THE

DETECTION & CORRECTION

OF

VISUAL IMPERFECTIONS

WITH

TEST-TYPE

BY

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TO

PROF. ALFRED L. LOOMIS

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AND

PROF. LUDWIG MAUTHNER

OF VIENNA,

Who as a critic of opthalmic literature and a clear and popular instructor in Opthalmology excels every living man, this little work is dedicated.

AUTHOR.

PREFACE.

THIS little work is divided into chapters, each one of which (as far as is practical) will be sufficiently complete to give the reader an intelligent and practical idea of the subject considered therein.

If its purpose is fullfilled, no previous or technical knowledge of the subject will be required to thoroughly understand it. The table of contents will enable one at a moment's notice to refer to and familiarize himself with any subject it contains.

The Eye being so delicate an organ and so easily injured, no one should trust himself to fit spectacles with a less knowledge of the subject than this little work contains.

BUCKLIN, 200 WEST 42D ST.

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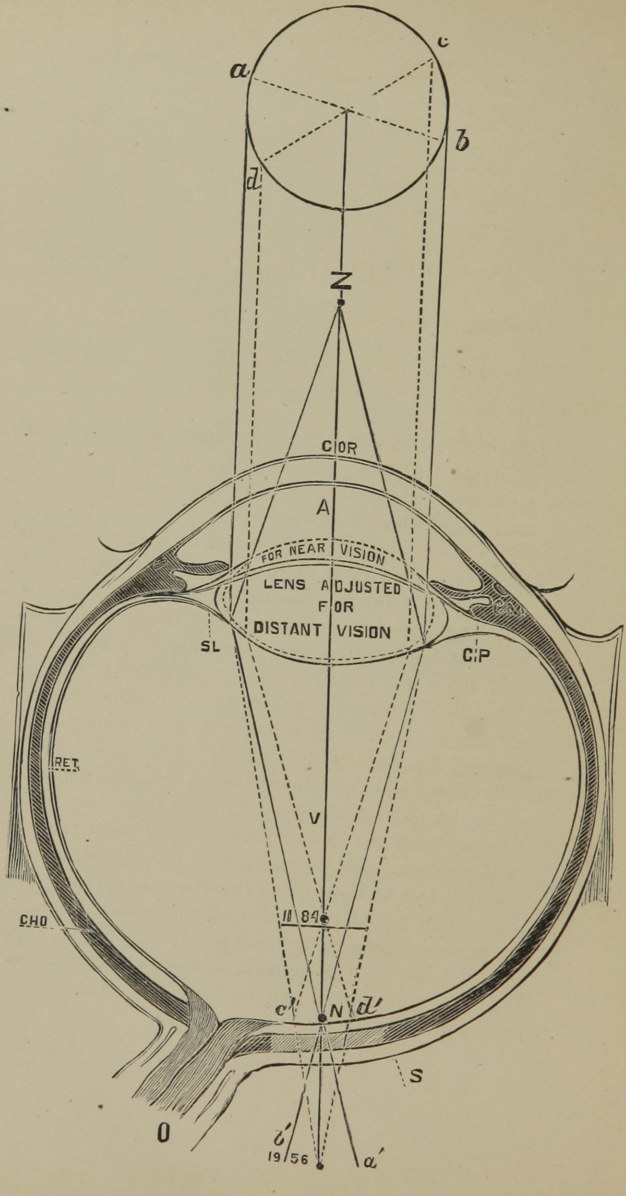
Note.—It will be found advantageous to mount these visual tests on card-board before bringing them into active use.

Test text for Near Vision.—Table 1.

Radiating Lines used in testing Astigmatism.—Table 2.

Test for Distant Vision.—Table 3.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CHAPTER I.

GENERAL ANATOMICAL DESCRIPTION OF THE EYE.

This end will be attained by simplv describing figure 1.

S..... *The Sclerotic* is a firm fibrous membrane. It is chiefly to maintain the form of the globe, to protect the delicate strictures within the globe and to give attachment to the muscles which move the eye-ball.

Cor... *The Cornea;* a transparent structure, forming the anterior, projecting sixth of the globe; dense and resisting, allowing, however, the free passage of light, covered on its convex surface with several layer of transparent epithelial cells (Bowman's membrane) and on its posterior surface with the membrane of the aqueous chamber.

C. P.. *The ciliary processes* are folds of the choroid which form its anterior border and which embrace the folds of the suspensory ligament of the lens.

C. M. *The ciliary muscle,* formerly called the ciliary ligament, a muscular ring situated just outside of the ciliary processes, arising from the circular line of junction of the sclerotic with the cornea and passing over the ciliary processes to become lost in the fibrous tissue of the choroid. This is sometimes called the tensor of the choroid, and is to relax the suspensory ligament of the lens, which by virtue of its "*elasticity*" (Helmholtz) becomes more convex.

I..... *The Iris* regulates the amount of light which is admitted to the eye.

Ret. . *The retina* or sensitive layer, upon which visual impressions are received.

Lens. *Crystalline lens*, surrounded by its capsule.

S. L. . *The suspensory ligament*, the anterior layer of which connects with anterior capsule of the lens and the posterior layer with posterior capsule.

A. ... *The anterior chamber*, containing aqueous humor.

V. ... *Vitreous* humor.

O. .... *Optic nerve*, through which the visual impression is conveyed to brain. (Flint)

The Nature of a Lens.

The human eye being simply an optical instrument the simplest example of which is a convex lens, therefore it becomes necessary for us to enquire into the elementary nature of a simple optical instrument or convex lens.

If a ray of light passes through a prism of glass and then falls upon a screen, it will be found that it has been bent or deflected from its original course toward the thick edge of the prism. The light will also be dispersed into *colored rays of light*, the violet ray being deflected the most, and the red ray the least. This latter fact will be considered under *the effects of color on distance*, or chromatic aberration.

A convex lens is made up of an indefinite number of small prims with their thick edges joined in a common centre.

A prism deflects all rays of light toward its thick edge, consequently all rays passing through a convex lens will be converged toward a common centre, and if the lens be of equal thickness and density, they will all join at one point, or the common centre, which point will be situated at a distance behind the lens corresponding to its strength. If the rays of light come from a distance greater than 20 feet, or in other words, are parallel rays of light the distance from the lens to this common point measured in inches is the "focal distance," or the number of the lens.

The common point of union of the rays is called the "*focus.*" If we reverse the direction of the rays by placing the luminous body at the focus of the lens, it will be found that the lens possesses just sufficient power to make the rays of light, which pass through it, parallel ; therefore, if light comes from a point 3 inches distant, it will take a 3 inches convex lens to make them parallel. If it should come from a point 6 inches distant, the 3 inch lens owing to the divergence of rays of light coming from near objects, would not bring the light to a focus at 3 inches. One-sixth of the lens would be used in making the diverging rays parallel, the remaining sixth of the lens would unite these parallel rays at 6 inches behind the lens. By bringing the object from 20 feet to 6 inches distant we have displaced the focus of the lens 3 inches farther back which, if applied to our eye, would displace the retinal image so far behind the retina that we never could see near objects, were it not for the faculty we have of changing the thickness of our lens when required. This will be more fully and practically considered under accommodation or *near and distant vision.*

A concave lens consists of an indefinite number of prisms with their thin edges joined in a common centre, therefore all rays of light, which pass through such a lens, begin to diverge toward the periphery of the glass. If an eye be so long that parallel rays are brought to a focus so far in front of the retina that distant objects are seen indistinctly and the object must be brought up to 6 inches before the rays are sufficiently divergent to displace the retinal image far enough back to produce distinct vision, the defect may be remedied by using for distant vision a concave glass, which make parallel rays of light diverge to the same degree as if they came from an object 6 inches distant.

This subject will be more practically considered under *Myopia.*

CHAPTER II.

THEORY OF VISION.

Having learned what a convex lens is, let us follow the example of Francis Maurolycus, who made the first approach to the correct philosophy of vision in 1575, by comparing a convex lens to the lens in the human eye.

Let us take a convex lens, No. 10, in one hand and a sheet of paper in the other. If rays of light coming from an object twenty or more feet away fall upon the lens they will be united in one point (the focus), ten inches behind the lens. If our sheet of paper is placed here we will find a bright, round, light spot. If the paper is carried a *little* farther back a sharp, distinct, inverted image of the object, is formed on the paper.

This is exactly what takes place in the normal eye when at rest. The cornea and lens is represented by the glass lens. The space between paper and lens, represents the dark chamber of the eye. The paper represents the retina. The minute inverted image formed upon the retina is conducted to the brain through the optic nerve, and thus the simple visual act is complete. Although Maurolycus rejected his own theory upon the ground that the images must all be seen inverted. Nevertheless this was the path by which the correct theory of vision was reached.

The next step after Maurolycus' discovery was made by John Baptist Porta, the inventor of the camera obscura. He compared the instrument invented by him with the human eye.

He compared the dark chamber with the chamber of the eye, but of the part which the ground glass screen represented, he had an entirely incorrect idea ; he supposed the cornea alone acted upon the light, and that the inverted image was formed on the anterior surface of the lens. A *clear* theory of vision as we have already given in our experiment with glass lens and paper, was first given by John Kepler, 1604.

Des Cartes in 1637 was probably the first to practically demonstrate that an inverted image is formed upon the retina. He removed all the coatings of the eye from its posterior pole and placed in the opening a piece of ground glass, upon which he had the satisfaction of seeing the retinal image formed.*)

DIAGRAMMATIC EYE.

We will devote our attention next to a more practical application to the eye, of the principles already considered.

With the simple explanation that there is about twenty-five millimeters in an inch and that one millimeter is the 0,039 of an inch, I will excuse myself for using this system of measurement where I consider it advisable.

Fig. 1†) is a vertical section of an eye ; for purposes of illustration I have multiplied the diameter of the normal eye and also the experimental results obtained from an eye of normal diameter by four. The normal eye being twenty millimeters or about $^9/_{10}$ of an inch in diameter at its optical axis, consequently the figure will be about 80 millimeters or $3\frac{1}{8}$ inches in diameter. If in figure 1 A B be an object colored red, from which the rays of light are sharply focused on the retina, and C D be a violet object, the dotted lines from which are united at a point 11.84, in front of the retina we have an exaggerated diagrammatic representation of *chromatic aberration*, the centre of the retinal image must have a

*) Helmholtz gives credit to Scheiner as having demonstrated the retinal image at Rome in 1625. (*Mauthner.*)

†) See illustration opposite page 9.

red tinge and be surrounded by a violet circle of *dispersion.* Should we let a b represent the violet object, the rays from which are exactly united on the retina, the red rays would become focused upon the plane a′ b′, consequently the centre of the retinal image is violet and it is surrounded by a red circle of diffusion. The experiments of Fraunhofer, Helmholtz and Matthiessen, which demonstrate that red objects appear 26 inches nearer than violet objects which are at the same distance, may be found in "*Optische Fehler des Auges,*" (Mauthner) page 36th. If A B represent a distant object, the rays from which are brought to a focus on the retina while the lens is at rest, and the point Z represents an object 3 inches distant, then the lens should retain its same form, the rays would be focused at a point 19,56 mm behind the retina. It is only when the lens changes its form, as is represented by the dotted line, that rays from an object situated at Z can be brought to a focus on the retina. This change in form is brought about by active contraction of the ciliary muscle. A *spasm* of this muscle, or a weakening of it, is a source of much trouble with young people who have severe tasks to perform with their eyes. These difficulties will be considered under paresis and spasm of accommodation.

In this diagram the truthfulness of Maurolycus' views in comparing the lens of the eye with a glass lens and also the comparison of Porta between the eye and a *camera obscura* is well illustrated.

CHAPTER III.

ACUTENESS OF VISION.

Our third table is a collection of square letters for testing the acuteness of distant vision. They were prepared by Prof. Snellen and are the standard visual tests which are generally accepted in all countries.

To use this test, place the patient at 20 feet from the table; if he can read the last line, which is marked X X, his vision is numerically expressed as $\frac{20}{20}$—if he reads line marked X X X, then vision is $\frac{20}{30}$. Thus it will be found that amount of vision may always be represented so that it is universally understood by using 20 for the numerator and the number of the last line that can be seen for the denominator, or the distance in feet he can read the letters, for the numerator, and the distance he *should* read the letters, for the denominator. The numbers over the letters express the distance they should be seen.

We have before us the universal measure by which the acuteness of vision in all civilized countries is measured. Let us inquire upon what basis this measure is made and how it came to be adopted.

It will not be without interest to look back and see that the measure, which we are using, although a good one, is based upon an erroneous statement made by Hooke in 1705, who said that the sharpest eye could hardly distinguish two stars that were less than half-a-minute apart, and not more than one in a hundred could distinguish two stars which were less than one minute apart.

A more faulty statement could not have been made. Under the most favorable circumstances stars, which are $6\frac{1}{2}$ minutes apart, require the sharpest eyes to distinguish the spaces between them. A tailor, named Schön, who died in Breslau, Germany, in 1837, was the only man who has ever been able to distinguish the third and fourth moon of Jupiter with his naked eye. The third moon is 5 minutes, and the fourth 8 to 10 minutes from the planet. Consequently, if seeing the intervening space between two heavenly bodies, which are 8 to 10 minutes apart, is the measure for the acuteness of vision of the acutest eye ever known. The incorrectness of Hooke's statement is very glaring. Hooke's statement has been handed down from author to author, till it became a law, so that Boettcher is found in 1870 explaining, why heavenly bodies are seen under a smaller angle than terrestrial bodies. Prof. Snellen going upon this supposition, placed himself in the centre of a circle 40 Paris feet in diameter and constructed a row of letters, the height of which is five minutes of this circle ; the stripes and openings of the letters are one minute; thus in the letter C the stroke is one minute, and to distinguish it from an O the white opening must be seen, which measures one minute.

He supposed that the eye, that could read C, could distinguish objects one minute apart. What one sees, when he sees a letter, is hard to say; he says it is C, because he is acquainted with the character and knows it. One who can tell the C with ease, will find it impossible to count the squares of a checker-board where the black squares are seen under one minute and the intervening spaces are the same. Therefore the man who reads the last line of Snellen, cannot always distinguish objects situated one minute apart. Although it does not fulfill the scientific requirements, for which it was constructed, still it is a good measure for determining acuteness of vision, and the last line just represents the average acuteness of vision. Hooke's statement is therefore nearly true of terrestrial objects and entirely untrue of heavenly bodies.

An anatomical fact, which determines under how small a visual angle two points can be seen, is not without interest. The visual spot upon which all our impressions from the outer world are received, is the $^1/_3$ to $^1/_5$ of a millimeter in diameter. It consists of cone-like nervous elements which are in connection with the brain through the optic nerve and which stand very near to each other.

The diameter of these cones is the three-thousandth of a millimeter. Therefore as long as a retinal image is not larger than the three-thousandth of a millimeter, it can only fall upon one cone or upon two adjoining cones. In this case the two black points would be seen only as one, that is they would run together.

As soon as the retinal image is the four-thousandth of a millimeter, then it is large enough to cover three cones, thus leaving one at each extremety of the retinal image to discern the black point and one cone in the middle of the retinal image to perceive the intervening white space ; therefore the four-thousandth of a millimeter is the smallest possible retinal image, by which two points can be seen separately. In the average normal eye *this* retinal image corresponds to an object seen under an angle of about one minute. Therefore one minute is the smallest angle under which two distinct points can be seen separately.

DISPLACEMENT OF RETINAL ELEMENTS.

Large Vision (*Megalopsia*);
Small Vision (*Mikropsia*);
Irregular Vision (*Metamorphopsia*).

The above are interesting peculiarities. They are due to the retinal elements being displaced by inflammatory action.

In large visions the rods and cones, owing to the contraction of cicatricial tissue, are drawn closer together so that a retinal image, which formerly fell on rods which were the four-thousandth of a millimeter apart, falls upon retinal elements which were *formerly* twice that distance apart, *consequently* the impression of the object carried to the brain is the same as when the object was large enough to cast an image upon these elements before they had changed their positions.

I have seen two cases of this kind of trouble. The first one said, "when I close my bad eye, everything looks normal; when I close my good eye, people on the street look twice as big as they should." The ophthalmoscope showed only slight pigmentation in the region of the visual spot, the same amount of change is frequently seen without producing any symptoms.

The second case thought objects looked a quarter larger from one eye than from the other; she had double "*optic neuritis*" (inflammation of optic nerves).

In Small vision the rods and cones are drawn away from each other. This case complained that objects in one eye looked "*very small.*" She had an acute inflammation of the choroid.

The only case I ever saw of *irregular vision*, complained that a straight line looked irregularly curved.

I have said that the table, which is in use, represents the average acuteness of vision, but it does not require us to see objects under one minute. I am convinced that, while this fact is well known, it is not generally understood, and I believe it is owing to this misunderstanding that the treatment of refractive errors is being run into the ground by enthusiasts.

Articles are constantly being published by enthusiastic specialists, which show that their authors are unconsciously, but conscientiously falling into the most absurd errors, simply because of this misunderstanding as to what the acuteness of vision of the human eye *is*, or *may* be.

Let me illustrate this fact by my own case. I was about twenty-two years of age ; my eyes had never troubled me, although I had used them very hard by gas light. My health from some unknown cause became impaired and I had weak eyes. I consulted an oculist of reputation. I was placed at 20 feet from Snellen's test type. I could read the last line ; through convex glass 30 I could read it very well. It was therefore considered that I had at least $\frac{1}{30}$ of far-sightedness and as this was hardly enough to account for the trouble I was having, it was supposed I must have more, and glasses No. 20 were given me. I was recorded as far-sighted. Had I been subject to any nervous disease, or had I at the time sore or red eyes, I would have been handed down to posterity as a case in an invincible statistic, as to what trouble my eyes had caused me and what good glasses had done. Having had neither trouble I was spared giving testimony in favor of a method which would condemn eight-tenths of humanity to the use of glasses in their youth.

I had no abnormal error of refraction. I had my eyes examined by experts in *England*, *Germany*, *Austria*, and *New York*, and every one decided that they were normal, without knowing what was the opinion of the other.

Let us now examine how this blunder was made. He did not stop to consider that this line of letters represents only the average acuteness of vision. I can with *good light* read that line at 40 feet.*) Now, if I am only 20 feet away, it will take considerable glass to make me see so poorly that I cannot read this line of letters.

Suppose I stand at 40 feet from this line of letters and by placing a glass No. 30 before my eye, thus carrying the second nodal point the $\frac{1}{4}$ of a millimeter farther forward, this very slight magnification *does not* confuse the detail of an object ; for that distance I prefer the object slightly magnified. The rules, which are later given for the selection of spectacles, will prevent you from selecting improper spectacles, but they do not determine the refractive condition of the eye down to the hair splitting nicety that enthusiasts claim.

A trained eye can distinguish sharply between magnification and distinctness, an untrained eye cannot, because one chooses this slight magnification or says, he sees nearly as well. It is no evidence that the antero-posterior diameter of his eye is too short. I have seen a hundred cases examined in this manner where in many instances $\frac{1}{36}$ or $\frac{1}{30}$ was all the error of refraction claimed to exist, and these cases are now statistical evidence of the connection between certain diseases and errors of refraction.

In cases of farsightedness, where it is wished to split hairs, as to whether Hyperopia of $\frac{1}{36}$ exists or not, I

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*) Test made in open air.

know of no means so reliable as the ophthalmoscope in the hands of *one who is expert.* Every oculist goes through the motions of determining visual imperfections with the ophthalmoscope, but as my farsightedness was substantiated with the ophthalmoscope as being $\frac{1}{20}$, when $\frac{1}{60}$ should be detected, I am forced to conclude that some do not understand the method, although it is very simple and easily acquired.

The practical selection of spectacles will be considered later.

CHAPTER IV.

CHROMATIC ABERRATION

Is the only visual imperfection which exists in *every* eye. Clergymen who study in rooms illuminated by stained glass windows of various colors, suffer from this visual imperfection. Persons studying by lamps covered with fancy shades, which have two or more colors, also suffer from the same visual defect. One plain glass window, which illuminates the study table, or a plain lamp shade, and the trouble disappears.

Through this visual imperfection the color of objects deceives us as to their distance.

Artists avail themselves of this general visual defect in producing distance on canvas by coloring an object red when they wish it to appear near, and violet when they wish to retire it.

We have seen in a former chapter that the nearer an object is, the more diverging are the rays of light which come from it, and the more the lens power must be increased by muscular efforts in order to focus them upon the retina. A given prism of glass bends red rays of light much less than violet; it therefore follows that red rays of light are more difficult to bend or converge than violet rays. This was also true of divergent as compared with parallel rays of light.

This makes it evident that color and distance, independent of *light* and *shade*, are interchangeable. The lens in the human eye should unite rays of light from violet and red objects at the same point, but it does not.

The discussion between Newton and Euler as to whether this error existed in the human eye, is not without interest. Newton's belief, that the human eye had this defect and also that it was impossible to construct a lens that was free from it, led to his inventing the reflecting telescope, while Euler's belief, that it did not exist in the eye, led to his inventing refractive telescopes now in common use. Without referring to the details of Fraunhofer's experiments, by which he not only demonstrated the existence of this error in the human eye, but with which he measured it, I will give you his results. At the far point of distinct vision with the eye at rest a violet object must be *twenty-six inches* nearer in order to be seen with the same distinctness as the red object.

I hope that in as much as chromatic aberration is a universal visual imperfection, the prominence which I have given it will not be considered too great for our limited space.

CHAPTER V.

ACCOMMODATION.

When looking at a distant object through an opera glass you will notice that in order to see a near object distinctly, you are obliged to change the focus. This is not only true of an opera glass, but is equally true of the human eyes. In the first case you change the length of your glass, but the eye being unable to change its length, changes the thickness of the crystalline lens sufficiently to compensate for the nearness of the object.

This change is caused by the ciliary muscle contracting and relaxing the capsule of the lens, so that it through its elasticity becomes thicker. The change in form, which the lens undergoes, is shown by the dotted line around the lens in figure 1.

Here, while the lens was at rest, it focused parallel rays of light coming from a-b upon the retina, but in order to bring the diverging rays of light to a focus from the near object Z, it was necessary for the lens to change its form to correspond with the dotted lines.

If the point Z is six inches distant it is necessary for the lens to increase its strength to a degree corresponding to a glass lens No. 6, because we know it takes a lens of this strength to make rays of light coming from a point six inches distant parallel, and we know that the eye, when at rest, can just bring parallel rays of light to a focus on the retina. Having two eyes, as the object is brought near, they must be converged that they may both become directed at the near object. Should the proper relations between this power of convergence and accommodation become disturbed we have a fruitful source of trouble, which gives rise to *convergent squint* (cross-eyes), weak vision and double vision. The amount of accommodation which a young person may possess, is well illustrated by the following case. A boy reads $\frac{20}{20}$ through a convex six inch. glass and also reads the finest print well. If he can read $\frac{20}{20}$ through a glass No. 6, that shows that, when he looks without a glass, he has to increase the strength of his crystalline lens to an amount equal to glass lens No. 6, to see distant objects. To see objects at six inches he must increase it twice as much thus he readily increased the power of his lens to a degree corresponding to a glass lens No. 3.

Weakening or *paresis* and *spasm* of the muscle which produces the change in the form of the lens, gives origin to one form of weak or bad vision. The eye being so short that the demands for a change in the form of the lens are greater than the muscle can produce, is the trouble experienced by far-sighted people.

A hardening or loss of elasticity in the lens so that, notwithstanding the muscle works well, the lens fails to change its form, causes the trouble which old people experience. When from these changes the lens becomes opaque so that the light cannot pass through, we have cataract.

CHAPTER VI.

VISUAL TESTS.

The practical questions which you have daily to decide are, **why** does this person come for glasses and **what** shall I do for him? *Is he*

NEAR-SIGHTED - - - -	*(Myopic)*
FAR-SIGHTED - - - - -	*(Hyperopic)*
OLD-SIGHTED - - - - -	*(Presbyopic)*
WEAK-SIGHTED - - - -	*(Asthenopic)*
BAD-SIGHTED - - - - -	*(German: Schlecht-sichtig—Amblyopic)*
ASTIGMATIC - - - - -	*(Far or near-sighted in one meridian)*

All attempts which have been made to answer these questions by the means of test type alone have been failures.

The necessary apparatus consists of a collection of lenses extending from No. 60 to No. 5, which have been neatly arranged in compact case by The Spencer Manufacturing Co. at an exceedingly reasonable price.

They have the further advantage of being handsomely mounted in celluloid, steel, rubber, or gold frames in pairs, and many be sold from the case to be used as eye-glasses ; being made by machinery, they can be replaced at any time at very moderate expense.

Turning to our third table, we find the acuteness of vision is below the normal standard, perhaps $\frac{20}{70}$. In which case one of several conditions may be present—He may be too far-sighted to see the letters—may be near-sighted—may be astigmatic, or may be amblyopic.

Let us refer to fig. 1 and acquaint ourselves with the nature of these various visual defects, before we proceed to differentiate them. In normal sight or emmetropia the rays of light are brought to a sharp focus on the retina—thus rays of light from the object a, b, are brought to a sharp focus at the point N. If we shorten the eye 11.84 mm., we have *hyperopia*, $\frac{1}{3}$—(requires convex glass No. 3 to correct it.) To produce the same degree of myopia $\frac{1}{3}$, we must lengthen our schematic eye 19.56 mm. Remembering that all results have been multiplied by four, for purposes of making the eye large for illustration, the normal eye is eighty mm. in diameter, for hyperopia $\frac{1}{3}$, it is 11.54 mm. less in diameter, and for myopia $\frac{1}{3}$, it is 19.56 mm. more in diameter.

It will be seen that the eye must be lengthened nearly twice as much to produce a given degree of myopia, as shortened to produce the same degree of hyperopia.

The circles of diffusion (the distance between the lines coming from a, b,) are nearly twice as great in myopia $\frac{1}{3}$, as in hyperopia $\frac{1}{3}$, as a result of which the retinal image is twice as indistinct in myopia as in hyperopia. Myopia and hyperopia having been disposed of, we will next enquire into the nature of *astigmatism.* If the lines a, b, represent the rays of light in the horizontal plane, it is seen they are united upon the retina. If the dotted line c, d, representing rays of light in the vertical plane, are, owing to a *sharper curve* of the cornea in the vertical meridian, brought to a focus 11.84 mm. before the retina, we will have *myopic astigmatism.* If the lines from a, b, represent the *vertical* meridian, and the dotted lines which come to a focus at 19.56 mm. behind the retina, represents the rays of light in the horizontal meridian, we will have hyperopic astigmatism.*) If the dotted lines, which unite at 11.84 mm. before the retina, represent the rays of light in the vertical plane, *and* the dotted lines which unite at 19.56 mm. behind the retina, represent the horizontal meridian, we will have *mixed astigmatism.* Where, owing to different curves in the cornea, rays in both meridians are united in front of the retina, but at different distances, we have compound myopic astigmatism, where rays in both meridians are united behind the

*) In myopic astigmatism the vertical curve of the cornea is usually abnormally sharp, in hyperopic astigmatism the horizontal curve of the cornea is flat. The faulty curve may however be in any meridian.

retina, but at different distances, we have compound hyperopic astigmatism. *Presbyopia,* (old sight,) where the lens becomes so hard from age or other causes, that when the ciliary muscles contract the lens from want of elasticity, fails to change its form as is shown by dotted lines around lens in fig. 1, we have *presbyopia.* Asthenopia (weak vision,) is either accommodative—muscular—or retinal. If the ciliary muscles become weakened from any cause, so that it cannot produce the usual change in the form of the lens, or if we have hyperopia or astigmatism, which we are struggling to overcome by accommodation, weak vision may result.

If we cannot converge both eyes for the distance we wish, to work without tiring, we have muscular asthenopia. In other words, if we cannot accommodate for the point, where we want both eyes to converge, or cannot converge for the point we want both eyes to be accommodated, we have weak vision.

The weak vision may be purely of a nervous character, and not dependent on any of the above causes, in which case it is called retinal asthenopia.

Amblyopia, (bad sight.) Where, notwithstanding a sufficiently perfect retinal image is *received, and* owing to brain trouble or poor conduction through optic nerve, a person does not see, it is called *amblyopia.*

Hoping that the nature of the various visual imperfections is understood, we will proceed to their differential diagnosis.—If the vision is below $\frac{20}{20}$, and it does not improve by the use of convex glasses, hyperopia *is not* the cause of poor vision.

If the vision is $\frac{20}{20}$, and the patient complains of weak eyes, hyperopia, presbyopia, or weak accommodation may be present.

If the vision of $\frac{20}{20}$ is *equally distinct* through convex glasses, hyperopia is present, and the *strongest* convex glass, which does not make vision less distinct, may be given. If convex glasses do not improve distant vision, but do improve or relieve near vision, the weakest convex glasses, which are required to read with, represents either the amount of presbyopia, or the amount of failure in the accommodation, owing to a weak ciliary muscle. If the amount does not correspond with the amount of presbyopia, which is usually found to exist at the patient's age, (see presbyopia) or if there is a history of impaired health or paralysis, you will be able to draw a reasonable conclusion whether it be presbyopia or weak accommodation. If the vision is not $\frac{20}{20}$, you should next try concave glasses ; if they do not improve the vision, correctible myopia is not the cause of the poor vision.

Sometimes hyperopia and presbyopia exist together, in which case the glass suitable for distant vision is not strong enough for near vision. Such a person may require a weak convex glass for distant vision, (better to do without if he can,) and a much stronger glass for near vision. Where myopia and presbyopia exist together, patient may require a concave glass for distant, and a convex glass for near vision. If neither convex or concave glasses improve vision, he should next direct his attention to the radiating lines, which are all exactly alike in table 2. The table is placed at his *far* point of distinct vision ; if some of the lines appear darker than others, he is astigmatic, and suitable spectacles will not be found. A cylindrical glass must be ground for his special case, which frequently improves vision like magic.

If all of these tests fail in locating the trouble, the patient from some lesion in brain, optic nerve, or eye, is amblyopic, and should lose no time in finding out *what* his trouble is.

Each of the above visual defects will be more fully treated under its respective head.

Selecting Spectacles.

Testing each eye separately and finally together, you should commence with weak convex glasses and rapidly increase the numbers, till the highest glass has been found, through which the person can *plainly* read $\frac{20}{20}$, or the best possible vision has been attained, or you have satisfied yourself, that convex glasses do not improve vision. You may *then* commence with weak concave glasses, and if they improve vision, give the *weakest glass**) with which the best vision is attained.

You should not be content with the patient's saying

*) Exception—spasm of accommodation.

he sees better, but should satisfy yourself that his vision has been improved to a measurable degree. Persons having bad vision without being near or far-sighted, will say they see better through a concave glass ; this is simple due to the contraction of the pupil, which results from the accommodative efforts to overcome the concave glass.

They will also frequently say, they see better through a convex glass. This is the result of slight magnification of objects by the convex lens, which is usually of advantage to eyes, which have reduced acuteness of vision. The improvement of vision is however only slight and hardly of a measurable degree.

A small pupil being of advantage to one having a refractive error, a large pupil is naturally disadvantageous. If you cover one eye (with the hand) of a person who is near or far-sighted, the pupil of the other eye enlarges, and consequently makes the vision considerably poorer than it was with both eyes.

The young person who has weak vision *from* or *squints* as a result of hyperopia, should receive the strongest convex glass with which he can possibly read $\frac{20}{20}$, and he may require a stronger glass.

The near-sighted person should receive the weakest concave glass with which he can obtain the best and most comfortable distant vision.

Presbyopic persons should have the *weakest* convex glass with which they can see comfortably required objects at the required distance. All other rules are superfluous. *Asthenopic* persons who have no visual defect, but have a weak accommodation, may sometimes rest their eyes by the temporary use of weak magnifying glasses for near work.

Having convinced yourself by the use of glasses, that a person is neither near-sighted or far-sighted, the astigmatic disk will generally answer the question whether he is astigmatic or not.

Commencing with the convex cylindrical glasses with the axis vertical, you may steadily increase the strength of the lens, till you are satisfied that they do not improve vision, or the best vision has been obtained. The axis of each glass should be rotated right and left from vertical to horizontal. (See astigmatism.)

You may next proceed in the same manner with the concave cylindrical glasses, rotating the axis of each glass right and left from horizontal to vertical.*)

Spherical lenses may be combined with cylindrical lenses and with prisms, and they are also combined with each other in a variety of forms.

One who has not had a great deal of practical experience, will find that the mistakes they make in prescribing other than plain spherical lenses, will be

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*) The axis of a cylindrical glass should always be noted on a diagram. If a perfect understanding exists between mechanic and investigator, it may be indicated in degrees to the patient's right or left from the vertical, or beginning at horizontal meridian indicate from patient's left to right as the hand of a clock.

very annoying to himself and patient, as well as expensive. I recommend every one to send their *astigmatic*, as well as all other complicated cases to a competent ophthalmic surgeon for a *prescription* for their glasses. You will keep the confidence of your patients better, as well as gaining the reputation of being a reliable man.

CHAPTER VII.

NATURE AND CAUSE OF MYOPIA (NEAR-SIGHTEDNESS.)

As you have already seen in fig. 1, the near-sighted eye is one that has a too long antero-posterior diameter. The rays of light cross in the eye so far forward, that they cast a confused image upon the retina. I believe a child may be born near-sighted. It, however, generally is developed after birth. The tendency is generally hereditary, but may not be.*)

The pressure brought upon the eyes by the internal muscles converging both eyes at a near point, will cause the globes to elongate in proportion, as they are soft or unable to resist this pressure. This soft condition of the globes may be inherited, or it may be caused by a simple inflammation of the coatings of the eyes.

Children having a given tendency to soft globes by inheritance, will have them elongate in proportion, as

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*) Prof. Jäger found many newly born infants myopic. Dr. Eley found the opposite condition to exist.

they bring pressure to bear upon them. Bad light makes the strain greater. Bad position at a desk increases it. The younger the child, the softer the globe, and the less pressure will it bear without stretching. Children who have a tendency to myopia, might in many instances avoid great injury, by giving proper attention to *light*, *position*, and delaying their school tasks as long as possible, till age has given the eyes firmness, and also by avoiding all kinds of unnecessary and foolish tasks, as French or music, when they perhaps have no talent for either, and only pursue them at the expense of their vision.

Testing and Correcting Near-Sightedness.

Case I. If the letters on the third table cannot be read, but fine print can be read *well* from a distance of 8 to 14 inches, it is plain that near-sightedness is present. It will sometimes be found, that myopia is not made out in so simple a manner. We then begin with the weakest *convex* glasses, and rapidly increase their strength, if at each step, instead of vision being improved, it is worse. We next begin with a weak concave glass, and increase the numbers rapidly, till the best possible vision has been attained. The vision is frequently brought to a normal standard immediately, or *decidedly* improved. The fact being settled, that the person is near-sighted, it only remains to decide what glass he must have.

In determining this question, common sense is quite as useful as science. Your duty is to give the person a pair of glasses, with which he is satisfied, and at the same time to know enough, not to let him have a glass that will injure him. Perhaps he makes the statement that he sees well enough near-by, and only wants a glass for the distance ; he should then be allowed to have the *weakest* glass with which he can obtain the *best* and most *agreeable* distant vision—an eye-glass will be the most acceptable frame. To avoid possible mistakes, the vision should be tested *in each eye separately.*

Let the patient hold a small card before one eye and find the number of the glass required for that eye; then changing the card, find the proper glass for the other eye. If there is a decided difference between the eyes, it will frequently be found, that after the proper glass has been selected, one eye sees much better than the other. Let the patient take two pairs of glasses, the one in the right hand being the one required for the right eye, and in the left hand the other. Now see if he finds it more agreeable to look through glasses of different powers, or to use a pair of glasses of the same power ; he will probably choose glasses of the same strength, the number being that which is adapted for his best eye.

If the amount of vision which the eye possesses, is the same, and there is a decided difference in the glass required for each eye, some will tolerate separate correction of each eye, and some will not. The question can only be decided by practically trying. If the person is so near-sighted that he cannot follow his vocation, and needs to wear glasses to see what is going on about him, there is no objection to giving him glasses in the form of eye-glasses, which are only to be used occasionally, as in church or theatre, which brings his vision up to the normal standard, although the glasses are very strong. The glasses which he wishes to wear continually should have riding-bow frames, and should be the weakest with which he can see comfortably *required* objects at a *required distance.* He should be encouraged to take the weakest glasses with which he thinks he can see "well enough," notwithstanding they do not bring his vision quite up to the average standard. For example, a student who is very near-sighted, must have a glass constantly before his eyes, which will enable him to see the features of his instructor at a respectable distance. He will generally tell you how weak a glass he is willing to accept. A pair of eye-glasses may be given, which, when worn outside of the spectacles, will bring his vision to the normal standard; when occasion requires him momentarily to see at great distances, he may use both pairs of glasses.

When the glasses required to produce the best vision do not exceed No. 8, they will prefer that glass; when the glass is stronger, one must use his judgment in each individual case.

Progressive myopia blinds people, and bad selection of glasses increases the myopia ; therefore you will pardon me for devoting so much time to selecting a simple pair of near-sighted glasses.

Give the weakest glass to near-sighted people, with which satisfactory or the best vision can be obtained.

False Near-Sightedness.

This is better explained by a practical example.

A young man who says he has always seen well in the distance, suddenly finds he can no longer see well in the distance. Upon inquiry find he is an engraver, and has been confined very closely to his work ; he finds that his sight for small and near objects is also bad. He reads the line No. 50 at 20 feet; convex glasses make it worse. A concave glass No. 30 enables him to read the last line No. 20 distinctly ; apparently this is a case of myopia. The man has in fact a card from one of our leading eye institutions with the diagnosis of myopia written upon it. He is also having trouble in reading and finds that convex glasses are of assistance to him. This immediately makes one suspect that he has spasm of the accommodation. Upon examination with the ophthalmoscope, his eye is absolutely normal. By paralyzing his accommodation with atropine his myopia disappeared. He was a subject for *beef*, *iron* and *rest*, and not for spectacles.

Be suspicious of a young person who has been using his eyes hard, and who says he formerly saw well at a distance, but now requires concave glasses to see at a distance and convex glasses relieve near-vision.

If the interest of the patient is consulted, he should be sent to some competent specialist for advice. One may with considerable certainty suspect the existence of the difficulty from the history of the patient. A solution of atropine, four grains to the ounce, dropped in the eye three times a day for two days, will make the myopia disappear, and thus confirm the diagnosis. I would however not advise any one to use atropine in a patients eye, till they had tried it in their own. The unpleasant effects of an enlarged pupil cannot be appreciated till experienced. It frightens a patient usually sufficiently to make them leave you.

I seldom use atropine in any patient's eye for the simple purpose of determining an error of refraction, notwithstanding the many authorities who believe it necessary.

A cross-eyed person may sometimes be an exception to the above; the reason why will be shown later.

Spasm of the accommodation is more frequent than most authorities admit. I have always found it in young people who were over-working their eyes. I can find no solution of the question, except that it is caused by the stretching of the choroid, when the eye begins to give way and elongate under pressure. I believe it is the first signal that the hyperopic will become emmetropic, and that the emmetropic eye will later become myopic, providing the eye continues to be overtaxed. Students who enter college poorly qualified, are subject to this form of trouble, and if they are really industrious, are quite sure to come out of college with eyes damaged from myopia. Such a student is incapacitated for study, and should be forced to lighten his task or stop, and not worry through the college course at the expense of his vision. What good does his degree do him, if, on obtaining it, he has acquired *progressive myopia,* and is incapacitated for an active professional or literary life? I have seen this form of trouble three times during the last six months. One was an engraver, and two were college students. Middle-aged engravers, who do all of their fine work through *magnifying glass* fastened on *one* eye, never get spasm of the accommodation, simply because when only one eye is used, there is no strain on the internal muscles to produce convergence. The power which elongates the globe is therefore not called in use.

CHAPTER VIII.

NATURE AND CAUSE OF HYPEROPIA (FAR-SIGHTEDNESS.)

It has already been shown in fig. 1, that a far-sighted eye is one whose diameter is too short for the lens system, which it possesses. The rays of light cross so far back, that the retinal image falls behind the retina. A far-sighted eye is not especially adapted for distant vision ; it can never see further than a normal eye, but it is difficult for such an eye to see near objects well. It is usually the result of a faulty development of the eye. It may be acquired by the atrophy of the globe, which age brings about by the dislocation of the crystalline lens from a blow on the eye or by the removal of the lens when it has become opaque or cataractous.

A person who has a high degree of far-sightedness, usually thinks that he is near-sighted because he is too far-sighted to see even distant objects. His *far-point* of distinct vision being further away than the heavens, there is nothing on earth which is not too near for him to see. He frequently squints his eye-lids together just like a near sighted person for the purpose of diminishing the amount of light which enters his eyes.

He may complain he cannot read nights, or after reading a short time the print runs together; this may be also true in day-light. He may complain simply of weak eyes.

He may complain that one eye commences to squint inward.

TESTING AND CORRECTING FAR-SIGHTEDNESS.

If the last line of letters marked 20 can be read at 20 feet, but the person cannot read fine print near-by, it is commonly said that one is far-sighted. A more faulty statement could not be made.

A person may fulfill the above conditions, and not be *far-sighted;* a person may be *far-sighted*, and not be able to read any of the letters on table No. 3, but *can* read good-sized print near-by, for which reason all systems which have attempted to differentiate visual defects by *test type alone*, have been failures.

Place the patient at 20 feet from table No. 3 ; if he can read the last line, remove the table to the greatest distance that he can read the last line ; the number of the strongest convex glass through which he can still read the letters *distinctly*, represents the amount of his far-sightedness, and is the glass he should have. Thus, if the glass be No. 20, he is said to be far-sighted $\frac{1}{20}$.

Far-sightedness only requires correction, when it gives rise to unpleasant symptoms, as *bad vision*, *weak vision*, or *squint*. In all of these cases the *strongest* glass with which line No. 20 can be read at 20 feet may be given.

If these do not relieve the squint, an operation is necessary. As squint is the only way in which far-sightedness may of itself produce blindness, a knowledge of the connection between squint and far-sightedness is of practical value.

CONNECTION BETWEEN FAR-SIGHTEDNESS AND SQUINT.

As an object is brought near to us we are obliged to focus strongly, and at the same time our two eyes must converge, that they may both be directed at the same object.

The person who is far-sighted $\frac{1}{10}$, must accommodate twice as much to see an object at ten inches, as a person with a normal eye. In far-sighted people it sometimes happens, that when both eyes are converged for a point ten inches distant, the eyes are not focused for that distance, till they have become converged for a point five inches distant, consequently at any point where both eyes can be directed, they are never focused.

If a child in this "*fix*" observes, that by converging one eye at the point five inches distant, the same amount of accommodation will take place in the eye directed at the object ten inches distant, as if it were also converged for a point five inches distant, he will have learned how to help himself out of the difficulty. By squinting he sees everything distinctly, and without he sees nothing distinctly, consequently he squints or becomes cross-eyed.

Seventy-seven percent. of all cases of converging squint are due to this cause (Donders.) If, at an early period of the squint, before the muscle has undergone organic contraction, a pair of convex glasses be given, which entirely neutralize the hyperopia, the child will be unable to see distinctly when he looks cross-eyed, and will see distinctly when he does not look cross-eyed. The glasses have thus cured the squint by making the unusual amount of accommodation unnecessary. I maintain, that the greatest error the medical profession ever made, is the encouraging of parents who have squinting children, to wait till they are older, before the squint is treated. To illustrate my views in a very practical way, I will give you a history of the following case.

Mr. F., referred to me by Dr. M. He commenced to look cross-eyed when a child ; the correction of the squint was delayed from time to time, till he was twenty-three years of age. From the long disuse of the squinting eye he had lost all vision in it. Having still good vision in the other, he was very much pleased with having his eye made perfectly straight by an operation. He was well contented with his condition, till one day while using a hammer, a piece of the hammer broke off and perforated his good eye, making the removal of the eye necessary. *He now appreciates* the grave mistake, which his parents, (encouraged by the family doctor,) made, in allowing his squint to go uncorrected so long.

Another case is that of a little girl eight years of age, where glasses No. 12 so overcame her far-sightedness, that she immediately gave up squinting. It is now two years since the glasses were ordered, and I find the acuteness of vision equally good in both eyes, it formerly having been poorer in the squinting eye. Should she from any accident lose one eye, the advantage which she would have over the first case is too evident to require any comment.

A most remarkable case is that of a little girl referred to me by Dr. F., who, after having squinted for *four years*, gave it up upon receiving convex glasses, which entirely neutralized the hyperopia. In *three months* the squinting eye regained its former acuteness of vision, being able to read $\frac{20}{20}$ with ease. Many will be incredulous, that such a result is possible ; I am however ready at any moment to produce the patient.

CHAPTER IX.

PRESBYOPIA (OLD SIGHT.)

As the fortieth year approaches, the lens of the human eye begins to grow stiff and hard from age, the eye-ball may also shrink slightly, thus becoming smaller. The muscle which produces accommodation retains its power, but the lens having lost its "*elasticity*," the muscle finds it impossible to change the thickness of the lens sufficiently to cause distinct images of near objects to fall upon the retina. The trouble first shows itself by requiring the paper which is being read, to be held further away. It is found particularly difficult to read at *night*. If the old person finds no other means of relief, he will read with a candle in his hand, which he holds between his eyes and the paper he is reading, thus unconsciously counteracting the diffusion of the retinal images, caused by his inability to accommodate, by making his pupils small.

Seven out of every ten cases a spectacle dealer meets are of this nature.

The human lens degenerates so regularly with advancing years, that it was formerly attempted to number the glasses which these people used, by their age. The glass for a person forty years of age was No. 40.

It has also been attempted to arrange different sizes of print, so that the number of the glass could be determined by the number of the print which the individual can read.

These test texts are very ingeniously arranged, but in actual practice they vary so much from what one actually finds that they are not to be recommended.

The weakest pair of glasses with which a person can read his daily newspaper comfortably, at a distance of 12 to 15 inches, is the glass he must have.

He might be able to read one or two lines, which would indicate glasses No. 30, but if obliged to read his newspaper for an hour, would require No. 20 or 18 to do so comfortably.

He should delay wearing glasses for distant vision as long as possible, and then commence with the weakest glasses which will answer the purpose.

A presbyopic person will begin with using glasses only by lamp light, later he will be obliged to take his night glasses for day glasses and a slightly stronger pair for night work. The person who follows this rule retains a much more satisfactory *range of accommodation.* He who takes a strong enough glass for long night work and uses the same for day work looses his accommodation more rapidly because he fails to exercise it.

Persons whose occupation requires them to look alternately in the distance and near by, (as a book seller who looks up at the shelf to see the book and then turns to his note book,)find it impossible to change their glasses continually.

One devise for overcoming this difficulty is a fine spectacle with the upper half of the lenses so flattened that he looks over the spectacles when looking at a distance and through the lenses when observing objects near by.

As the case advances and the man requires spectacles for distant vision one of three methods may be adopted to meet the requirements of his occupation. One will prefer to wear two pairs of *eye glasses* with hooks, or a cord about his neck, and will change from one pair to the other as occasion requires, another will choose to wear a light pair of spectacles for distant vision, when he wants to see a near object he will put on a light pair of eye glasses over his spectacles the sum of both lenses being the lens which he requires for near vision.

Another prefers two glasses in one frame with a cut through the middle, the upper glass being the weaker glass. My experience with glasses, where two focuses are ground on the same piece of glass, has not been in their favor where there is considerable difference in their strength, the edge between them acts as a prism, and is very unpleasant, displacing the floor and showing the colors of the spectrum.

Hyperopia, far-sightedness and presbyopia may be combined in which case the table of Donders, showing the usual presbyopia corresponding to a given age is convenient as a check against the patient choosing a too great magnifying power.

AGE.	GLASSES REQUIRED.	
	Where distant vision is now *normal.*	Where distant vision *was* normal.
48	$^1/_{60}$	$^1/_{60}$
50	$^1/_{40}$	$^1/_{40}$
55	$^1/_{30}$	$^1/_{28}$
58	$^1/_{22}$	$^1/_{20}$
60	$^1/_{18}$	$^1/_{16}$
62	$^1/_{14}$	$^1/_{12}$
70	$^1/_{10}$	$^1/_{7\cdot5}$
75	$^1/_{9}$	$^1/_{6\cdot5}$
80	$^1/_{7}$	$^1/_{4\cdot5}$

If a man sixty years of age is found to have a (hyperopia) of $^1/_{10}$, by testing his distant vision, we know that he is not far out of the way when he chooses No. 6 to read with, which is a little more than the sum of his farsightedness and presbyopia. The great mistake which is generally made in treating presbyopic patients, is, their glasses are too strong to begin with and they are increased faster than necessary, as a result of which they become very early so presbyopic that they can see at no distance without a glass. *Always give the weakest glass with which one can read comfortably.*

CHAPTER X.

ASTHENOPIA.

(Weak vision) is frequently due to some error of refraction which the muscle of accommodation is constantly struggling to overcome. If a patient is sufficiently farsighted to be just able to overcome it when reading he will complain of weak eyes. If the farsightedness be so great that notwithstanding he uses his accommodation to the utmost he cannot see distinctly, he will give up trying and be contented with seeing indistinctly. The muscles which converge the eyes at a common near point may become weakened so that they are tasked to their utmost, to keep up the necessary amount of *convergence*—thus we have muscular asthenopia.

The far point of distinct vision may be so near that muscles of ordinary strength cannot direct the eyes at this point without tiring as in very near-sighted people. The near-sighted person usually knows how to avoid such difficulties if he wishes to see a near object at which he cannot direct both eyes, he simply closes one eye or turns his head so that his nose excludes one eye from seeing the object. In correcting a visual defect we may give glasses which exactly correct the visual defect but they reduce the amount of accommodation required, without reducing the required convergence thus causing weak vision. A given amount of accommodation having always been associated with a given convergence, therefore, when the necessary amount of accommodation for seeing a given object at a given distance has been changed by glasses, it may be found difficult to maintain the same amount of convergence which was maintained before there was any change in the *accommodation*, which amount of convergence is necessary to avoid double vision, the necessity of trying both eyes together is therefore plain, although each eye has been tested separately. *It will frequently be found that* glasses which answer well when *each eye is used separately will not answer when both eyes are used at the same time.*

If a person is weak-sighted and has a visual imperfection it is fair to suppose that it is the cause of the weak vision till the defect has been properly corrected and no benefit derived.

The weakness of vision may be due to a reduction of the normal amount of accommodation so that it causes a strain to produce the usual change of form in the lens necessary for seeing near objects.

It may be caused by an inflammation of any of the tissues of or surrounding the eye.

Treatment—correct the visual defect if any.

If no visual defect is present, person is young, can see good at a distance but cannot read well, his accommodation is weak, his general health must be improved as much as possible. He should have rest. If obliged to read, weak magnifying glasses may be given, which make reading comfortable. They are only to be used when necessary and to be dispensed with as soon as health returns sufficiently to make it possible. Something is sometimes reached by making people who have very weak eyes read five minutes and increase the time five minutes each day till they can read a respectable length of time. (Dyer.)

If there is any preponderence of the internal over the external muscle of the eye or vice versa, it will be detected by placing a prism of 8 degrees with the base *exactly upward* before one eye, and have the patient look at a spot on a sheet of paper, the spot will be seen double, if the muscles are of equal strength they will be over each other. The external muscles are frequently found to be the strongest, and it is only when their strength exceeds a certain amount expressed in prisms that it is considered abnormal, where one muscle is stronger than the other the spots on the paper will not be over each other. Our limited space will not allow us to go into the details of muscular asthenopia.

Bad sight (or amblyopia,) is a word I take from the German, (Schlechtsichtigkeit.) Under this head I place all cases which see poorly, and which, after having tested their vision you cannot find out why they do not see To one *not* skilled in the use of the ophthalmoscope all errors of refraction which cannot be corrected, all intraocular diseases, all diseases of the optic nerve and all diseases of the brain which make vision bad, come under this head.

CHAPTER XI.

ASTIGMATISM.

The nature of astigmatism has been described in chapter 6.

Astigmatism is due to a deformity of the globe in which one curve of the cornea is sharper than another. If the vertical curve is sharper than normal while the horizontal curve is normal the rays of light in the vertical meridian will be brought to a focus earlier than rays in the horizontal curve, consequently if such an eye observes a pin hole in a card board which is placed in the window, the hole will be magnified in its vertical diameter, thus appearing vertically oval, this condition is called myopic astigmatism. Where one meridian is too flat and the other normal it is hyperopic astigmatism. All meridians may be curved too sharp but not equally *sharp* this is compound myopic astigmatism, all meridians may have an abnormally flat curve but be curved unequally, this is compound hyperopic astigmatism. One meridian may be curved too sharp while the other is abnormally flat, this is mixed astigmatism. The majority of persons have a slight astigmatism, so long as it is below $\frac{1}{60}$ it seldom interferes decidedly with vision. Cases where the correction of $\frac{1}{60}$ has *greatly* improved vision have undoutedly a much higher degree of astigmatism than has been corrected.

If a person sees badly and you have failed to find any satisfactory spherical glass ask him to look at the radiating lines in table No. 2. If he says some lines are blacker than others you may be sure he is astigmatic and will require a cylindrical glass, cut to order, for his special case.

If the vertical curve is the sharp one, the horizontal line will be magnified, consequently is the black one, so long as the magnification is not so great as to make the line indistinct, when this point is reached the vertical line will retain its former size while all the horizontal lines will look blurred and indistinct.

The horizontal curve being flattened all lines in the vertical meridian are made indistinct, while the horizontal line remains black because it has not been made indistinct, but its breadth is not magnified. Before *ordering* a glass for astigmatism it is necessary to have the patient obtain a written prescription or order from an expert, showing how the glass must be ground. It is never advisable to trust the ordering of such a glass to any but an experienced person. There is no visual defect where the disturbance of vision bears so unconstant a relation to the amount of the defect as in astigmatism. Astigmatic persons usually see badly at a distance, and print blurs badly when they read, usually the glasses which correct the defect produce a decided improvement in the vision. Sometimes the vision is brought to the normal standard like magic, other times the improvement although marked is not satisfactory, other times the correction of the defect does not appear to improve the vision any. The brain undoubtedly becomes accustomed to the distorted form of the retinal image so that its proper correction or return to its true proportions is not agreeable Astigmatism where one half of the rays in a given meridian are refracted more than the other half, is usually due to inequalities in the crystalline lens, it cannot be corrected and is called irregular astigmatism. It does not vanish upon immersing the eye in water as do other forms of astigmatism due to faulty corneal curves.

Were it not for this defect, which is present to a greater or less extent in every eye, most of us would be able to see the moons of Jupiter without a telescope.

Astigmatism is usually readily detected with the opthalmoscope, when it amounts to $\frac{1}{36}$ or more it is easily detected, and under FAVORABLE circumstances $\frac{1}{60}$ may sometimes be detected. The common way of detecting and correcting it is to try the patient with the CON-

VEX cylindrical glasses, (axis vertical and rotate right and left to horizontal,) if none are found which improve vision, the concave cylindrical glasses are tried in the same manner. Where both curves of cornea are faulty one meridian may be corrected by a simple spherical glass, the difference in the meridians being supplied by a cylindrical glass. Two convex cylindrical glasses may be required with their axes at right angles, a convex cylindrical may be required in one meridian while a concave cylindrical is required in the other.

The axes of the glasses should be carefully noted, when the best vision has been obtained, the patient should be given time in complicated cases to practically try the glasses by reading half an hour, for mistakes are quite expensive to the one prescribing the glasses. The glass or combination of glasses with which the best vision can be obtained is the required glass. It is only to be obtained by practically trying the glasses.

A cylindrical glass being the *only* glass with which no harm can be done to the eye of the patient there is no objection to giving a glass which the patient finds improves his vision, but unless one has had long experience, I would always insist upon the patient obtaining a written order from some reliable oculist before furnishing the glasses. The mistake is sometimes made of trying cylindrical glasses before it is fully decided whether spherical glasses improve the vision, persons having myopia $\frac{1}{20}$ will see better with a concave 20 cylindrical glass than without, as they are then corrected in one meridian which is better than not being corrected in any meridian but much worse than when corrected in all meridians by a simple concave glass.

A Few Practical Hints on Inflammatory Affections.

First. If a person comes to you complaining of *pain* in his eyes with DILATED pupils, ask him if he don't see rings around the lamp? He probably will say he does. If so, you assure him that unless he give prompt attention to his eyes he will *certainly* lose his sight. *Don't give* him any glasses although he says he sees better with them. He has "*glaucoma.*"

Second. If you see a child that begins to squint and you cannot cure it immediately with glasses, you are doing the parent a favor when you assure him that the child will lose the sight of the squinting eye unless he attends to it.

Third. If a person says everything looks smoky, "I see better when I first get up but soon everything looks smoky," he probably has acute inflammation of the *choroid.* If he places himself in the hands of some intelligent ophthalmic surgeon he will probably make a rapid recovery, if not he stands a good chance of losing his sight.

Fourth. Floating specks in the eye may or may not be of any great significance.

Fifth. A complaint of fixed black specks usually indicates beginning cataract, which, when ripe, can be removed. The success of the operation always depends largely upon the delicateness with which it is performed, clumsy operators have horrible results, while no surgical operation is so successful as cataract, when carefully performed.

Sixth. A red eye, where, when the under lid is pulled away from the globe the redness appears more intense upon the eye ball than upon the lid, the iris (when the felloweye is covered with the hand) is sluggish in its movements or does not move at all, and when compared with a normal eye is of a hazy dull color and devoid of the natural clearness of the normal iris, is a dangerous eye, such an iris will stick fast to the lens and do much mischief in a short space of time.

Seventh. Ingrowing eyelashes and granular lids destroy sight by scratching the cornea, which finally becomes white, "*pannus.*"

Eighth. Ulcers on the cornea destroy eyes by perforating and having the iris become fast in the wound, this frequently forms a source of irritation for years. By being awake to a few of these most important facts one is able frequently to give his patient most valuable advice.

CHAPTER XII.

Spectacles in General.

They are manufactured from glass or native crystal. Where glass is used, pure white glass free from bubbles of air or spots is the best. Natural crystal, commonly called pebbles, should also be free from specks, it is much harder than glass, much more difficult to grind and consequently more expensive. They have only a single advantage over glass, they are so hard that they are not easily scratched. Pebbles disperse the colors stronger than glass, consequently in strong glasses the rainbow colors are much more likely to show in a pebble spectacle than in the purest white optical glass. The only practical advantage of pebbles over glass, which has always kept them in the English and American markets is, they enable us with all honesty to gratify persons who do not know what they want, but simply wish to pay more than the usual price or more than their friend did for their spectacles.

Spectacles are *spherical cylindrical* and *prismatic.* Spherical glass are divided into concave and convex. If a hollow sphere be made to revolve and is used as a grinding instrument and a plain piece of glass be ground on its outer surface, a *plano concave* glass will result, if both sides of the glass are ground on the sphere a *bi-concave* glass will be produced.

Should one side of the glass be ground on a small sphere and the other side on the internal surface of a much larger sphere a *concave periscopic* glass is produced.

Should the sphere be divided and a plain piece of glass be ground on both sides on its inside surface to fit the sphere, a *bi-convex* glass would be produced.

If one surface be ground on the inner surface of this sphere and the other surface on the outer surface of a much larger sphere we would have a positive, or convex periscopic glass. Plano convex or concave glasses not being in use we will go immediately to the much disputed point of the advantages of periscopic glasses over bi-convex or bi-concave glasses.

The word periscopic means that it is easier to see through the periphery of the glass. It cannot depend upon an increase of the visual field which these glasses produce as compared with the bi-concave and bi-convex glasses. The field of vision being theoretically *smaller* through a concave periscopic and *greater* through a convex periscopic glass.

In practice it is impossible to make the visual field measure any more with one glass than the other, neither is it possible to obtain an increase of the acuteness of vision which is measurable. You will probably find some one who complains of the ground having a peculiar appearance of being bent upwards so that they have trouble in walking, or a carpenter will say that every board he planes looks hollow, when he has his spectacles on, and the only way he can satisfy himself that it is not so, is, by seeing if a straight edge fits the hollow. He probably is wearing a pretty strong pair of bi-convex glasses, which, if exchanged for periscopic glasses the trouble will disappear. We are therefore forced to conclude that the only practical advantage of periscopic over bi-concave and bi-convex glasses is, the avoidance to a certain degree of the prismatic effects of the peripheral portions of the glass.

If a plane of glass be placed against a *revolving cylinder* and ground till it fits the cylinder we have a plano-concave cylindrical glass. It may be concaved on both sides then we have a bi-concave cylindrical glass. If the glass be ground on the concave side of a section of a hollow cylinder, a plano convex cylindrical glass is the result. Such a glass acts only upon rays of light which fall in the meridian, crossing the axis upon which the glass is ground, therefore if the vertical curve of a cornea is too sharp we can compensate for it by placing a concave cylindrical glass before it, with the axis horizontal.

If the horizontal curve be too flat, as is usually the case in hyperopic astigmatism, we can compensate for it by placing a convex cylindrical glass with the axis vertical. The axis is always placed at right angles to the faulty meridian we wish to correct.

Glasses are frequently cut spherical on one side and cylindrical on the other, or they may be cut convex cylindrical on one side with the axis in a certain direction, while the other side is concave cylindrical with the axis in another direction.

A prism is a wedged shape piece of glass, it is used where the muscles of the eyes are too weak to direct both visual axis at a common point, to displace the entire retinal image so that it falls upon the visual spot, although the visual axis of the eye is not directed at the observed object. In other words, instead of moving the eye to the place where the retinal image falls we move the retinal image, thus resting weak muscles from fatiguing exertions. A prism is frequently combined with a glass which corrects a visual defect, both being ground out of one solid piece of glass.

We now come to the much disputed subject of *colored* and *tinted glasses.*

Blue and tinted glasses will be used independent of their merits, in proportion as the fever for blue glass exists in a certain locality. Every one will remember the blue glass fever which was epidemic in the United States, a few years ago. A London smoke glass allows all rays of light to pass through, it simply diminishes the quantity of light without disturbing the proportion which exists between the color rays.

A blue glass allows all spectral rays to pass through but changes the proportion which exists between the blue and other color rays.

Every one is acquainted with the irritating nature of yellow and red rays of light. It is therefore not unreasonable to believe that where the eye is irritable from disease or the illumination is unusually intense, the weakening of the light by smoked glass, or the excluding of a certain proportion of the most irritating rays of light, by blue glass, is agreeable. If blue glasses are to be worn simply because others wear them, simple eye glasses with blue lenses answer. If the eye is really to be protected the large watch crystal shaped glasses are the best. Those that are blown are much cheaper and usually act as weak concave glasses, while those which are ground are free from such action and are better.

Tinted Spectacles.

Without going into any lengthy discussion as to the theoretical comparative merits of tinted and white glass let us look at the subject practically.

If four pairs of spectacles are placed side by side, one being a finely polished white glass, one common green glass, one tinted glass, another an old pair which has been badly scratched. A person selecting spectacles will prefer any pair rather than the finely finished pair. There is an unpleasant glance to a finely polished pair of spectacles which is not found in any of the other three pairs,*) if he will take the well polished spectacles and wear them a few days till he becomes accustomed to the glance and sharp retinal images. They fulfill much better the optical purposes for which they are intended than either of the others, which have no

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*) I frequently send a patient away rejoicing by simply covering his spectacles with finger marks.

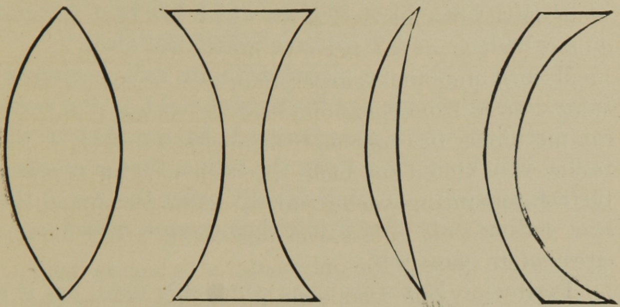
glance, and do not make the retinal image as sharp. The advantage of glasses made from pure white optical over *common* glass, is very easily demonstrated by placing the lens in the opening of an adjustable dark box and catching the inverted image on a piece of ground glass or on a dark screen. The image formed by the lens made of pure white optical glass is decidedly brighter and sharper than that cast by a lens manufactured from common glass. If you are however, from pecuniary or other motives, inclined to favor poor spectacles or tinted spectacles you will have little difficulty in convincing such a judge of the advantages of poor glass or tinted glass over pure white glass. The purest white glass is the only material which is recommended by any one who is authority in America, Germany or England, for the manufacture of spectacles.

If you had lived in Berlin during the blue glass rage, you would have been obliged to give your patients blue glasses or spectacles, or if the fever should break out again in the United States, you will have to sell blue glasses.

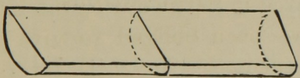
The white glass used by the Spencer Optical M'f'g Co., in their factory, I am satisfied is harder than the English or German white glass, and I think on the average, will be found purer and freeer from inequalities. It is impossible to tell the difference between a pebble lens and one manufactured from a good clear piece of white glass by looking through it.

In ordering glasses the optician should always take pains to know just what he wants and know how to order it. I therefore attach a diagram of the various glasses in use.

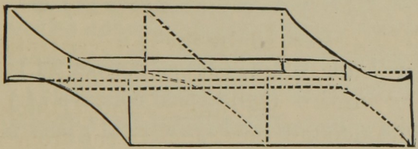
A B C D



E



F



A is a double convex lens, (say No. 14.)
B is a double concave " "
C is a periscopic convex. "
D is a periscopic concave. "

E is a section of a cylinder or a convex cylindrical glass. Rays of light which pass through this glass in a plain at right angles to its axis will be brought to a focus, while rays of light which are in the plain corresponding with its axis are not acted upon.

F is a plain piece of glass which has been ground on a cylinder. It is a concave cylindrical glass.

If such a glass be placed with its axis horizontal before our schematic eye the rays of light in the vertical meridian which now unite 11.84 mm. before the retina, will be united upon the retina, thus correcting the astigmatism. Oculists usually order the No. of the lens stating only that it is either *concave* or *convex*—*spherical* or *cylindrical.*

Periscopic lenses are most commonly used, but if a special form is desired it must be stated.

A = $+ {}^1/_{14}$ S = (bi-convex 14) = $+ {}^1/_{14}$ spherical.
B = $- {}^1/_{14}$ S = (bi-concave 14) = $- {}^1/_{14}$ spherical.
C = $+ {}^1/_{14}$ S (periscopic convex 14) = $+ {}^1/_{14}$ spherical (periscopic.)
D = $- {}^1/_{14}$ S (periscopic concave 14) = $- {}^1/_{14}$ spherical (periscopic.)
E = $+ {}^1/_{14}$ C = (cylindrical convex 14.)
F = $- {}^1/_{14}$ C = (cylindrical concave 14.)

Where a spherical and cylindrical glass is required for an eye, they are both ground on the same piece of glass, the spherical surface being on one side and the cylindrical surface on the other. When required the Nos. of lenses are written with the sign of combination thus, + $^1/_{14}$ S ⊂⊃ $^1/_{14}$ C axis — vertical or so many degrees to right or left of vertical *or* so many degrees from horizontal indicated from *patients* left to right.

If you want a periscopic glass for a person who is not near-sighted, do not forget to say when you give the No. of the glass, that it is *periscopic convex.*

If it is for a near-sighted person, say periscopic *concave*, persons frequently send for a concave glass No. —, because they notice that one side of the glass is concave without noticing that the other side has a sharper convexity. It finally comes out that they wanted convex periscopic lenses.

The nature of a spherical lens may be determined instantly, by looking through when held at a distance and then moving it, if it is convex, every object will move in the opposite direction from which you move the lens, if it is concave, objects will move in the same direction.

If you have a convex cylindrical lens the objects will move in the opposite direction from which the lens is moved, providing the motion is not in the direction of its axis. When motion is in direction of its axis, observed objects remain stationary.

If you have a *concave* cylindrical glass, objects remain stationary when it is moved in the direction of its axis, and move in the same direction when the lens is moved in any direction *not* corresponding to its axis.

The Old or Inch System and The New or Metric System.

In the old or inch system a lens of one inch focal distance is the unit of comparison, and all other lenses have a greater focal distance but a less refractive index than their unit of measure.

In the old system the focal distance of lens No. 3, was 3 inches and its refractive index was $\frac{1}{3}$. In the new or metric system a lens whose focal distance is a meter is taken as the unit of measure, and the refractive index of this lens is 1—dioptric, the next lens is No. 1.25 or a refractive index of $1\frac{1}{4}$ dioptrics. The object of the new system is:

First. To make the measure of glasses uniform throughout all civilized countries.

Second. It was intended to make the focal interval more regular, this was however found impossible.

Third. One of its most practical advantages are, the laity are not able to cheat the oculist or optician by finding through an accidental observation the No. of the glass with which they see best, and then wander off and buy them at a street corner. For the practical oculist who has become accustomed to knowing the focal distance as well as the refractive index of a glass, by a glance at its number, it is not as convenient as the old system. In the new system we know little or nothing about the focal distance of the glass. I think it would have been more fortunate if they had retained the same glasses, (which they in fact have done,) and measured their focal distances by the metric system. The reason for a small focal interval between the weaker glasses, and a longer one between the stronger glasses is well shown by the following example :

Take glass No. 80, suppose it is not strong enough and I try to increase its power by moving it an inch further away from my eye, it then becomes a glass of one inch less focal distance, a No. 79, the difference between a $\frac{1}{79} - \frac{1}{80} = \frac{1}{6320}$, the increase of power which can be obtained by moving such weak lenses away from the eye, is too little to be of any advantage, therefore we must have lenses of different focal distances. If however you take a convex 2 and move 1 inch away from the eye it becomes convex one. The optical effect of this glass has been increased 3 thousand times more than in the former case. In this way the large focal intervals are compensated for by moving the glass a little farther away from the eye, thus the interval $\frac{1}{18}$ which exists between 2 and $2\frac{1}{4}$ can be divided up to meet any possible requirements.

The following table is taken from Mauthner, the glasses of the old and new system may be rapidly compared by referring to the table.

OLD SYSTEM. Numbers in inches.	NEW SYSTEM. Numbers in dioptrics.	OLD SYSTEM. Numbers in inches.	NEW SYSTEM. Numbers in dioptrics.
(160)	0.25	8	5.
80	0 5	7½	(5.25)
60	(0.67)	7	5.5
50	0 75	6½	6.
40	1.	6	6.5
36	(1.11)	(5¾)	7.
30	1.25	5½	7 5
24	1.5	5	8.
(22)	1.75	4½	9.
20	2.	4	10
18	2.25	3¾	10.5
16	2.5	3½	11.
14	2.75	3¼	12.
13	3.	3	13.
12	3 25	2¾	14.
11	3.5	2½	16.
10	4	2¼	18.
9	4.5	2	20.

Opticians have a short method of estimating the value of lenses of the new system. They consider a lens, No. 36, equal to one dioptric, two No. 36 lenses, equal to two dioptrics or $\frac{\quad}{18}$ etc., the difference between the value thus obtained and the true values which are found in the tables, are so small that one can prescribe glasses according to this system and they will usually be satisfactory, although the difference in focus shows promptly in a focusing box. The method is however convenient, and the amount of error is illustrated by the following example.

Suppose 2 dioptrics is called for, and you give $\frac{1}{18}$, $\frac{1}{20}$ is however the nearest corresponding glass—the difference between $\frac{1}{18}$ and $\frac{1}{20}$ is only $\frac{1}{180}$. This difference is rather too small to make much trouble.

A large proportion of the people to whom one is obliged to exhibit his spectacles are dishonest and ready to take advantage of a person who is expert in selecting glasses. They will under pretence that they wish to buy draw out what you think is the proper number, and then owing to a previous engagement, be obliged to leave, remarking they will call again. They go to the first street corner vender of spectacles, and ask him for the number you thought was suitable. One who takes sufficient interest in the subject to familiarize himself with the new system will be able to protect himself perfectly against this class of customers by ordering his glasses marked in the metric system. Both systems are now so generally understood that one may use either method equally well in prescribing glasses.

CHAPTER XIII.

TEST OF NEAR-VISION.

Table 3 is the first page of Snellen's "*test-text*" for testing near-vision. Its only practical advantage over other fine print is: it is systematically arranged and in universal use. The distance at which each text should be read in order to be seen under an angle of five minutes, is indicated in figures above the text. It will, however, be found that persons can frequently read these fine letters at a distance representing five minutes, but cannot read the large letters in table No. 3 under the same angle (of five minutes). This discrepancy I simply mention. The formula representing the acuteness of vision is

$$\text{Vision} = \frac{d}{D}.$$

Large D represents the distance at which the text *should* be seen, and d represents the distance at which it *can* be seen.

The first should be read at five decimeters, or 19,68 inches. I, however, can read it at 24 inches with good light, therefore my vision $= \frac{d}{D}$; $d = 24$ inches, $D =$ 19,68 inches, $V = \frac{24}{19{,}68}$ or approximately $\frac{24}{19}$.

In using these test-texts no attention need be given to fractional parts of an inch. This text may be used as simple print in fitting *presbyopic persons* with glass, no attention being given to the numbers, only when you wish to *record* the acuteness of near-vision.

D = 0,5 = 19,68 inches.

The Gallic tribes fell off, and sued for peace. Even the Batavians became weary of the hopeless contest, while fortune after much capricious hovering, settled at last upon the Roman side. Had Civilis been successful, he would have been deified; but his misfortunes, at last, made him odious in spite of his heroism. But the Batavian was not a man to be crushed, nor had he lived so long in the Roman service to be outmatched in politics by the barbarous Germans. He was not to be sacrificed as a

D = 0,6 = 23,63 inches.

defection and the decay of national enthusiasm, he determined to be beforehand with those who were now his enemies. He accepted the offer of negotiation from Cerialis. The Roman general was eager to grant a full pardon, and to re-enlist so brave a soldier in the service of the empire. A colloquy was agreed upon. The bridge across the Nabalia was broken asunder in the middle, and Cerialis and Civilis met upon the severed sides. The placid stream by which Roman enterprise had connected the

D = 0,8 = 31,49 inches.

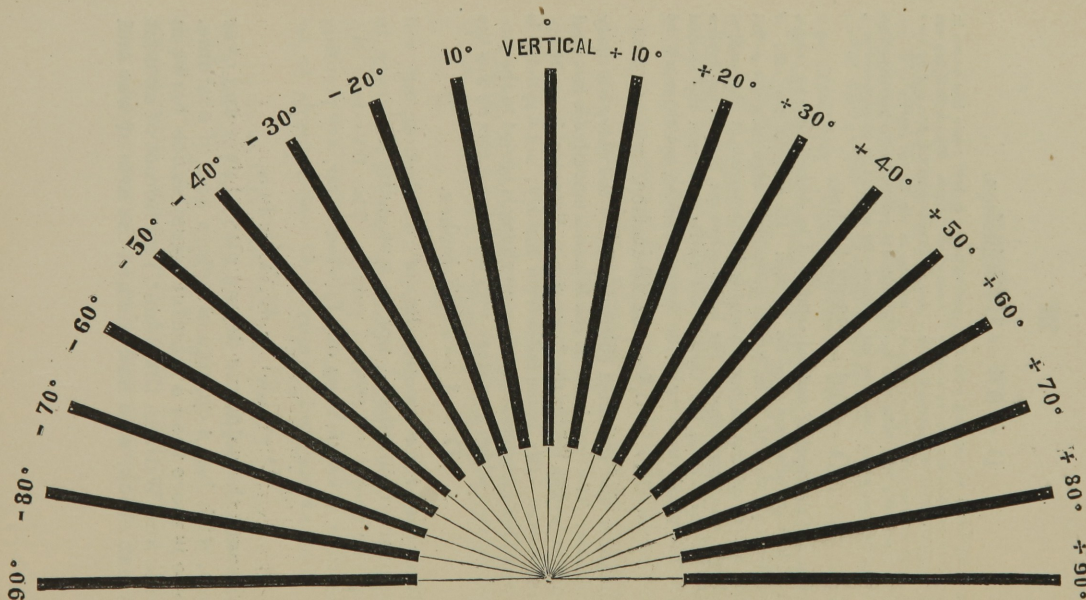
commander and the rebel chieftain.—Here the story abruptly terminates. The remainder of the Roman's narrative is lost, and upon that broken bridge the form of the Batavian hero disappears for ever. His name fades from history; not a syllable is known of his subsequent career; everything is buried in the profound oblivion which now steals over the scene where he was the

D = 1 = 39,37 inches.

Even the vigorous exercise of wood-chopping will not insure immortality, nor is systematic diligence in sleep the secret of eternal youth. The friends of Mr. Gladstone, it seems from our London letter, are pointing out that at one-and-seventy their leader needs to be

D = 1,25 = 49,21 inches.

to present the selfsame drama played over and over again, with but a change of actors and of costume. There is more than a fanciful resemblance between Civilis and William the Silent, two heroes of ancient German stock, who had learned the arts of war and



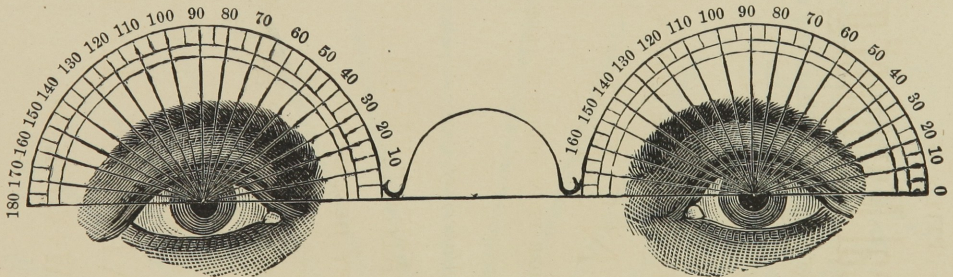
Those to whom these lines do not appear alike for all distances, are astigmatic, and if eyes are weak, they must have glasses ground for their special case.

Test for Distant Vision

consists of square letters marked CC—C—LXX—L—XL—XXX—XX ; these numbers indicate the number of feet at which the letters should be seen.

Prescription Blanks for Physicians' or Oculists' Use.

℞



Right Eye.		Left Eye.	
Spherical,		Spherical,	
Cylind.,	Axis,	Cylind.,	Axis,
Do.	"	Do.	"
Prism,	Base,	Prism,	Base,

Distance between centres of Pupils, in.

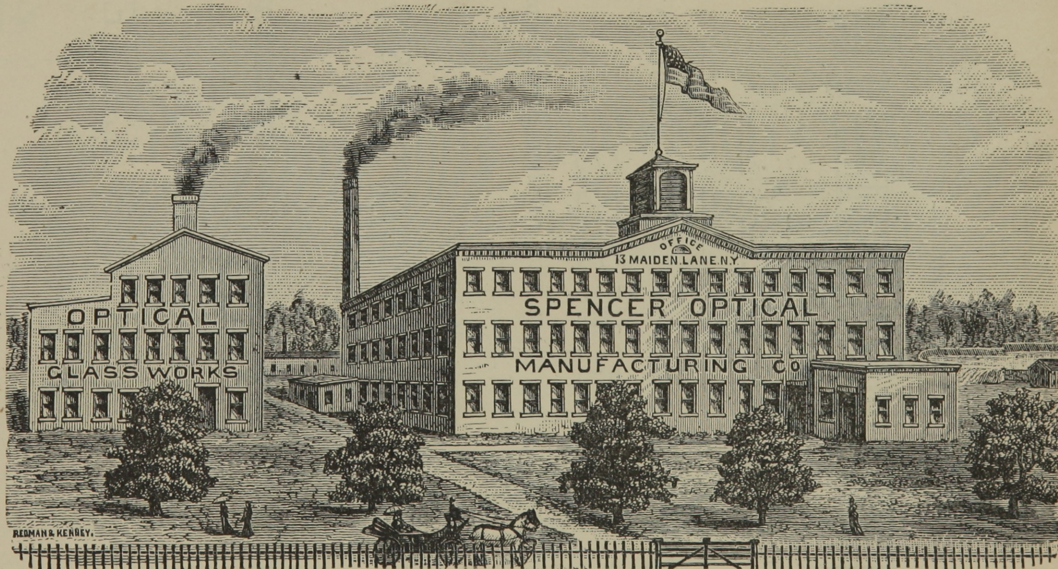
Nose Rest, " " Temples, "

Bow,

M. D.

188

These Blanks furnished to the Trade when desired.


OPTICAL
GLASS WORKS
OFFICE
13 MAIDEN LANE N.Y.
SPENCER OPTICAL
MANUFACTURING Co
REDMAN & KENNEY.

CC.

A

C.

C E

LXX.

G L N

L.

P R T 5

XL.

V Z B D 4

XXX.

F H K O S 3

XX.

U Y A C E G L 2