even this test yields to that which is given by the patient himself when he commences to wear the glasses which have been ordered.

REMARKABLE ACUTENESS OF VISION IN HYPERMETROPIA.

In a description of this defect of hypermetropia it should be noted that hypermetropic eyes sometimes enjoy an unusual degree of acuteness of sight, and, in fact, when young, they are very apt to boast of their power of vision. They cannot only read all the No. 20 line without an error when seated at twenty feet but will also call off the letters on the next line
HYPERMETROPIA.

The parents of such a boy will tell how the child can see things with an ease and distinctness which they themselves do not possess. They may laugh at the suggestion of any defect in the eyes of their child, and ridicule the thought of glasses as long as the child can get along without them.

PREJUDICE AGAINST GLASSES.

There is no use denying the universal prejudice that has existed in the public mind, but which, fortunately, is not so pronounced now as formerly that glasses are an injury when they can be avoided for fear the patient may become so dependent upon them as never to be able to remove them. This is certainly not good grounds for an argument, but the proper light in which the matter should be viewed is that if Nature is dependent upon a glass which affords relief and removes strain, such means of assistance should not be withheld.

If the pain in hip disease is arrested by a properly-adapted support, should the splint be denied the patient because he feels his dependence upon it? Is there any more reason why a patient with defective eyes should go through life without the relief that glasses only can afford, simply because of unfounded prejudice against their use?

A case is related of a physician who refused to allow an oculist to examine his children’s eyes, with the statement that no child of his should ever wear glasses with his consent. The children suffered from weekly attacks of sick headaches, and finally one was fitted with a $+3.25$ D. lens, another with the same sphere combined with $5^\circ$ prisms, and the third was also highly hypermetropic and astigmatic. Immediate relief was afforded in each one of these cases by the correction of an optical defect which had rendered their early life one of suffering. This is not an uncommon experience with oculists and opticians.

SICK HEADACHES.

There is every reason to believe that there are thousands of sufferers from sick headache who are struggling through life with an uncorrected hypermetropia, who have made unsuccessful efforts for relief at the hands of doctors and drugs, and who have in despair abandoned all hope of cure. This
is an interesting study for the ambitious optician, and forms a wide and promising field for the exercise of his skill and judgment.

The statement is made by eminent authorities that the gastric symptoms which accompany typical attacks of sick headache are not due to "biliousness," or "disordered liver," or "dyspeptic conditions," or "the use of tobacco to excess," or "living too high," but they are reflex in character, and, in the majority of cases, due to hypermetropia. These attacks often occur without any explainable cause, and they are sometimes even cured by eating, drinking or smoking, while at other times they are aggravated by similar indulgences. Every known remedy in the pharmacopoeia has been tried, at first with success, acting almost as specifics, and later proving entirely valueless, until finally life is rendered really unendurable.

The brain and central nervous system preside over all the functions of life. If now this ruling spirit is disturbed by the irritation caused by a constant strain to use the eyes in the face of an uncorrected hypermetropia, may not this disturbance manifest itself by an interference with the normal functions, as shown by nausea, vomiting, dizziness, and other evidences of impaired animal life? This reasoning is plausible, and although they are the views of an extremist, they contain much of truth, and suggest a train of thought and experiment that can be successfully carried out by every intelligent optician.

RECAPITULATORY REMARKS.

Before concluding this chapter on hypermetropia, at the risk of possible repetition it seems desirable to mention again a few of the important points that should be borne in mind in adjusting glasses for the correction of this defect.

In obtaining the history of the case the optician should ascertain whether or not the patient has been wearing glasses, and if so, what kind, what number, and how long. Even though they are entirely unsuitable, they may serve as a guide in making the test and prevent the prescription of similar glasses, which the optician might be led to give if he was not thus warned.
In testing the vision at twenty feet, every letter in the No. 20 line may seem black and the outlines of the letters clearly defined, and the presumption would be that the patient was emmetropic, but he might be hypermetropic: the determination of which depends on the acceptance or rejection of a convex lens. A weak lens is used (generally + .50 D.), and if the patient rejects this it is reasonable to infer there is no hypermetropia present (barring those cases of latent defect, which do not enter into our consideration now).

If, on the other hand, this convex lens is accepted, it is fair to assume the case is one of hypermetropia. Then a stronger one is tried, and still a stronger, the patient all the while looking at the No. 20 line, until he says the letters are slightly dimmed or less distinctly seen. This lens is then to be compared with the previous one and with several weaker and stronger, until finally the one chosen is the strongest that affords the best vision. If the degree of defect is found to be considerable, the lenses may be increased .50 D. at a time, but ordinarily the better plan is to change only .25 D., and thus allow the accommodation to gradually adapt itself to the convex lenses.

It is customary to fit one eye at a time, but this monocular vision is never as satisfactory with either eye as is binocular vision, and, in fact, if there is not much difference in the acuteness of vision of the two eyes they may be tried together, when a stronger lens will usually be accepted. When the refractive power of the eyes varies so much as to produce discomfort, then they must be measured separately and the best eye accurately fitted, and an approximate correction given to the other eye, not allowing a great enough difference between the lenses to cause discomfort. In these latter cases the eyes will gradually accustom themselves to the glasses, so that in time a much greater difference will be borne than at first seemed possible.

When presbyopia begins to steal over the hypermetropic eye, as it does earlier in life than normal, and the accommodation becomes unequal for reading and fine work, two pairs of glasses are required, the new and stronger glasses for close use, while the old and weaker glasses which the patient has
been wearing for his hypermetropia, and to which his eyes have become accustomed, remain good for distance. A person with a hypermetropia of 2 D. and wearing glasses of that strength to correct it, would, in the ordinary course of events, at the age of forty-five years have a presbyopia of about 1 D.; such a person would therefore need +3 D. for reading, and continue to wear his +2 D. for distance.

**ARTIFICIAL HYPERMETROPIA, OR APHAKIA.**

Aphakia is the term used to represent that condition of the eye in which the crystalline lens is absent from its position in the center of the pupil. This may result from luxation of the lens and its removal from the plane of vision, or if the capsule of the lens be punctured or ruptured its substance may be dissolved in the aqueous humor and removed by absorption.

By far the most frequent cause, however, for the absence of the lens is its extraction from the eye by one of the various operations for cataract. Inasmuch as the crystalline lens is the principal refracting medium of the eye, its removal leaves the eye intensely hypermetropic and destitute of all accommodative power; it is in a state of absolute hypermetropia. It has been conclusively proven that in the absence of the crystalline lens there remains not the slightest trace of accommodation. This fact establishes the correctness of the universally adopted theory (if, indeed, it needs any corroboration) that the power of adjusting the dioptric apparatus of the eye for close vision depends entirely upon changes in the convexity of the crystalline lens.

In chapter VI. of this work on The Physiology of Vision will be found an illustration of candle-flame images in the eye, three in number, the first being erect and reflected from the cornea, the second, also upright, is formed on the anterior convex surface of the crystalline lens, and the third is inverted and reflected from the posterior concave surface of the lens. When the flame is moved up and down, the two erect images move with it and the inverted one in an opposite direction. In aphakia there remains only the single image
on the cornea, the two reflected from the surface of the lens being absent.

The eye being left in a condition of absolute hypermetropia, it becomes necessary to measure its degree, which can be readily accomplished by means of the test by trial lenses. Strong convex lenses will be required to take the place of the absent lens, the strength of which will, of course, be influenced by the previous condition of the refraction of the eye; if formerly hypermetropic, stronger glasses will be called for, and if myopic, weaker convexes will suffice.

If the degree of myopia was as high as 10 D. or more, its aphakial condition might readily be one of emmetropia.

When the crystalline lens is removed from an emmetropic eye, the glass that is needed to take its place and bring parallel rays to a focus on the retina is usually about +10 D., sometimes a little stronger. On account of the absence of all accommodation, stronger glasses will, of course, be required to focus on the retina the divergent rays proceeding from near objects. In order to determine the proper glass for reading, we add to the first glass one whose focus represents the distance at which the patient wishes to read. For instance, if 10 D. was found to be the proper lens for distance, and ten inches was decided on as the desired point for reading; then the latter, which equals 4 D., is added to the former, and the result is a lens of +14 D. for reading.

An artificial accommodation may be produced by a change in the distance of the spectacles from the eyes, thus adapting them for intermediate points, on the principle that as the spectacles are moved farther away down the nose, their refractive power is increased and the reading point is brought nearer, while as they are pushed up close to the eyes their power is lessened and the reading point is moved away.

**APHAKIAL VISION.**

In addition to the hypermetropic refraction caused by the removal of the crystalline lens, a certain degree of astigmatism is also the result of the operation, most likely due to failure of the wound to heal properly. This astigmatism is generally "against the rule," and is apt to be more noticeable during
the first month or two after the operation, or until the cicatrization has become complete, and then it gradually diminishes for several months. It usually does not amount to more than 3 D., but even a slight astigmatism should be sought out and corrected.

Even after the most successful operations for cataract vision very rarely equals \( \frac{2}{3} \), for the reason that there is not perfect transparency in the line of vision, on account of slight opacities on the posterior capsule of the lens, which can often be detected by the ophthalmoscope. The amount of vision varies very considerably; an acuteness of \( \frac{2}{3} \) (that is one-tenth of the normal standard) is considered sufficient to class the case among the successful operations, while a vision which will enable the patient to find his way around is not to be despised.

In adjusting glasses for patients after a cataract operation, it is customary to wait until all redness has disappeared from the eyes, which may be a month or two, and even then they should not be worn constantly at first. In the meantime smoked glasses of various degrees of tint are worn as protectives. The “cataract” glasses should be set in strong spectacle frames, because their great convexity makes them thick and heavy.

**TWO PAIRS OF GLASSES.**

When two pairs of glasses are required, for both distance and reading, either on account of the high degree of hypermetropia or on account of the approach of presbyopia, there are several ways of arranging the glasses to meet the requirements of the person’s occupation.

In one case two separate and distinct pairs of glasses may be given, one pair for distance, and the other pair for reading, and the patient changes from one pair to the other, as occasion requires. This is the best way to place the glasses for the welfare of the eyes and is to be recommended to patients, although it involves so much more trouble and the possibility of not having the second pair of glasses when needed, that many persons object to it and prefer to arrange their glasses in some other way.

In such cases the person may wear his distance glasses constantly, put them on in the morning when he arises and
take them off at night when he retires, and then when he wants to read or write or look at small objects close at hand, he places an additional pair of glasses over his distance glasses, the sum of the two pairs being equal in strength to the lens required for reading. This extra pair of glasses may be either in the form of eye-glasses, or a spectacle front that should correspond in dimensions with the frame that is worn for distance, and in place of the usual temples is provided with small hooks at each end that are readily fastened to the constant spectacles, with but little danger of dropping or displacement. This is a very convenient arrangement, as many hypermetropes can testify.

**BI-FOCAL GLASSES.**

In other cases bi-focal glasses are preferred, the upper and larger portion being for distance, the lower and smaller portion for reading. The split bi-focals, in which the distance and reading portions were of the same size, are no longer used, they having given way largely to the cemented form, the reading strength being obtained by cementing a small convex shell on the lower portion of the distance glass.

The advantages of bi-focal glasses to those persons who need assistance for both distance and reading, are the convenience and satisfaction of having both pairs of lenses constantly before the eyes, and only a slight turn of the head and eyes required to bring either pair into use as desired. Many persons wear this form of bi-focals with the greatest comfort, and declare they could not get along without them.

The disadvantages of double-focus glasses are the annoyance caused by the line of separation between the two glasses and the difficulty in walking. This latter trouble is due to the fact that the patient must look through the reading glasses, and as these are adapted for vision at twelve to fifteen inches,
As this patient was young and had never worn glasses, it seemed advisable not to give too strong a glass to commence with, and hence a pair of +2 D. were prescribed for constant wear. In a week he returned with the report that his eyes were free from ache or pain, and that he could read comfortably for two hours, which is in marked contrast with the moment or two's reading which was his limit before.

It is interesting to note that although a mydriatic was employed, it was of no real value in determining the glasses required; and the writer is free to say that he could have corrected the defect just as well without the use of the drug. And what is true in this case applies equally to other cases, in the great majority of which satisfactory glasses can be prescribed without the thought of a mydriatic.
CHAPTER XII.

MYOPIA.

Myopia is an optical defect, the condition of its refraction being such that the focus of parallel rays lies in front of the retina. It is the direct antithesis of hypermetropia, from which it differs in every respect.

In myopia parallel rays of light are converged to a focus in the vitreous humor before they have reached the retina. After meeting in focus the rays cross and continue until they strike the retina in circles of diffusion; consequently, the image formed is blurred and indistinct.

The Refraction of a Myopic Eye.

In hypermetropia (as was demonstrated in the last chapter) the rays of light strike the retina before they have had an opportunity to unite in a focal point. In myopia, on the other hand, the rays have met in focus and over-crossed before they reached the retina. In both cases the retina receives only circles of diffusion, and in neither case is the formation of a distinct image possible, this latter being found only at the principal focus of the eye, where the rays at this point of union produce a sharp and well-defined image.

FORMS OF MYOPIA.

1. Refractive Myopia.

In the first case there is an excess in the static refraction of the eye, due to an increase in the curvature of one or more of the dioptric surfaces, or to an augmentation of the index of
refraction of the nucleus of the lens, thus causing the rays to meet in focus too soon in front of the retina, which may be at its proper position.

In the second case, the eye-ball is too long antero-posteriorly in the direction of its visual axis, oftentimes on account of pathological changes in the coats of the eye. This removes the retina from the principal focus of the eye, and is the form in which myopia usually occurs.

This elongation of the ball of the eye depends, in the great majority of cases, upon the formation of a posterior staphyloma, which means a protrusion backward. The coats of the eye first become softened and thus are rendered liable to give way under pressure; this bulging occurring at the outer side of the optic disk, toward the yellow spot, and causing a thinning of the tissues and oftentimes an atrophy of the choroid. This elongation of the visual axis is so constant that every certain degree of myopia corresponds to a definite increase in the length of the eye-ball.

**AMOUNT OF LENGTHENING OF VISUAL LINE IN AXIAL MYOPIA.**

The following table (after Donders) shows the increase in length and the total measurement that correspond to the degree of myopia:

<table>
<thead>
<tr>
<th>Amount of Myopia</th>
<th>Increase in Length</th>
<th>Length of Axis</th>
</tr>
</thead>
<tbody>
<tr>
<td>.50 D.</td>
<td>.16 Mm.</td>
<td>22.98 Mm.</td>
</tr>
<tr>
<td>1 &quot;</td>
<td>.32 &quot;</td>
<td>23.14 &quot;</td>
</tr>
<tr>
<td>1.50 &quot;</td>
<td>.49 &quot;</td>
<td>23.31 &quot;</td>
</tr>
<tr>
<td>2 &quot;</td>
<td>.66 &quot;</td>
<td>23.48 &quot;</td>
</tr>
<tr>
<td>2.50 &quot;</td>
<td>.83 &quot;</td>
<td>23.65 &quot;</td>
</tr>
<tr>
<td>3 &quot;</td>
<td>1.01 &quot;</td>
<td>23.83 &quot;</td>
</tr>
<tr>
<td>3.50 &quot;</td>
<td>1.19 &quot;</td>
<td>24.01 &quot;</td>
</tr>
<tr>
<td>4 &quot;</td>
<td>1.37 &quot;</td>
<td>24.19 &quot;</td>
</tr>
<tr>
<td>4.50 &quot;</td>
<td>1.55 &quot;</td>
<td>24.37 &quot;</td>
</tr>
<tr>
<td>5 &quot;</td>
<td>1.74 &quot;</td>
<td>24.56 &quot;</td>
</tr>
<tr>
<td>5.50 &quot;</td>
<td>1.93 &quot;</td>
<td>24.75 &quot;</td>
</tr>
<tr>
<td>6 &quot;</td>
<td>2.13 &quot;</td>
<td>24.95 &quot;</td>
</tr>
<tr>
<td>6.50 &quot;</td>
<td>2.32 &quot;</td>
<td>25.14 &quot;</td>
</tr>
<tr>
<td>7 &quot;</td>
<td>2.52 &quot;</td>
<td>25.34 &quot;</td>
</tr>
<tr>
<td>7.50 &quot;</td>
<td>2.73 &quot;</td>
<td>25.55 &quot;</td>
</tr>
<tr>
<td>8 &quot;</td>
<td>2.93 &quot;</td>
<td>25.75 &quot;</td>
</tr>
<tr>
<td>8.50 &quot;</td>
<td>3.14 &quot;</td>
<td>25.96 &quot;</td>
</tr>
<tr>
<td>9 &quot;</td>
<td>3.35 &quot;</td>
<td>26.17 &quot;</td>
</tr>
<tr>
<td>9.50 &quot;</td>
<td>3.58 &quot;</td>
<td>26.40 &quot;</td>
</tr>
<tr>
<td>10 &quot;</td>
<td>3.80 &quot;</td>
<td>26.62 &quot;</td>
</tr>
<tr>
<td>10.50 &quot;</td>
<td>4.03 &quot;</td>
<td>26.85 &quot;</td>
</tr>
<tr>
<td>11 &quot;</td>
<td>4.20 &quot;</td>
<td>27.08 &quot;</td>
</tr>
<tr>
<td>Amount of Myopia (D.)</td>
<td>Increase in Length (Mm.)</td>
<td>Length of Axis (Mm.)</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-------------------------</td>
<td>---------------------</td>
</tr>
<tr>
<td>12</td>
<td>4.73</td>
<td>27.55</td>
</tr>
<tr>
<td>13</td>
<td>5.23</td>
<td>28.05</td>
</tr>
<tr>
<td>14</td>
<td>5.74</td>
<td>28.56</td>
</tr>
<tr>
<td>15</td>
<td>6.28</td>
<td>29.10</td>
</tr>
<tr>
<td>16</td>
<td>6.83</td>
<td>29.65</td>
</tr>
<tr>
<td>17</td>
<td>7.41</td>
<td>30.23</td>
</tr>
<tr>
<td>18</td>
<td>8.03</td>
<td>30.85</td>
</tr>
<tr>
<td>19</td>
<td>8.65</td>
<td>31.47</td>
</tr>
<tr>
<td>20</td>
<td>9.31</td>
<td>32.13</td>
</tr>
</tbody>
</table>

The antero-posterior diameter of the normal eye is 22.82 mm., which is about \( \frac{9}{10} \) of an inch. In the higher grades of myopia, an increase of 1 D. represents a much greater addition in length of the ball than in the lower grades. For instance, a myopia of 1 D. causes an increase of \( \frac{32}{100} \) of a millimeter, as compared with \( \frac{6}{100} \) the enlargement in an eye of 20 D. myopia over one of 19 D., the increase in the higher degree being more than twice as great as in the commencement of the defect. The average increase for every dioptre of defect is about \( \frac{47}{100} \) of a millimeter, which equals nearly \( \frac{1}{20} \) of an inch.

In an organ so small as the eye, which measures less than an inch in diameter, the addition of even \( \frac{1}{10} \) of an inch cannot be disregarded. And when we consider the eye as an optical instrument, comparable to a photographer’s camera or a microscope, and when we call to mind how the slightest movement of the screw will throw both of these instruments out of focus, it can be readily understood that the addition of \( \frac{1}{60} \) of an inch to the length of the eye-ball is sufficient to disturb the dioptic adjustment of the eye and to impair the clearness of the image formed upon its retina.

In a myopia of 5 D. the amount of lengthening is \( \frac{13}{11} \) millimeters, or \( \frac{1}{11} \) of an inch; in a myopia of 10 D. the amount is \( \frac{33}{11} \) millimeters, or nearly \( \frac{1}{6} \) of an inch; in 15 D. of myopia, \( \frac{61}{11} \) millimeters, or \( \frac{1}{3} \) of an inch; while in an extreme case of myopia of 20 D., \( \frac{91}{11} \) millimeters is added to the length of the ball, which means the addition of more than \( \frac{1}{6} \) of an inch, making such an eye measure \( \frac{17}{2} \) inches as compared with \( \frac{9}{20} \) of an inch, which is the normal standard.

A careful study of this table is interesting and important, and serves to impress upon the optician the actual organic changes in the coats and shape of the eye-ball, upon which the production of myopia depends.
The one great cause of myopia is long-continued use of the eyes for small objects close at hand; and, therefore, myopia may be considered as a product of civilization—as a penalty of progressiveness. The use of the eye for close vision calls for an effort of accommodation, and when long continued, may cause a spasm of the ciliary muscle. The adjustment of the dioptric apparatus of the eye for the divergent rays of near vision, transforms it temporarily into a condition similar to myopia; and if the accommodation continues its spasm and fails to relax, a condition of accommodative myopia is produced. In this case the eye-ball is not elongated and there is no real myopia, but all the symptoms are present and the defect is simulated by the spasm of accommodation.

The permanent production of real myopia depends upon the congestion, inflammation and giving way of the coats of the eye-ball. The ciliary muscle is connected with the choroid, and, therefore, in the exercise of the function of accommodation there is a strain upon the latter; and when the eye is overtaxed, as is frequently the case with school children and those compelled to use their eyes continuously for near work, an inflammation of the choroid is apt to follow.

In addition to this, the close position at which the object is held necessitates a marked convergence of the optic axes, which causes a strain of the muscles and a pressure upon the tunics of the ball. Then, too, the stooping position that is generally indulged in during such employment, also tends to increase the congestion and inflammation by favoring an accumulation of blood in the eye. In this way a continuation of the congestion and pressure gradually leads to a bulging at the posterior pole of the eye.

THE EFFECT OF SCHOOL LIFE UPON THE SIGHT.

There is no doubt that the origin of many distressing diseases can be traced to the school life of the sufferer. The pathological conditions are not in all cases the direct result of unsuitable school existence, but it may be that the improperly constructed school buildings and badly managed
school life simply fan into a flame the spark of heredity which many unfortunate children receive from diseased parents.

The deleterious influence of education and intellectual advancement upon the bodily health is everywhere apparent. The mind is cultivated at the expense of the body, and it almost seems as if mental advancement goes hand in hand with physical retrogression. Certain it is, that uneducated and untutored races present types of bodily development superior to those nations that are renowned for civilization and knowledge.

The eye furnishes a striking example of the truth of these statements. The vision of those persons who are engaged in farming and kindred occupations is but seldom impaired, while in savage and barbarous races the statement is made that myopia and astigmatism are positively unknown. We are compelled to regard school life as disastrously prolific of refractive errors, by far the most frequent of which is myopia.

SCHOOL STATISTICS.

As early as the beginning of the present century the fact was recognized that the oftentimes unnatural requirements of school life resulted in injury to the eyes of many of the children; and several writers in those early days called attention to these important matters and to the relation that seemed to exist between the demands of civilized life and the production of myopia.

The statistics that have been compiled bearing on this subject are enormous. The examination of the eyes of more than ten thousand school children in Breslau and vicinity by Cohn, and the published results of his extensive investigations, in 1865 and 1866, called public attention to school hygiene and gave a great impetus to the discussion of this important subject. Similar examinations have been repeated from time to time by other observers in different cities, until at the present time the children who have been subjected to a study of ocular conditions by competent examiners for statistical purposes, compose an army of more than two hundred thousand. These investigations have occurred in all civilized countries, and have been made under all circumstances of age, sex, race, health,
heredity and school architecture and management. Many of these investigations have been so arranged as to follow a certain number of pupils from class to class and from school to school, and they all point to one inevitable conclusion, viz., that mental culture is obtained at the sacrifice of ocular perfection, and that such imperfections are usually myopic in their nature.

Certain facts have been established by these investigations, which may be briefly mentioned as follows:

1. The eye at birth is hypermetropic, and during early childhood the hypermetropic eyes greatly outnumbered the emmetropic and myopic ones. An examination by one observer of children three months old, showed them to be all hypermetropic.

2. Emmetropia was comparatively rare, but the percentage of those eyes which most nearly approached this condition remained almost uniform throughout school life.

3. Myopia was entirely absent, or very rare before the commencement of school life, and was found to increase steadily in percentage with the progress of the pupils in the schools, while the percentage of hypermetropia diminished in approximately the same degree. Not only does the number of myopic scholars increase from the lowest to the highest schools, but the increase is in direct proportion to the length of time devoted to the strain of school life.

We cannot burden this chapter with the statistics compiled by the various European and American observers, but as Prof. Cohn's work was the most extensive and most notable, and stands as the representative of all the others, we give his figures as follows:

<table>
<thead>
<tr>
<th>School Type</th>
<th>Percentage of Myopia</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary schools</td>
<td>1.4 per cent.</td>
</tr>
<tr>
<td>Elementary schools</td>
<td>6.7</td>
</tr>
<tr>
<td>Intermediate schools</td>
<td>10.3</td>
</tr>
<tr>
<td>High schools</td>
<td>19.7</td>
</tr>
<tr>
<td>Gymnasia</td>
<td>26.2</td>
</tr>
<tr>
<td>Universities</td>
<td>59.5</td>
</tr>
</tbody>
</table>

The fact that in the universities fifty-nine students out of every hundred are myopic is an appalling one, and when contrasted with the small percentage in the primary schools (only
one out of every hundred), there is certainly abundant food for the most serious thought, which appeals however more to those engaged in the education of children than to us as opticians.

**GENESIS OF MYOPIA.**

The manner in which abnormal circumstances act in causing an elongation of the axis of the eye, which is the physical condition present in myopia, has been well described by Fenner in the following graphic words:

"As a nation or community becomes wealthy, refined and elevated in social position, the inhabitants are more inclined to cultivate the intellectual faculties; hence they spend much time in close study, requiring a great and prolonged tension of accommodation in reading, writing, etc. They usually sit bending over a desk in stooping position, the abdominal organs are compressed, preventing the free return of the blood from the head.

"The insufficient illumination at many schools and colleges necessitates the bringing of the eyes very near the book, so as to obtain a larger visual angle, and as the book usually rests on a desk or table, the head has to be bent over; this posture produces an increased flow of blood to the eyes, whilst the higher degree of convergence necessary causes an increased pressure of the lateral recti muscles on the equator of the globe, thus increasing the intra-ocular pressure.

"The congestion of the fundus oculi causes softening of the scleral tissue, which gives way under the increased pressure, and the organ is elongated backward (a condition of posterior staphyloma); the other portions of the sclerotic coat are supported by the broad muscles. The retina is then pushed backward behind the focus of the dioptric apparatus.

"When this condition once commences, all the causes which first gave rise to it, act with increased force. There is a greater stooping posture necessary, because the eyes have to be brought still nearer the object; an increased convergence is demanded, and the congestion of the fundus oculi increases; consequently the softening processes progressively augment, causing the posterior portion of the sclerotic to
yield more and more. Hence myopia is usually progressive, particularly in its higher grades.

"There is greater tendency to the development of this condition of the eye in youth from the causes above mentioned, because then the scleral tissues are softer and consequently more yielding than in later life. With the increase of age this coat hardens, becomes firmer and better able to withstand intraocular pressure; hence it is rare that the posterior staphyloma giving rise to near-sightedness commences after the twentieth year."

**Why Children Are More Prone to Myopia.**

From the foregoing statements that the development of myopia depends upon a daily and continuous use of the eyes upon small objects close at hand, accompanied by strong convergence and with the patient in a stooping posture, it might naturally be expected to find this error of refraction of frequent occurrence among tailors, seamstresses, embroidery and lace makers, and all artisans whose trades require accurate near-vision.

But the fact is myopia is much more rare among these people than in the wealthier and more intellectual classes. This apparent paradox can be explained as follows: these working people do not engage in their occupations until they are of adult size, when the tissues of the sclerotic and the other coats of the eye have become sufficiently firm to resist the disturbing influences which their work engenders. While in the case of the higher classes, the eyes are exposed to the dangers of myopia at the tender age at which these children are usually placed at school.

In addition to the difference in the ages of these two sets of people, there is probably another factor that is brought into action, and that is the well-known fact that when the mind is actively engaged in study, an increased quantity of blood flows through the brain, causing a temporary congestion, which is shared by the eye on account of its proximity, thus adding to the previous plethora of the fundus of this organ.
ANATOMICAL CHANGES IN THE FUNDUS OF THE MYOPIC EYE.

In view of what has been said, that myopia means staphyloma and that the degree of myopia corresponds to the amount of extension of the fundus, it follows that myopia and posterior staphyloma are almost synonymous terms, and it is evident that the *myopic eye is essentially a diseased eye*, more so than any other error of refraction. The invention of the ophthalmoscope places in our hands the means of observing the changes taking place in the fundus of the eye upon which the production of myopia depends, and of noting the progress of the morbid processes.

The extension of the globe of the eye is at the expense of the sclerotic coat, which grows thinner and thinner, until in high degrees of myopia it becomes transparent, and sometimes when the eye is turned inward, the dark pigment of the choroid becomes visible through it. As the property of the dense and firm sclerotic coat is to give the eye its form and to support its interior structure, it naturally follows if this protecting coat be stretched at any part, the contents of the eyeball lying adjacent to this will suffer a corresponding change in position.

Thus it happens that the choroid coat also becomes extended and atrophied, particularly on the outside of the optic disk, as well as in the region of the yellow spot.

**THE MYOPIC CRESCENT.**

The choroid attains its greatest thinness around the outer edge of the optic disk, where it forms a white, shining concentric disk, resembling a meniscus in shape. The dark pigment cells are obliterated, the small capillary blood-vessels no longer carry the red blood, and there remains the marble-white, crescent-shaped patch of atrophy. If the distension extends entirely around the disk, the atrophic portion becomes annular in shape.

The ophthalmoscope admits of careful observation of these changes. Some remains of pigment are often seen about the convex border of the crescent. Although the atrophy usually assumes the crescentric form, yet it may vary, some-
times forming a complete ring around the disc as already stated, or extending outward in an irregular patch. This increase in atrophic surface around the optic nerve enlarges the size of the normal blind spot.

The presence of the crescent just described depends largely upon the degree of myopia; in slight cases in young persons it may be entirely absent, but in cases of 6 D. and over in adult persons it is almost invariably present.

The position of the yellow spot may also be changed; it approaches the posterior pole of the eye-ball until the visual line almost corresponds with the optic axis. In very high degrees of the defect, it may even pass to the inside of the axis of the ball.

**Heredity.**

Myopia is regarded as an hereditary disease, and there is a universal popular impression that the defect is handed down from parent to child. When a myopic patient is questioned, he can usually name some other member of his family as being similarly affected, perhaps a parent or grandparent, an uncle or aunt, a brother or sister.

But there are many difficulties that stand in the way of a thorough investigation of hereditary influence, and perhaps all that can be claimed is that a predisposition to myopia is often transmitted to posterity, and not the disease itself. So that it may be regarded as an established fact that myopia rarely develops in an emmetropic eye, and never in a hypermetropic eye, without a predisposition to it derived from ancestors.

**Preventive Measures.**

Whatever an ounce of prevention may be to other members of the body, it certainly is worth many pounds of cure to the eye. This delicate organ will stand a great deal of use, and not a little abuse, but when once thrown off its balance, it very rarely can be brought back to its original perfection of action, and it becomes liable ever after to a return of disability of function.

On this account and from the fact that modern civilization has imposed upon the eye an ever-increasing amount of strain, one might suppose that the greatest precaution would
be observed to maintain the organ in a condition of health. And yet it is safe to say that there is no organ in the body, the welfare of which is so persistently neglected as the eye.

It is not uncommon, and certainly not improper, to have the first teeth of children four and five years of age filled instead of extracted; while the eye, the most intellectual, the most apprehensive, and the most discriminating of all our organs, receives scarcely a passing thought, much less an examination.

**How the Child Suffers.**

It seems never to occur to parents that the principal agent in acquiring an education is the eye. The child is placed in school without the slightest inquiry on the part of either parent or teacher as to whether it has the normal amount of sight, whether it be near-sighted or far-sighted, whether vision is clear or blurred, whether it sees with one eye or two eyes, or whether the act of vision is accomplished at the expense of an unnatural strain upon the nervous system.

It has been truthfully said, and cannot be repeated too often, that "a near-sighted eye is a sick eye," and it not infrequently happens that a near-sighted child is a sick child, the reason for which is as follows: a myopic boy is unable to successfully compete with his schoolmates in their usual games, for the reason that most of them lie beyond the range of his vision. Subjected to ridicule on the part of his companions for clumsiness and inaptitude, due to a defect of which neither he nor they are aware, he relinquishes in disgust one by one of the health-giving sports in which he can never hope to excel, and takes to books until reading becomes a passion.

Not only the abstraction from fresh air and exercise, but the very conditions under which the eyes are used, are detrimental to the general health. The book is brought nearer the eye, the head is bent upon the chest or over the table, till the shoulders become curved and the chest contracted, and normal respiration is interfered with.

Such a child cannot see clearly the features of his companions, his parents or his teachers, nor catch the ever-varying expression of the eye, or the subtle change in the muscles of the face, by which an idea is emphasized or a principle en-
forced. His sense of the beautiful in nature is hampered and curtailed. Earth, sea and sky make up for him a world different from that of his companions, and it is no wonder that his views of men and things are different also.

He judges of men and their intentions rather by the sound of the voice than the expression of the face, and is apt for that reason to be suspicious of strangers. In unfamiliar neighborhoods and with insufficient light, he is timid and cautious. With all this studiousness and devotion to books, the statement is made that near-sighted people, as a whole, are not any more intellectual than those who have normal eyes, because studiousness and intellectuality are not always convertible terms, as most people think they are.

Of course these remarks do not apply to those cases of myopia which have been corrected at the commencement of school life with the proper concave lenses, but to those other cases of the defect which exist among young and growing children and which, being neglected, gradually become worse as adult age is reached.

ORIGIN OF THE TERM MYOPIA.

In hypermetropia, as was demonstrated in the last chapter, the patient is able, by the use of the accommodation, to overcome the defect and maintain clear vision. But in myopia, on the contrary, the exercise of the accommodation would only make the eye more near-sighted; nor does the eye possess any other power of its own to correct this error of refraction, except that such a patient falls into the habit of half-closing the lids, or nipping them together. In this way the more circumferential rays are cut off and the central rays only are allowed to enter the eye, the lids thus forming a stenopagic apparatus to the improvement of the clearness of the image formed on the retina. This gives rise to the word myopia, which is derived from two Greek words, meaning to "contract or close the eye."
Diagram of a Myopic Eye, showing that the divergent rays which proceed from F. P. (the far point) are exactly focused upon the retina.

HOW DIVERGENT RAYS ARE FOCUSED IN MYOPIA.

When parallel rays pass through a convex lens, they are brought to a focus at a certain point on the other side of the lens, which is known as the principal focus of the lens. If divergent rays are made to pass through the same lens, the focus would be farther away; while in the case of convergent rays the focus would be nearer than the principal focus.

The statement has been made in this chapter that in myopia the rays meet in front of the retina, but it should be remembered that this refers only to parallel rays, or to convergent rays which focus still farther in front. The focus of divergent rays is farther back than parallel, thus approaching the retina, and if of the proper degree of divergence will meet on this membrane.

Now in nature there are no convergent rays of light; such rays exist only when made so artificially. Hence we are interested at the present time only in parallel and divergent rays, the two forms in which we find light to exist, the former proceeding from distant objects and meeting in front of the retina of the myopic eye; the latter issuing from objects near at hand and focusing on the retina as shown by the diagram.

There is in front of the myopic eye a certain space within which vision is clear and beyond which it becomes indistinct, the dividing line of which is marked by the far point, which varies with the degree of defect. The higher the grade of myopia the closer the far point, the lower the degree the more distant the far point. It follows from this that if any object can be brought close enough to be within the far point of any
myopic eye, it will be clearly seen. While if it is moved farther away so as to get beyond the far point, the rays begin to lose their divergence and focus in front of the retina and vision is no longer distinct. Thus it is seen that the myope is shut up in a little world of his own, the limits of which are determined by the distance of the far point.

In the correction of myopia, the concave lens that is prescribed causes the rays that pass through it to enter the eye divergently, thus throwing the focus back upon the retina, and restoring distant vision to normal clearness.

PREVALENCE OF MYOPIA AND ITS COMPARATIVE FREQUENCY IN DIFFERENT CLASSES OF SOCIETY.

Myopia is more common in the cities, and in those nations and among those classes of people, whose advanced civilization, and whose occupations require extended use of the eyes for close objects. It is not equally prevalent in all civilized countries, nor in all parts of the same country.

It is much less frequently found among persons brought up in rural districts, or among those who devote themselves to occupations requiring but little use of sharp vision for small objects. On the contrary it is among this class that hypermetropia prevails to a much greater extent.

VISION OF MYOPES.

It is not unusual to find in the slighter degrees of myopia, where the error of refraction is less than 2 D., that the patient himself is not conscious of its existence, until perhaps it is accidentally discovered when comparing distant vision with some emmetropic friend; or by trying on the concave glasses of some myopic friend, when it is found that everything is more clearly seen and objects are visible at greater distances.

With such a myopia the patient will be able to read fine print without convex glasses until he is probably fifty or fifty-five years of age. Thus the late appearance of presbyopia will tend to compensate for the diminished range of vision for distant objects. It is for these reasons that Donders gives his preference to the slightly myopic eye, because he argued
that the slight indistinctness with which distant objects are
seen in early life, is more than counterbalanced by the ability
to read and write at a later period of life without the use of
convex glasses.

In higher degrees of myopia if there is a fair amplitude of
accommodation present, the patient naturally falls into the
habit of bringing small objects close to the eyes, oftentimes
much nearer than there is any necessity for, and as it is in-
convenient to bring his book or work close to his eyes, he
bends the body so as to assume a stooping position, the more
so the higher the degree of defect.

The half-closed lids and the wrinkling of the skin of the
forehead, gives the features a peculiar expression, by which
the myope can often be recognized; and this habit, like many
others when once formed, is hard to abandon and is often kept
up even after the myopia has been entirely corrected by con-
cave glasses, and the necessity for using the lids as a stenopaic
apparatus no longer exists.

As has already been stated, objects situated beyond the
far point are seen in diffusion circles; while within this point
vision is just as good as in an emmetropic eye, or perhaps even
a little better. Inasmuch as small objects in order to be sharply
defined, must necessarily be held much closer in this defect
than normal, the visual angle under which they are seen is
proportionally larger; consequently the image formed on the
retina is of greater size, thus impressing more of the percipient
elements of the layer of rods and cones.

In addition to this the pupil is more dilated in myopia,
thus allowing additional light to enter the eye and enabling
the patient to see with less illumination. But while near vision
is possible with a feeble light, distant vision on the contrary
is improved by a brilliant illumination, because the strong
light contracts the pupil and thus diminishes the size of the
diffusion circles. For this reason the myope can see very
much better by looking through the pin-hole disk from the
trial case.

When the degree of myopia is greater than 6 D., there is
generally more or less disturbance of near vision in addition
to the impairment of distant vision, and this is not to be won-
dered at when the morbid changes that have taken place at the fundus of the eye are considered. Excessive use of the eyes in near vision produces a feeling of strain and they become painful; following which there appears redness of the conjunctiva and an increased flow of tears.

Musce voluntantes.

In all form of ametropia, but especially in myopia, complaints are often made of dark spots or floating bodies, which make their appearance in the field of vision and dance before the eyes, and which have received the name of muscae volitantes. The constant appearance of these floating specks is a source of considerable annoyance and alarm to myopes, not only from the way in which they engage the attention, but also from the fears which they excite.

They are variously described by different persons, and are most noticeable when the eyes are turned toward a white surface, such as a white-washed wall or ceiling, or a white cloud. They follow the movements of the eye, and are especially annoying during the act of reading as they float across the page. They do not, however, interfere with vision, as it is characteristic of them that they never cross the axis of vision, nor obscure or conceal the object looked at, but rather move about the lateral portions of the field.

There is no real opacity of the vitreous humor, and an examination by the ophthalmoscope fails to detect in these cases any floating opaque particles. They are caused by shadows thrown upon the retina by very minute particles in the vitreous body, perhaps the remains of embryonic tissues. They are more visible to myopic persons than to others, because of the greater length of the eye-ball, thus allowing a shadow of larger size to be cast upon the retina. The number of these spots may be increased by any condition which disturbs the balance of the circulation and thus alters the density of the fluids within the eye.

If not excessive in size or number, these spots may be regarded as more or less physiological and the effort must be made by the individual to ignore them. Patients often complain of the exaggerated and fantastic shapes they assume,
ascribing them to disorders of digestion and torpidity of the liver. But when they are abundant and increasing, they may indicate serious structural change, and should lead to a careful examination by a competent oculist.

Donders says: "I have seen instances in which anxiety about muscae volitantes amounted to true monomania, against which all reasoning and the most direct demonstrations were in vain."

Any marked increase in the size and number of these spots may be regarded as evidence of morbid changes taking place in the vitreous humor, and if they become so bad as to seriously disturb vision, an examination by the ophthalmoscope will generally reveal turbidity in this humor. Sometimes there are such subjective symptoms as sparks, luminous chains, flashes of light, brightly illuminated white or colored rings, which often appear in the field of vision; they are more noticeable in darkness than in daylight and are, of course, very alarming to the sufferer. Their appearance is an indication that some serious condition is impending in the fundus of the eye, and which may result in amblyopia. Even after the onset of these unpleasant symptoms, if great care is exercised in the use of the eyes and all excesses and irregularities of habits are avoided, vision may be preserved in a fairly good condition for a long time.

The myopic eye is more liable to be attacked by disease of its internal structures than is the emmetropic eye: as chorioiditis, which often leads on to hyalitis and inflammation of the vitreous, conditions which are serious and very much to be dreaded; hence the great importance of care in the use of such eyes, which require careful watching in order that complications may be early detected and receive skillful treatment.

DETERMINATION OF THE EXISTENCE OF MYOPIA.

The presence of myopia and its degree can be readily determined by the test letters of Snellen, which are hanging on the wall twenty feet away.

If the patient is able to read the No. 20 line there can be no myopia; if, however, he cannot see the letters on this line, but can perhaps barely distinguish some of the larger lines, a
weak convex lens is placed before the eyes; this at once blurs the vision and excludes hypermetropia. A convex lens is used as a matter of proper routine, even though the symptoms all indicate myopia, in order to escape the grievous error of mistaking hypermetropia for myopia, as has been frequently done, to the discredit of the optician and the suffering of the patient.

After this procedure the way is clear for the use of concave lenses; a weak one is first tried which instantly clears vision and enables more letters to be seen. A stronger one is used with the result of a still greater improvement; thus by a gradual increase in the power of the lenses the acuteness of vision is brought up to \( \frac{2}{5} \) clearly and sharply. This proves the existence of myopia, and the number of glasses will indicate the degree of the defect.

As soon as the vision is raised to \( \frac{2}{5} \), the optician must stop, because then he has measured the grade of the myopia. In this defect it is a not uncommon thing for glasses to be prescribed very much stronger than are really necessary. If the patient is not old, and the power of accommodation unimpaired, an increase in the strength of the glasses will allow the distant type to be seen equally well or, perhaps, even a little better.

When a concave lens is placed before a myopic eye of greater strength than is necessary to neutralize the defect, the eye is rendered hypermetropic and the ciliary muscle is called into action to overcome the diminishing effect of the minus lens, just as is the case in hypermetropia. This tension of the accommodation carries with it a contraction of the pupil (which in myopia is apt to be large), thus cutting of the peripheral rays and acting on the principle of the pin-hole disk, improves the distant vision. Hence there is a constant tendency for the glasses chosen in myopia to be stronger than are necessary, and such glasses at once begin to strain and irritate the eye.

This logically leads to the rule that is laid down in myopia, *that the very weakest glasses* with which the No. 20 line can be seen at twenty feet, are the proper ones to prescribe. In hypermetropia, it will be remembered, the strongest convex glasses which were accepted at twenty feet, were recom-
mended; in myopia, the weakest concave glasses. The reason is the same in both cases: to assist the accommodation or at least to avoid overtaxing it. The stronger the convex glasses the more support given to the ciliary muscle; the weaker the concave glasses the less tax upon this muscle.

**Diagnosis of Myopia.**

The diagnosis of myopia is not usually a difficult matter. Distant vision is below the standard, and is at once raised to normal by the proper concave lenses. The impairment of distant vision by itself is not an evidence of myopia, because this may be present in a great many other conditions. But when this diminished acuteness of vision instantly yields to the proper concave lenses, the proof is positive that the case is one of myopia and nothing else. In cases of impaired vision from other causes, the application of concave lenses will produce little if any improvement.

In the chapter on hypermetropia great stress was laid on the importance of distinguishing that defect from myopia, and the reader was warned that impaired distant vision and holding objects close to the eyes, did not necessarily indicate myopia, but might occur in hypermetropia. The skilled and wide-awake optician will hardly fall into this error, and yet it has happened quite often among mere spectacle sellers, and thus tends to bring discredit upon opticians as a class.

In any case of impaired vision where it is desired to measure the refraction by trial lenses, the invariable rule is to commence the test with convex lenses, and if they are accepted at all, the case is regarded as one of hypermetropia and concave lenses must not be tried. Perchance the latter were placed before the eye, they would most likely be accepted also; then the case would be obscured and the optician in a quandary—convex and concave lenses both accepted, which is correct?

But if the rule just mentioned be adhered to, the case is kept free from any such doubt. Then, if convex lenses are absolutely rejected, it is proper to try concaves, and if the latter raise the vision to normal, myopia must be the defect that is present.
MYOPIA AND AMBYLOPIA.

The term amblyopia usually signifies dimness of vision, and as this is the one prominent symptom of myopia, there is some danger that the two conditions may be confounded. In both cases the acuteness of vision is impaired, and there is the tendency to bring small objects very close to the eyes in order to get the benefit of the magnified retinal images.

Strictly speaking, amblyopia is only a symptom; it is a term used to express the defective vision from which the patient suffers, which is not dependent upon an error of refraction, but is due to functional disturbance or disease of some part of the visual apparatus, either the retina, the optic nerve or the brain. It is possible that this condition may exist without any evidences of it visible to the ophthalmoscope, although we usually expect to find some atrophy of the optic nerve.

This is not the place to give a detailed description of amblyopia, but we will simply mention some of the forms in which it occurs: congenital or acquired, temporary or permanent, and symmetrical or non-symmetrical. Amblyopia ex anopsia is due to lack of use of eyes; reflex amblyopia to irritations in some other part of the body; traumatic amblyopia to injury; uraemic amblyopia to kidney disease; tobacco and alcohol amblyopia to abuse of these agents; hysterical amblyopia, night-blindness, day-blindness, etc.

The one diagnostic feature of amblyopia by which the optician will be able to recognize it, is its inability to respond to any glass that may be placed before it, and the failure of the pin-hole disk to afford the slightest improvement in the acuteness of vision. By attention to these points myopia can always be readily distinguished from amblyopia.

NEAR VISION IS GOOD.

While in myopia the distant vision is very much impaired, at the same time the near vision is quite good, and the recognition of myopia is made possible by the existence of these two factors. If either one of them is missing it cannot be myopia; while if both are present there is little room for doubt.
There are very good reasons why close vision should be good in myopia. Such an eye by its refractive condition is adapted for near vision, the divergent rays of which are focused without any accommodative effort, and hence reading, writing and sewing may be done without any tax on the ciliary muscle. Then, too, on account of the excess of refractive power which such an eye possesses, there is a slight magnification of the image formed on the retina, and hence small print and fine stitches in sewing which might be intolerable to other eyes, are quite possible to the myope.

On account of this sharpness of proximate vision, near-sighted persons consider themselves fitted for occupations requiring good vision for small objects close at hand, as engraving, watch-making, etc., but if the occasion presents itself they should be warned that myopic eyes are usually sick eyes, and if their defect is of high degree they should be advised against the choice of these trying occupations, and recommended to others that do not require such contiguous use of the eyes.

How often do we see persons bending over their desks when writing, with their eyes very close to the paper or sometimes looking obliquely at it. This, in many cases, is only a habit, and may occur with emmetropes or with those only slightly myopic; but habits once former are hard to break, and gradually such changes take place in the eye that develop or increase the myopia, and the near-sight that was once a habit becomes a necessity.

If, at the commencement of these symptoms, the patient is advised of their serious tendency, and is instructed how to avoid the danger, by keeping the book at the proper distance, by holding the head erect and by frequently resting the eyes in looking for a few minutes at distant objects, the trouble can probably be nipped in the bud and the eye prevented from becoming myopic.

SO MANY PERSONS WEARING GLASSES.

The middle-aged individual of to-day is astonished as he walks along the streets at the great number of persons wearing glasses, and he is particularly struck by the large proportion
of spectacled children. He hears so many young people com-
plaining of their eyes, that he involuntarily remarks that things
must be different from the time when he was young, and that
children didn’t wear glasses then. There is no doubt that
diseases of the eye are on the increase, and our present school
system, with its increased demands upon the eyes and brains
of children far beyond the capacity of their years, can be justly
charged with a large part of the growing trouble.

The eye, like any other organ, or like any delicate instru-
ment, may be abused, and the bad effects of such abuse are
more noticeable during its growing period. The coats of the
eye-ball do not reach their full firmness and power of resistance
until about twenty years of age, the time when the rest of the
body approaches maturity. Consequently before this age, and
particularly between the ages of six and sixteen, during what
may be called the school years, the eye is liable to injury from
overwork. Thus is the causation of myopia in youth ac-
counted for, and if ever “an ounce of prevention is worth a
pound of cure,” it is in the attention that should be given to
the eyes of growing children.

After twenty years of age a good eye can be abused in
many ways by overwork without much danger of the produc-
tion of myopia, although a train of other evils may result.
One-fourth of the same application of the eye at the age of
ten, with its walls and structures soft and yielding, would
cause its posterior wall to give way and bring about myopia;
whereas when the eye is well hardened by full growth, a much
greater amount of eye application can be borne continuously
without the fear of causing the walls of the eye-ball to bulge
and injuriously changing the shape of the organ. Hence the
well-known fact that the danger of the production of myopia
by abuse of the eyes, is peculiar to youth and to its growing
state.

CAN MYOPIA BE CURED?

The question naturally arises, and it is one that is often
asked the optician, “Is there any cure for myopia?” The
answer to this is unfortunately always in the negative. It
would scarcely be reasonable to expect that the dense and firm
fibrous tissues forming the sclerotic coat of the eye, after
having been softened and extended and thinned out, could ever be returned to their normal condition and position, so that the weakened and yielding fibres would contract and regain their original tonicity, and thus restore the posterior part of the sclerotic to its primary form and thickness, and replace the retina again in the position where parallel rays of light would focus upon it when the eye is at rest. A little reflection will show that such a change is impossible.

But while myopia cannot be cured, much can be done to lessen its progress and alleviate its dangers. That by improved school hygiene, education of the laity, and careful and uniform correction of refractive errors, it is susceptible of material mitigation in a community, has been fully proven by the careful and painstaking investigations of many oculists in different cities.

**DOES AGE IMPROVE THE MYOPIC EYE?**

The popular notion that the degree of myopia grows less or is entirely neutralized with age, is far from correct. It is true that in slight degrees of myopia (as 2 D. or less), the inevitable senile changes which tend to diminish the refractive powers of the dioptric media, are sufficient for a time to neutralize the effect of the changed position of the retina, and enable such eyes to dispense with convex glasses for near vision until a very late period of life.

In addition to this the myope begins to notice that he does not hold his book so close as formerly, not because his myopia is growing less as might naturally be supposed, but because the presbyopic changes are stealing on and his eye is no exception to the rule.

In myopia the focus of rays is in front of the retina, partly because of excessive refraction and partly on account of the length of the eye-ball. Now as the person gets into middle age the over-refraction is reduced, and as a consequence the rays do not come to a focus so soon, which thus approaches the retina, the source of the rays of course remaining at the same distance. For similar reasons the object may be moved farther away and the rays will meet in focus at the original location. Therefore, as age creeps on, the myope increases
his reading distance, using his eyes with the same ease as before. Not because the myopia has undergone improvement, but on account of the recession of the near point due to the presence and progress of presbyopic changes. The actual myopia has not been diminished, as shown by the far point of distinct vision remaining at the same place, all the changes and apparent improvement having taken place in the position of the near point.

There is one change in the eye that accompanies age, that does seem to improve the vision of the myopic eye, and that depends on the size of the pupil. As years creep on the pupil contracts, sometimes almost to a pin point, thus cutting off some of the circles of diffusion which are so annoying to a myope when looking at a distance, and in this way clearing the vision by allowing only the central rays to pass, but without in any way influencing the degree of myopia.

**Effect of Holding the Book Farther Away.**

The attempt has been made to lessen the amount of myopia by requiring the patient to hold his book or keep his work at a greater distance, and thus after a few weeks' practice the myope is often able to read considerably farther off, and he thinks that his defect has diminished; but the experienced optician knows that he has been holding his book closer than is really necessary (as all myopes are apt to do), and that, furthermore, the degree of defect is measured by the far point instead of the near point, and that for any distance less than the former the accommodation is brought into action.

Suppose an emmetrope is accustomed to hold his book twelve inches from his eyes, and by the advice of some friend he tries to habituate himself to read at a distance of sixteen inches instead; he simply reads with less effort of accommodation.

So it is with a myope; if he increases the distance at which his book is ordinarily held, he simply sees with less exercise of accommodative power. No matter where the reading is held, the normal eye still remains emmetropic and the near-sighted eye is no less myopic, as evidenced by its far point being unchanged in position.
While this plan of treatment of holding the book at the greatest possible distance does not diminish the degree of the myopia, yet it is most timely advice for the myope to act upon, and it yields most excellent results in checking the progress of the organic changes taking place in the fundus of the eye. It lessens the amount of convergence needed, and thus removes a great part of the pressure of the lateral muscles on the ball, while the erect position of the head retards the flow of blood to the already congested tissues, and thus restrains the softening processes upon which the giving way of the scleral tissues mainly depend. Therefore, the myope should be instructed to cultivate the habit of keeping his book and work as far from his eye as possible.

**MYOPIA NOT DEPENDENT UPON CONVEXITY OF THE CORNEA.**

Formerly myopia was thought to be due to an excessive convexity of the cornea, and systematic efforts were made to lessen this by compression; but now since the defect is known to be dependent upon an extension of the posterior walls of the eye, it becomes apparent that such treatment is not only useless, but injurious, because the pressure might have a tendency to still further increase the elongation. Myopia then is incurable, and only the lower grades are neutralized (and that but partially) by the compensation of senile changes during the later years of life. As the eye then cannot be restored to a normal condition, the management must consist in endeavoring to arrest the progress of the abnormal changes, and at the same time to render vision easy and comfortable by neutralizing the error of refraction, as far as it can be done without injury to the eyes, and to increase the distance of the near point in order to diminish the excessive convergence and thus lessen the tension of the recti muscles, so as to remove their pressure from the ball.

**DISTANT VISION IMPAIRED.**

To all near-sighted persons distant objects appear as in a fog, which increases with the degree of defect until even close objects present blurred outlines. Where the myopia is but slight, there is so little inconvenience that the patient himself
may not be aware of his defect until contrasted with the sharper sight of some friend. On the other hand, a highly myopic person will be unable to distinguish the features of a person who is no farther away than three or four feet.

The first intimation that a child's eyes are growing defective comes in the form of a complaint that the blackboard in the school-room, which could be clearly seen last year, is now very much blurred when viewed from the same desk, and the teacher is requested to allow a change of seats, nearer to the board, in order that the letters and figures upon it may be visible to the pupil. A little questioning will develop the fact that the child cannot see faces across the street and cannot even recognize his own parents at a distance.

Now that attention has been called to the matter, it is noticed that in reading and studying at home the book is held much closer than formerly. If the parents themselves are myopic (as is not unlikely) they recognize the symptoms in their child as corresponding with their own myopic condition. Probably then the parent tests the child with his concave lenses, and if distant objects are brought out clearly a similar pair are purchased for the child.

But this is a very improper and injudicious thing for the parent to do, and it is a well-established rule that concave glasses should never be supplied to a child except after a most careful and thorough examination by some one especially skilled in this line. It is possible there may be no myopia at all, but only a condition simulating it, dependent upon a spasm of accommodation, and if concave glasses were given under such circumstances the eyes would suffer irreparable injury.

Such a case of spasm of the accommodation may present all the symptoms of myopia, so much so that even an expert refractionist may almost be misled. But if the symptoms are rightly interpreted and the condition early recognized, the danger of a confirmed defect may be averted. Whereas, if improperly managed, the defect which at first was only apparent becomes real and the vision gradually grows worse and worse.
SECOND SIGHT.

This term is applied to those cases occurring in persons of advanced years who have been using the regular convex lenses for the correction of their presbyopia, and who begin to find that their glasses are too strong; that they can read better with weaker ones, or perhaps with none at all. In other words, it is a return of reading vision late in life, and persons of advanced years are able to dispense with their customary convex lenses. But it should be remembered that this improvement in near vision is accompanied by a corresponding impairment of distant vision.

The explanation of this (seemingly mysterious) occurrence is as follows: Ordinarily in old age the crystalline lens has become harder and denser and flatter, thus crippling the act of accommodation and necessitating the use of convex glasses to supplement it. This is a physiological change which occurs in every eye without exception.

Now in certain cases the lens commences to imbibe fluid and to lose its dryness and hardness. This is accompanied by swelling of this humor, which is made possible by the elasticity of its capsule. Then, instead of being hard and flat, it is soft and swollen, and having become more convex it has increased its refracting and magnifying power. This is the first step in the formation of cataract, although for many months and even years the lens may retain its transparency, even though altered in shape and consistency. But sooner or later opaque streaks or spots begin to make their appearance in it, and gradually the whole lens loses its clearness, and when it has become entirely opaque the condition is known as cataract.

The statement has been made that when second sight makes its appearance before seventy, it foreshadows blindness from cataract in a comparatively short time—perhaps in six months, certainly within a few years.

When the privilege of second sight first makes its appearance in extreme old age, that is in persons of eighty years and upward, the pathological changes in the lens are not likely to progress very rapidly, and the eyes will probably last as long
as the patient does, because the debility of old age is apt to prove fatal before the opacity in the lens has made sufficient advance to restrict the sight.

Concave lenses, for a longer or shorter time, will improve the distant vision in these cases, just as in regular myopia, while reading may be possible without any glasses. But after a time, as the degeneration in the lens substance progresses, the passage of light to the retina is impeded and obstructed, and then vision becomes impaired both near and far, and glasses are no longer of any assistance.

**THE FAR POINT THE MEASURE OF THE MYOPIA.**

The distance of the far point represents very closely the grade of the myopia, and therefore in order to save time and to quickly determine the approximate glass required in any case of myopia under examination, without going through the process of trying a great many different numbers of glasses, a procedure both tedious to the patient and tiresome to the optician, the far point can be soon located and the extent of the defect at once becomes apparent.

The patient is requested to read small-sized print, not necessarily the finest on the reading card, but somewhat smaller than the letters on this page, while the card is slowly moved away to the farthest distance from the eyes at which the letters still remain legible. If the myopia be of high degree and the near point very close to the eyes, the very smallest print can be used. If ten inches is found by this means to be the far point, then 4 D. is the approximate measure of the myopia and a concave lens of that number is the proper correction, or nearly so.

In order to determine if such glass is the one that ought to be prescribed, it is placed before the eye of the patient, who is requested to look at the test-card, hanging twenty feet away, and read the lowest line he can make out; and then by trying alternately weak convex and weak concave lenses, placed before the original glass, the proper number is soon determined.

If the — 4 D. lens affords a vision of \( \frac{2}{3} \), a + .25 D. is placed before it, and if the No. 20 line still remains legible, then a + .50 D. is tried. If this dulls the vision quite notice-
ably, then the $-4\text{ D.}$ lens reduced by the $+0.25\text{ D.}$ would be the proper correction, and the prescription would be $-3.75\text{ D.}$, because the rule in myopia is to order the very weakest glass with which satisfactory vision is possible.

If, however, the $-4\text{ D.}$ lens does not raise the acuteness of vision to $\frac{20}{20}$, then a $-0.25\text{ D.}$ is placed before it; this improves vision slightly, but still it is not up to the normal standard. Then a $-0.50\text{ D.}$ is tried, and this brings out the

![Fig. 112](image)

No. 10 line clearly, every letter being sharp and distinct. This proves that the first lens is not quite sufficient to entirely correct the refractive error, and a higher number must be substituted, which we have found to be $-4.50\text{ D.}$

**EXPLANATION OF THE FAR POINT.**

The myopic eye is at rest when adjusted for its far point, just as an emmetropic eye is at rest when adjusted for infinite distance; the divergent rays from the far point in the first case, and the parallel rays from infinity in the second case, being
each focused on the retinae of their respective eyes without any effort of accommodation.

Now, when a concave lens of the proper focal distance is placed before the eye, the rays that pass through it from a distance will assume the same divergence as if they proceeded from the far point, and hence will be exactly focused upon the retina in the same way. Therefore, the parallel rays from a distance, after having been made artificially divergent, will afford distinct vision of the remote objects from which they proceed; just as in the case of the naturally divergent rays from a close point, which enable near objects to be clearly seen.

This will explain why a far point of ten inches indicates a myopia of 4 D., and why a concave lens of the latter strength will correct the defect, and is a beautiful illustration of the adaptation of the refractive properties of lenses to the correction of the errors of refraction of the human eye.

WHY MYOPIC EYES ARE REGARDED AS STRONG EYES.

There is a widely prevalent, popular notion that the eye of the myope is superior in strength to any other form of eyeball. Notwithstanding the statement that has already been made that such an eye is a diseased eye, there is some foundation for this idea to become fixed in the public mind, in that the myope, more readily than the emmetrope, can distinguish minute objects, in the examination of which he is able to bring them much closer to his eyes, just as an emmetrope would be compelled to place a magnifying glass before his eye for the same purpose.

This proximity increases the size of the image formed on the retina as well as the quantity of light reflected upon it, and as a consequence vision is made much more distinct. The dilated pupil, which is common in myopia, allows of a still further increase in the illumination.

If an optical student (who is emmetropic) desires to test for himself the supposed superiority of the myopic eye, he can make himself artificially near-sighted by placing before his eyes a convex lens; in this way an addition is made to the refractive power of the eye, parallel rays are brought to a focus in front of the retina, distant vision is very much blurred, and
even near vision is not entirely satisfactory. Such an experiment will tend to demonstrate the fact that the apparent superiority of the myopic eye is more fancied than real, except in slight degrees (2 D, or 3 D, or less).

In these latter cases it is not uncommon to find many persons who are utterly unconscious of any defect in their sight. Not having any special need for sharp distant vision, they walk along the streets without a suspicion that others can see better than themselves. Only a few moments ago the writer had an illustration of this fact in his own office: a lady had compound myopic astigmatism and a visual acuteness of only \( \frac{20}{60} \). Very naturally and properly we suggested glasses for constant wear and to improve distant vision. The lady indignantly repelled the suggestion, and going to the window she pulled aside the lace curtain and triumphantly exclaimed: "I don't need glasses for distant vision; I can see those numbers on the doors (they were very large), and if I was acquainted with those people I could recognize every one of them. My sight is all right; all I need is glasses for reading." Such a remark seemed ridiculous from a patient whose acuteness of vision was only \( \frac{20}{60} \), but she was so determined that it seemed useless to argue with her.

**Progressive Myopia.**

Myopia is a defect which does not decrease in degree; in fact, it even does not usually remain stationary, but its natural tendency is to increase. Such a condition is more than a simple error of refraction; it is really a disease, and one that is fraught with many dangers to the eye.

The optical characteristic of a myopic eye is that the position of the retina is behind the focus of parallel rays; its anatomical and pathological characteristic is that this departure of the retina from its normal condition is due to a distention of the eye-ball, caused by a giving way of the coats of the ball at the fundus. As the membranes thus become attenuated, their power of resistance is at the same time diminished; in the face of this fact it is hardly to be expected that the trouble would remain stationary, when all the conditions are favorable for its increase. As the distention grows the myopia progresses, dependent upon a real disease of the eye.
On account of the elongation of the myopic eye-ball in its antero-posterior diameter, resembling somewhat the shape of an egg, its very form causes it to suffer its greatest pressure backward. This fact, together with that mentioned above (thinning of the coats of the eye and diminished power of resistance), will account for the progressive tendency of myopia.

Of course, it can be easily understood that the higher the degree of myopia the more likely it is to assume the progressive form, even in more advanced years; while in youth almost every case of myopia shows a tendency to be progressive, and this is really the critical period for the myopic eye.

The term progressive myopia is reserved for those cases where the defect increases rapidly and is accompanied by symptoms of congestion and irritation, and does not apply to those cases where the progress of the defect is very slow and where the eye is free from all unpleasant symptoms.

**POSTERIOR STAPHYLOMA.**

The general acceptance of posterior staphyloma as the anatomical basis of myopia rests upon two factors:

1. Descriptions of myopic eyes after death.
2. Ophthalmoscopic examinations during life.

Myopic eyes of low or medium degrees (such as are usually acquired during school life) do not present this condition of posterior staphyloma, but it is always found in eyes having a myopia exceeding 10 D.

The axial diameter of a normal eye is about 23 mm., which is considerably increased by the presence of posterior staphyloma; of the recorded cases the shortest measured 27 mm. and the longest 32 mm. corresponding respectively to a myopia of 11 D. and of 20 D.

As the thinning of the walls of the eye in these cases usually extends forward, the transverse diameter is also, as a rule, greater than normal, ranging from 24½ mm. to 28 mm., as compared with 22 mm. to 23 mm., the normal measure.

The ophthalmoscopic appearances of posterior staphyloma are marked and unmistakable. The characteristic symptom is a white crescent at the edge of the optic disk, generally at the outer side. This crescent varies greatly in size, from a small
arc to a large zone, and may extend all around the disk, and even encroach on the region of the yellow spot, its greatest extent being always in this direction. Its edges may be sharply and distinctly defined, or may be irregular and gradually merge in the surrounding healthy structure.

There may be patches of pigment about the margin of the white crescent, or scattered over its surface. The crescent itself is of a brilliant white color, which makes the disk by contrast appear abnormally pink. On account of this whiteness of the background, the small blood-vessels that pass over it are rendered more visible and are more easily discerned than elsewhere on the retina. The whiteness is due to a thinning and an atrophy of the substance of the choroid, which, indeed, may be found entirely lacking at this spot, thus allowing the glistening sclerotic to come into view. Hence the white crescent is simply a portion of the sclerotic, which, for the reasons mentioned above, becomes abnormally visible.

On account of the wasting of the choroid there is an absence of the pigment cells, and this removal of the natural protection against excessive light gives rise to the sense of glare which such patients frequently complain of. As might be expected from this, the sight of these myopes is often much improved by a tinted glass, which, under the circumstances, is not only allowable but advisable.

DEGREE OF MYOPIA.

The writer has frequently asked the following question of his optical students, "Upon what does the degree of myopia depend?" and the almost invariable answer has been, "The distance of the far point." This shows an incorrect conception of the point involved. The location of the far point simply indicates or represents the amount of the myopia, which depends upon the distance of the focus of parallel rays in front of the retina. The nearer the focus is to this membrane the lower the degree of defect; the farther the focus is removed from it, the higher the grade of myopia.

This, distance of the focus cannot be directly estimated, but can be determined indirectly by measuring the excess of
refractive power. When the refraction of the eye exactly corresponds with the length of the optic axis, the condition is one of emmetropia; when the former exceeds the latter, the eye is known as a myopic one, and the concave lens that neutralizes the surplus will indicate the grade of myopia. Suppose a — 4 D. lens is required: this proves that there is a myopia of 4 D., and that there is an excess of refractive power of 4 D., which causes parallel rays to focus in front of the retina. The concave lens diminishes the refraction of the eye and gives to parallel rays sufficient divergence to throw their focus back upon the retina and thus afford clear vision.

**APPARENT OR ACCOMMODATIVE MYOPIA.**

The attention of the optician should be called to a condition of apparent or false myopia, which is not myopia at all, but is made to simulate it on account of a spasm of the accommodation, by means of which the refraction of the eye is increased and parallel rays are brought to a focus in front of the retina.

Ordinarily the ciliary muscle acts just sufficiently to focus divergent rays on the yellow spot and to adjust the eye for the every-day purposes of close vision. But this little muscle may fall into a condition of abnormal activity, known as spasm of the accommodation, where the muscle refuses to relax and continues indefinitely to keep the eye in a condition of over-refraction. This is the optical condition present in myopia, and gives rise to all the symptoms of this defect. This ciliary spasm may occur in emmetropia or more often in hypermetropia, as explained in the last chapter, where we gave warning of the danger of mistaking hypermetropia for myopia.

Spasm of the accommodation is of more frequent occurrence than is generally supposed, and in addition to the apparent myopia which it causes, also gives rise to marked symptoms of asthenopia during reading or close work. The pupil is contracted and the ophthalmoscope will show congestion of the optic disk and retina. When the vision of such a patient is tested with the trial lenses there will be noticeable variations in the appar-
cut refraction: sometimes he will prefer one glass, sometimes another. When the amplitude of accommodation is measured there will be quite a discrepancy between the position of the far point and the degree of apparent myopia. For instance, the location of the far point may be ten inches from the eye, which would lead to a suspicion of a myopia of 4 D. But when the acuteness of vision is taken, such an error would be at once discovered. The patient can read all the letters on the test card, and only a weak concave lens is required (perhaps — 1 D.) to raise the vision to the normal of 2/6. In this way the diagnosis between real myopia and apparent myopia due to spasm can often be made.

The fact should not be overlooked that spasm of the ciliary muscle may be dependent upon an insufficiency of the internal recti muscles. The excessive muscular effort required to maintain the necessary degree of convergence carries with it an extreme contraction of the ciliary. Just as in hypermetropia the extra accommodation causes an extra convergence which may result in convergent strabismus: in both instances produced by the close relation which naturally exists between the functions of accommodation and convergence. In these cases a pair of prisms, bases in, may assist in relaxing the ciliary spasm.

Spasm of accommodation is most apt to occur in nervous individuals, when the system is enfeebled or the nervous force exhausted; and, strange to say, the degree of spasm bears no relation to the vigor of the ciliary muscle. In fact, it is usually found in connection with a weakened accommodation, and instead of being an evidence of extra strength, must be regarded as an indication of nervous debility. This is proven by the fact that eyes exhausted by overwork are the ones that are subject to spasm, and the accompanying asthenopia tends to increase the spasmodic action.

The treatment of cases of spasm of accommodation will oftentimes tax the skill and ingenuity of the optician. One method of management consists in the use of convex lenses, a moderately strong pair for reading and a weak pair for distance. As is well known, the use of the convex lenses constantly and persistently encourages a relaxation of the spasm,
and the patient who was apparently near-sighted, is soon able to read the No. 20 line without the concave glasses that were formerly necessary.

Of course, the wearing of convex lenses in this way makes vision indistinct, and the patient is apt to rebel. Sometimes, with intelligent persons, if the rationale of the treatment is explained, their cooperation may be secured. But if not, the distance glasses may be dispensed with and reliance placed on the reading glasses, to which very few persons will object.

In some stubborn cases it may become necessary to invoke the services of a physician, and place the eyes under the influence of atropine, which may need to be continued for several weeks before the spasm is overcome and the ciliary muscle completely paralyzed. Then the exact condition of the refraction can be determined, and if hypermetropic, as it often is, the correcting convex glasses should be prescribed at once and the patient directed to wear them and become accustomed to them while the muscle is recovering from the effects of the drug.

**SYMPTOMS OF MYOPIA.**

The two principal symptoms are the impairment of distant vision and the improvement of close vision. The eyes are usually large, full and prominent, and the pupils dilated, although as age creeps on they gradually contract, thus diminishing the circles of diffusion and slightly improving vision. The young myope makes use of the same principle to assist vision by half-closing his lids, which habit indeed is so characteristic of this defect as to give occasion for its name, the word myopia originating from two Greek words, meaning “to close the eyes.”

On account of the impairment of distant vision, myopes are inclined to avoid out-door sports, and rather prefer indoor amusements, as reading, drawing, etc., which do not require good vision at a distance. But, unfortunately, such habits cause congestion of the eyes, and thus favor the increase of myopia. Of course, where the correcting glasses are worn early in life, the boy has his range of vision widened, and in this respect is placed on an equality with his com-
panions, and then he has the same desire as they to join in all their games.

In progressive forms of myopia the field of vision may be limited and besides show numerous blank spots, on account of patches of retinal atrophy.

In some cases of myopia there may be evidences of considerable irritation of the eyes, especially after using them by artificial light for any great length of time. The conjunctiva may be blood-shot and the lids red, while the patient complains of pain, sensitiveness to light, a feeling of eye-strain, eye-balls sore to the touch, and the annoying "muscae volitantes," which have already been described.

The symptoms of myopia that have been enumerated are both subjective and objective, the former depending on the visual sensations of the patient, and the latter on what the optician himself observes.

PREVENTION OF MYOPIA.

The importance of the prevention of myopia cannot be too forcibly impressed upon parents, teachers and school directors, in order that the conditions which cause it may be understood and removed. This is an age of prevention rather than cure. Everywhere efforts are made to prevent disease and all questions pertaining to hygiene and sanitary reform receive the closest study and attention. The prevention of small-pox, diphtheria, yellow fever, cholera and tuberculosis is enforced by law, and is facilitated by laboratory work with the microscope and test tube. This certainly shows the unselfish interest physicians manifest in the welfare of mankind, because it is evident that the existence of disease is more profitable to the medical profession than its absence; but the discovery of a prophylactic measure affords more satisfaction to a physician than a new method of cure.

The optical profession should measure up to the same standard, and should exhibit the same commendable spirit in developing measures of hygienic reform as it pertains to the eye, and in educating the public along the same lines. The scope of this book will not permit an extended reference to this subject or a complete description of the work that has
been and should be done in this field, but a brief mention of
some of the practical points bearing on the prevention of
myopia is at least necessary.

Consideration must be given to those conditions of school
life which tend to develop this defect; and the first thought
that arises is that children should not be sent to school unless
their general health is robust enough to endure the strain. In
addition, the refraction of the eye should be examined, as
well to detect any possible defect as to determine their capac-
ity for the work on which the child is just entering. The im-
portance of this latter procedure as a prophylactic measure
will commend itself at once to those interested in the welfare
of children's eyes.

LIGHTING OF SCHOOL ROOMS.

The school building should be lighted sufficiently and
properly, and should also be so constructed as to afford the
pupils all the advantages possible in the way of location, ven-
tilation, sanitary plumbing, pure and abundant water, etc. The light in the school room should be direct, and not re-
lected from the walls of adjoining buildings.

Light that is insufficient or ill-arranged is the most poten-
tial factor in the causation of myopia in the school room,
because such light compels a lessening of the distance between
the eye and the book when reading or writing, and therefore
the question of proper light becomes an all-important one.

The light should be sufficient in quantity, should come
from above the level of the eyes, and as far as possible, should
fall upon the desk from the left-hand side. This arrangement
of light could be best secured if the school rooms were of an
oblong shape, all the windows located in one of the long sides,
the desks placed in rows at right angles to this wall, and the scholars facing that end of the room which allows the light
to fall from the left. The windows should extend upward to
the ceiling, starting about four feet from the floor. The total
window surface should be one-fifth of the floor area, with the
panes as large as possible.

It would be better if the education of children could be
carried on entirely by daylight, but in cloudy weather, in the
afternoons of the short days in mid-winter, and in night schools, artificial illumination becomes a necessity. The usual naked gas jets are mentioned only to be condemned. The improved Welsbach burners afford an excellent light, and if properly placed over the children's heads and in sufficient numbers, would constitute a satisfactory method of artificial illumination. If electricity is available for introduction into the building, the incandescent light is perhaps the best substitute for daylight. It is capable of uniform distribution and concentration, and does not heat or vitiate the atmosphere. The lights should be ample in number, properly shaded and brought close enough to the desk to afford an abundant illumination.

SCHOOL DESKS AND SEATS.

In addition to the proper lighting of the school room, the question of the construction of desks and seats is one of no little importance, as it doubtless is partly responsible for the increasing percentage of myopia found in school children, and certainly improper seats and desks produce injurious results upon the health of the children, particularly affecting their lungs, abdominal organs, spine and figure.

A crooked and stooping posture cannot always be blamed upon the pupil, because for anatomical and physiological reasons it is impossible for a child to assume and maintain a good posture with unsuitable seats and desks. The faults may be enumerated as follows:

1. Improper backs or no backs.
2. Too great distance between seat and desk.
3. Disproportion between height of seat and of desk.
4. Unsuitable form and slope of desk.

This naturally leads to a brief mention of the essentials in proper school furniture. The seat must be of such height as to allow the feet to rest upon the floor, which is accomplished by adjustable seats and measuring the distance from the sole of the foot to the inner bend of the knee. The seat should be generously wide, slightly concave, but without any inclination, and its front edge about two inches under the edge of desk. Some authorities consider this overlapping of the
desk as unnecessary, claiming that the edge of desk and of seat should be on same plane.

The seats should have comfortable backs, corresponding in size to the height of pupil. They must not be too high.

![Diagram of a child sitting at a desk.]

Showing the improper position assumed by the pupil because the seat and desk is too low, and the edge of the desk is too far in front of the seat. The child is compelled to sit on the front of the seat, the body falls forward and finds support upon the elbows, which rest upon the desk. In writing, the left arm is used for support while the right hand is employed, which causes the vertebral column to be partially turned upon its long axis and the body to be placed in a distorted position. The head falls forward toward the work and turns to the right; this brings the face too near to the page, the left eye closer than the right. The normal relation between the plane of the face and the work is thus disturbed, while the abnormal near point adds greatly to the strain upon the accommodation and convergence.

coming only far enough to support the shoulders and leave the head free to assume the proper position. The top of the desk must be just high enough to allow the elbow to rest upon it without displacing the natural position of the shoulder.
In order to meet all the requirements, it is evident that the size of the desk and seat should correspond to the size of the pupil. But it is equally obvious that a desk rigidly constructed for all the pupils of a certain grade or a certain age,

would fall short of answering the purpose on account of extremes in size which may exist. Therefore it is not only necessary to have desks and seats of different sizes for the various grades, but they should also be easily adjustable to
meet the requirements of each pupil in that particular grade. After the seat and desk has been adapted to the length of the leg and height of body the adjustment must be fixed by a key which should be in the hands of the teacher, so as not to allow of any alteration by the pupil himself.

Inclination of Top of Desk.

The reasons given why the top of the desk should slope are so interesting and important from a physiological and hygienic standpoint for the benefit of adults as well as children, that the optician should not be lacking in the knowledge which is therein implied.

The eyes are moved in different directions by six muscles. The movements of the two eyes are associated, and only certain sets of muscles of both eyes can be brought into simultaneous action. For instance, we cannot turn one eye up and the other down, but we can only move both eyes at the same time in the same direction, either up or down. We can use both internal recti muscles in the act of convergence, but we cannot use the two external recti muscles and turn the eyes from parallelism to divergence. We can use the internal rectus muscle of one eye with the external rectus of the other, as when the eyes are turned to the right or left.

Of the various combinations of muscles, some can be comfortably kept in action for a length of time, others only for a few seconds. Thus it requires considerable effort to converge the eyes and look upward at the same time; while, on the other hand, we can converge and look downward with ease. If we want to see distinctly a line or a plane, instead of a point, a particular turning of both retinae is necessary for each position of the object. When this turning can be produced by a combination of muscles which can be effected with ease for a length of time, then we can look at the object steadily and comfortably.

Therefore the proper position of the book in reading does not depend on chance, but is a physiological necessity. If it is constantly disregarded the eyes become fatigued and a condition of asthenopia may intervene. This is the reason why it is so tiring to look at those pictures in a gallery which are
hung high on the wall, while the same number of pictures can be examined without fatigue if placed on easels below the level of the eyes. Likewise it is hurtful to the eyes to read while lying down, and if this pernicious habit is persisted in will sooner or later produce a painful and weak condition of the eyes.

Consequently, if we want to look for any length of time at any plane surface, as for instance, the page of a book, it is necessary to place it and hold it in such a position as to form an angle of about $45^\circ$ with the horizon, and then direct the axis of vision of our eyes downward at an equal angle of $45^\circ$, so that a right angle will be formed by their intersection; or in other words, that the visual axis may be perpendicular to the surface of the book. This is the ideal position for the book and eyes in reading, and if the reader will look around him he will see how many persons disregard these plainly proven propositions. For writing, the same inclination for the paper would be equally advantageous, but for obvious reasons this would scarcely be practicable, and for this purpose a less angle is recommended, usually about $20^\circ$. It is possible to have a desk so constructed that the inclination of its top might be changed by a simple mechanism.

It is obvious that a flat-top desk not only prevents the direction of the visual axis at that angle most favorable to the natural and easy movement of the eye-ball, but also encourages a stooping position with its attendant evils of close sight and gravitation of blood to the eyes.

The influence of school life upon the figure of the child and in the causation of curvature of the spine, as well as the disastrous effects that crooked and stooping positions at school may have upon the heart and lungs and abdominal organs, are important matters for serious consideration, but it is not in place to discuss them here, as they are beyond the scope of this work.

**BLACKBOARDS AND MAPS.**

Attention should also be given to the distance and location of blackboards, as an important factor in the hygiene of school vision. They should not be placed so far away from any scholar as to necessitate a strain in order to see the marks
upon their surfaces, but those pupils who have defective vision should be given front seats near the board. No blackboard should ever be placed between two windows, as the scholar could not see the writing upon it without subjecting his eyes to the irritating glare of light which enters the eye from an improper direction, while the board remains in shadow; but the light should be so arranged as to illuminate the board without causing its rays to be reflected in such a manner as to obscure the characters that are inscribed thereon.

Some authorities have recommended, as a desirable substitute, white surfaces with black crayons, on the presumption that black marks on a white background can be seen at a greater distance. But on the other hand, the reflection from a large extent of white surface is more apt to be annoying and irritating to the eye than is the same amount of black surface, and therefore we think the old form of blackboard and white crayon cannot be improved upon. For similar reasons, the writer has been using in his office for determining the acuteness of vision and measuring the refraction, a black card with white block letters upon it, and finds it very satisfactory.

THE TYPE OF TEXT-BOOKS.

The size and form of the type used in school books are of great importance from a hygienic standpoint. All authorities agree that the Latin letters are the best for all kinds of reading. The crooked zig-zag lines of the German letters are by common consent considered very trying to the eyes, and hence that form of letters should never be employed in text-books. It is altogether likely that this type, in connection with the studious habits of the German nation, are responsible for the larger percentage of myopia in that country, in speaking of which an author says, "it is certain that if Germany would absolve itself from nationalism sufficiently to declare an emancipation from its miserable type, there would be less myopia among its people."

The normal acutenity of vision is based upon the ability to distinguish letters which subtend an angle of five minutes, but it would be very unreasonable to expect the eyes to keep at a task for any great length of time which called forth their
utmost endeavor. This will become evident to any one who compares the strain and effort to read small (diamond) type, with the ease and comfort with which a larger type (long primer) is read, and the latter (the size in which this article is set) is the smallest which should be allowed in school books, or for that matter in any book intended for general reading.

The distance between the lines has much to do with the legibility of the page and with the ease with which it is read. When the lines are crowded as closely together as the type will permit, the page has a dark and unattractive appearance, and the labor of reading is relatively increased, as is evident to any one who will compare a closely set page of reading matter with one that is liberally leaded. The fact is, a proper spacing between the lines is really of more importance than the size and height of the letters, and the weight of opinion is that this space should not be less than two and a half millimeters, or one-tenth of an inch. The printing should be well done, so that the letters show up clear and distinct. If a large edition of a book is issued, those first run off are clearest, and later on the print begins to appear somewhat blurred and defective. As soon as this is noticeable the type (or electrotype which is generally used) should be rejected and new metal demanded.

The paper should be of good quality, as otherwise the beneficial effect of large type properly spaced would be neutralized. It should be reasonably thick and opaque, so that the impression of the type on the opposite side should not show through. The surface of the paper should be dulled, so that there may be no unpleasant reflection from it, and of a cream tint.

PROPER PENMANSHIP.

We do not propose to go very deeply into the consideration of the question of vertical or slanting handwriting, but some mention of it is due on account of the agitation of the subject at the present day. There appears to be a growing sentiment in favor of the erect system, because the slanting form seems to favor an unnatural position of the body and of the paper, and thus tend to the development of myopia. But if the desk and seat are of the proper proportions, and the pupil rightly seated with the paper in a central position in front of
him, the question of the selection of the kind of script is immaterial from the standpoint of the hygiene of vision, which is the only point in which we, as opticians, are interested.

**HOURS OF STUDY.**

Young children should not be expected to use their eyes more than a few hours each day; all their work should be done in the school room, and when they leave it their minds and bodies should be free from any set tasks. As the child increases in years and advances into the higher grades, some amount of study is necessary out of school, and it seems possible that more harm may be done to the eyes by indiscretion in the home work than in school hours. Children are usually under less discipline at home than at school; they are often allowed to read what, when and how they please; no provision is made for proper desks, seats or light; the child assumes various positions and often reads while reclining, with light that is perhaps insufficient or coming from a wrong direction.

As a rule, children are sent to school too early in life; in many instances because the mother wishes to be rid of the annoyance of the child for a few hours each day, and because the law allows it. Seven years of age is young enough for a child to enter school, although six years is the legal age; but really such an important matter cannot be regulated by statute, but should depend on the physical condition of each individual child.

**PREVENTIVE MEASURES.**

In the prevention of the development of myopia in children, the importance of giving to the child for his playthings objects of considerable size becomes evident. Small ones, books with fine print and games with minute figures, all impose a tax upon the accommodation and should be avoided. On the other hand, out-door plays should be encouraged, because they do not require any close vision, or at least all play objects should be sufficiently large not to require any effort of accommodation. After the child enters school he should not be required to keep his eyes uninterruptedly upon the book, as some teachers with mistaken zeal insist upon, under penalty of receiving a bad mark for misconduct, but he should rather
be encouraged to rest his eyes and relieve their fatigue by looking up from his books and glancing around at more distant objects.

Frequent interruption of any kind of confining work is essential to symmetrical development and the maintenance of a healthy condition of the body, and this is especially true of the young. If one attempts to hold up an object at arm’s length, and thus imposes a continued effort upon these muscles, a feeling of strain and exhaustion soon becomes apparent, and the act must be quickly discontinued; and yet the muscles of the eyes are often forced to do similar work: is it any wonder then that myopia results?

Myopia is seldom congenital, although it may be hereditary and appear soon after birth. It rarely develops, however, before the eighth year of life, more often the tenth, and reaches its maximum about the age of twenty. Where an inherited predisposition to myopia exists, the child should be kept out of the school room as long as possible; perhaps until he is ten or eleven years old. In the meantime, and in fact all through life, open-air sports should be encouraged, with gymnastic exercises for the development of the body and perhaps an intermixture of properly assigned manual labor.

The fact should be impressed upon the minds of parents and educators that it is better to devote the years of youth to laying the foundation of a healthy constitution and strong eyes than to encourage forced intellectual advancement at the expense of feeble health and impaired vision. The moral of this advice is emphasized by the country boy, raised upon the farm and receiving but few educational advantages, who so often outstrips his city cousin, whose life from four years of age has been spent in kindergartens and graded schools.

For those predisposed to myopia, mental education should be always subject to the physical condition, and earnest, systematic study should not be commenced until the sixteenth year, when the body is stronger and the coats of the eye firmer and better able to resist the encroachments of myopia. Even then it would be better if the child could be taught privately, instead of being placed in the general class and expected to keep pace with his normal-sighted companions.
MYOPIA.

In order to prevent the onset of myopia, or its increase, the stooping position and a close approximation of the book, which taxes both accommodation and convergence, must be avoided; the patient should be instructed never to read in a moving car or carriage, where the continual jarring requires a constant change in the accommodation; not to continue close vision too long at a time without suitable periods of intermission; to maintain a reading, writing or working distance of at least twelve inches, and more if possible; to select books and newspapers printed in clear, large type; to avoid fine sewing and tedious fancy work; to write a large hand (as myopes are especially prone to small writing); to see that daylight is sufficient in quantity and coming from the proper direction; not to use the eyes by artificial light, or as little as possible; and if symptoms of irritation become manifest, or there is a marked increase in the myopia, to give the eyes complete rest.

TESTS FOR MYOPIA.

In myopia the distant vision is impaired, while the close vision remains fairly good, and therefore if a person is unable to make out the large letters on the test card, hanging twenty feet distant, but can easily read the small print six or seven inches away, it is fair to presume he is myopic. This is a rough test, but it is one of value, and can be made at any time and under any circumstances and without any outfit. An ordinary newspaper can be made to suffice, the letters of the title line forming the distance test and the small type the near test. Of course, if with the impairment of distant sight near vision is also defective or impossible, there is something more than myopia; perhaps amblyopia, or some diseased condition.

The differential diagnosis between myopia (which is correctible with glasses) and an organic disease (which is beyond the reach of optical help) can be quickly made by means of the pin-hole test, which has been described and illustrated on pages in The Optician's Manual. The trial case contains one or two of these pin-hole disks, made of hard rubber and mounted in a metal ring with handle; but in the absence of a test case, a card or a stiff piece of paper can be punctured with a pin; an equally efficacious pin-hole test is at hand, and one
that can be made and used in any lonely cabin in the backwoods.

The principal tests for myopia are:
1. Trial case and test types.
2. Ophthalmoscope.
3. Retinoscope.
4. Refractometer, optometer, prisoptometer.
5. Scheiner’s method.
6. Chromatic test.

**TEST WITH TRIAL LENSES.**

The patient is seated facing the test card of Snellen, which is well illuminated and hanging twenty feet away. The trial frame is placed on his face and carefully adjusted for height of nose and pupillary distance. Both eyes should be kept open, but only one eye should be tested at a time, the other being excluded from vision by a solid rubber disk being placed in the trial frame over it.

The left eye being thus covered, the patient is asked to name the letters on the lowest line which is legible to him. If he reads the No. 20 line, that is if his visual acuteness is $\frac{20}{20}$, the eye is presumably emmetropic, although latent hypermetropia may be present. If he reads the line hesitatingly and makes some mistakes in naming the letters, there is probably some astigmatic element in the case. But either of the above conditions precludes the existence of myopia, which cannot be present if the vision is wholly or even partly $\frac{20}{20}$, because this defect markedly impairs the acuteness of vision.

If, however, the patient cannot distinguish any letters on the No. 20 line, and perhaps cannot even read the 30 or 40 lines, we may infer the possibility of myopia; but first in order to prevent error, convex glasses must be tried in order to detect any hypermetropia. If they are immediately and positively rejected, it is then proper to begin to suspect myopia, and we ask the patient to take the line near type (which a myope is easily able to read) and move it away from him to the greatest possible distance from the eye at which it can still be seen distinctly. The distance from the eye to the type
is then carefully measured, which, when converted into dioptries, will represent (at least approximately) the degree of myopia, and the corresponding concave lens will be the proper correction. This glass is placed in the trial frame in front of the eye and the distant vision is again tested. The strength of the lens is diminished or increased, if necessary, until the maximum acuity of vision is obtained, always remembering to give the preference to the weakest glass.

The other eye is then similarly tested, and when both eyes are corrected an effort should be made to reduce the strength of the glasses by placing weak convex lenses in front of them. If any glass above +.50 D. is thus accepted, the examiner's suspicions should be aroused as to the possible existence of spasm of accommodation. Otherwise the lenses may be considered as correct.

A recent book says: “Take in your hand a +.50 D. S. and a — .50 D. S., trying first one and then the other before the eye you are testing. Whichever lens gives the best vision, after a careful trial, will be an indication of what kind of lenses (convex or concave) the patient is going to need.”

Now we are compelled to take issue with the author of this work, as we cannot consider such a method of testing as proper. It is a well-known fact that a weak concave lens will be accepted for distance by almost any eye, even by emmetropic and hypermetropic eyes, and in slight degrees of the latter defect will be preferred to weak convex. Therefore when weak plus and minus lenses are tried alternately, the patient will most likely select the concave, or else he will be confused and will be unable to decide between them. The writer feels that he can make the positive statement that in such a method of testing the convex lens would never be chosen; this makes the test entirely one-sided and robs it of its value.

The advice given on these pages has always been to commence the test with convex lenses, and if they are accepted at all, not to confuse the patient or run the risk of error by trying concaves, and this advice is especially applicable in cases where the vision is \( \frac{20}{20} \) or nearly so. Where the vision is markedly below normal, the rule still holds good to begin the
examination with convex lenses, and only in case of their positive rejection is it proper to try concaves.

After these preliminaries, suppose — .50 D. lens quickly and unmistakably improves vision on the test card, it is probable the case is one of myopia and needs concave lenses. Then the — .50 D. is removed and a — .75 D. is substituted for it with a still greater improvement in vision, which possibly may now reach the normal standard of $\frac{3}{2}0$, in which case this lens would be the measure of the defect. If not, a — 1 D. is next tried, and as long as a further improvement in vision is obtained, the lenses are gradually increased in strength a .25 D. at a time until the best vision is secured that it is possible to get with concave spherical glasses, always remembering that the weakest glass is the one to be preferred.

This lens is then placed in the back groove of the trial frame and the rubber disk slipped in front of it, and a similar test made of the other eye. After the second eye has been carefully measured, the rubber disk is removed from before the first eye and the patient can see with his both eyes together, each properly corrected as far as can be with spherical lenses.

The frequent change of lenses in the trial frame is more or less confusing to the patient, and should be avoided as much as possible. Hence in high degrees of defect, instead of increasing .25 D. at a time, it is better to jump .50 D., or even 1 D., until something near the normal acuteness of vision is reached, and then proceed more cautiously and with shorter steps. When lenses are found that afford pretty fair vision,
instead of removing the lens and replacing it with another, its strength may be increased or decreased by holding before it alternately a \(-0.25\) D. and a \(+0.25\) D. If with the convex lens vision remains as good, then the concave lens in the frame is stronger than is necessary, and should be reduced a quarter of a dioptric. If on the other hand the \(-0.25\) D. produces a marked improvement in vision, then the lens in the frame is not quite strong enough, and should be replaced by one a quarter of a dioptric stronger.

**NORMAL VISION NOT ALWAYS POSSIBLE IN HIGH MYOPIA.**

If with the lenses found according to the above methods the patient, at twenty feet, can read the No. 20 line clearly and distinctly, it is right to assume that the full defect has been measured and the proper correcting lenses found. Even if the vision is less than \(\frac{2}{5}\), with these glasses it does not prove they are incorrect; it simply shows this is the best vision attainable with concave spherical lenses.

In high degrees of myopia it is an unfortunate fact that vision cannot be raised to normal by any glass, and this may perhaps be comforting knowledge to some conscientious opticians who have vainly endeavored to find some glass that would afford a vision of \(\frac{2}{5}\). There are two reasons for this—the impaired sensibility of the retina and the diminishing effect of concave lenses. Either one of these would be sufficient to account for the lessened vision, while the two together only serve to make it more pronounced.

In extreme cases of myopia there is great bulging of the fundus and stretching of all the coats of the eye, in which process the retina is the membrane that suffers the most, its layer of rods and cones being separated and fewer of them being impressed by the image formed, and therefore the degree of vision would be lessened. The function of a concave lens is to minify, and the diminution of an image by strong minus lenses is very marked, and hence such a glass, by reducing the image formed, would tend to impair the acuteness of vision very perceptibly. When these two causes act together and an image smaller than normal is received by a less number of rods and cones than natural, the wonder
really is that the vision is as susceptible of as much improve-
ment as it is.

TEST WITH OPHTHALMOSCOPE.

In emmetropia parallel rays are brought to a focus ex-
actly on the retina and, therefore inasmuch as the retina is
located precisely at the principal focus, the divergent rays
proceeding from it (after being acted on by the refracting
media of the eye) would emerge from the cornea parallel.

In myopia, on the other hand, the retina is placed beyond
the principal focus and parallel rays unite and cross over be-
fore reaching it. Under such conditions the rays proceeding
from the retina would emerge from the eye convergent and
would meet at this far point.

When looking into an emmetropic eye with an ophthal-
moscope, the observer must approach within two or three
inches in order to see the details of the fundus clearly. In
myopia, on the contrary, nothing can be clearly seen at such
a close distance with the naked eye, but on withdrawing the
instrument from fifteen to twenty inches, the optic disk and
blood-vessels will gradually come more or less clearly into
view.

In a case of myopia of 4 D. the rays reflected from the
retina would converge and meet at a distance of ten inches
from the eye and form there an inverted image, which can
be clearly seen by the optician, at his ordinary distance for
small objects (say from ten to twelve inches), by calling into
action his accommodation and adjusting his eye for that par-
ticular spot at which the aerial image is formed. In this case,
where the image is at ten inches and the observer's eye ten
inches from that, it will be found that a distance of twenty
inches will be the proper one to assume. The precaution
must be taken not to approach the image too close—that is,
the optician must always keep beyond his own near point, else
his accommodation will not suffice to afford him a distinct
view.

That this image is inverted is proven by the fact that
when the observer moves his head slightly from side to side
the image moves in the opposite direction, hence a contrary
movement of the image, when the ophthalmoscope is held
some little distance away, is one of the diagnostic tests for myopia.

Direct Method.—Inasmuch as the emergent rays from a myopic eye are convergent, it is evident that such converging rays cannot be focused upon the retina of an emmetropic observer, and hence an erect image of the myopic fundus is impossible without the aid of a concave lens to lessen their convergence.

The rule then in simple myopia is to ascertain the weakest concave lens that will render the fundus clear and distinct as being the approximate measure of the defect. After a few trials it is easy to decide which concave lens, rotated into the sight hole of the instrument, will afford the clearest image.

The accuracy of this method (the direct method of the ophthalmoscope) presumes the corneae of observer and patient to be in actual contact, but as that is impossible, the distance between them should be added to the focal length of the lens found as above.

For instance, by referring to the illustration (page 164) the rays are seen to cross ten inches from the myopic eye. Suppose the observer placed his eye one inch in front of it, then the position of the focus is nine inches back of his cornea, and therefore a — 4.50 D. lens in the aperture of the ophthalmoscope would render the rays parallel and allow them to be focused on his retina without any effort of accommodation. But as is evident from the illustration, this — 4.50 D. lens is more than the full measure of the defect: but by adding the distance between the eyes of patient and observer to the focal distance of the lens found as above, the result will be the exact measure of the myopia present in patient's eye (1 inch added to 9 inches = 10 inches focal distance, or a refractive power of — 4 D.; it being understood that an increase of distance represents less optical defect).

The rule then is that the weakest concave lens that renders the details of the fundus clear and distinct will be the extent of the myopia. Suppose when the optician looks into an eye through the aperture of his ophthalmoscope everything about the fundus appears blurred and indistinct; a convex lens is then rotated into the sight hole, with the effect of making it
worse; now the weakest concave lens is tried, and at once the fundus begins to look clearer; then another and another is used, until finally all the details of the eye-ground are brought out distinctly, and this lens will approximately represent the degree of the myopia. It should always be remembered that preference is to be given to weakest concave lens that renders the fundus distinct.

SELF-RELAXATION OF THE ACCOMMODATION.

In attempting to determine the amount of myopia by the direct method of the ophthalmoscope, the accommodation of both observer and patient is supposed to be at rest, and upon this fact rests the accuracy of this method. Otherwise a condition of false myopia is temporarily produced by the involuntary use of the ciliary muscle in either optician or patient, which would require a concave lens to enable the details of the fundus to be clearly seen. This is an error into which many beginners fall, thinking they have a case of myopia to deal with, because a concave lens brings out the blood-vessels and optic disk more sharply, whereas it may be emmetropic or even hypermetropia metamorphosed by the accommodation.

The patient's accommodation is encouraged to relax by the dark room, and by requesting him to direct his eyes to a distance, without however attempting to fix the vision on any particular object. But it is not so easy for the optician to relax his power of accommodation, because he is inclined, naturally, to look at the fundus of the patient's eye as at a near point; whereas it should be viewed as if at infinite distance with a relaxed ciliary muscle.

The faculty of placing the ciliary muscle at rest is one that can be acquired by the optician, in the practice of which the following exercises have been recommended as facilitating that end.

1. The optician directs his eyes toward the ceiling, and while in that position holds above them a sheet of white paper upon which there is a black ink spot. When he notices that the spot appears double, the paper and the eyes are to be slowly lowered and the endeavor made to keep the gaze directed into distance and the accommodation at rest, in which case the dot
MYOPIA.

will continue to appear double, even when it is below the level of the eyes. It is comparatively easy to get the double vision when the spot is high up over the eyes, but the difficulty increases as the object is lowered to the level of or below the eyes.

2. The finger or a pencil should be held ten or twelve inches in front of the face, and as long as the gaze is kept at a distance and the accommodation remains quiescent, the object will appear double.

3. While reading a book or card of fine print, held quite close to the eyes, the optician attempts to look through and beyond the book or card, as it were, when the lack of accommodation will cause the letters to run together and become blurred. At the same time the convergence can be felt to lessen and the eyes to assume a parallel condition.

By a frequent repetition of these exercises, the optician can learn to bring an object close to the eyes without bringing into play his accommodation or convergence, and with the accommodation thus under his control, he is in a position to obtain the most accurate results in the estimation of the amount of myopia by the direct method of the ophthalmoscope, which, however, should always be verified by the subjective examination.

INDIRECT METHOD OF OPHTHALMOSCOPE.

By the indirect method the eye is viewed at a distance of twelve to fifteen inches (usual reading distance) through a strong convex lens held at its focal distance from the patient's eye. An inverted image of the optic disk and blood-vessels is seen, which is sharper but smaller than by the direct method. In myopia this inverted image of the disk is smaller than in emmetropia, but increases in size as the strong convex lens is withdrawn from the patient's eye. While the indirect method gives a larger field, and thus favors a more rapid examination of the whole fundus, yet for determining the refraction of an eye the direct method is much to be preferred, and besides it is not so difficult for the beginner to learn.
TEST WITH RETINOSCOPE.

The essentials for the retinoscope test, with full instructions as to how it should be conducted, were described in the chapter on "Hypmetropia." When the shadow in the pupil moves in an opposite direction to the light on the face, the eye is known to be myopic (the plane mirror being used), and concave spherical lenses are placed in the trial frame until the weakest glass is found which reverses the movement of shadow and makes it travel in the same direction as the light on the face. This is the correcting lens at the distance at which the examination is conducted, to which must be added the lens representing that distance (— 1 D.).

Suppose, for example, the far point of the myopic eye is at ten inches, and if the eye was examined at a distance of twenty feet a concave lens of 4 D. would render the rays of light parallel and stop all retinal reflex. But as the examination is conducted at a distance of only one metre or forty inches, a lens of — 3 D. will be sufficient to halt the reflex; and, therefore, in estimating the total amount of myopia, 1 D. must be added.

TESTS WITH INSTRUMENTS.

Refractometer.—As the patient looks through this instrument at the test card, hanging fifteen or twenty feet away, any desired number of convex or concave lens can be placed before his eye by simply rotating a wheel on the side of the tube, which is marked in dioptries and fractions thereof, and numbered in red and white to distinguish between convex and concave. The revolving dial is first placed at the zero mark, so that no focus whatever, either spherical or cylindrical, may be before the eye at the time the test is begun. The patient is asked to name the lowest letters which are visible on the card. In myopia he will be able to see only the largest letters, or in high degrees none at all. As a matter of precaution, the wheel is turned toward convex lenses, which at once throws a deeper blur over the card and letters. Then the rotation is made toward concaves, with the effect of brightening and clearing the card, and the degree of myopia is estimated by reading the
graduation on the indicator after the focusing adjustment had been turned as far to the right as necessary to make the small letters clear and distinct, and then back a little, if possible, without casting a blur upon them. The most important point, and one to be kept constantly in mind when dealing with myopia, is to obtain the best vision with the instrument so adjusted that it registers the very smallest amount of defect, and to prescribe accordingly the weakest glass.

![The Refractometer](image)

*Optometer.*—This instrument consists of an adjustable stand supporting a horizontal rod, which has two movable slides for holding lenses, with a test card at the far end and an eye shield at the near end. To measure the amount of myopia, a concave lens of 8 D. is placed in the clip of the eye shield and a convex lens of the same strength placed in the slide and moved away from the eye. The patient looks at the small test card, and the point where the type appears brightest will indicate the proper correcting lens, as shown by the scale marked on the rod.
Prisoptometer.—This instrument contains a double prism, set in a large disk, which can be revolved from 0 to 180°, and which has the effect of doubling all objects which the patient looks at. The test object is a white circular disk hanging sixteen feet away, and if the person is emmetropic the two disks seen are just touching each other. If, however, there is an excess of refraction, as in myopia, the disks will overlap and then minus lenses must be placed in the holder of the instrument to separate them, and that lens which makes them merely in contact will be the measure of the myopia.

These three instruments are the ones in most common use for measuring the refraction of the eye. They are all based on scientific principles, but all act in a different way. Any one or all of them would prove valuable adjuncts to an optician's outfit, but they must always be considered as subordinate to the test case.

Scheiner's Test.

Two small perforations are made in a card close enough together so that rays passing through them will enter the pupil. The patient looks at a candle flame twenty feet away, which in emmetropia will appear single, because the two sets of rays passing through the two holes exactly meet upon the retina. In the elongated eye-ball of myopia the two sets of rays will have united and crossed before reaching the retina, and as these diverging sets of rays strike this membrane two images of the flame are formed. That concave lens placed behind the card which fuses the two images into one, will be the measure of the amount of myopia. In this defect the two images are homonymous in contrast with hypermetropia,
where the images are crossed. In order to determine which form is present, a red glass should be placed in front of one perforation, and if the flame on the same side is red the diplopia is homonymous and the case one of myopia.

**CHROMATIC TEST.**

This test depends upon chromatic aberration, or the unequal refraction of the different colored rays of which white light is composed. The red rays being the strongest, are turned least from their course, and the violet being the weakest, are deviated most. A cobalt lens is used for this test, because it suppresses all the intermediate colors and allows only the red and blue to pass. The blue rays being more strongly refracted, are brought to a sooner focus, and the red rays being least refracted to a later focus. In the myopic eye, where the retina is too far back, it approaches the position of the focus of red rays, whereas the blue rays have already met in focus and strike it in divergent rays. Hence when such an eye looks through such a lens at a lighted candle twenty feet away the flame will appear of a distinct red center with a blue border. This subject has been illustrated and explained in detail on pages 78, 79, 285, 286 and 287, of Volume I.

**TREATMENT OF MYOPIA.**

As the one thing of which the myopic patient will chiefly complain is poor vision so his single desire is to get glasses that will enable him to see well; consequently the treatment of myopia by the refracting optician, and, indeed, the principal remedial measure, even in the hands of the oculist, consists in the careful adaptation of the proper concave glasses for the correction of the anomaly. To afford good vision both for distance and reading, as well as to prevent unnecessary convergence, requires no little skill on the part of the optician. A myopic person should never be allowed to choose his own glasses, because he is apt to pick out those that are too strong and thus impose an extra tax upon his accommodation (which in this defect is weaker than normal), and this would tend to aggravate and increase the very defect which he is endeavoring to correct.
TREATMENT BY CONCAVE LENSES.

The first step in the adjustment of glasses for the correction of myopia is to ascertain the acuteness of vision, as shown by the lowest line the patient can read on a Snellen’s test card, hanging twenty feet away. One eye is to be tested at a time, and preferably the one that has the best vision, the other being covered with an opaque disk. If he can distinguish only the largest letter, the one that is marked 200, his visual acuteness equals \( \frac{200}{20} \). In high myopia even this large letter will not be legible, and then it becomes necessary to place the card at a closer distance or allow the patient to approach the card until the No. 200 letter becomes readable, and the distance at which it is first seen will represent the numerator of the fraction that is used to express the visual acuity. For instance, if he has to come as close as eight feet his vision would equal \( \frac{\frac{8}{20}}{20} \).

The patient is then asked to resume his seat at twenty feet from the card, and the test with concave lenses commences. The optician having satisfied himself that the case is one of myopia, places a weak concave lens before the eye and notices how much improvement in vision is afforded. Then a stronger and a stronger is tried, until that one is found that produces the greatest amount of vision, the preference invariably being given to the very weakest glass that accomplishes this result. It is always better in myopia to err on the side of giving a glass that is too weak than one too strong.

GLASSES IN LOW MYOPIA.

In the low grades of myopia as 2 D. or 2.50 D. or less, the glasses are necessary only to enable the patient to get a distinct view of distant objects. At school, to discern the blackboard; at church, to see the preacher; at the theatre, to view the actors; when out doors, to behold the scenery; or any occasion when it is desirable to see distinctly farther away than arm’s length; in a word, to comprehend the world and the beauties of nature and art as other people do; these are the purposes fulfilled by glasses in the slighter degrees of this defect. Of course, there are many persons, after having once
experienced the satisfaction of perfect distant vision afforded by the concave glasses, who are unwilling to do without them and get into the habit of wearing them more or less constantly even in doors and for close work.

But in these slighter degrees of the defect the use of glasses is entirely unnecessary for close vision, and not only so, but they even impose a strain upon the accommodation, and hence should be removed when engaged in reading or writing. The reason for this is obvious: In these cases vision is perfectly good out to the far point, which is situated at eighteen or twenty inches from the eyes, sufficiently removed to allow of good vision in the customary close use of the eyes; such being the case, there is no need for glasses, and especially as instead of improving vision they tend to impair by diminishing the size of the retinal image and calling into action the ciliary muscle. Their persistent use under these circumstances would favor an increase in the error of refraction, or might even give rise to the progressive form of myopia, which is always a source of anxiety to both optician and patient.

GLASSES IN HIGH MYOPIA.

While in the lower grades of myopia glasses may be regarded somewhat as a luxury, and their use a matter of indifference, in the higher degrees of the defect they become an actual necessity and cannot be safely dispensed with. In these cases they are needed not only to improve the distant vision, but also to increase the reading distance, and in addition they play an important part in harmonizing the accommodation and convergence and preventing an increase of the defect.

In the medium degrees of myopia (5 D. or less), where the patient is not old and the range of accommodation good, the full correction, as a general rule, may be allowed. But in the higher grades two pairs of glasses must be prescribed, because the glasses needed for the full correction are entirely too strong for close work and impose an unnecessary and unbearable tax upon the accommodation, and then the question naturally arises as to what is the proper strength of glass to adopt in each particular case?
Without glasses the myope is compelled to hold his book unnaturally close, which is not only very uncomfortable, but in addition proves a source of strain to the function of convergence. If he wears his full correction glasses, the lessening in the size of the retinal image by the strong concave lenses, and the impairments in the function of the retina due to the stretching which it has undergone, originate and encourage a desire to bring the object nearer to the eye in order to obtain a larger visual angle. In the first case there is tension of accommodation and convergence, the greatest strain being on the latter; in the second case there is a similar tension of both functions, but now the greater strain is upon the former. Between two evils, the proper plan is to choose the least, but a still better method is to avoid both of them if possible. In this case it might be difficult to decide which was the greater evil of the two—the strain upon the accommodation or upon the convergence, but the way is open by which both in a measure can be avoided.

RULE FOR DETERMINING THE READING GLASSES IN MYOPIA.

Instead of allowing the patient to read with his full correction glasses we select a pair which only partly neutralizes the error of refraction, or in other words those glasses which remove the far point to a convenient reading distance of twelve to fifteen inches. The rule may be expressed somewhat as follows: Subtract from the glasses which are the full measure of the myopia those glasses the focus of which represents the distance at which the patient desires to read or work.

As thirteen inches is regarded as a proper reading distance, and as a glass of +3 D. represents a distance of thirteen inches, therefore it is customary to subtract about 3 D. from the full measure of the defect in order to arrive at the correct glasses for close use. In some cases it may be desirable to subtract a little more and in some cases a little less, depending on the age, the amount of available accommodation and the distance at which the patient desires to use the glasses. This point can readily be determined by the trial of several numbers slightly weaker and slightly stronger than those indicated by the above rule, and the choice being given to that
one that affords the most satisfactory vision at the distance desired.

Finally, the glasses must be submitted to the test of actual experience, and the patient, after a few weeks' trial, will be able to say whether they are pleasant or unsatisfactory, whether the eyes are comfortable or whether symptoms of asthenopia have been provoked, and thus will be decided the question as to the suitableness of the glasses for continued wear or whether they should be changed for others of a different power. Sometimes no glasses can be found which render near vision entirely comfortable, and then it becomes necessary for the person to abandon all work or occupation requiring close use of the eyes.

In high myopia, if the person had not previously worn glasses it is inadvisable to prescribe the full correction at first, because such strong glasses are unpleasant and they are apt to disturb the relative association of accommodation and convergence. In these cases the better plan is to commence with weaker numbers and gradually increase their strength from time to time, as the eyes become accustomed to them, until finally the full correction can be worn for distance without producing unpleasant symptoms or injurious disturbances.

It is important that the patient, and still more so the optician, should have a clear idea of the purposes for which the reading glasses are prescribed in myopia. They are not intended so much to magnify the print or enable the person to see better (in fact, concave lenses necessarily minify objects seen through them) as to increase the distance at which reading can be accomplished to enable the person to read at the customary distance and thus relieve the strain upon the convergence. If the old habit of holding objects close to the eyes is still continued, then reading glasses are not only useless but positively harmful. Hence the importance of impressing upon the patient the necessity of keeping the book as far away as the glasses will allow.

There can be no fixed rules by which glasses should be adjusted in every case, but each must be treated upon its own merits. Many myopes wear their full correction constantly, both for near and distance, without suffering any inconveni-
ence and apparently without any injury to their eyes, while others can scarcely bear their correction for distance much less for reading.

While the writer was penning these lines a patient consulted him, thirty-five years of age and wearing — 6.50 D. glasses. Has worn these same glasses for twenty-three years, using them for all purposes, near and far, and without any difficulty. Recently has suffered from headache, which he attributes to an attack of la grippe, but his physician advised him to consult an oculist. On examination I was surprised to find a myopia of only 5 D. in R. E. and 4 D. in L. E. The remarkable point about this case is that his glasses should have been so comfortable for close work all these years, in spite of the fact that this defect was over-corrected (thus rendering his eyes really hypermetropic) and that he was approaching the time of life when a lessened accommodation would call for a weaker concave lens.

**Donders’ Advice.**

In discussing the importance of the proper selection of glasses in individual cases of myopia, Donders’ remarks are so apropos that they are worthy of reproduction on these pages, and especially as everything issuing from the mouth or pen of this gifted man is universally accepted as gospel truth by all seekers after optical knowledge, alike by oculists and opticians. He says: “The prescribing of spectacles for myopes is a matter of great importance. While emmetropic and hypermetropic eyes do not readily experience any injury from the use of unsuitable glasses, this may in myopes, particularly on account of the morbidly distended condition of the eye-ball and of the tendency to get worse, be very dangerous. There exists in general a dread of the use of too strong glasses. It is laid down as a rule: Rather too weak, or no glasses, than too strong. In this rule the necessary distinction is lost sight of. Too strong glasses make hypermetropic eyes myopic, and myopic eyes hypermetropic. The rule therefore cannot be equally true for both. In fact it is in general much less injurious to produce a certain degree of myopia than of hyper-
metropia, in which last particularly much is required of the accommodative power. The rule would therefore be more correctly stated thus: In hypermetropia we must beware of giving too weak; in myopia of giving too strong glasses; a rule the second part of which we should especially insist upon. But even by this little is gained. Not using glasses, or using too weak glasses, may also be injurious to myopes. All the circumstances must therefore be studied, which can exercise an influence on the choice of glasses. It is difficult to reduce these to definite rules."

**A PERSONAL EXPERIENCE WITH CONCAVE GLASSES.**

M. Sarcy, a well-known French critic, had congenital myopia, and in later life became temporarily blind. In one eye he suffered a retinal detachment, and in the other a cata-

ract. By means of an operation vision in the latter eye was restored and became better than ever. He relates an interesting bit of personal experience in the following words:

"I was born near-sighted: many physicians assert that persons are never born near-sighted, and only become so. Science may say what it pleases; I was born myopic. One day, prompted by a spirit of mischief, I got hold of the big silver spectacles which my father wore and clapped them on. Fifty years have passed since then, but the sensation I experienced is keen and thrilling to this day. I gave a cry of astonishment and joy. Up to that moment I had seen the leafy dome above me only as a thick green cloth, through which no ray of sunshine ever fell; now, oh wonder and delight! I saw that in this dome were many little brilliant chinks; that it was made of myriad separate and distinct leaves, through whose interstices the sunlight sifted, imparting to the greenery a thousand forms of light and shade. But what amazed me most, what enchanted me so that I cannot speak of it to this day without emotion, was that I saw suddenly, between the leaves and far, far away beyond them little glimpses of the bright, blue sky. I clapped my hands in ecstasy and was mad with astonishment and delight."
HOW MYOPIA DISTURBS THE NORMAL RELATION EXISTING BETWEEN ACCOMMODATION AND CONVERGENCE.

The far point of a myope is always situated at a finite distance, and is determined by the degree of the defect. A myope of 4 D. has a far point of ten inches, and can see at that distance without any effort of accommodation, but he must converge four meter angles in order to maintain binocular vision. Now, in the case of an emmetropic eye the accommodation and convergence are used in equal proportion, and hence a distance of ten inches would call for 4 D. of accommodation and four meter angles of convergence.

Therefore in myopia the convergence is necessarily used in excess of the accommodation, a condition just the reverse of hypermetropia where the accommodation is used in excess of the convergence. Nature will allow to a certain extent the use of one function in excess of the other as a result of nerve education, but she inflicts a penalty for this as shown by the frequency of "eye strain" under these conditions.

In myopia the fusion effort must be greater than in emmetropia, and the greater this effort the more the fatigue of the internal recti muscles; this fatigue leads to "insufficiency" of the muscles and thus matters are made worse. A myope requires more convergence of the visual lines because vision takes place so close to the eyes, and this is particularly difficult in this defect on account of the elongated shape of the eye-ball which impedes its movements. There may be no actual weakness of the internal recti muscles, but only apparently so on account of the excess of work they are called upon to perform.

DIVERGENT STRABISMUS.

In the previous chapter it was shown that hypermetropia was the direct cause of a majority of the cases of convergent squint. And as myopia is a condition of the eye exactly the reverse of hypermetropia, it will be found that many of the cases of divergent squint occur in connection with near-sightedness. The accommodation is used but little, while the convergence must be excessive, which latter continues until the eyes have reached the maximum state of convergence, and then the energy and tone of the internal recti muscles soon
become exhausted, and as it tires and gives way the eye turns outward. The power of accommodation still remains unimpaired, but the power of convergence is worn out, because the limit within which the two functions may vary has been overstepped.

As soon as the object is brought nearer than the extreme limit of convergence in binocular vision will permit, divergent strabismus necessarily takes place, and this may occur even if there be no actual insufficiency of the internal recti muscles, just as in hypermetropia there may be no actual weakness of the ciliary muscle; but simply that in each case the muscles have laid upon them work which is beyond their power to perform. While the convergent strabismus of hypermetropia usually makes its appearance in childhood, the divergent squint of myopia is rarely developed until a more advanced age, and is usually connected with the progressive form of the defect.

If the myopia develops slowly, the internal recti muscles may gradually increase in size and strength sufficiently to perform the excessive labor demanded of them, but usually there is a deficiency of power of one or both of these muscles to maintain the required convergence for any length of time, and especially if the progress of the myopia has been rapid. In such cases the internal recti muscles are too weak to resist the action of the external, and the eye rolls outward and double vision results. When once an insufficiency of the internal recti has manifested itself, the muscles do not readily regain their strength even after considerable periods of rest; they become less and less able to sustain prolonged action, until finally the insufficiency becomes so annoying that artificial assistance must be sought or binocular vision abandoned.

TREATMENT OF THE MUSCULAR INSUFFICIENCY ACCOMPANYING MYOPIA.

Insufficiency of the internal recti muscles is usually found in cases of myopia ranging from 4 D. to 7 D., and when it occurs the advice is at once gratuitously offered by all the friends to rest the eyes, which the patient is inclined to adopt because it affords temporary relief. If these muscles are not
strained, naturally they will cease to ache. But, as in the case of all other muscles, if they are not used they undergo loss of tone, and hence the more they are rested the less they will be able to work. Therefore the common prescription of rest is bad, unsound in principle and disastrous in practice. The writer has seen cases of this kind who could not use their eyes at all, where reading for only a minute brought on pain and lachrymation. Such persons being debarred from reading and almost every use of the eyes, have nothing to do but to dwell upon their own troubles, and they are constantly worried by the fear they will some day become blind.

The proper principle to adopt in the management of these cases is to train and strengthen the muscles by discreet use and by gymnastic exercises. The right lenses for reading are carefully chosen according to the directions already given, and then they must be accorded a patient trial to see how far or how long their use is practicable. By increasing the reading distance these glasses lessen the effort of convergence, which is thus made more nearly equal with the accommodation. If, however, this method fails to afford the desired relief it may become necessary to combine prisms.

In the slighter degrees of myopia, some authorities recommend that the glasses should be worn constantly, for the following reasons: In this way the eyes are practically made emmetropic; the accommodation is brought into action instead of allowing it to remain idle; there is no occasion to hold the book close, a habit which has much to do in the causation and aggravation of myopia. Priestley Smith says: "My present custom is to encourage rather than discourage, with proper limits, the use of the accommodation; in other words, to advise those who can to use the same glasses for reading and distance, and where this is impossible, by reason of weak accommodation, still to give reading glasses as strong as can be worn with comfort."

The full correction of the myopia restores the harmony between the functions of accommodation and convergence, a procedure which may be quite practical in young persons, but for this very reason in older patients it is not well borne. The habit of converging in excess of accommodation has become
so fixed for so many years, that it cannot even by practice be easily relaxed, and under such circumstances if the wearing of the glasses be insisted upon, they may become a cause of eye strain instead of a means for its removal.

For such persons, if the myopia be less than 5 D., the wearing of glasses for distance will be all that is necessary. As a matter of fact there are many persons with a myopia of 3 D. or less, who never use glasses at all; they are not inconvenienced by the partial indistinctness of distant vision, which is scarcely marked enough to prevent the recognition of ordinary-sized objects, while their near work can be accomplished at the usual distance without any strain upon the eye.

THE OTHER SIDE OF THE QUESTION.

Landolt's views are somewhat different from those given above; he says: "A myope must be prohibited from wearing a concave glass for any distance at which he can see clearly without accommodation. Correcting glasses have a very serious disadvantage for the myope, because they force him to make an effort of accommodation from which his ametropia grants him dispensation, and they deprive him of another advantage, i.e., of the larger size of the retinal images obtained by the naked eye, and which the glasses make smaller."

After all, each case must be managed on its own merits; on the one hand we must avoid an overtaxing of the accommodation by a too strong concave lens, and on the other hand we must prevent the strain of excessive convergence, because the stooping position of the head which accompanies it favors congestion and leads to increased intraocular pressure, and thus tends to the increase of the defect. With this view, the concave glasses that lengthen the reading distance to twelve or fifteen inches, play an important part in relieving eye strain and preventing increase of the myopia.

MUSCLE TESTS.

In order to determine the relative or absolute weakness of the internal recti muscles, a trial should be made to see what strength of prism they are able to overcome. For this purpose the patient looks at a lighted candle placed at a distance
of twenty feet. Then a weak prism is placed before one eye, base out, causing a momentary diplopia, which soon disappears. Now a similar prism is placed before the other eye, with a like result. This is repeated with increasing prisms until the double images of the candle flame can no longer be united into one by any muscular effort.

If it is found the muscles can thus overcome a pair of prisms of 12° each (making a total of 24°), they cannot be considered as deficient in strength, and the prismatic element will scarcely need to be added to the necessary concave lenses, the use of which alone may be all that is necessary to restore the normal relation between accommodation and convergence, and thus relieve all the eye symptoms. Such use of the eyes may be regarded as gymnastic exercise, to be stopped before it produces undue fatigue, and to be resumed at regular intervals. Sometimes there will be a good deal of pain at first, especially with nervous persons and those who have been trying the "rest" cure, but they must be encouraged to persevere notwithstanding.

If, however, the internal recti muscles cannot overcome the diplopia caused by a pair of prisms of 12°, bases out, they must then be regarded as absolutely weak, in which case it may become necessary to combine prisms in order to assist and strengthen them.

In cases of high myopia (that is, from 6 D. to 20 D.) the eyes are often saved the convergence effort at the expense of binocular vision; that is to say, the person uses only one eye for vision and the other squints outwardly. If such a condition has continued long enough to become a confirmed habit, it is scarcely worth while to attempt to correct it; in fact, it is an almost impossible task to restore binocular vision and cause the two eyes to work in harmony. In many of these cases it will be found on examination that one eye is used chiefly for reading and the other principally for distance, and to make the effort to disturb such an arrangement oftentimes does more harm than good, and here the optician must be content to give the proper glass to each eye for its own particular use.

In contrast with the 24° prism, which the eyes can overcome when placed base out, we find that not more than 6° or
8° can be borne when placed base in. This marked difference is owing to the fact that in the first case the internal recti muscles are brought into action, and in the second case the external, and that the former are so much stronger than the latter because they need to be used so much more.

When it comes to prisms being placed vertically, but very few persons can overcome more than 1° or 2°, because the superior and inferior recti muscles are relatively so much weaker than either the internal or external recti. The nomenclature of, and the tests for, the various muscular anomalies have been described in the chapter on “Method of Examination,” to which the reader is referred.

ABUSE OF THE EYES.

The eye, like any other organ of the body, and in the same manner as any delicate instrument, may become the subject of abuse, the bad effects of which are most noticeable during its growing period. The coats of the eye-ball do not reach their full measure of firmness and power of resistance until adult age, about the twentieth year of life, the time when the rest of the body arrives at maturity.

Consequently before this age, and particularly between the ages of six and sixteen, during what may be called the school years, the eye is liable to injury from overwork. This
results (as has been stated earlier in the chapter) in the production of myopia. After the twentieth year of life the eyes may be abused in many ways by overwork and insufficient or improper light without much danger of causing myopia. One-fourth of the same application of the eyes at the age of ten, with its coats and contents soft and yielding, would cause the posterior wall to give way and bulge and bring about the defect of myopia. Whereas when the eye is well hardened by full growth a much greater amount of eye application can be borne continuously without the fear of causing the walls of the eye to stretch and injuriously changing the shape of the organ. Hence the fact obtains that the danger of the production of myopia by abuse of the eyes is peculiar to youth and to its growing state.

We sometimes meet persons having a slight degree of myopia who are so little inconvenienced by it that they are not conscious of being near-sighted: in fact, consider their vision as up to the normal standard. The existence of the defect may be accidentally discovered by contrast with the sharper sight of some friend, or by casually trying on a pair of concave glasses which happened to be in their way, and which brightened up distant vision to such an extent as they never before believed possible.

Others may complain of their near-sightedness, calling attention only to the fact that they are compelled to hold their book very close, but never making mention of their inability to see distant objects.

**CORRECTION OF MYOPIA.**

The correction of myopia is by means of concave lenses properly adapted, and the manner in which they act can be readily understood. It will be remembered that in this defect parallel rays of light meet in front of the retina; if now the focus can be thrown back just far enough to correspond exactly to the location of the retina, then and only then does clear distant vision become possible. This is accomplished by means of concave lenses, which spread the rays of light and cause them to enter the eye divergently, and then (the refractive power of the eye remaining the same) thy will not meet
in focus so soon as the parallel rays; this is equivalent to throwing the focus farther back, and if the concave lens corresponds with the degree of myopia the focus will be exactly upon the retinal surface.

PRACTICAL POINTS.

In myopia, up to a certain degree, there is usually no disturbance of close vision, but when it exceeds 5 D. then there is apt to be some trouble in reading.

In the higher degrees there is no distinct vision beyond a few inches from the eyes, and consequently as such a myope cannot fix objects, his eyes assume a peculiar far-away look.

In the slighter degrees the only inconvenience suffered is a limitation of distant vision, so that if the person does not wish to wear glasses no very great harm is done, only the loss of pleasure of seeing the world quite as distinctly as other people see it. The reading limit is not interfered with, as the measure of the myopia (say 2 D.) indicates that the person is able to read as far away as twenty inches, and therefore in these cases there is no occasion to hold the book close, but it may be kept at the usual reading distance where there is no very great demand made upon either the accommodation or convergence. But it is just in this class of cases that the precaution should be taken to guard against any inclination to hold the book too close or to read by any kind of insufficient light on account of the imminent danger of increasing the myopia by these means.

Floating specks before the eyes, sparks, flashes of light, white or colored rings, are not uncommon in this defect, and they are apt to cause the patient a great deal of uneasiness; but they are not usually of any special pathological import.

BENJAMIN FRANKLIN, THE ORIGINAL BIFOCAL MAN.

In myopia the effects of presbyopia are not felt at the usual time, perhaps not until the age of fifty-five or sixty; but when it does manifest itself, there is the double inconvenience of needing glasses for both distance and reading. This annoyance would be felt by clergymen, lecturers, and others who might desire to look at the book in their hand one moment, and then to look at the audience, some of whom might be at
a distance of fifty feet or more. This was the case of Benjamin Franklin, and as he was a very busy man and could not afford to waste so much time as might be required to constantly change his glasses if he wore separate pairs for reading and distance, he had made to his order a pair of spectacles which contained in the one frame both pairs of glasses, known as divided or double focus spectacles, and he was the first to wear this form of spectacles, which are so common at the present day.

The eyes should be examined at intervals, perhaps once a year, to determine the degree of myopia, so that if there is any tendency to an increase of the defect, it may be at once detected. Spectacles should be worn for distance, or for distance and reading as may be indicated, with the proviso that the book be kept well away from the eyes, not allowing it to get any nearer than eighteen inches, except in aggravated cases where such a reading distance is impossible even with the most suitable lenses.

**STRAIN ON THE ACCOMMODATION.**

When a near-sighted person is given a pair of concave lenses of sufficient strength to completely correct his defect, the eyes are thereby rendered emmetropic, and when reading is attempted with these glasses the accommodation is called upon for the same amount of effort as in a normal eye. But as has already been stated the accommodation in myopic eyes is always feeble, the more so the higher the degree of defect, and hence it is not equal to the task; so that to ask such a person to read through concave glasses of full correction is to expect an impossibility; or else it is accomplished at the expense of a great strain upon the accommodation, which is lessened if the book be held at an inconveniently great distance from the eyes.

There is one thing about concave glasses of which patients frequently complain, and that is they make everything seem smaller. This is partly real and partly comparative. Concave lenses have the property of making objects smaller just as convex lenses magnify them. But besides this, to the uncorrected myopic eye on account of its increased refractive power
objects appear larger than they really are and their outlines imperfect; concave lenses concentrate the sight, make the outlines of objects distinct, and in contrast with the former vision, smaller.

**Surgical Treatment of Myopia.**

This chapter would be incomplete without some reference to the surgical treatment of myopia, that is, the removal of the crystalline lens for the purpose of reducing the excessive refraction. It cannot be denied that in theory this method of treatment is most excellent, and forms an ideal way of neutralizing the defect. While it is sound in theory and feasible in practice, and attractive to the ophthalmic surgeon who is making a brilliant reputation by skillful operations, yet when it is considered entirely from the patient's standpoint it will scarcely become a popular procedure.

Unlike a strabismus operation which does not open the cavity of the eye-ball, the removal of the crystalline lens is a most serious matter and violently disturbs the normal condition of the organ of vision. The parts most affected are the ciliary region and adjoining portions, a region which is particularly liable to inflammatory reaction after injury or operation. This is shown in the history of cataract operations, where an occasional eye will go wrong without any apparent cause and in spite of every precaution being taken to avoid such a calamity.

A case of myopia and one of cataract have no points in common. The latter has practically lost his sight and there is only one means by which it can be restored, and hence while he has everything to gain by an operation, he has nothing to lose in case it is unsuccessful, as he is a blind man in either case. In myopia on the other hand, even in the highest degrees of defect, a fair amount of vision is always obtainable by means of properly adjusted glasses, which might be entirely lost by the failure of the operation. Besides, there is some risk that the operation might give rise to detachment of the retina, and the possibility of such a disastrous sequence might well make the boldest surgeon hesitate.

Many hundreds of cases of removal of a normal crystalline lens for the relief of high myopia have been reported in
Europe, particularly in Germany. But so far this country has furnished very few such cases, and in view of the readiness of our surgeons to take up new operations, this certainly speaks well for their conservatism. Perhaps an additional reason may be found in the fact that we have given more attention to the correction of extreme myopia by lenses than is the case abroad.

The writer neither commends nor condemns this operation, nor do we think our readers should ever assume the responsibility of advising for or against it, but such grave cases should rather be referred to the ophthalmic surgeon for advice and such treatment as he may deem necessary. At the same time we feel the optician should be kept advised of the latest knowledge on this subject and of the optical principles involved.

DEGREE OF MYOPIA CALLING FOR OPERATION.

The first thought that arises in the consideration of this subject is as to the amount of myopia that would suggest the advisability of removing the crystalline lens. Some operators would place the limit at 10 D., others at 14 D., while still others would extend it to 16 D. Of course the higher the degree, the greater might be considered the need for the operation. It seems reasonable to place the lower limit at about 14 D., because the reduction in the amount of myopia by the extraction of the lens, while it varies in different eyes, will scarcely be less than 14 D. and may extend to 20 D. Therefore, in a case of 10 D. the removal of the crystalline lens would leave the patient markedly hypermetropic, so that there would scarcely be any advantage in its removal, unless possibly in the hope of preventing an increase in the defect, if the same seemed imminent. But it is an error to suppose that every case of myopia of 8 D. or 10 D. is progressive, or that there is danger of approaching blindness.

THE REFRACTION OF APHAKIC EYES.

This leads to a consideration of the changes brought about in the refraction of an eye by the loss of its crystalline lens, concerning which there has been much misunderstanding and many misstatements in the current literature of the
subject. In the ordinary cases of aphakia after cataract operation, the previously emmetropic eye calls for a lens of about +10 D., from which it might be inferred that the extraction of the crystalline lens in myopia would lessen the defect by about 10 D. But a clear understanding of the optical principles involved shows that it does more than this, which is also corroborated by experience.

A +10 D. cataract lens, placed as it usually is about half-inch in front of the eye, would be equal to about 16 D. of refractive power of a crystalline lens in its place. This fact is in accord with the principles of optics, and partly accounts for the wonderful refractive changes which aphakia produces in high degrees of myopia. But the arguments in favor of this operation rest not alone upon a neutralization of the myopia or a reduction in the strength of the concave lenses, but also upon the probability of checking an increasing myopia and the retino-choroiditis that accompanies it. In this direction the operation promises much, not in the positive improvement of every eye any more than every cataract operation can be guaranteed to be successful, but a satisfactory result in a fairly good proportion of cases.

AGE FOR OPERATION.

When the operation is performed on cases between the ages of ten and twenty-five years the best results are attained. Under ten years of age it is rare to find myopia sufficiently high to justify an operation, while in those older than twenty-five the myopia has ceased to progress, or else the changes at the fundus are such as to contra-indicate an operation. This latter is really an important factor; a very careful ophthalmoscopic examination must be made to determine the amount of retinal and choroidal change, on which will depend the benefit that can be expected and by which the surgeon will be guided in arriving at a conclusion as to the advisability of the procedure. The limit of age has been placed as high as fifty years, but the fact is that patients past thirty years of age will rarely submit to an operation, because they have become accustomed to their condition and their vision does not grow any worse.
SHOULD BOTH EYES BE OPERATED ON?

This is a question about which there is a good deal of difference of opinion. The truth is that if one eye was fairly good the operation would be scarcely justifiable, and it would only be resorted to in case both eyes were equally bad, in which case it would seem as if the binocular operation was proper.

DONDER'S WORDS.

In this connection it is interesting to read the words of Donders, uttered forty years ago. He says, "When in a case of highly myopic structure of an eye, a lens affected with cataract has been successfully extracted and a nearly emmetropic condition has been obtained, the operator has been exposed to the temptation of endeavoring, by the abstraction of a normal lens, to remove the myopia. A patient who was an amateur in dioptrics endeavored to induce me to perform this operation.

"But I need not say that such a momentous undertaking, doubly dangerous where a myopic and a transparent lens are concerned, without that, even in the most favorable cases, any real advantage is to be expected, would exhibit culpable rashness. Not only would the staphyloma posticum continue equally threatening, but we should also have sacrificed the accommodation—an advantage which that of somewhat larger images than would be obtainable by neutralizing glasses, could by no means counterbalance."

RESULTS OF THE OPERATION.

The amount of vision to be obtained by an operation will depend upon the fundus changes, modified by the surgeon's skill in performing his work. Cases have been reported where it was impossible by any glasses to raise the vision to \( \frac{20}{200} \), or in other words to enable the patient to see even the largest letter on the test card at a distance of twenty feet, where a vision of \( \frac{2}{3} \) was secured after the extraction of the crystalline lens. This is certainly a remarkable result, which cannot be accounted for by a simple reduction in the amount of myopia;
but there are in addition three factors that enter into the question:

First, the size of the retinal image is increased. This varies with the amount of ametropia remaining after the operation, it being one and a half times larger when the aphakic condition is emmetropic.

Second, the retinal illumination is greater. In a highly myopic eye the strong concave lens that is required diverges or scatters the rays of light, and hence fewer of them can enter the eye than in emmetropic aphakia, where the rays would be nearly parallel.

Third, the dispersion of light is less. If a case of corrected myopia is compared with a case of emmetropic aphakia, it will be seen that there are at least five refracting surfaces in the former condition as against one in the latter, or against three in a case of aphakia that requires glasses; with the advantage in the latter case that the glasses required would be much weaker than the strong concave lenses used before the operation, and therefore there is less reflection and less aberration.

THE LOSS OF ACCOMMODATION AFTER OPERATION.

One of the points used against the advisability of the operation under consideration is that the increased acuteness of vision is nullified by the loss of accommodation, but a close consideration of this argument robs it of some of its strength. After the usual cataract extraction the glasses required for distance and reading may range from + 10 D. to + 20 D. Such strong glasses focus the rays of light upon the retina at a very acute angle, and hence a slight displacement of the object quickly throws the retinal image out of focus. On the other hand, in the elongated eye of myopic aphakia the rays reach the retina at a greatly reduced angle, which admits of considerable variation in the position of the object viewed without throwing it much out of focus.

Besides, even if lenses are required in myopic aphakia, they are of such low refractive power that they can be made up as bifocals, and if accurately prescribed and carefully adjusted, will prove of great convenience and secure for the patient the
brightest degree of vision which surgical skill has rendered possible.

**OPACITIES OF THE CORNEA.**

Opacities of the cornea, which have resulted from some preceding inflammation, may seriously impair the vision, and yet escape notice on a casual examination. Inasmuch as a clouded cornea lessens the visual acuteness and causes the patient to hold his book close to his eyes, thus simulating myopia, the optician who fits glasses for the correction of this defect should be on his guard, and must be able to exclude a defective cornea as a cause of the impaired vision. The transparency of the cornea is best determined by oblique illumination by a convex lens, as described and illustrated in the chapter on “Method of Examination.” It would be rather embarrassing for the optician, after putting the patient through a tedious and fruitless examination with the trial case, to learn that the so-called myopia was due to scars on the cornea, and hence could not be remedied by glasses.

**CAUTION IN PRESCRIBING CONCAVE LENSES FOR YOUNG PEOPLE.**

In the early part of the chapter reference was made to apparent or accommodative or false myopia, and the necessity for its recognition in order to avoid falling into the danger of giving concave glasses when myopia was not really present. Such a condition results from spasm of the accommodation, and is most apt to occur in youth; therefore, it is not always proper and safe to give concave glasses to all young persons indiscriminately, simply because their vision was improved by them. This is a truth that is universally recognized, as is evidenced by the following question taken from those given at the written examination for the diploma of the Worshipful Company of Spectacle Makers of England, November 1, 1898.

“Question No. 9.—A boy aged twelve has vision = \( \frac{6}{6} \), but with a concave lens of 1.25 D. he has vision \( \frac{6}{8} \). What tests would you employ to ascertain the nature of his defect?”

The answer, as prepared by the examiners in charge, is: “It is very unlikely that this is true myopia. I should test for astigmatism in the usual way, and also for hyperopia, by taking the place of the near point, and by these means ascertain the
real nature of the defect. It is almost certainly astigmatism, either myopic, or perhaps hyperopic.

The serious condition of an eye affected with high myopia and the responsibility involved in prescribing glasses in such cases is emphasized by the following question taken from the same examination:

“Question No. 11.—A youth aged twelve sees best with — 14 D. Would you give him this correction on your own responsibility? And if not, state your reasons.”

The answer prepared was: “On my own responsibility I would not give glasses in this case. I should look upon it as a diseased condition, and as one that is likely to increase seriously unless proper medical treatment be obtained.”

VALUE OF CONCAVE GLASSES.

Roosa says: “Gustavus Adolphus was near-sighted, and it is said that he lost his life at the battle of Lutzen because he had no correcting lenses and got among the soldiers of the enemy, thinking them to be his own.” One of the most successful Union generals of the late war, more fortunate than the great Swedish commander, was wise enough to recognize the fact that he was astigmatic, and ordered a pair of cylindrical glasses to be ground for himself, with which he said he was enabled to be a much better soldier than without them.

Yet a great many people—and by no means are they always unintelligent and uneducated—prefer to see as they have always done, “in a beautiful haze,” as one lady once described her short-sighted vision to me, than to be startled by seeing distant objects with distinctness. But there are myopic persons who appreciate the delight of seeing well. One of my New York patients, a full-grown woman, after her eyes had been fitted with a pair of concave cylinders, with which she probably saw clearly at a distance for the first time in her life, told me that after passing down Broadway she turned and walked up, because, to use her graphic language, “I have had seen the street before, although I was born very near it.”

“It has been said that the Jews have more myopia than other people. There seems to be no valid ground for this as-
sumption other than can be found in the fact that Jewish vocations the world over are usually those of shop-keepers, money-changers, etc., which necessitates close application to books and textures. In countries where the great mass of the inhabitants turn to open-air employments, and the Jew, naturally, gravitates toward commercial life, no surprise need be experienced if an examination of scholars shows a wide discrepancy in the development of myopia. Proof, however, fails to demonstrate the same variance where Jew and Christian are reared alike, and where inherited tendencies from one generation to another can be estimated upon a basis of similarity."

A CASE OF HIGH MYOPIA.

Mrs. E. S——. Aged thirty years. Complains that eyes pain her and she is compelled to hold everything so very close to her eyes in order to see. Has always been near-sighted, but never wore glasses. She is not able to see the test card across the room, much less any letters on it. — 18 D. lenses gave her the best vision, with which, however, she could read only the No. 70 line, and there was no other glass that enabled her to read any lower. But although an emmetrope would consider this very poor sight, yet it is so very, very much better than she has been able to see at any time in her life, that she thinks the glasses are splendid. According to the rule given in this chapter, we would deduct about 3 D. for the reading glasses, but a trial shows that — 14 D. gives her the best vision for close work. Hence — 18 D. was ordered for general wear and distant vision and — 14 D. for close use. Six weeks later her husband reported glasses as very satisfactory and couldn’t do without them.

There are two conclusions that can be pretty certainly drawn from this case, and the first is that if she had commenced to wear glasses in youth, as she should have done, a much weaker glass would have sufficed, and the defect would not have increased to such a serious degree. The second is that the failure of the present glasses to raise the visual acuteness to normal is due to a partial amblyopia, or a blunted sensibility of the retina, which in turn was caused by the circles of diffusion which have been formed on this membrane for the
past thirty years. Rays of light did not focus upon the retina naturally, nor were they made to do so artificially, and hence a focal point was unknown upon this membrane and clear vision had never been experienced, and as a consequence its impressibility was markedly lessened.

**MYOPIA IN RELATION TO EYE-STRAIN.**

There is no power an eye possesses that will overcome myopia or improve the defect in vision except by compressing the eye-ball slightly in squinting or half closing the lids; hence myopic persons are not subject to the muscular strain which hypermetropes constantly and unconsciously exert in order to be able to enjoy clear vision. As soon as the latter opens his lids the accommodation instinctively contracts, to prevent the diffusion circles that would otherwise be formed upon the retina; whereas in myopia these circles cannot be dissipated by any amount of muscular effort, a tension of the accommodation only serving to make them more pronounced.

Besides, a myopic eye can read and perform all the functions required of it, when book or paper is held sufficiently close to the eyes, with less accommodative effort than in a normal eye. In contrast with which the hypermetropic eye is called upon to exert an unnatural effort of accommodation even for distant vision, which is much intensified when engaged in close work; hence the fatigue, the blurring of letters upon a printed page, the watering of eyes, the pain in head and eyes, and the many other ills that have been described in the previous chapter.

Myopes can scarcely help being aware of some defect in their vision, because of their inability to see across the room distinctly or to recognize friends on the street. Thus they naturally gravitate to occupations where the work is brought close to the eyes, because they have no difficulty in seeing near objects. Near-sighted children are liable to be considered precocious beyond their years, because they prefer to read rather than to play out-of-doors. It is generally safe to conclude that a child is near-sighted when it avoids the usual
games of childhood in order to gratify a taste for reading and in-door amusements.

Myopia is less liable to cause nervous disturbances, except it leads to muscular insufficiency and asthenopia. And yet the number of myopes applying for relief is not small, because the defect of vision is so apparent and cannot be concealed by an effort of the eye, as in hypermetropia.

The writer can speak of myopia from a personal standpoint. When a student in the medical department of the University of Pennsylvania, his eyes were examined under atropine by Dr. Risley at the commencement of the course, twenty-four years ago, and were found slightly hypermetropic and weak convex glasses prescribed. The excessive demands upon the eyes in pursuing the prescribed studies resulted in asthenopia and a continued trouble with eyes all through the course, until at graduation in 1878 a myopia of 2 D. was found to be present, and Dr. Risley considered the case of sufficient interest and importance to make and publish a report of it, as illustrating the production of myopia. At that time this subject was being generally discussed, and examinations of school children were being made on large scale in this country and abroad in order to determine the exact relation between school life and study, and the causation of near-sightedness; and the writer's case formed an apt illustration, and was one among many which proved the dire effects of excessive application in causing an elongation of eye-ball.
APPENDIX.

Optical Symbols and Abbreviations.

Ac.......................... Accommodation.
Aet.......................... Age.
Am.......................... Ametropia.
An.......................... Anisometropia.
As.......................... Astigmatism.
Asth.......................... Asthenopia.
Ax.......................... Axis.
Cc. or — (minus).............. Concave.
Ce.......................... Centigrade.
Cm.......................... Centimeter.
Cx. or + (plus).............. Convex.
Cyl.......................... Cylinder.
D.......................... Diopter.
D. Cc.......................... Double Concave.
D. Cx.......................... Double Convex.
D. T.......................... Distance Test.
E. or Em.......................... Emmetropia.
H. or Hy.......................... Hypermetropia.
Hl.......................... Latent Hypermetropia.
Hm.......................... Manifest Hypermetropia.
Ht.......................... Total Hypermetropia.
In.......................... Inches.
L. or L. E.......................... Left Eye.
M. or My.......................... Myopia.
Mm.......................... Millimeter.
N.......................... Nasal.
Nv.......................... Naked Vision.
O. D. (Oculus Dexter)........ Right Eye.
O. S. (Oculus Sinister)........ Left Eye.
O. U. (Oculi Unati)........ Both Eyes.
P. or Pb.......................... Presbyopia.

199
P. Ce. Periscopic Concave.
P. Cx. Periscopic Convex.
P. D. Inter-Pupillary Distance.
Pl. Plano.
p. r. (Punctum Remotum) Far Point.
Pr. Prism.
R. or R. E. Right Eye.
R. T. Reading Test.
Rx. Prescription.
Sb. Strabismus.
S. or Sph. Spherical.
T. Temporal.
Ty. Type.
V. Vision.
W. P. Working Point.
+ Plus—Convex.
— Minus—Concave
⊙ Combined with.
L. At Right Angles.
° Degree.
Δ Prism-Diopter.
′ Foot and Minute.
″ Inch and Second.
‴ Line, the twelfth part of an inch.
= Equal to.
∞ Infinity, 20 feet or further.
The Shadow Test and Use of the Retinoscope

THIS NEW WORK ON SKIASCOPY far excels all previous treatises on the subject in comprehensiveness and practical value to the refractionist. It not only explains the shadow test in its practical application to the work of refraction, but expounds fully and explicitly the optical principles underlying it. In depth of research, wealth of illustration and scientific completeness this work is unique.

Bound in cloth; contains 231 pages—73 illustrations and colored plates.

Sent postpaid on receipt of $1.50.

Published by THE KEYSTONE,
19TH & BROWN STS., PHILADELPHIA, PA., U.S.A.
NOTICE TO READERS.

*The Optician's Manual* is a republication in book form of the serial *The Optician's Manual* published monthly in *The Keystone*, from May, 1890, to November, 1896, inclusive. While the serial, as published with much new matter and illustrations in this second edition, covers the science of practical optics, it is the intention to continue the serial in *The Keystone* in order to make it, when complete, not only the standard treatise on optical science as a whole, but the most complete and comprehensive work on each subdivision of the science. It will be necessary, therefore, for optical readers who desire to study Hypermetropia, Myopia, Astigmatism, Asthenopia and Muscle Test at greater length and in minutest detail, to continue to read *The Optician's Manual* in *The Keystone*, as several years will elapse before the continuation of the serial will be complete and procurable in book form. For this and other reasons a perusal each month of the Optical Department of *The Keystone* will make the present work doubly valuable.

Address, **THE KEYSTONE**

*The Organ of the Jewelry and Optical Trades*

19th & Brown Sts., Philadelphia, Pa., U. S. A.

*Subscription Price, for the United States, Canada and Mexico, ONE DOLLAR PER ANNUM. For Foreign Countries, $2.44 (10s.)*

202
OPTOMETRIC RECORD-BOOK.

A record-book, wherein to record optometric examinations, is an indispensable adjunct of an optician's outfit.

The Keystone Optometric Record-book was specially prepared for this purpose. It excels all others in being not only a record-book, but an invaluable guide in examination.

The book contains two hundred record forms with printed headings, suggesting, in the proper order, the course of examination that should be pursued to obtain most accurate results.

Each book has an index, which enables the optician to refer instantly to the case of any particular patient.

The Keystone Record-book diminishes the time and labor required for examinations, obviates possible oversights from carelessness, and assures a systematic and thorough examination of the eye, as well as furnishes a permanent record of all examinations.

Sent Postpaid on Receipt of $1.00.

Published by THE KEYSTONE,

The Organ of the Jewelry and Optical Trades

Nineteenth and Brown Sts., Philadelphia, Pa., U. S. A.
<table>
<thead>
<tr>
<th>RETURN</th>
<th>OPTOMETRY LIBRARY</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO</td>
<td>215 Minor Hall</td>
</tr>
<tr>
<td></td>
<td>642-1020</td>
</tr>
</tbody>
</table>

**LOAN PERIOD**

<table>
<thead>
<tr>
<th>HOME</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
</tbody>
</table>

ALL BOOKS MAY BE RECALLED AFTER 7 DAYS

**DUE AS STAMPED BELOW**

---

UNIVERSITY OF CALIFORNIA, BERKELEY

FORM NO. DD23, 2.5m, 4'77 BERKELEY, CA 94720