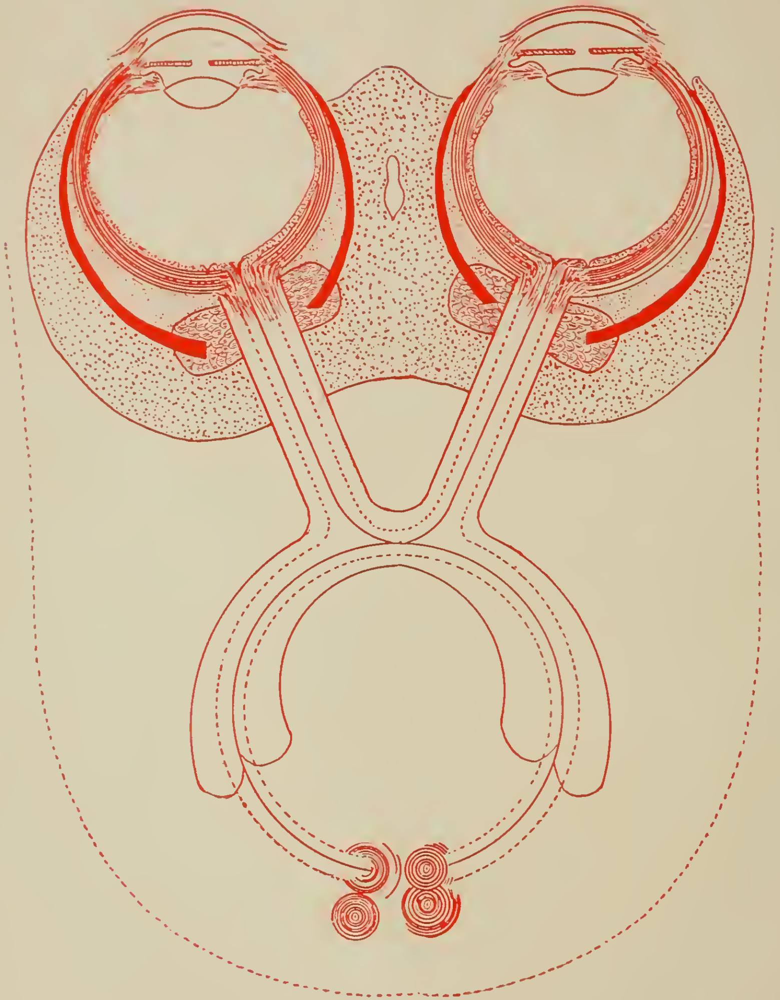
...AL TRUTHS

Dr. McCormick



OPTICAL TRUTHS.

ILLUSTRATED.

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TO THE

SWEET SPIRIT,

WHO HAS BEEN, IS, AND EVER SHALL BE

MY INSPIRATION,

THIS BOOK

IS

DEDICATED.

CONTENTS.

PART II.

ABBREVIATIONS.

ACC. Accommodative power.
AM. Ametropia.
AS. Astigmatism.
C. Cornea.
CC. or CVE. Concave.
CM. Centimetre.
CX. or CVX. Convex.
CYL. Cylinder.
D. Dioptre.
E. Emmetropia.
F. Formula.
H. Hyperopia.
L. Left.
M. Myopia.
MM. Millimetre.
O. D. Right eye (*ocular dexter*).
O. S. Left eye (*ocular septimus*).
O. U. Both eyes (*ocular unose*).
PCC. or PCVE. Periscopic concave.
PCX. or PCVX. Periscopic convex.
PP. Punctum Proximum (near point).
PR. Punctum Remotum (far point).
R. Right.
SPH. Spherical.
V. Vision, or acuteness of vision.
+. Plus.
−. Minus.
=. Equal to.
⊃. Combined with.
⌐. Combined with at right angles.
∞. Infinity, twenty feet away.

INTRODUCTION.

In the practice of ophthalmology one of the essentials is a general knowledge of the nervous system, what it is, whence it cometh, and whither it goeth.

It is simply a complete telegraph system, intimately connecting every portion of the anatomy.

In structure it is a series of tubular membranes containing in a minute and continuous stream, matter identical with the brain substance, through which electrical energy is transmitted.

This energy is of two kinds, *galvanic* and *faradic.* The first is generated by the digestive organs, and is constant; the second, is an intermittent current generated by molecular friction throughout the body.

The nervous system is divided into two classes, the *cerebro-spinal* or *animal*, and the *sympathetic* or *organic.*

There are two currents of nerve force: The *afferent*, from the peripheral parts to the nerve centers, and the *efferent*, from the nerve centers to the peripheral parts.

The brain is the chief nerve center. All force is sent there, and thence distributed in every direction and in such proportions as conditions require. To do this the brain gives off twelve pairs of cranial nerves and the spinal cord, the latter being the grand trunk line which supplies the minor centers, or plexuses, in the body.

There are two functions devolving upon the nerves, *motion* and *sensation.*

The cranial nerves are numbered and named as follows:

I *Olfactory*, nerves of smell.

II *Optic*, nerves of sight.

III *Motor Oculi*, motor nerves, which supply all the muscles of the eyes, save two.

IV *Patheticus* or *Trochlear*, motor nerves, which supply the superior oblique muscles of the eyes.

V *Trigeminus*, nerves of sensation and motion, having three main branches, one to the eyes, and two to the upper and lower jaws.

VI *Abducens*, motor nerves, which supply the external recti muscles of the eyes.

VII *Facial* or *Portio Dura*, motor nerves of face, ear, palate and tongue.

VIII *Auditory*, nerves of hearing.

IX *Glosso-Pharyngeal*, nerves of taste.

X *Pneumogastric*, nerves of motion and sensation, which supply the lungs, stomach, heart and their accessories.

XI *Spinal Accessory*, to the Tenth.

XII *Hypo-glossal*, nerves of motion of the tongue.

The nerves given off from the spinal cord number 31 pairs, and they form five principal centers or plexuses, as follows, in the order of vertebral subdivisions: Cervical, 8 pairs; Dorsal, 12; Lumbar, 5; Sacral, 5; Coccygeal, 1.

Each nerve contains both animal and organic qualities, so that we have not only the power of motion and sensation, but also the sympathetic relation between all parts which is absolutely necessary to health and control of functions.

In normal physiological conditions the distribution of nerve force .s proportional to the capacity for supply, and Nature has so arranged that the brain contains a reserve stock for emergencies. Were it not for this wise provision the suspension or decrease in capacity of the source of supply would, surely and speedily, result in death.

In youth the quantity of reserve force, as well as the capacity for supply is greater, hence the more speedy recovery from injuries and ills. Extraordinary drain upon the nerve supply can be endured without discomfort, because of these conditions. When, however the reserve supply is exhausted, the demand is made directly upon the capacity of the machinery and trouble follows.

Any abnormal physiological condition, or functional demand which requires more than the normal proportion of nerve force in one direction, will have evil effects upon other functions as soon as the reserve is reduced below the safety line. One of these is the intense thought associated with grief, joy, fear, anger and other emotions, because the demand is directly upon the chief source of supply.

In this connection it is interesting to note by experiment, the effect of thought upon the various functions. The phenomena of blushing, turning pale, etc., are illustrations of the influence of thought upon the nerves which control the circulation of blood.

The influence of the mind upon the body is being recognized by the medical colleges of today, and psychology is one of the special branches taught. The Faith Healers find the basis for their work in the same proposition, coupled with a fanatical belief that they are especially endowed by God.

Each case which presents itself to the ophthalmologist has individual peculiarities, and only a thorough knowledge of elementary principles of anatomy, physiology, neurology, physics, psychology and mathematics will enable the practitioner to meet them with credit to himself and comfort to his patients. He must also cultivate his common sense, and look for the simplest way out of any difficulties which may arise.

In the following pages the author endeavors to give information, accompanied by practical reasons for each proposition, and trusts it will be of service to all into whose hands it may come.

The cuts, excepting those of instruments, were all made expressly for this work, and are correct according to the laws which they illustrate.

The colored plates were drawn by Professor Frank Rumble, of McCormick Optical College. Those representing retinæ were made from ophthalmoscopic observations.

PART I.

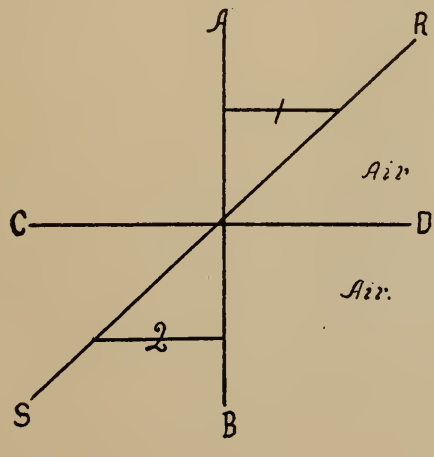
CHAPTER I.

The Laws of Refraction Stripped of Complications.

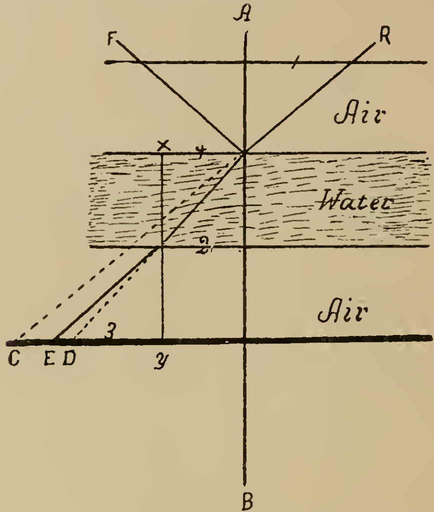
Definition—Refraction is the deviation in its course a ray of light suffers in passing obliquely from one transparent medium to another of different density.

The amount of refraction is governed by the angle of incidence and the density of the medium, and it is measured according to natural laws.

Air is taken as the standard of measurement of refraction, and is, therefore, designated by the unit, 1, because a ray in passing from one space to another, in air, would suffer no change in its course, and angles formed by it with vertical lines would always be of equal size.



Let the line starting from *R*, in the cut, represent a ray. After crossing the line *A B* at the line *C D* it continues on its course toward *S* without deviation, consequently angles 1 and 2 are of equal size.



The cut above shows what would occur if a ray from *R* should come in contact with a body of water at the point where it crosses the line *A B*. Its course would be changed, for the reason that its movement is swifter in the rarer medium, and, its lower edge, meeting the obstruction first, would be retarded in its progress, while the upper edge would continue its speed, thus gaining on the other, so that the course of the ray through the denser medium would be toward *D* instead of in the direction *C*. As it passes obliquely through the water, it will be seen the lower edge would be released first, and, renewing its original pace, would gain on the other edge, recovering what it had lost at the first surface, and would pass toward *E*, parallel to, but not on the line of its original course.

From the amount of deviation as shown by the comparative proportions of the angles formed in the two mediums, we learn the proportionate rates of speed at which a ray will move through various mediums. Air, being the rarest is taken as the standard. All other mediums are compared with it, and the expressed ratio is called *Index of Refraction*. The proportion of the angles in air and water is as 4 is to 3, hence, the index of water is 1.33, because it would take 1⅓ of its angle to equal the angle 1 in the air. The proportion of air and glass is as 3 to 2, so the index of glass is 1.50. The diamond has the greatest refracting power, the proportion of air and diamond being 5 to 2, therefore its index is 2.50.

According to its index of refraction water would cause the ray to change its course so that the length of the angle formed by the ray and the vertical line at the lower surface (2 in the cut) would be in proportion to that formed by the ray and vertical line at the same distance (1) above the first surface, as 1 is to 1.33.

The same law applies in passing from the dense to the rare medium below, the angle at *3* being 1.33 times as great as that at *4*.

A ray is called *incident* before it enters the denser medium, *refracted* during its passage and *emergent* after it has passed.

The angle formed by the incident ray and the vertical line *A B*, is called the *angle of incidence*; that formed by the refracted ray and the same line, the *angle of refraction*; and that formed by the emergent ray and the line *x y*, the *angle of emergence*.

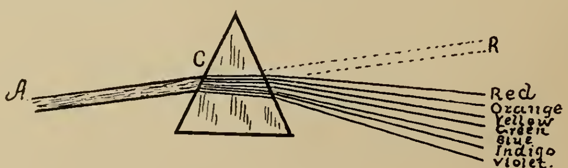
A ray, in making a passage as illustrated, suffers the loss of a portion by reflection at the first surface, and it is a law of optics that *the angle of reflection always equals the angle of incidence*, hence it follows that the reflected portion would pass toward *F* forming another angle with the line *A B*, called the *angle of reflection.*

It will be observed that the angles of emergence and incidence are of equal size; therefore, a ray starting at *E*, would pursue the same course, and *R* would be the emergent ray, which fact gives us another law, viz.: *The course of returning rays is always upon the same lines by which they enter.*

If an incident ray forms an angle with the perpendicular greater than about fifty degrees it will suffer total reflection. This is called the *limit angle.*

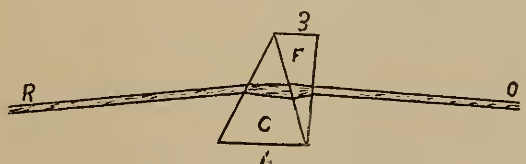
It is well known that natural light is composed by a combination of all the spectral colors. The passage of a ray through any medium which reduces its original speed causes a derangement of its components, the medium absorbs a portion, while it also makes an attempt to disperse it into its elementary colors; so, any ray, in passing from one transparent medium to another of different density, suffers from *reflection*, *dispersion* and *absorption*; and, if it passes obliquely, it also suffers *refraction.*

Were it not for reflection we could not see objects which are not in themselves luminous; and, were it not for dispersion and absorption the power of the reflected light would be so great as to be painful to the nerves of vision.

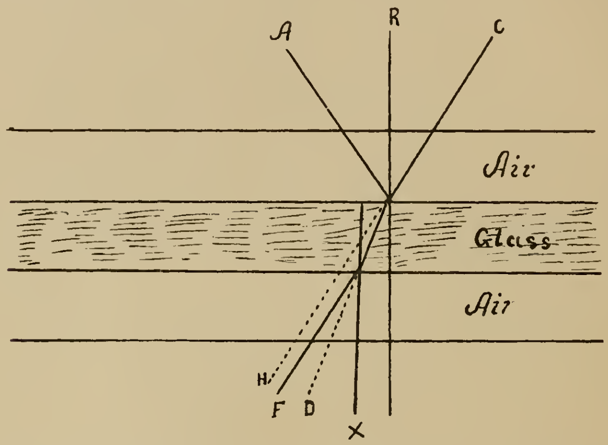


This figure illustrates the dispersive power of glass, with the ray passing from *A* toward *R*, at such an angle of incidence that the greatest possible effect from the prism, *C*, is shown.

It is a curious fact that *flint* glass, with a refractive power about equal to, has twice as much dispersive power as the *crown* glass from which spectacle lenses are made. It was the discovery of this which enabled the makers of the finer grades of optical goods, such as microscopes, etc., to attain their present approximate to perfection. Previously two factors interfered with the successful use of lenses with more than about twenty-five diameters magnifying power. These were *chromatic* and *spherical aberration*. The first is the effect of the dispersive power, and is the term employed when the image is fringed with color; the second is the result of imperfect refraction, the edge rays in high power lenses violating the law and coming to a focus just a little sooner than those which pass the main body of the lens, thus causing an indistinct image. The discovery referred to has enabled the manufacturers to overcome both of these factors and thus utilize the whole field of the lens. Formerly it was necessary to rough-grind the marginal field to even partially overcome the difficulties.

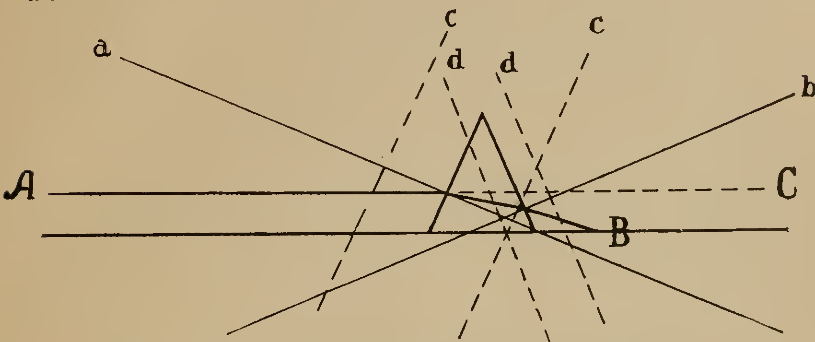


This cut shows the dispersion of the ray from *R* in the crown glass, *C*, and the contrary effect in the flint glass, *F*, which reunites the parts, and the emergent ray becomes white again. The flint glass, *3*, being *half as strong* in refractive power as the crown, *6*, and of the *same* dispersive power, the result is a refractive power of 3 in the combination, without any dispersion. It is upon this principle that *achromatic* and *aplanatic* lenses are made. The first means the chromatic aberration is corrected, and the second is a lens in which all faults are corrected.



This figure illustrates refraction by glass. A ray from *C* upon meeting the surface of the denser medium would be refracted and take the course toward *D*, forming an angle of refraction in proportion to the angle of incidence as 1 is to 1.50. At the other surface it would again suffer refraction and take the direction *F*.

Reference to the illustrations shows that rays of light always move in straight lines. There are *breaks* but no *bends*. It will be seen, also, that in passing from the rare to the denser medium the ray is broken *toward* the perpendicular to the surface, and in passing from the dense to the rarer medium it is broken *from* the perpendicular.

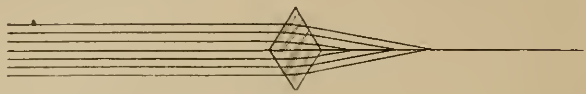


This illustration demonstrates the effect upon a ray passing a prism. Consider one surface at a time. The line projected from *A*, upon meeting the first surface would be broken and follow the line drawn through the denser medium to the second surface, which it would meet at a different angle, the result of which would be a second break and the final course taken to *B*. The dotted lines are drawn to enable the measurements to be taken correctly, according to the index of refraction, lines *a* and *b* representing the perpendiculars to the respective surfaces, and the lines *c c* and *d d* the distances from the surfaces at which the measurements were taken.

LAW—*Rays of light in passing a prism are always broken toward the base line.*

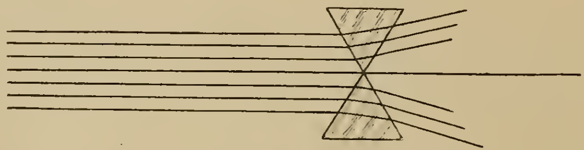
An eye at *A* would see an object placed at *B* as if it were located at *C*. This is called the *virtual* or *imaginary* image, and it is always seen at a point nearer the apex of the prism than the object is really situated. This is the reason convex lenses magnify, and concave minify objects seen through them.

Now if we should take another prism and place it with its base abutting the base of the first one, we would have this:



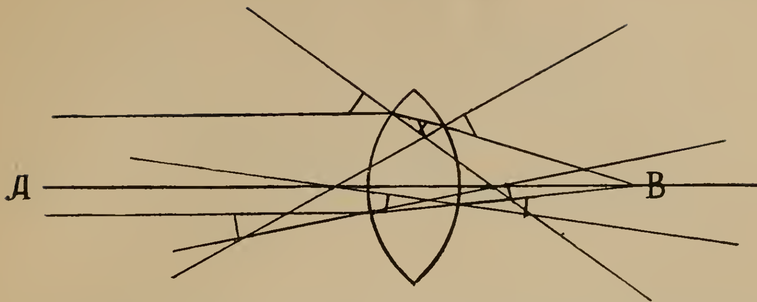
Project parallel rays through it and they will meet at points along the base line or *axis* as it is now called. Here we have the principle upon which convex (+) lenses are formed.

If we place the prisms with their apices toward the axial line the effect would be just opposite, showing the principle of concave (—) lenses, thus:

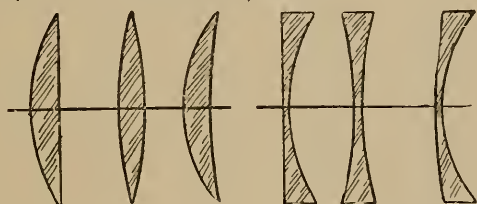


Observe that in both preceding illustrations the central line passes through without refraction. This is because it meets the surfaces at a perpendicular. It is well to remember that, referring to lenses of all kinds, the word "*axis*" means *without refractive power.*

Note, in the convex cut, that while parallel rays meet on the axis after passing the prisms, they do not meet at a point common to all. In order to utilize the principles of refraction for optical purposes it is necessary to grind the surfaces of the prisms so that they will be *curved* instead of *plane*, when we have the effect of a multitude of prisms, of different angles, and parallel rays passing them will be converged to a single point on the axis, no matter if they are at different distances from the axial line before entering, as the following drawing shows:

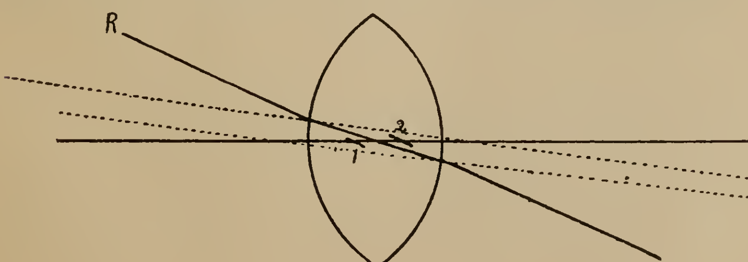


The fact that the curvature of either surface would, if continued, form a perfect sphere, caused the name *spherical* to be given such lenses. They may be either convex or *concave*, and each class is subject to three forms of construction, thus:



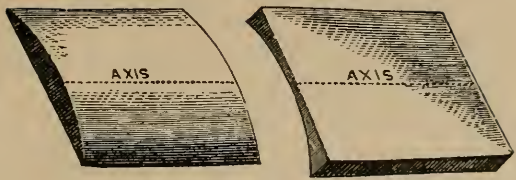
1, Plano-Convex; 2, Bi-Convex; 3, Periscopic Convex; 4, Plano-Concave; 5, Bi-Concave; 6, Periscopic Concave.

A true *nodal point* is the center of curvature; but, the nodal points of a lens are located upon the axis in the following manner:



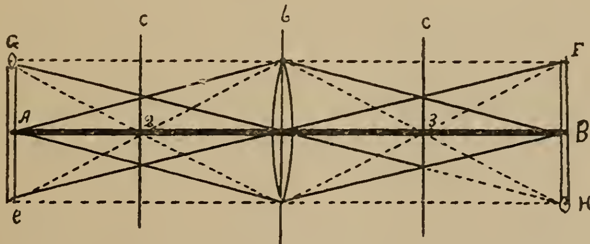
A ray starting from *R* towards *1*, on the axis, would be refracted and cross the axis as shown in the cut, and at the other surface would be refracted again, taking the course in line with point *2* on the axis. The points *1* and *2* are designated as the *nodal points* of the lens, and the point between them, where the refracted ray crossed the axis is the *optical center* of the lens. All rays which cross the axis at or between the points *1* and *2* are called *secondary axial rays*. As the deviation of such rays is very slight in thin lenses, such as spectacles, it is ignored, and in drawings all are passed straight through the optical center. The rule, then, is: The *nodal points* are those points upon the axis where secondary axial rays would cross did they not suffer refraction; and the *optical center* is the point on the axis where the refracted secondary rays actually cross.

There is another class of lenses in which the prisms are arranged bases in for convex and bases out for concave, but, instead of being arranged around a central point, as in the sphericals, they are placed on either side of a line drawn from edge to edge, and all rays passing through the lens on that line do so without refraction. This line is called its *axis*. The full measure of power of such lenses is always on the meridian at right angles to the axis. The curvatures of these lenses would, if continued, form cylinders, hence they are called *cylindricals*. They are made only in the forms plano-convex and plano-concave, because of the frequent necessity of combining them with sphericals, making what are called sphero-cylinders, or compound lenses, in which there is refractive power in all meridians, but in the two principal ones, viz.: on the meridian where the axis is, and the one at right angles to it, there is, respectively, the minimum and maximum power.



Convex Cylinder. Concave Cylinder.

The following figure illustrates the chief points to be remembered in determining how and where images are formed by convex spherical lenses. The line from *A* to *B* is called the *principal axis* of the lens, (*6*), because it passes through the center of curvature of both surfaces and the ray which follows this line is not refracted; also, because it must be distinguished from the *secondary axes*, two of which are shown by the lines *e F* and *G H*. All rays which cross the principal axis at the optical center of a lens are secondary axial rays.



All rays which do not pass through a lens on the line of its principal axis suffer refraction, but, as has been stated, the deviation in their course of the secondary axial rays is so slight that it is not considered. The points at 2 and 3 are called the *principal focal points* because rays which come from the opposite side of the lens, parallel to the principal axis, would focus at those points, which are immovable. The lines *c c* are called the *principal focal planes* because they correspond to the principal focal points. The dotted lines forming the diamond-shaped figures extending from *e* to *F* and *G* to *H* and the black lines from *A* to *B* are called the *edge rays*. By noting how they converge to their several axes, forming points after passing the lens, the manner in which images are formed, and the reason they are reversed, will be seen. Rays from any point on the object *G e*, will be focused at a point on the other side of the lens on the plane *F H*, and the point will be in line with the first point and the optical center of the lens. The point upon the principal axis where the object is placed is the *first conjugate focal point*, and the corresponding point on the other side of the lens, where the image is formed, is the *second conjugate focal point*, and the distances between each of those points and the lens are, respectively, the *first* and *second conjugate focal distances*. A rule to locate where images will be formed is to multiply the first conjugate focal distance by the focal length of the lens and divide the product by the difference between the two first figures; the result will be the second conjugate focal distance, which, in + lenses is always on the opposite side of the lens. The word "conjugate" means "yoked together," and it is applied to the points described because they are movable, the position of the second being always dependent upon the first. In the cut the object is placed at twice the focal length of the lens and its image is formed at the same distance on the other side, and is of the same size. Move the object farther away, and the image will be formed closer to the lens and be reduced in size; move the object closer, and the image will form farther away and be increased in size.

CHAPTER II.

Measurement of Lenses and Prescription Writing.

A + lens which brings parallel rays to a focus at one metre (39.37 inches) beyond it, is taken as the standard of measure and is numbered *one*. All others bear the same relation to it that pieces of money bear to $1.00.

If the natural course of rays is parallel, and + 1.00 changes their course so they meet on the axis one metre beyond it, + 2.00, having twice as much power, would cause the focus to occur twice as quickly, or at one-half the distance of the first; + 3.00, having three times the strength of + 1.00, would focus three times as quickly, or at one-third its focal distance; + .50 being one-half as strong as + 1.00, would bring rays to a focus twice as far away. As 39.37 inches is is so nearly 40 inches, it is sufficient for all practical purposes, to figure on that basis.

As + 1.00 is the number, and 40 inches the focal length, of the unit of measurement, if we have the number of a lens and want to know its focal length we divide the number into 40, and the result is the figure desired. If we have the focal length and want the number, we divide 40 by the focal length and the result is the number. + 2.50 is of 16 inches focal length, because 2.50 is contained in 40 sixteen times. A lens of 10 inches focus would be + 4.00 because 10 is contained in 40 four times.

Lenses are not made in smaller fractions than eighths, so that when a figure is divided into 40 and the result is not in eighths we put it in the class to which it is nearest. For example a 15 inch focus would give number 2.66 ⅔ when the calculation is made thus: 40 divided by 15 equals 2.66⅔. As 2.625 is the nearest, we so class it. It is customary to ignore the third figure in the decimal expression, so the number would be 2.62 or 2.63.

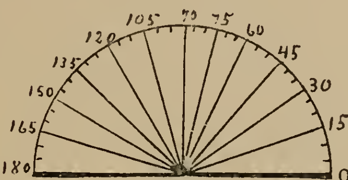
In practice it is rarely ever necessary to use smaller fractions than quarters, because, if the eye is below normal, so that + lenses are required, it should be given full correction, or a little more; and if it is above normal, so that — lenses are used, it should be undercorrected. That is, if + 1.12 is called for by the test, give + 1.25; if — 1.12 is the test, give — 1.00.

The word "*Dioptre*" means "to see through," hence it was chosen as the name for the unit of measure.

As has been shown in the chapter on refraction, — lenses are negative quantities, made by reversing the order in which prisms are used for +, therefore the numbering applies to both. Also to cylinders.

It is easy to tell + from —, because if a + lens is held between the eye and an object and moved back and forth to right and left, or up and down, the object will appear to move in the direction *opposite* to that in which the lens is moved, and the stronger the lens the more decided the motion. Take — lenses and the motion is *with* the movement of the lens.

Spherical lenses have equal power in all meridians, while cylindricals have power only when moved across the line corresponding to the axis. To find the axis of a cylinder, hold it between the eye and some straight object and rotate it. The object will appear distorted in shape except when either the axis or the meridian at right angles to the axis is on the line corresponding to the correct position of the object. Having found that position, move the lens sidewise and up and down, the meridian where there is no motion to the object is the axis. Make a mark on the edge of the lens showing where the axis is, then lay the lens flat on this figure, centre over centre, and read the meridian from the figures.



Sphero-cylinders will cause the object to move in all directions, but in one meridian there will be the greatest, and in the one at right angles to it, the least motion. Locate the two principal meridians as described in the case of cylinders.

To ascertain the number of a lens use lenses of the opposite kind which have the numbers on them, to neutralize the one unknown. If a + lens of unknown power be neutralized with a — 1.00 sphere we know it must be + 1.00. If a + 1.00 cylinder axis 90 stops all motion in a — cylinder we know it must be — 1.00 axis 90. If we have a + compound (sphero-cylinder) and — 1.00 — 1.50 axis 45 neutralizes it, we know it is + 1.00 + 1.50 axis 45. If it is a compound and + 1.00 — 2.50 axis 180 neutralizes it we know it is —

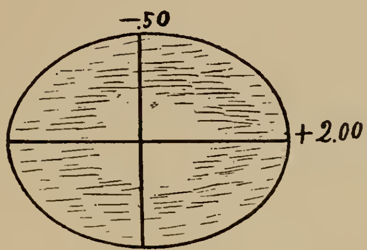
1.00 + 2.50 axis 180. There are such things as crossed-cylinders, but people who understand their business never have any use for them, except in the very rare instances where the astigmatic error is so great that a sphero-cylinder would give more spherical and chromatic aberration. Even then, the *sphero-toric* lens (one in which there is a spherical curvature on one surface, and both a spherical and cylindrical curvature on the other) is better in most cases. It is a fact, however, that all compound lenses are cross-cylinders in effect.

Prescription Writing.

One of the most important features in the optical business is the writing of prescriptions correctly, yet more errors are committed in this respect than in any other (except possibly, the prescribing of — lenses where + should be used.)

The incorrect writing does not affect the result so far as the patient is concerned, but it frequently involves more work for the optician who grinds the lenses. For example: a combination written + 2.00—2.50 ax. 180 means a + spherical lens is combined with a — cylindrical with its axis at 180, or the horizontal meridian.

In analyzing this we must remember that the 180 is not a lens, but is the particular meridian upon which the *axis* of the *cylinder* is placed, and signifies that the cylinder has no power there. Next, we must remember that spherical lenses have power in all meridians equally, so the power of the combination on the horizontal meridian is furnished entirely by the spherical, and is, of course, + 2.00. Next, the other principal meridian is always at right angles to the first, which makes it the 90th meridian; on this line *both* lenses have power, and as one is + while the other is —, the real effect is only the difference between them. The — being 2.50 while the + is only 2.00, the balance is in favor of the — by 50, so, when the combination is made into a lens the power in its two principal meridians will be represented thus:



Had the prescription been written —.50 + 2.50 ax. 90 the effect would be the same, because now the axis of the cylinder is vertical, and it has no power on its axis, while the — sphere, having power in all meridians takes full effect on the vertical, and on the opposite meridian the + 2.50 neutralizes the — .50 and has + 2.00 remainder.

Manufacturing opticians carry what they call blank cylinders in stock; that is, a square piece of glass with the cylinder ground on one surface, and grind whatever sphere is desired on the other side, then lay a pattern on and cut the lens so the axis of the cylinder is at the proper meridian. In the prescription as written first it would require the grinding of + 2.00 while as written last it would only require — .50, a saving of three-fourths of the work. If all practitioners would observe these points it would facilitate greater speed in filling their prescriptions and often result in lighter weight lenses.

The following law will enable any one to tell at a glance if a prescription is written correctly:

A prescription for a compound lens is always correct as it comes from the trial frame, *except* when the signs of sphere and cylinder differ and the cylinder is less than twice as strong as the sphere.

\+ 1.00 + 1.00 ax. 90
\+ .50 + 1.50 ax. 45
\+ 1.00 + .75 ax. 60
— 1.00 — 2.00 ax. 120
— 2.00 — 1.50 ax. 75
— 1.00 — 1.00 ax. 150
\+ 1.00 — 2.00 ax. 135
— 1.00 + 2.00 ax. 165
\+ 1.00 — 3.00 ax. 180
— 1.50 + 4.00 ax. 140

or any other axis, would be correct, because the signs are alike; or, differing, the cylinder is *at least* twice as strong as the sphere.

\+ 1.00 — .50 ax. 60
\+ 1.50 — 2.00 ax. 180
— 1.00 + .75 ax. 90
— 1.00 + 1.50 ax. 45

or any other axis, are wrong, because the *signs differ*, and the cylinder is *less* than *twice* as strong as the sphere.

The meridian given as the location of the axis of the cylinder is called the *first principal meridian* and the one opposite to it is the *second* principal meridian.

Having learned that a cylinder has *no power on its axis* we have the following law governing the analysis of compounds.

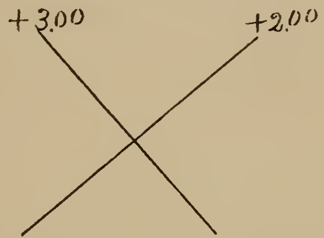
To Put on Cross: 1st meridian, 1st lens. 2d meridian *both* lenses.

Now consider as the first principal meridian the line of the cross which requires the weakest lens.

To Take off Cross	Correct meridian of least defect first, with a sphere. Allow for its effect on the second meridian, and finish with a cylinder, axis on the meridian first corrected.

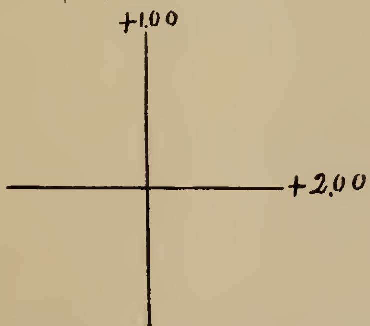
This is a *law* because it always works. If a prescription is written correctly it will prove it. If written incorrectly it will correct it.

+ 2.00 + 1.00 ax. 45



+ 2.00 + 1.00 ax. 45 was *correct*, because the meridian of *least* defect was corrected first.

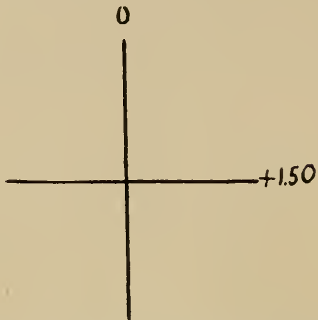
+ 2.00 — 1.00 ax. 180



+ 1.00 + 1.00 ax. 90, is the correction, and shows the first written *incorrectly* because the meridian of *greatest* defect was corrected first.

This law sometimes exposes a compound to have only the effect of a simple cylinder, thus:

+ 1.50 — 1.50 ax. 180

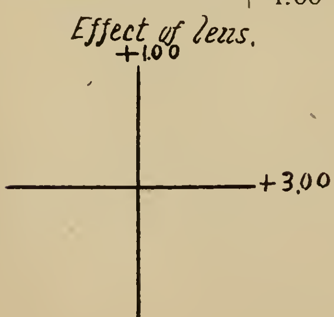


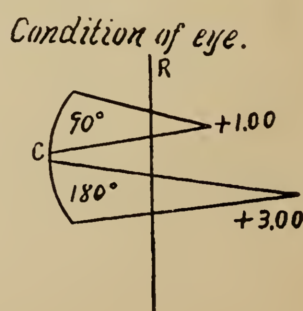
In this instance, there being no defect at one meridian, a sphere would be superfluous, as + 1.50 ax. 90, a cylinder, does the work and the cost of the lens is reduced.

Another important point in this connection is that an expert in analysis of prescriptions is able to tell at a glance the name of the error from which his patient suffers.

For example: If the lenses are +, it means the eye is *below* normal; if they are —, the eye is *above* normal. In the first instance it would mean the retina was in front of the focus of its own dioptric system (the cornea, crystalline lens and humors), and in the second instance the retina is behind the focus.

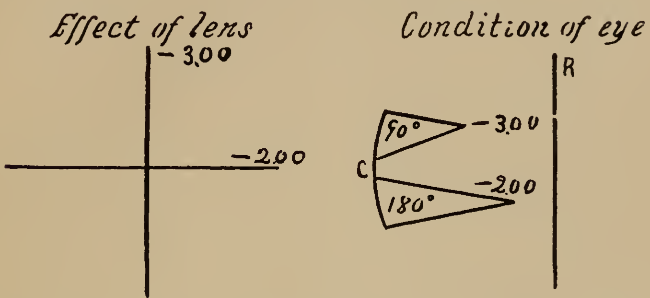
+ 1.00 + 2.00 ax. 90





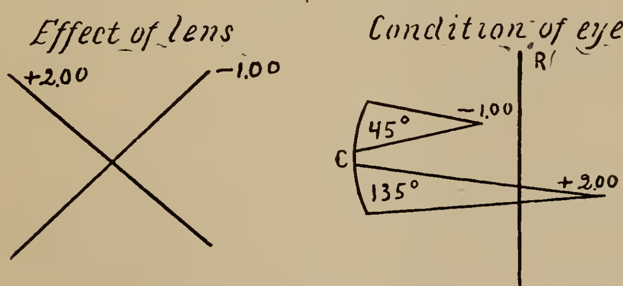
Showing the eye is too short all over, but of greater defect in one principal meridian than in the other. The line *C* in the cuts represents the cornea, and the line *R* the retina.

— 2.00 — 1.00 ax. 180



Showing the eye is too long all over, but of greater defect in one principal meridian than in the other.

— 1.00 + 3.00 ax. 45



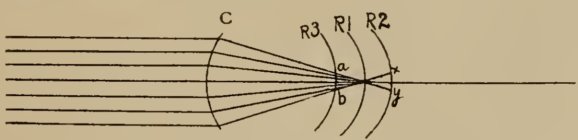
Showing the eye too long in one meridian and too short in the other.

The names for all of these conditions are given in the chapter on "Refraction of the Dioptric System of the Eye."

CHAPTER III.

Refraction of the Dioptric System of the Eye.

In the dioptric system of the eye, both cornea and lens, the principal refracting media, are convex. They therefore belong to the same class as the convex lenses, which have been demonstrated to be collective. So the dioptric system of the eye is always collective. If it is normal, rays will be focused on the retina in points equally distributed so that perfect images of objects will be formed. This condition is called *Emmetropia* (normal).



In this case *R 1* (in cut) would be the retina. *C* represents the cornea.

Its collective powers may be too great, in which case the effect would, of course, be to bring the rays to a point before reaching the retina, and they would cross, so that instead of reaching the retina, *R 2*, (in cut) in points, they would form a *circle of diffusion* of a diameter equal to *x y*. This condition is called *Myopia*.

Or, its collective powers may not be great enough, and the rays would not have reached a point when they came in contact with the retina, *R 3* (in cut) when the interference with the vision would be just as great, *a b*, as in the previous instance. This condition is called *Hyperopia* or *Hypermetropia.*

Then, there may be conditions where two meridians of the same eye are of different curvatures. This is called *Astigmatism.*

There are five kinds of astigmatism, viz.:

Simple Myopic Astigmatism, where the curvature in one meridian is normal, and in another, at right angles to the first, there is too much.

Compound Myopic Astigmatism, where the curvature is too great in both meridians, but is greater in one than in the other.

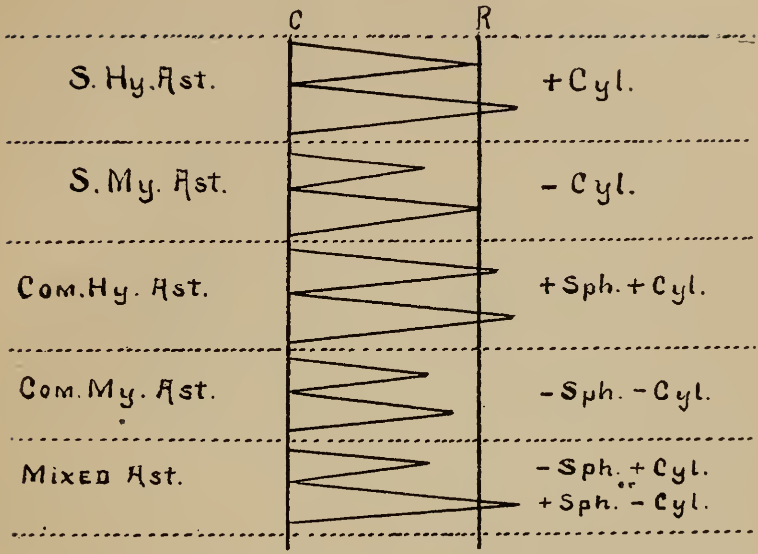
Simple Hyperopic Astigmatism, where the curvature in one meridian is normal, and in the other is not great enough.

Compound Hyperopic Astigmatism, where the curvature in neither meridian is sufficient, but in one is more deficient than in the other.

Mixed Astigmatism, where the curvature is greater than normal in one meridian, and less than normal in the other.

Occasionally a case is found where the curvatures of two principal meridians not only differ from each other, but the curvature in one or both meridians is irregular, thus precluding the possibility of correction by known methods. This is called *Irregular Astigmatism.*

The following diagram represents the foci of the two principal meridians in each of the several kinds of astigmatism. The line *C* represents the cornea and the line *R* the retina. It also shows the kind or combination of lenses which will be required for each.



Defective conditions are all classed generally under the head *Ametropia* (meaning abnormal). So any eye which is not Emmetropic is Ametropic.

The refractive properties of the dioptric system are of two kinds, *static* and *dynamic*. The static is measured when the muscles of accommodation are at rest, and the eye is adapted to the most distant point at which it can see distinctly. This point is called *punctum remotum* (far point). The dynamic refraction is measured when the accommodative muscles are exerted to their fullest capacity, and the nearest point at which it can see distinctly is called its *punctum proximum* (near point). The difference between these two points is called the *range of accommodation*. The *amplitude* of accommodation is the exercise required of the muscles to adjust the eye to objects between the far and near points.

The simplest manner in which to measure the amplitude of accommodation is: First, see that the eye is normal for distance, when the nearest point at which ordinary print can be read distinctly, expressed in dioptres, is the amount of the amplitude of accommodation. Example: If a patient is able to read clearly within five inches of his face, we divide 40, the focal length of one dioptre, by 5, the focal length of the eye, and the result is 8; that patient, therefore, has an amplitude of accommodation equal to eight dioptres.

Persons with normal eyes possess the greatest range of accommodation at the age of about ten years, when they can so increase the convexity of the crystalline lens that rays from an object less than three inches from the cornea will be focused on the retina. But this power gradually decreases, until, at the age of forty, or thereabout, the loss of accommodation is so great that the near point is more than thirteen inches distant, and it becomes necessary to use spectacles for reading and near work. This loss of accommodation is called *Presbyopia*.

As rays of light coming from a point twenty feet distant are practically parallel, that distance is spoken of as *infinity*, and the far point of the normal eye is at that point, while the nearest point is within thirteen inches.

The far point of the myopic eye, it being more convex than than normal, would, therefore, be nearer than infinity, and its near point would be the nearest point at which, by exercising its accommodation, images would be formed distinctly.

The far point of the hyperopic eye, would be beyond infinity, because it is less convex than normal, and its near point, like the others, the nearest point at which, by exerting its accommodation to its utmost capacity, clear images would be formed on the retina.

EMMETROPIA.

(Measure, within the Eye.)

Emmetropia is that state of refraction in which the retina is situated at the principal focus of the dioptric system.

From the definition we understand that the healthy emmetropic eye ought to see distinctly at a distance. This is true. But the fact that a person sees more distinctly at a distance without than with glasses, does not prove that he is emmetropic. The definition refers strictly to the static refraction, and a hyperopic eye may simulate Emmetropia, or even Myopia, from a spasm of the accommodation.

The following table shows the average power of accommodation and the near point of the emmetropic eye at several periods of life.

At 10	years,	14.	dioptres,	2 75	inches	near	point.
20	"	10.	"	4 00	"	"	"
30	"	7.	"	5.50	"	"	"
40	"	4.5	"	9.00	"	"	"
50	"	2.5	"	16.00	"	"	"
60	"	1.	"	40 00	"	"	"
70	"	.25	"	160.00	"	"	"

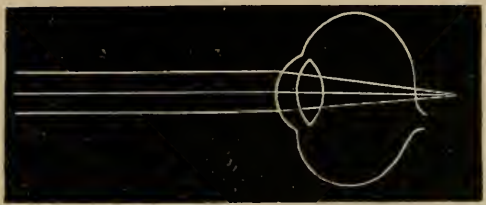
We must not conclude from this that because an emmetropic eye, at 40 years of age, can see distinctly at nine inches, it does not need the aid of spectacles. It must be remembered that in order to bring its near point to nine inches, its maximum power of accommodation is required, that no muscle can long maintain its full power, and any strain upon it in excess of that which is reasonable, works harm. How much, then, is reasonable?

If rays of light coming from infinity, parallel, will be brought to a focus by a + 3.00 D lens thirteen inches beyond it, rays started from the focal point would be divergent, but, upon passing the lens would become parallel. Therefore a + 3.00 lens before an emmetropic eye would enable it to read at thirteen inches without any effort of accommodation, because the rays from that point after passing the lens would enter the eye as if they came from infinity. Without such lenses the dynamic force of the eye would have to be exerted just 3 dioptres to equal the former result. At ten years of age, then, after calling into service the necessary 3 dioptres for reading, the child has still in reserve 11 dioptres. At 30 years, the last period where no difficulty is experienced in reading for hours without glasses, the reserve force, after utilizing the 3.00 D, is 4.00 D, which must be taken as the minimum reserve necessary.

Therefore, when the emmetropic eye, at forty years, is required to read without glasses, the 3.00 D deducted from its maximum power of 4.50 D, leaves it only 1.50 D in reserve, or 2.50 D less than the standard, and it is overtaxed.

An eye may be emmetropic and yet vision be poor, for it may may be diseased, in which case no lenses could be found which would materially improve vision.

HYPEROPIA
(Beyond Measure.)



Hyperopia is that state of refraction in which the retina is in front of the principal focus of the dioptric system.

Hyperopia is not always a deficency of length of an eye along its antero-posterior axis, but may be from a weakness or lack of density of the dioptric apparatus which renders it incapable of focusing rays upon the retina. In any event it is the result of imperfect development of the individual, and, in high degrees is recognized by the flattened appearance of the face and the diminutive size of the eyeballs and corneal area.

The inability of the dioptric system of the hyperopic eye to focus parallel rays upon its retina necessitates the constant use of a portion of its dynamic force, the amount required equaling the degree of Hyperopia, and to this must be added 3.00 D when the eye is used for work at thirteen inches. For example, an eye which is hyperopic 2.00 D must use 2.00 D of accommodation in order to see distant objects distinctly; then, when the object is brought to thirteen inches, 3.00 D more effort is necessary, 5.00 D in all. As the normal condition requires no effort for distance and 3.00 D for the near point,it is clear that the hyperopic eye is over-taxed 2.00 D at all times. It is not strange, therefore, that individuals so afflicted complain of sick stomach, pains in eyes and head, and even suffer nervous prostration, and insanity in aggravated cases.

As the retina, in such cases, is in front of the principal focus, the remedy must be found in convex lenses, and the strongest the patient will accept, when found in the manner described elsewhere, will not be too strong. The object in prescribing lenses is to assist Nature in the performance of her functions, not to supplant her.

It will be found, usually, that hyperopes under thirty-five years of age will need no additional strength of lens for reading, for the reason that their dynamic refraction, formerly devoted to making the eye emmetropic, is, after correction, in reserve for near work.

The crystalline lens in its position is nearly equivalent to a 11.00 D lens placed in front of the eye, so that in case of loss of this portion of the dioptric system, through cataract or otherwise, an eye which had been emmetropic before, would become hyperopic, and an eye which was myopic before, would be hyperopic after, unless the myopia exceeded 11.00 D. The loss of the crystalline lens is called *Aphakia.*

This error of refractlon is the most difficult to fit, on account of the development of the apparatus of accommodation, which sometimes simulates emmetropia, or even myopia, and, unless well understood and closely watched while testing, will at least conceal a portion of the amount of hyperopia. Therefore, it behooves the student to apply himself particularly to the mechanism of the accommodation and its effects in such cases, and also to the principles given in the "Rules for Testing" in the next chapter.

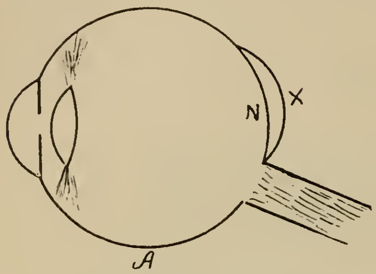
The muscular insufficiencies which are often found associated with hyperopia are explained in detail in the chapter entitled, "Operations, Medicines and Prisms, Three Great Ophthalmological Blunders."

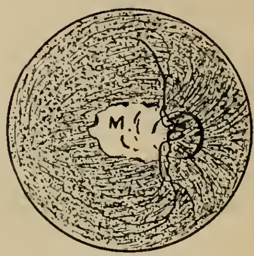
MYOPIA

(To Close the Eye.)

Myopia is that state of refraction in which the retina is behind the principal focus of the dioptric system.

It has been called a "disease of civilization," because it is rarely found among savages, or in partly civilized countries. It may be hereditary or acquired, and the amount may be increased by continuous use of the eyes at short distances. In some instances this increase is very rapid from a swelling of the vitreous humor, causing the eyeball to bulge backward along the antero-posterior axis, and in such cases there is great danger that the retina will be torn, because of its delicate nature, and the visual sense seriously impaired, or even entirely destroyed. Such a condition is called a posterior staphyloma (meaning bulging backward). This is illustrated in the following cuts, *A* showing the projection of the tough sclerotic coat from its normal position *N*, to *X*, and the other showing the mutilation of the retina at *M*, which is in the region of the macula, or field of most acute vision, exposing the sclerotic coat.





This condition, called *Malignant Progressive Myopia*, occurs in children, and is one of the most difficult to treat, because its origin is uncertain. Constitutional treatment, rest and the correction of the refractive errors, may result in checking the disease until the patient reaches maturity, when it is not liable to grow worse.

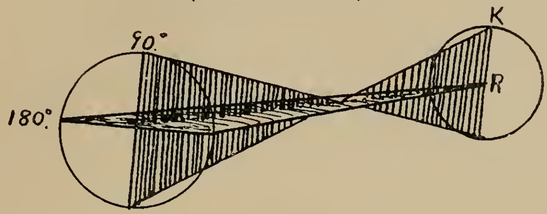
In ordinary cases the retina being situated behind the focus of the dioptric system, parallel rays are brought to a point and cross before they reach it; consequently, in order to see clearly, rays must be divergent upon coming in contact with the cornea, therefore concave glasses which will neutralize the excessive convexity of the eye are the remedy.

A myope of 3.00 D. would read at thirteen inches without glasses, and without any effort of accommodation, were it not for the convergence of the two eyes which is necessary to maintain binocular vision; this act however, requiring a supply of nerve force to the internal recti which is furnished by the third nerve (which also supplies the muscles of accommodation) stimulates action of the accommodation and increases his myopia. This explains why, under the old methods of fitting such cases, so many are over-corrected.

The muscle troubles of myopes are caused by incoordination, not from excessive nerve strain, as in hyperopia.

ASTIGMATISM

(Without a Point.)



This cut illustrates the impossibility of securing a single point from a system where there is greater power in one meridian than in another. It will be observed that rays from the 90th meridian focus before reaching the circle around *R*, and, having crossed, form a circle with a diameter equal to the length of the lines at *K*, while rays from the 180th meridian come to a point at *R*, so that the rays from one meridian spoil the effect of the other and the result is no perceptible point from either.

Astigmatism is that state of refraction where the retina is at the principal focus of the dioptric system in one meridian and in front of or behind it in another. Or, where the retina is in front of or behind the focus in both meridians, but at a greater distance in one meridian than in the other. Or, again, where the retina is behind the focus in one meridian and in front of it in another.

There are two seats of astigmatism, the commonest being in the cornea. The other, which is very rare, is in the crystalline lens.

The first should be called *static astigmatism*, because it is measured when the eye is at rest, and is unchangeable. The second should be called *dynamic astigmatism*, because it manifests itself usually during accommodation, and sometimes necessitates an altogether different correction for reading from that for distance. It is due to unequal contraction of the ciliary muscle, or a weak spot in the lens capsule, or both, which causes the lens to assume greater convexity in one meridian than in another. Cases are found where the crystalline astigmatism during accommodation completely corrects the corneal error, and vision is perfect with a spherical lens. The astigmatism of the crystalline, however, may add itself to that of the cornea, in which case it might be static.

Astigmatism is of two classes, regular and irregular. As have been enumerated elsewhere, there are five kinds of regular astigmatism. Irregular astigmatism is an unevenness of curvature in addition to the two meridians being of different focal lengths. There are cases where this unevenness affects only one meridian, and such cases may be corrected by prescribing stenopaic (slotted) discs, which shut out the light from all except the meridian of symmetrical curvature.

The astigmatic eye does not receive upon its retina a perfect image of objects at any distance. The accommodative apparatus attempts to afford a remedy, but of course fails, because its power is exerted equally in both meridians, and the difference between them remains the same; the only result being strain upon the nervous and muscular systems, headaches, nausea and general discomfort to the individual.

The remedy is a lens or combination of lenses which will equalize the curvatures.

ANISOMETROPIA.

(Unequal Vision.)

Anisometropia is that condition in which the refraction of the two eyes is decidedly different, causing vision to be unequal.

It is not uncommon to find a trifling difference between the eyes, but they are not classified as anisometropia until the difference is sufficient to cause discomfort, or possible loss of acuteness in one.

There are three kinds of anisometropia, (1), where both eyes fix at once, and binocular vision exists; (2), where each eye is used alternately; (3), where one eye only is used, the other being permanently excluded.

This defect has been the cause of much argument with reference to its correction. Oculists who base their conclusions on their knowledge of materia-medica exclusively, for the reason that they have never educated themselves to consider the mechanics of the anatomy, argue that there is a "point of toleration," in the acceptance of correction, similar to the "point of toleration" of drugs.

This is not true. The correction should be made as early as possible, and the practitioner should inform himself, and his patient, of the reason for the disturbance, which is that, whereas, an abnormal relation did exist, to which the nervous system was compelled to adapt itself, and that relation being disturbed, required a readaptation to the new condition, it would, for a time, affect the entire system, causing great discomfort; but, being a mechanical change, it is only a matter of a few days, or weeks, until the new order is established, and all is satisfactory.

If the vision in one eye is very poor, and the other is good, and the correcting glasses do not bring the bad eye up to the standard of the good one, it is good practice to reduce vision in the good eye to the standard of the bad one, by over-correcting with + or under-correcting with — lenses. After a few weeks, if the bad one shows no signs of improvement, it is because the nerve is affected, and the attempt to equalize them will have to be abandoned. Sometimes the correction of the bad eye brings it up just enough to interfere with the comfort of the good one, and it may be left off entirely, not because the patient would not "tolerate" it after a time, but because it does no good, and only causes an unnecessary drain upon the nervous system. Common sense should always be used in such matters.

PRESBYOPIA.

(Old Sight.)

While Presbyopia is not an error of refraction, it is entitled to a place in this chapter, because the dynamic refraction is changed by it, so that glasses are required for reading purposes even by Emmetropes. It is the only one of all refractive troubles which is caused by advancing years, and comparatively young people bring it on by over-working the nerves which supply the muscles of accommodation.

It is a loss of nerve force, and of the elasticity of the crystalline lens and its associates in the mechanism of accommodation.

The usual working point is 13 to 16 inches from the eyes; therefore, after an eye is made emmetropic, whether with + or — lenses, if it cannot adjust itself to near points, it will require + spherical lenses over the others.

As the emmetropic eye is already adapted to rays coming parallel to its axis, it follows that it will never need a stronger lens than the number represented by the distance the object is from the eye. To read at 16 inches will never require more than + 2.50, because that is enough to start the rays into the eye parallel to the axis. To read at 13 inches will never require more than + 3.00. At 10 inches, + 4.00, etc.

As 13 inches is the usual reading distance, 3.00 D is the total amount of presbyopia one can have, although many eminent writers have compiled wonderful tables to show that it may be 8.00 D, or even more. This is not so, for the reasons shown in the paragraph above. Any power over + 3.00 used for reading at 13 inches represents hyperopia. They also assume to fix the amount of lens required at different ages, which is impossible.

In adding for reading to a correction for an error of refraction, the addition is *spherical only*, and, of course, the cylinder (if there be one) is not changed. Thus, a prescription for distance being:

L. + 1.00 + .75 ax. 90
R. + 1.00 + 1.00 ax. 60
add + 2.00 for reading, would be
L. + 3.00 + .75 ax. 90
R. + 3.00 + 1.00 ax. 60

If the prescription for distance read:

L. — 3.00 — 2.00 ax. 180
R. — 2.50 — 1.50 ax. 180
add + 3.00 for reading, it would be
L. — 2.00 ax. 180
R. + .50 —1.50 ax. 180

In this case the reading lens for the left eye would be a simple cylinder, and for the right, a compound, mixing + and —.

Sometimes the addition for reading results in the prescription for the reading glass being written incorrectly according to the law of prescription writing. Thus:

L. + 1.00 — 2.50 ax. 180

R. + 2.00 — 4.00 ax. 45

add + 2.00 for reading, would be

L. + 3.00 — 2.50 ax. 180

R. + 4.00 — 4.00 ax. 45

which is technically incorrect, but, putting it on the cross and analyzing it, we write it correctly, thus:

L. + .50 + 2.50 ax. 90

R. + 4.00 ax. 135

Remember, after the correction for distance is made, the addition for reading is given to both eyes at once, and the *added lenses* must be of equal power.

The amount added for reading depends upon whether accommodation is *totally* or only *partially* gone. The object of the lenses is to do as much of the work as the patient is unable to perform. I have never found occasion to use less than + 1.00 in such cases, and, of course, never more than + 3.00 for 13 inches.

CHAPTER IV.

The "Fogging" Method of Measuring Errors of Refraction.

Of all appliances and methods for measuring errors of refraction those which involve the least complication and give the best results should commend themselves most highly to the practitioner.

The *Fogging* system of using the trial lenses is the only one which affords at once simplicity, speed, accuracy, opportunity to test binocular vision, accommodation, the muscles and reduces the necessity for the use of mydriaties to emergency cases.

It should be remembered "fogging" involves a principle, and, to make it a success, the broad scope of that principle must be understood thoroughly.

Rules for Proceedure.

FIRST—Question the patient. This means the general health, special ills of the past and present, such as headaches, indigestion, constipation, piles, loss of appetite, female disorders, hysteria, nervous debility, etc., all are factors which assist in the diagnosis of cases.

SECOND—Examine the retinæ with the ophthalmoscope, by the direct method, which affords a view of the real article, not a picture of it, as is seen by the indirect method.

THIRD—Adjust the trial frame so the pupils are perfectly centered therein, cover each eye, alternately, with the black disc, and direct the patient to read aloud the letters on the trial card, which should be at a distance of fifteen or twenty feet. The lines on the card are all numbered and the figures over each line indicate the distance in feet (or metres) at which that line is read by the normal eye. Therefore if a patient is seated fifteen feet from the card and the smallest line which can be read correctly with ease is the one numbered thirty, the acuteness of vision with that eye is expressed thus, $\frac{15}{30}$. If patient is twenty feet away, and reads the same line, it would be expressed $\frac{20}{30}$. If the metric system is used on the card the twenty feet line will be numbered 6 and the thirty feet line 9, so the acuteness would be expressed $\frac{6}{9}$. By either system such a result would indicate only two-thirds of the normal acuteness is present.

FOURTH—If there be a difference in the acuteness of the two, correct the best one first, because, it, having been accustomed to doing the most work, will accept the proceeding more intelligently, and thus, by way of the brain, aid in securing the best results on its fellow. Permit no one in the operating room but yourself and the patient. Begin the test by placing in the *front cell* of frame a + sphere of sufficient strength to fog or blur vision so patient cannot see better than number 200, or the largest type on the card. Direct that constant attention be paid to keeping the eyes fixed toward the card, because if they are turned upon nearer objects it stimulates action of the accommodation and interferes with the work. Now begin with — .25 and — .50 spheres, holding one in each hand. Stand at patient's right, with the left hand resting lightly on the forehead, the right, with handle of lens between the thumb and first finger, while the second and third fingers touch the cheek just enough to enable you to hold the lens steady. Try the weaker one first, than the stronger. Of course the last one will be best, then replace the —. 25 in the case, retaining the — .50 and take a — .75. Compare them as before, making the change from one to the other quickly after patient has shown what line can be read, then if the — .75 is best, put the — ,50 in the case and get — 1.00 for comparison with the — .75. When a decided improvement is shown by patient reading three or four lines it is good practice to take two lenses of the same power, say two —. 75s and compare them in the manner described, as the improvement shown by the second lens at each comparison has taught patient to expect it, and the effect of this is to aid in coaxing the nerve supply of the accommodation to cease acting. In other words the patient is deceived by the trick, which should be repeated as often as benefit is shown, only increasing the strength of the — lens .25 at a time as needed until vision is *almost as good* as it was with the naked eye. If + 3.00 is the fogging lens, and by our test we find — 1.75 held in front of it permits $\frac{20}{30}$ dimly when vision was $\frac{20}{30}$ plainly with the naked eye, it is time to stop. Now the differences between + 3.00 and — 1.75 is + 1.25 which is the spherical part of the correction. Therefore, put + 1.25 in the rear cell of frame *before* removing the fogging lens.

FIFTH—Search for astigmatism by directing attention to astigmatic charts comprising various designs, figures or letters, formed by lines arranged at different angles in the several figures. If all appear equally distinct the astigmatism is, at most, very slight. If some of the figures appear plain while others appear blurred it proves astigmatism, and the two principal meridians of the eye are: one corresponding to the black lines and the other at exactly right-angles to it. The meridian at right-angles to the black lines is the one which is *corrected*, and the one corresponding to the black lines is the *uncorrected* one. This seems paradoxical to the beginner, and I have heard "oculists" say they knew it to be a fact but could not tell why. Anyone can solve the problem quickly by noting that the action of a + cylinder on light is to converge it to a line corresponding to the axis. It is the curvature in the opposite meridian which does this, and the same is true of any irregular dioptric system, including the eye. To correct the astigmatism take — cylinders, — .25 and — .50, as in the former proceeding with spheres, and hold them in front of the eye, axis at right-angles to the black lines, until one is found which makes all the figures of the chart appear equally distinct the instant the lens is in position, taking care to use the weakest cylinder which has the desired effect.

Another method of measuring the astigmatism is: After getting the spherical part of the correction, place the stenopaic (slotted) disk in the front cell, with the slot horizontal, have patient read the lettered chart as before, then turn the slot to various positions and if vision is better at one place than at others it proves astigmatism. After noting the acuteness of vision in the *best* meridian turn the slot to the position at right angles to it, and proceed with — spheres, holding them in front as before, until one is found which makes vision *almost* as good as it was with the slot in the first position. The weakest lens which will do this, gives the power of cylinder required. Laying the sphere aside, take a — cylinder of corresponding strength and put it in place of the slot, with its axis on the meridian where the slot first stood, this gives the power in the desired meridian.

SIXTH—Test the other eye, in the same manner.

SEVENTH—Leaving the correction before both eyes, cover each alternately, that patient may compare vision, and, if there is any difference, correct it.

EIGHTH—Test the power of accommodation, by having patient see how close to his face he can read a line of ordinary newspaper print. If this near point is less than six inches, and the patient has never worn glasses constantly, those prescribed for distance, according to the prescription written from the contents of the frame, will be sufficient for all purposes.

NINTH—If the near point is farther away than six inches, or, if the patient has been wearing glasses constantly, and complains that the eyes tire when reading, have the paper held at the greatest distance the individual expects to hold near work, and apply + spheres, (the same strength for each eye), to both eyes at once, in front of the distance correction already in the frame. Begin with + 3.00 and change them for weaker ones until a pair is found which permits comfortable vision. These will be the "addition for reading," and if patient desires bifocals, so state in your prescription. If two pairs are wanted, say so. The optican who fills your prescription will do the rest.

TENTH—Test the muscles. The simplest method is to place before one eye a double prism, and before the other a plane red glass, covering it with the dark disk. Direct attention to a light placed about twenty feet distant, and rotate the double prism until two white lights are seen, one directly above the other. Then uncover the other eye, and if the muscles are normal (orthophoria) the red light will appear in line with and half way between them. If they are out of position it is Heterophoria (abnormal). If the deviation is to right and left from the center, it is Exophoria if the lights separate, and Esophoria if they cross over. *The eyes in muscular insufficiencies always deviate the same way the lights do.* If the deviation is up or down and out, it is Hyperexophoria, and if up or down and in, it is Hyperesophoria. To measure the amount of trouble, prisms must be held in front of one eye (it makes no difference which) until one is found which brings all three lights in normal position. If the base of the prism is toward the nose it proves the internal recti are too active. If the base is the other way, the internal recti are too weak. The cause of the first is excessive strain upon the nerves which supply the muscles of accommodation and the internal recti; the result is a contraction of the latter and the eyes are pulled out of equilibrium. The cause of the second is a weakness of the same nerve from the strain upon it, and this conclusion is further established by an accompanying weakness of the accommodative power. If the base of prism is up or down it signifies weakness of the superior rectus in one eye or the inferior in the other. If it is in an angular position, it shows several muscles are involved. The weak muscles are always under the apex of the prism. *Prisms to be worn constantly should never be prescribed for these troubles. Correct the errors of refraction* and prescribe rest for a week or so, and Nature will *cure* the muscle trouble.

Deviations from the Rules.

There are some extraordinary cases, in the treatment of which it will be found necessary to deviate from these rules, because of intermittent nerve force, which enables the patient to see well through the slot one moment and fail to see anything clearly an instant later; or, the patients idiosyncrasies may interfere with the strict application of any rules; or, the error of refraction may be so great, and of such a character, (as a high degree of astigmatism), that only the general principles implied by the rules can be utilized. Hence the necessity for a clear comprehension of the principles.

If, after fogging a patient whose vision is very poor, say $\frac{20}{120}$, with the naked eye, the fogging lens must be entirely neutralized before vision returns to $\frac{20}{120}$, it proves + spheres will not be of benefit, so it is proper to remove the fogging lens and try the slot alone in the several meridians according to rule five, and if one meridian is worse than the other it will, of course, be corrected with a + or — cylinder. Then if vision is still below $\frac{20}{20}$ it may be improved with — spheres held in front of the cylinder.

Again, vision may be very poor and no sphere will be accepted, nor can the slot be used successfully. Then try cylinders, beginning with quite a strong +, say + 3.00, rotate it slowly before the eye and if it improves vision at one point and makes it worse at another, it proves astigmatism. Place the axis at the point where it gives best vision and proceed to increase or decrease its power, if vision is improved thereby, until the best results are obtained.

It should be remembered it is not always possible to improve vision to $\frac{20}{20}$, and sometimes it is not possible to improve it at all. But when this is the case it is something more than an error of refraction.

Another case may have poor vision, $\frac{20}{200}$, and no spheres or cylinders will be of service, but when the slot is placed in one position there is marked improvement, $\frac{20}{40}$. When the slot is turned to the other meridian vision is dim and nothing will improve it. In such cases it is proper to prescribe the slot, which can be made of brass or vulcanized rubber. The necessity for this peculiar device for aiding vision is irregular astigmatism, in which one meridian has a symmetrical curvature while the other has not, and consequently cannot be corrected. In this instance the good meridian was emmetropic, but it might have been hyperopic or myopic, and the correcting lens combined with a slot, in which case the proper lens would have to be frosted or shellaced, except at the opening, which is usually about one millimetre wide and ten to twenty millimetres long. It is possible for two principal meridians to be of regular curvature and all others uneven, requiring a cross-slot, and this might be combined with correcting glasses for those two meridians.

If spheres, and cylinders, and slots all fail, sometimes the pinhole disc, which shuts out all but the axial rays, affords such improvement that the patient is very happy to wear it constantly. Of course the hole would be made as large as possible and good vision maintained.

Caution.

If a patient comes complaining of headache or other symptoms of hyperopia, and, by the test seems to be a myope of less than 1.00 D, do not prescribe — lenses without first atropizing the patient, because it is very likely that the case is one of hyperopia with a *tonic spasm* of accommodation, which is a permanent involuntary cramp of the sphincter muscles of the ciliary processes.

If — lenses are required to fit a patient, always use the weakest which will give the results desired. A good rule, in this connection, is to give the weakest lenses which will give $\frac{20}{20}$ vision and then steal from the spherical part of the correction .25 or .50 D to reduce vision to $\frac{20}{30}$.

As long as a patient can see as well through a + lens as without it, it is not too strong.

As long as a patient sees as well without — lenses as with them, never prescribe them.

If — .50 ax. 90 gives $\frac{20}{20}$ vision, prescribe + .50 ax. 90 if it gives $\frac{20}{30}$ vision, even if the first was found under a mydriatic. And if — 200 ax. 180, or any other strong — cylinder gives $\frac{20}{20}$, and the patient still has accommodation, prescribe + .25 or + .50 sphere in connection with the cylinder and reduce vision to $\frac{20}{30}$. It saves a little nerve strain when coming up to the reading point, but the chief idea in this precaution is to avoid overcorrecting myopia.

If, in testing, vision is quite good one moment and the next is not so good by several lines on the test card, it indicates *clonic spasm* of accommodation (an involuntary and intermittent action), and to overcome it, the patient must be secluded from the presence of others who, by talking might interfere with the control of his nervous system. But, if vision is good when the patient begins to read a line, and it gradually fades away before him, it is the optic nerve which is affected, and absolute rest must be ordered, to be continued several days. Or, by atropizing, the 3d nerve supply may be shut off entirely, leaving a greater force for the 2d or optic nerves.

Clinical Hints.

If a patient, with the naked eye, sees some of the lines of the astigmatic charts more plainly than others, it *proves* astigmatism, but it does not prove what kind. Ordinarily if the vertical lines are plainest it indicates myopic astigmatism, and if the horizontal lines are plainest it indicates hyperopic astigmatism, but it is by no means certain that such is the case. Only the test will tell. The *best* meridian of the eye is always at right angles to the plain lines.

After correcting a high degree of myopia in children, it will, often, be found necessary to add + for reading, but the constant wearing of the correction will develope the accommodation so that after a few weeks or months the + will be no longer needed.

The wearing of glasses for hyperopia has, often, wonderful cosmetic effects. Ladies, whose faces have become rough and wrinkled prematurely from the constant effort to overcome the hyperopia, will find both defects have disappeared in a short time. The reason for this is that the contraction of the nervous system prevented the free circulation of nerve force, the blood supply was diminished, and the function of the lymphatics was practically cut off. After correction all these are restored and the complexion improves.

The contraction of the sphincter muscles throughout the body, in the effort to overcome hyperopia by accommodation, causes menstrual difficulties in females, and piles in both males and females. Hence it follows that the correcting glasses will remove the cause and Nature will restore normal conditions, unless the trouble has existed too long.

Epilepsy is a nervous disease, and very often finds its origin in hyperopia, the full correction of which sometimes acts with almost miraculous promptness.

If a patient is in a debilitated condition and needs different glasses for distance and near work, insist upon two pairs, instead of bifocals. Or "grab fronts" may be used for reading.

The correcting glasses in hyperopia often improve the hearing of persons partially deaf, by permitting additional nerve supply to be sent to the auditory nerves.

Correcting glasses often make patients sick at the stomach, because the entire nervous system has to adapt itself to the new conditions. Energy which has been demanded for the eyes is now left in the chief nerve center, and it, being unaccustomed to such a liberal supply, goes into hysterics, if you please, and, like a child with a new toy, requires several days to restore its equilibrium; in the meantime it sends nerve force in every direction to see if some function is in need of it. It sometimes surprises the stomach so that vomiting occurs. Do not be frightened by the old "spook" that such incidents mean the patient will not "tolerate" the correction. Explain the situation and tell patient to stick to it, and all will be well.

Sometimes, in a high degree of hyperopia, the accommodation will be so completely exhausted that, when corrected, the patient will not be able to read. In persons under thirty years, or thereabout, the accommodation will be all right in a few weeks.

If a patient reads $\frac{20}{20}$ with the naked eye it only proves he is not a myope and that he has no disease which affects the eye.

If he cannot read $\frac{20}{20}$, he may be a hyperope, or a myope, or an emmetrope with diseased eyes.

If he reads better than $\frac{20}{20}$ it *proves* he is a hyperope, and it is not uncommon to find as much as 1.00 or 1.50 D.

Tinted glass should not be used for lenses intended for constant wear. In cases of *Photophobia*, (an aversion to light), the cause is an error of refraction or a disease which has affected the retina, making it hypersensitive and the tinted glass only aggravates the trouble. Correct the error and give constitutional treatment.

Colored glasses without focus should not be prescribed save for exceptional cases, such as excursions on snow or water, or when the eyes are diseased so that it is imperative some protection be afforded. Then prescribe plane smoke. Never use the coquills, they have — cylindrical effects.

Anyone with an error of refraction should wear glasses constantly; the hyperope to relieve nerve strain, and, incidentally, to improve vision if it is below normal; the myope to improve vision and permit coordinate action of the muscles of accommodation and convergence.

After the eye has matured, which is at about the age of eight or ten years, if the correction is equal to the error no change of lenses will ever be needed. When presbyopia comes, at forty or thereabout, additional spherical power will be needed for near work only. This will be increased from time to time, as accommodation fails, until + 3.00 is reached, which will be all that will be needed, unless the individual desires to work on objects nearer than thirteen inches.

CHAPTER V.

Machine Tests—Objective and Subjective Methods Compared.

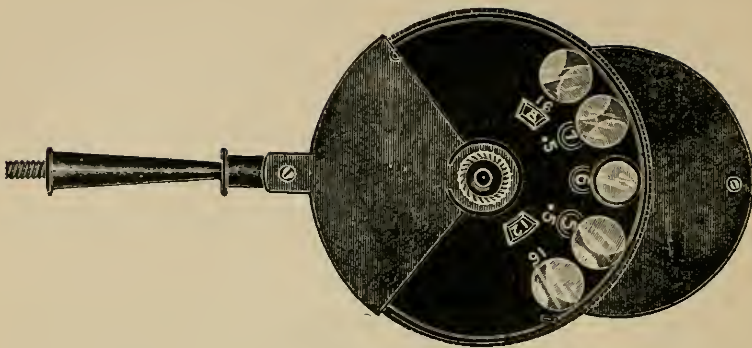
Under this heading come Ophthalmoscopy, Retinoscopy, Opthalmometry, Refractometry, Prismometry, etc.

Objective tests are those in which the patient takes no part, in the sense of using his visual powers, the correction being assumed to be determined by refraction and reflection of light from the observed eye.

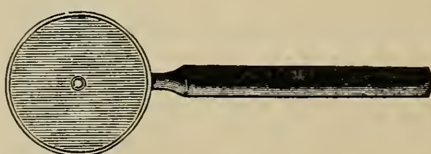
Subjective tests are those in which the patient's attention is directed to some object, while lenses or other devices are applied, and judgment is formed by what he sees.

Each method has its advocates and all are more or less enthusiastic according as their knowledge of optics is developed. They all belong to the science, and each has its points of excellence, under the manipulation of the expert. Here they shall be considered from the standpoint of their availability to the average practitioner.

The Ophthalmoscope, as a means of measuring errors of refraction, is only an approximate in the hands of the most accomplished expert, because, (1), it has nothing less than .50 D. lenses; (2), it is necessary that the observer's errors be corrected; (3), the observer must control his accommodation absolutely; (4), the patient must be



under the influence of a mydriatic. A very common paragraph in optical books is one in which the operator tells how he "corroborated" his other tests with this instrument. I have never yet seen one which stated the ophthalmoscope test had been corroborated by the subjective test. Let us be honest.



The Retinoscope, on account of its cheapness, and its halo of mystery to the patient, has its enthusiastic patrons, who claim it is the *only* test, that all other appliances were made in vain. It is, undoubtedly, a very interesting method, simple and reasonably accurate in the hands of any one who will give time to practice.

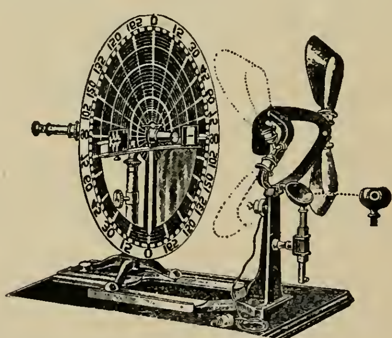
The enthusiastic retinoscopist, who, in a recent number of an optical journal, asserted that if a patient, under the subjective test, could not determine whether he could see better with + .25 ax. 90 or — .25 ax. 180, and the operator would prescribe the first when the second was needed, it would *double the astigmatism*, only demonstrated that he has not even a rudimentary knowledge of optics.

The operator sits 40 inches (one metre) from the patient, with a plane or concave mirror, and reflects the light from a lamp placed over or to one side of the patient, care being taken that his face is well shaded from all but the reflected light. Patient directs his visual axis a little to one side of operator, who will then see a red reflex from the pupil, and by rotating the mirror on its vertical axis the reflected field will move back and forth horizontally across the pupillary space, when a shadow will interfere with the circular illumination of the pupil. If the plane mirror is used the shadow will go *with* the operator's motion in hyperopia and emmetropia, and *against* it in myopia. If the concave mirror is employed the effect is reversed, the motion will be *against* in hyperopia and emmetropia, and *with* in myopia. The trial frame is put on patient's face, and + or — lens placed therein until one is found which stops all shadows or else reverses the motion slightly.

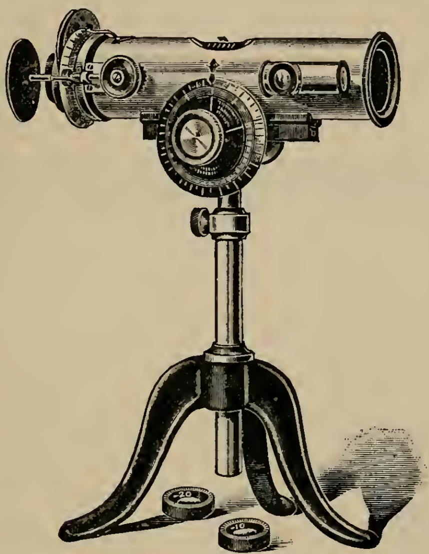
Having found the lens which stops the shadow in one meridian, record it, and proceed with the opposite meridian in the same manner. If, after correction, it is found the two meridians required different strengths of lens to fix them, say + 3.00 on the horizontal and + 2.00 on the vertical, astigmatism is present, and the prescription would be + 2.00 + 1.00 ax. 90. As the operator was seated only one metre distant, the patient is corrected to that point, and is, therefore, a myope of 1.00 D. To remedy this the spherical part of the correction must be *reduced* 1.00 D, making the correct prescription + 1.00 + 1.00 ax. 90. Should — lenses be required the same condition would be present at the close of the test, but to correct it 1.00 D must be *added* to the spherical part of the correction. If it is a case of mixed astigmatism, where + and — lenses are combined, the same condition would exist. If the spherical part is — it must be *increased* 1.00 D, and if it is + it must be decreased 1.00 D. If the shadows move obliquely when the mirror is rotated on the vertical or horizontal meridians, it indicates oblique astigmatism and the rotation of the mirror will be changed to the corresponding meridians.

If + or — spheres stop the shadow in all meridians it is simple hyperopia or myopia. Of course, if the + sphere is 1.00 D only, it indicates emmetropia, and if it is less than + 1.00 it indicates a low degree of myopia.

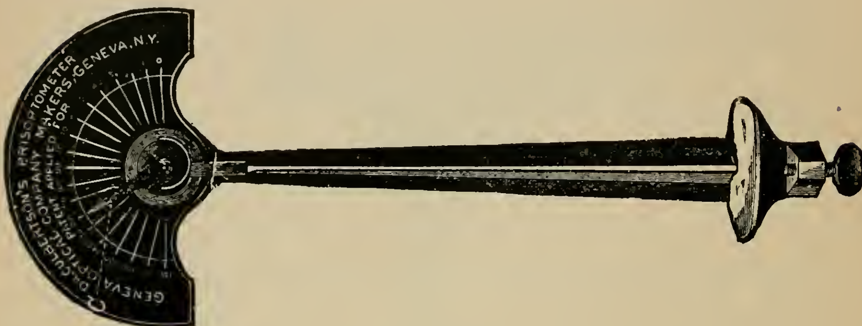
Obstacles which interfere with its more general adoption are: (1), the practice required to become sufficiently expert to render it even approximately reliable; (2), the objection of patients to having the light thrown into the eye; (3), the necessity for the dilatation of the pupil and suspension of accommodation by the use of mydriatics.



The Ophthalmometer is claimed by its friends to be the only means of obtaining exactly the axis of corneal astigmatism, and they say it will measure the amount approximately. It is not adapted to the measure of hyperopia or myopia. It is an impressive instrument as will be seen from the cut, and from that standpoint may be worthy of a place in the testing room.



Among the subjective tests the Refractometer shown above is entitled to a very high position among instruments. It imbodies the "fogging" principle in a very large measure, and is certainly the greatest *auxilliary* to the trial set yet offered to the public. It presents a fine appearance, and is of practical utility in the correction of all errors of refraction, speedily and accurately. The reasons it is not a *substitute* for the trial set are: (1), it is a monocular instrument, and vision of the two eyes cannot be compared after correction without exciting the accommodation; (2), it cannot be used to test for reading distance; (3), it cannot be used for testing the muscles. However, none of these qualities are claimed for it, so they cannot be put forth as objections.



The Prisoptometer is another subjective test which is adapted to the "fogging" system. Its essential principle, as its name indicates, is prisms. A double-prism is set in the eye-piece, which is attached to the pointer (*C* in the cut). The patient's attention is directed toward a target placed at a definite distance, and when the pointer is placed in a vertical position, he will see two targets, one above the other. As the pointer is rotated it rotates the prisms, and the targets, which are circular, will move around each other. If they touch, it indicates emmetropia, or hyperopia with active accommodation; if they lap, it indicates myopia; if they separate, it indicates hyperopia; if they lap or separate more at one place than another, it is astigmatism. The fogging is done by placing + lenses in cells attached in front of the eye piece. The same points of difference which make the Refractometer only auxilliary to the trial set, apply to this instrument.

There are optometers, astigmometers and other minor instruments without number, all of which have their "talking points," and involve optical principles to some extent. They cannot hope for a permanent place in the practitioner's rooms.

CHAPTER VI.

The Clinical Value of Perfectly Adjusted Frames and Lenses.

It is just as necessary that spectacles or eye-glasses fit the face, as it is for the lenses to neutralize the defects of refraction; for, if the frame does not fit, or the lenses chance to be decentered, the practitioner's work will be a failure.

The trial frame is of little use in taking the measurements, except that it gives the pupillary distance. The important points are the three measurements of the nose, *viz:* its height above the pupillary line, its width inside at the widest point, and the inclination of the crest, whether back of, forward, or on a plane with the lenses.

Have three frames of the following dimensions:

(1) Nose high, 3/16 inch; wide, 3/4 inch; crest on plane of lenses.

(2) Nose high, 1/8 inch; wide, 5/8 inch; crest back of plane of lenses 1/8 inch.

(3) Nose high, 1/16 inch; wide, 7/8 inch; crest back of plane of lenses 1/8 inch,

With these anyone can fit any nose, by making allowances which will be suggested at once when the frame is on the face.

The sizes of lenses run from small to large: Nos. 3, 2, 1, 0, 00, Jumbo, and there can be no fixed rule regarding what size to prescribe except that in rimless goods a size larger should be used than would be put in frames. The size and shape of the face have much to do with the size of glasses, and the best way to be sure about this is to have a few samples for exhibition and trial purposes. A narrow-faced child would require a 2-eye size to get the proper proportion between the pupil and temple distances, while a large round-faced man would require the largest size to look well and secure a width of temples which would cause them to clear the sides of his face.

An old frame to which the customer attaches value on account of its associations, and which does not fit, can be made to do so by putting in a new nose-piece.

Eye-glass frames are adjustable, and in all ordinary cases where there is sufficient nose to afford a resting place for the guards no measurements need be sent to the optician. In ordering the new-fangled guards, secure directions from their makers.

To duplicate frames, measure the pupil distance, temple distance, nose height, width, and inclination of crest, five measurements in all, upon cards made for the purpose, which any optical house will furnish free of charge.

PART II.

CHAPTER I.

Exposing Ophthalmological Charlatans and Their Practices.

"*There are tricks in all trades—except ours.*"

This is an expression which has been used for ages by the sly ones of all trades and professions, to inform their acquaintance and the public of the fact that there are opportunities for dishonest practice in every occupation. It is the seed from which has sprung the general distrust in the minds of the laity, and its reaction has involved many bright scholars, who are honest in every other particular, in dishonest treatment of their patrons, and they have trained their consciences to acquiesce in the rascality by the explanation that if they did not humbug their victims, some one else would.

In what is stated here regarding the charlatans of the ophthalmic profession let it be understood distinctly there is naught of malice, nor fear of the censure which it may, possibly, inspire.

There are two classes of charlatans in ophthalmic practice: (1), those who are ignorant of the fundamental laws of refraction, and of the relation between the eyes and the rest of the anatomy through the nervous system; (2), those who know their business but use questionable methods for mercenary reasons.

Each of these classes is divided into two branches which are often found arrayed against each other: (*a*), the medical doctors; (*b*), the refractionists. The result of their contentions is, the public becomes suspicious of both.

It is the author's belief that instead of erecting barriers of laws to shut out from practice any class, those barriers should be built from the more enduring material of general education upon the subject, which will enable the patron to choose between the true and the spurious practitioner, and it is his hope that the contents of this book may not only aid in the education of the masses, but that it may show clearly the spheres of classes "a" and "b," referred to above, and reconcile each to the existence of the other.

Much of the ignorance comprised in class "1" is the effect of an affection we will call "hero-worship," which afflicts many otherwise good people, who believe every assertion they find in the books of eminent authors, simply because of their eminence. And it is only fair to their eminences to say that in some cases they have been misunderstood, or they have been misquoted by instructors and others who have read or heard of their works.

One of my students, a young physician, came into the class-room recently and announced he had just heard that Dr. —— claimed to have cured a case of consumption by the use of prisms, and added that he would be d—d before he would believe it.

I replied, "me to," but at once explained that Dr. —— never made any such pretentions, I had read his own statement regarding the case which was evidently meant, and in it he said he visited an old friend who was bed-fast with consumption, that he operated on her recti muscles, and, two years later, learned the woman had recovered; and, as her improvement dated from his operation, he naturally concluded he had at least contributed in no small degree to the cure.

The gentleman who gave the young doctor such information was one of those "fool friends" who do one more harm than good. He had; evidently, never read Dr. ——'s book; but, knowing prisms were his hobby, he jumped at the conclusion that victory perched on the prism banner.

The principal charlatan is the self-styled "oculist," who, under cover of a medical license and an admantine cheek, without preparing himself especially for the work, opens for business in swell apartments and proceeds to humbug the people in a manner which ought to make the shade of P. T. Barnum moan with envy. First, he consults the patient, sometimes free of charge; second, he proceeds to examine the eyes with the ophthalmoscope by the "indirect method," by which at best he could only see an inverted picture, (the majority of them never see anything but the anterior portion of the globe, the cornea and iris, because they direct the patient to roll his eyes like a sick cow, while they look wise and horrified); third, he atropizes the eyes and proceeds to convince the patient that prompt and vigorous medical treatment is needed, which will require bi-weekly visits to the oculist, at $2 per visit, just as long as the victim will stand it. After a while he prescribes glasses, the measures for which are taken in a haphazzard manner, without even the semblance of a system.

AN EXAMPLE: A young man of 26 was attending a dental college and his eyes began to trouble him (pain and conjunctivitis). He went to one of these "oculists." He was ordered to quit college and report for treatment at least once in two weeks, which he did for about eight months, being treated each time to a touch of silver nitrate or some other equally noxious chemical. On the occasion of the third or fourth visit he was given a pair of glasses as follows:

L. + .75 + .50 ax. 90
R. + 1.50

Finally, when the "oculist" informed him an operation would be necessary, his patience became exhausted, he refused to be trifled with any further, and his brother brought him to me. I found a simple hyperopia of 2.50 D.

When informed he was not in a serious condition he was skeptical, and when I told him a little cool salt water would cure his conjunctivitis in a week, now that he would have his correction, he laughed incredulously. It required only four days for him to get well, nevertheless.

This brings us to the first point of gross ignorance, or criminality, whichever word suits the person who practices it. Not one such case as the above described in a hundred needs medical treatment, and it is a crime against Nature to use escharotics on the conjunctiva, or corneal cells. The cause of most cases of conjunctivitis is hyperopia, in which the strain upon the ciliary muscles sets up an inflammation which is communicated to the conjunctiva and lids, then the patient suddenly exposes his eyes to the cold winds and the sphinctre nerves and muscles at the mouths of the Meibomian glands contract, preventing the performance of their functions, and the matter is forced backward between the conjunctiva and lids which become "granulated." Medicines will not cure that condition. They may relieve it temporarily, but, the cause still existing, the trouble will recur. Correct the hyperopia, use an antiseptic lotion for a few days and Nature will do the curing.

ANOTHER EXAMPLE: A young lady of 22, was brought in by a student who could not muster courage enough to attempt the case after she told him she had been operated upon twice, and had fourteen pairs of glasses, powers varying from .50 to 1.25 D, from half a dozen oculists of this city. Examination revealed the fact that the first operation was tenotomy of the internal recti, and the second was advancement of the internal recti. I found her hyperopic 2.00 D, gave her full correction, and a month later she told the student it was a pleasure to live, although at first she wanted to throw the glasses away on account of the blurred vision, etc.

ANOTHER EXAMPLE: Young lady, aged 20, was "treated" for six months by one of the best known "oculists" in this country, who finally gave her

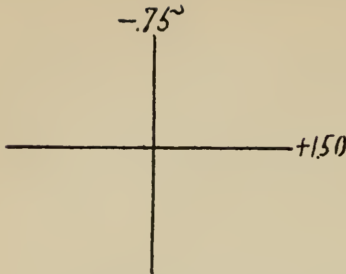
L + 2.00 — 5.00 ax. 180
R + 2.00 — 5.00 ax. 180

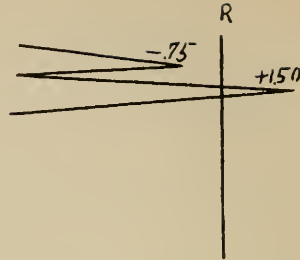
With these glasses she could see $\frac{20}{50}$ with the left eye and $\frac{20}{200}$ with the right. Without them vision was, L $\frac{20}{50}$, R $\frac{20}{120}$. There was no diseased condition when I saw her, nor had there been. I made a test and found the following:

L — .75 + 2.25 ax. 90
R — 5.00 ax. 180

These gave $\frac{20}{30}$ vision in each eye. She had worn his prescription faithfully for several months, because her father said the doctor's instructions must be followed. She says she never had either comfort or vision until she got the last pair.

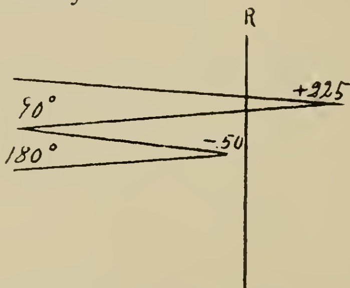
Now, some one will question her ability to see equally well with her left eye, naked, or with his lens on, so let us analyze the eye from my prescription which must be right, because she has both comfort and good vision.





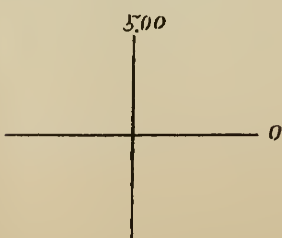
The diagram at the left shows the power of the lens combination on its two principal meridians, while the one at the right shows the foci of the two principal meridians of the eye with reference to the retina, which is represented by the line "R."

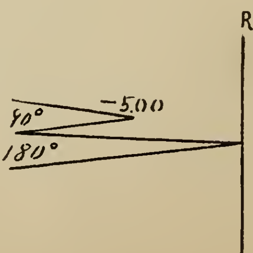
Now, put on + 2.00 — 5.00 ax. 180 and the effect on the principal meridians of the eye will be:



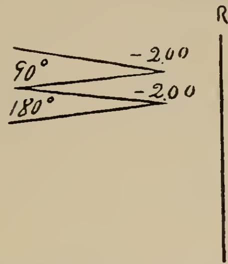
It will be seen that in either instance one meridian is within .75 of the retina which accounts for her having as good vision with as without the lens.

Not so with the other eye:





With his correction on the condition would be thus:



showing why vision in this eye was worse with than without the lens.

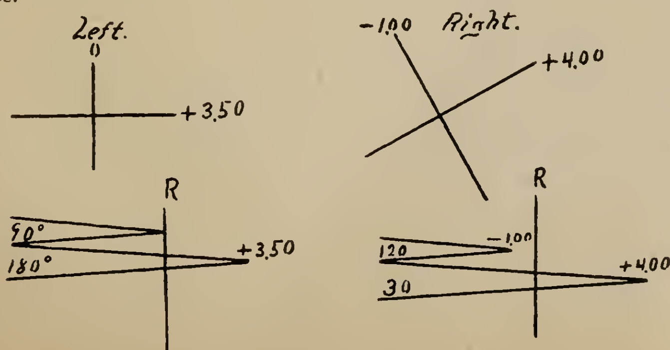
There is a publication which advertises itself as the greatest of its kind and says "its editors and contributors are the cream of the profession." Let us examine specimens of their work:

On page 5 of its January, 1897 issue the *Ophthalmic Record* has a contribution under the heading "Metamorphopsia" in which seven cases, measured under atropine, are recorded, and the lenses which were prescribed are given.

CASE III L $\frac{20}{80}$ + 3.50 ax. 90 $\frac{20}{50}$

R $\frac{20}{126}$ — 1.00 + 5.00 ax. 1.20 $\frac{20}{30}$

This cut shows the condition of the eyes as deduced from the lenses.

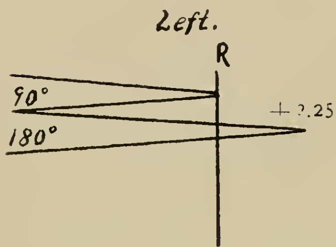


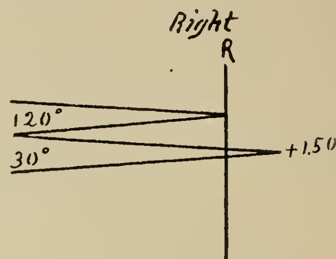
Here is what the contributor prescribed:

L + 1.25 ax. 90

R — 1.00 + 3.50 ax. 120

And here is the condition of the eyes with the lenses on:

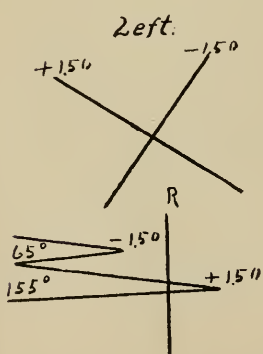


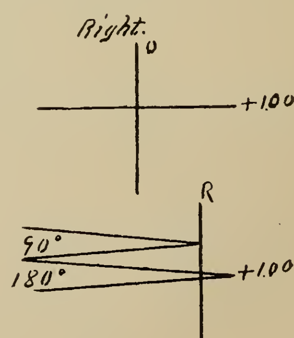


It is evident the glasses prescribed did not even approximate a correction of the error.

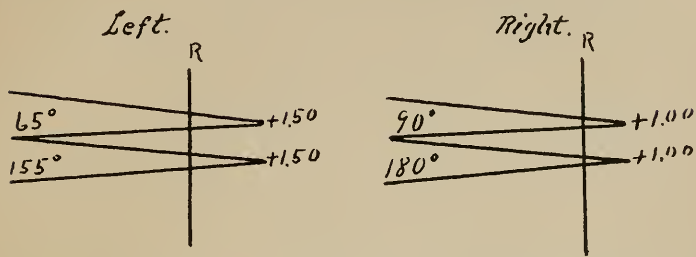
CASE IV. L $\frac{20}{70}$ + 150 — 3.00 ax. 1.55 $\frac{20}{20}$

R $\frac{20}{30}$ + 1.00 — 1.00 ax. 180 $\frac{20}{20}$





He prescribed L — 3.00 ax. 155
R — 1.00 ax. 180 with this effect:



Here he has left uncorrected 1.50 D hyperopia in one eye and 1.00 D in the other.

CASE V. L $\frac{20}{70}$ + 3.50 ax. 90 $\frac{20}{30}$
R $\frac{20}{70}$ + 3.50 ax. 90 $\frac{20}{30}$

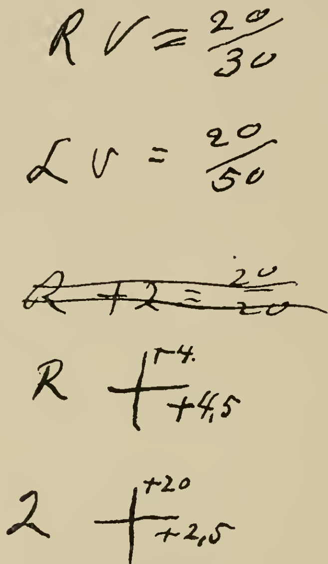
He prescribed + 3.00 ax. 90 for each eye, leaving .50 D. astigmatism uncorrected in each eye.

In three of the remaining cases he prescribed the full correction in myopia and none of the patients were over 27 years of age. This involves the maximum strain upon the accommodation when reading, a thing which common sense ought to forbid.

If such are the "cream of the profession" for humanity's sake let us take the skimmed milk.

Several years ago a lady was fitted by one of these "oculists" after atropinization for two weeks: L — 1.00 — 2.00 ax. 180; R — 1.00 — 3.00 ax. 180. She never had good vision. I recently gave her L — 1.00 + 6.50 ax. 180; R — 2.00 + 6.50 ax. 180, and she had $\frac{20}{30}$ vision at once. Her eyes have not changed; they were not fitted before.

I saw a "prescription" from one of the "experts" at the Illinois Eye and Ear Infirmary, recently. It was written on the back of one of the cards of admission to the poor. Here it is verbatim.


R V = 20/30
L V = 20/50
~~R + L = 20/20~~
R +4. / +4,5
L +20 / +2,5

It was sent to me by an optician for interpretation. I presumed the patient was the victim of a retinoscope fiend and that the lines meant the meridians of the eye so I made the following from it:

R. + 4.00 + .50 ax. 90
L. + 2.00 + .50 ax. 90

But I suggested that as vision was so much worse with the left than with the right to begin with, it was very evident the prescription was not even an approximate to the error.

If this is the kind of work they do free at such institutions it is time there were some laws passed to protect the public.

Another charlatan is the man who does his "fitting" with the ophthalmoscope, retinoscope ophthalmometer, etc., or, at least, he "corroborates" his trial set test with these instruments. In view of the fact that the ophthalmometer only measures corneal curvatures and its manufacturers only claim it is accurate as to the meridian where the axis of cylinder should be placed, and, as the ophthalmoscopes in general use have no lenses less than .50 D, the transparency of their proposition exposes it at a glance.

The utility of the retinoscope is doubtful, but it is infinitely superior to either of the others. The instruments all have their place, but, excepting the ophthalmoscope, all of them could be consigned to the scrap-pile and no one's eyes would suffer in consequence.

The ophthalmoscope is invaluable in studying the internal portion of the eye, but as an instrument to measure errors of refraction accurately, no one but a fakir would claim it.

It is the class herein described who constantly cry for "protection" by law from "non-professionals." Whenever these cries are heard, look out for incompetents. The ophthalmologist, or physician, or other professional person who knows his business, and practices it honestly, needs nothing but acquaintance to establish himself more securely than it would be possible for any law to do.

CHAPTER II.

Operations, Medicines and Prisms, Three Great Blunders.

It is unfortunate for his patients when a physician arrives at the conclusion he is greater than Nature, and the situation becomes truly alarming when we find the several text books and schools of medicine innoculating their students with such an idea, which has established a reputation second to none for virulence.

No physician ever cured anyone with medicines, operations, or by any other means. Skillful doctors have sometimes rendered such assistance to Nature that she was able to effect cures, but in many instances she was compelled to combat both the disease and the medicines prescribed by the incompetent physician.

The three great blunders in ophthalmic practice are operations, medicines, and the indiscriminate use of prisms. The reason for their existence is that blind faith in preceptors, referred to in another chapter, together with a lack of ambition in each individual to acquire additional knowledge by his own researches.

The function of an engine is to be the medium through which motive power is applied; and, without the force to operate it, it is useless. It is the same with the muscles—cut off their nerve supply and they cease to act.

It is obvious the practitioner should understand the mechanism of the organ with which he has to deal, and, without this knowledge he is a dangerous person.

The dioptric apparatus of the eye is controlled directly by the 3d nerve, which supplies the sphincter muscles of both the ciliary processes and the iris; and, in order that the direction of the visual axis may harmonize with the focus of the system, four of the rotary muscles are placed in charge of the same nerve, viz: the internal superior, inferior recti and inferior oblique. The amount of nerve supply required by the ciliary muscles in the act of accommodation regulates the supply to the internal rectus especially. Thus if the normal eye is accommodating to a point one metre distant, the convergence required to maintain binocular vision involves a strain of one dioptre on the branches of the 3d nerves which supply the internal recti. It may be computed, therefore, that for each dioptre of accommodation required in each eye there is an additional strain of one-half of that amount for convergence.

FOR EXAMPLE: The average amount of work required from the eyes of persons engaged in near work, is three hours per day. The usual working distance is about thirteen inches. In emmetropia this would require 3 D accommodation for each eye, and 3 D of convergence from *both*, making a total of 9 D. Now, let us figure by the second, $60 \times 9 = 540$ D per minute; and $540 \times 60 = 32.400$ D per hour; and $32.400 \times 3 = 97.200$ D, or the total amount of nerve force used each day in the normal condition.

The sensibility of the optic nerve has been termed, very properly, the "guiding sensation," because, so long as the power of vision remains, it is practically in control of all our movements. The motions of the eyeballs, therefore, are subject to orders from the macula, via. the optic nerve, to the brain, thence through the 3d, 4th or 6th nerves to the point where power is needed.

ANOTHER EXAMPLE: A hyperope of 2 D, in order to focus light from infinity upon the retinæ, must accommodate 2 D, and the normal tendency to converge to the 20-inch point, with that much accommodation would cause diplopia but for the demands of the "guiding sensation," which calls for sufficient power to be sent to the external recti through the 6th nerves to prevent that convergence. This requires, at least, 2 D of nerve force, thus we have 2 D accommodation in each eye, 2 D convergence and at least 2 D to restrain that convergence, making a total of 8 D per second. So, figuring as in the other example, we have 8 × 60 = 480 D per minute; 480 × 60 = 28,800 per hour; and, as the hyperope uses his accommodation all the time, for 16 hours daily, we have 28,800 × 16 = 460,800 D per day. Then, if he has the same work to do as the emmetrope, we add the 97,200 D to the 460,800, making a total strain upon the nervous system of the hyperope, 558,000 D daily. Compare this with the normal 97,200 D. The extra 460,800 must come from the reserve supply of nervous energy stored in the brain, and, when that is exhausted, trouble begins.

These troubles include conjunctivitis, muscular insufficiencies, and all sorts of nervous affections, from simple headache, to insanity, including periodical sick-headaches, dyspepsia, piles, nervous prostration and female diseases.

If the foregoing statement is true, it follows as a simple matter-of-course, unless the derangement of the system has existed so long that chronic organic disease has resulted, that the *proper* and *only* treatment needed is a complete correction of the hyperopia, together with such rest and other hygienic observations as common sense will dictate to any one with a little knowledge of the functions of the nerve force and mathematical ability to solve easy problems.

Even in chronic diseases, the correction of the hyperopia will assist the patient's recovery, and, in order that a full appreciation of this proposition may be had, I will make the broad assertion that so long as sufficient vitality remains to keep the afflicted one out of bed, the treatment suggested will effect a complete cure in ninety per cent. of all such cases.

Now, for the proofs: First, attention is called to the fact of the unnatural nerve strain in hyperopia, as has been shown, and these questions asked: Would not such strain have bad effects? Would not such effects be in proportion to the amount of error and the work required? I say, emphatically, yes. Second, I will cite a few of hundreds of cases which it has been my privilege to treat, with the results:

Mrs. R., aged 30, came with a cross-eyed boy, because she had heard I cured such difficulties without operation, which is sometimes possible, but in this case the child was too young—only four years. She inquired the cause of his trouble, and I informed her it was frequently a heritage from parents with defective eyes. She indignantly declared that neither she, her husband, nor any member of either of their families had ever needed glasses, and expressed her opinion of my statement in most unflattering terms.

As she prepared to leave, she said to the child, "Come on, dear; let us go home. Mamma has such a headache she can scarcely sit still." I asked if she often suffered from such attacks, and she replied: "Almost constantly, and at least once in two weeks I have to remain in bed for a day or so." Further questioning elicited the statements that she had "swallowed whole drug stores" and had been "treated by a dozen physicians without more than temporary relief." After questioning her closely regarding her general health, I asked to be allowed to examine her eyes, and found a simple hyperopic astigmatism in each eye, requiring + .75 ax. 90 to correct. I guaranteed a cure if she would wear the glasses constantly. She followed my instructions, and has not suffered one of her attacks for three years.

After she had worn her correction two months her huband came to see what could be done for him, and I found 2.25 D hyperopia, the correction for which he is still wearing with great satisfaction.

Incidentally the reader will please note that the hyperopia of the parents was the evident cause of the baby's cross-eyes.

Miss D., aged 17, domestic, general health good; headache and menstrual derangement, each successful attempt of the function preceded by convulsions. A. + 1.75 on each eye effected an immediate and permanent cure.

Young man of 18, farmer, had headache and a disordered circulation. Went to an "oculist" in an interior city who prescribed L. —1.25; R. —.50 — .50 ax. 180. His trouble increased, and the country doctor who was treating his blood, concluded his glasses were wrong and interfered with the action of the medicines. He came to me and I found the following corrections: L. + .25 + .50 ax. 90; R. + .25 + .50 ax. 90. He wore the glasses and continued the country doctor's medicines, and was perfectly well in three weeks.

Master E., of Danville, aged 14, had epileptic fits. Came to me wearing — lenses prescribed by an "oculist" who was at that time professor of ophthalmology in one of the largest medical colleges in Chicago. I gave him, L. + .50 + .50 ax. 90; R. + .75 + .25 ax. 45. He had one fit on the fourth day, and, when questioned, admitted he had left his glasses off several hours. He was given a lecture and has worn the glasses constantly since without a recurrence of the attacks.

Miss L., aged 20, seamstress, general health good, headache, retinal asthenopia, muscular insufficiency, accommodation weak. She brought two pairs of eye-glasses which had been prescribed "for near work, only," one of which was by a London, Eng., "oculist" who "treated" her eyes with atropia for three weeks; the other was by a Chicago optican who did his work in half an hour. The oculist's prescription was, L. + 1.75 + 2.00 ax. 105; R. + 2.00 + .75 ax. 60. The optican gave, L. + 1.00 + 2.25 ax. 135; R. + 1.00 + .50 ax. 60. Neither pair gave satisfaction, and they could not have done so had they been the proper correction, because, her nerves were on a constant strain as she wore them for "near work only," according to direction.

Her condition has been told with the exception that I found the muscular trouble to be 8° of exophoria. I knew that was a temporary condition, caused by the depleted nerve force, and so prescribed:

℞ Absolute rest from near work.
Plenty of sleep.
Out-door exercise.
5° prisms, base out on each eye for exercise ten minutes at a time, several times daily.

The prisms would be contra-indicated in most cases of exophoria, and these were given more to treat her *mind* than the muscles, because she had formed an opinion that she needed medicine rather than glasses.

After three days she returned, and I found the rest had restored her nerve force to such an extent that her accommodation was quite good, and her muscles now showed an esophoria of 10°. The original prescription was continued, except that the prisms were reversed.

Three days later she showed further improvement, and, after three more days' rest, she was strong enough to control her nerves while a satisfactory refraction test was made, which resulted in the following:

L + .75 + 2.50 ax. 130 $\frac{20}{30}$
R + 2.25 $\frac{20}{30}$

She was directed to wear *spectacles*, instead of *eye-glasses*, and to wear them *constantly*. Her accommodation was sufficiently strong to read and do all near work without additional aid.

After another week of rest her vision was $\frac{20}{20}$ in each eye and her muscle trouble had disappeared entirely. She has not had any eye trouble since.

Miss M., age 25, health good, no occupation, headaches, and inability to read at any near point. Test:

L $\frac{20}{200}$ + 4.00 + 1.00 ax. 135 $\frac{20}{30}$ +
R $\frac{20}{200}$ + 4.00 + 1.25 ax. 45 $\frac{20}{30}$ +
Exophoria 18°.

Accommodation so weak that + 3.00 was required in addition to the other lenses in order to permit her to read at 13 inches.

She was given the full correction, directed to wear it constantly, take plenty of sleep so the nervous system would have opportunity to recuperate, and report in three weeks. When she returned vision was $\frac{20}{20}$ in each eye, her muscle trouble was gone, and her accommodation so strong that she needed no addition for reading.

As these people, and hundreds of others, have all recovered without medicine, operation, or prisms (except in the one case where prisms were given for the influence on the mind), it proves conclusively that the proper way to treat all such cases is to *remove the cause entirely*, which is done when the error of refraction is corrected.

An operation upon either of these cases would have been criminal, because the result would have been a needless interference with the motion of the eyeballs. Medicines could not possibly do any good because the capacity of the machinery was insufficient to do the work. And "higher prisms" as they are sometimes called, by those who desire to express themselves in riddles, would be equally criminal with the operations, because the manner of their application is such that nerve strain is increased.

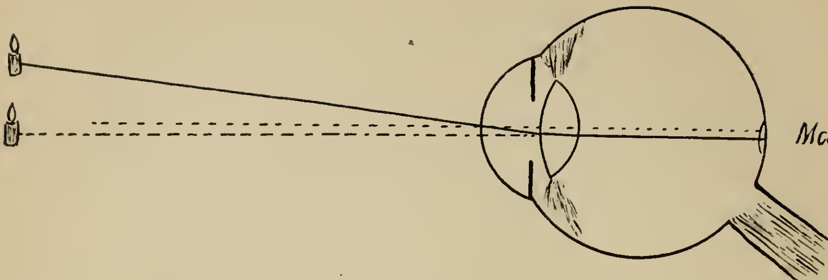
Conjunctivitis is very common in hyperopes because the constant action required from the ciliary processes causes irritation, which is conveyed to the conjunctiva by the ciliary vessels which perforate the sclerotic at the corneal margin, the lids become feverish and sudden contact with the cold, raw air of Spring and Fall causes contraction of the sphinctre nerves and muscles of the Meibomian glands in the tarsal cartilages, and the sebaceous matter which is secreted by them is forced back between the lids and conjunctiva, forming in little granules which are exceedingly painful. Medicines have no place in such cases, except some antiseptic lotion, such as salt water, or boracic acid solution. The correction of the hyperopia removes the cause and Nature does the rest.

I am well aware that I stand alone in my diagnosis of esophoria and exophoria by the tests; also that many dispute my claim that both eyes are affected equally, but all the evidence supports my position.

I have several reasons, however, for adhering to my proposition that in muscular insufficiencies the eyes deviate the *same* way the lights do.

First, the nervous relation of the ciliary muscles to the internal recti. If the accommodation is weak the internal recti must be, because they are supplied by the same nerves. Sometimes a patient will show quite a strong accommodation for a moment and yet show exophoria, but all that is necessary to prove the accommodation is weak is to have the individual read a short time.

Second, the center of rotation of the eye being the pivot upon which the visual axis revolves, and the distance from that center to the macula being so infinitely short compared with the distance to the object observed, a very slight deviation of the posterior end would cause the anterior end to move a great distance. Now, there is a *limit angle* to the deviation, which is never passed except in cross-eyes, and so long as it is not passed, the principal incident rays pass the cornea and *cross the optical axis before reaching the lens* and thus strike a prism base out, which deflects them to the macula, which sees the object in the direction they came from last, viz: toward the apex of that prism.



The cut illustrates my proposition. The candle at end of dotted line represents the apparent location of the candle in esophoria, where the eyes turn in, bringing the light with it.

Third, while others have been pursuing old methods and making repeated failures and no cures, I have worked upon the principle that errors of refraction are the sole cause of muscular insufficiencies, and have not made a failure in a single instance.

There are some who will dispute the assertion which refers to others in the preceding paragraph, and for their benefit I will give an instance of one of their " cures " which recently came under my observation:

One of my students, who found it difficult to believe my proposition, "because everyone is against you," said he, came into my office a few weeks after he had begun practice, and reported a phenomenal cure by prisms. He said the case was treated by his competitor but he had watched it with much interest, and was convinced that prisms could not have been dispensed with in that case. I asked for the prescription in full and he gave it as follows:

L. + 2.50 ⊃ 2° prism base out.

R. + 2.50 ⊃ 2° prism base out.

I made the following calculation: 2.50 D hyperopia in each eye, makes 5.00 D. The convergence naturally accompanying 2.50 D hyperopia would be 1.25 D in each eye, making another 2.50 D in both. The force required to be sent to the external recti to *prevent* the convergent tendency would be at least 2.50 D more, making a total nerve strain of 10. D. Figuring by the second $10 \times 60 = 600$ D per minute; $600 \times 60 = 36{,}000$ D per hour; $36{,}000 \times 16 = 576{,}000$ D nerve strain per day. "Now," said I, "don't you think, if you put on a + 2.50 sphere and thus save 576,000 D nerve strain each day, she would regard it something like a picnic to adapt herself to a 2° prism base out on each eye?" He whistled softly and said he never gave the hyperopia a thought. So, it will be found that where cures have been effected by their treatment it was where the correction of the hyperopia really did it, and the prisms only remained a monument to stupidity.

Fourth, I am inclined all the more to my demonstrated facts when I see an eminent professor in an Ohio medical college writing:

> "I am seriously impressed that operative procedures should be a *dernier ressort*, when all other means have failed—then advancement of the weak muscles, instead of tenotomy of the strong. There is not then the risk of diminishing the movement of the eye.
>
> "My experience has induced me to believe that there is a very intimate relation between spasm of the ciliary muscle and insufficiencies of the orbital muscles. I rarely now make an examination for refractive error, without making the test for insufficiencies, and I have been surprised at the frequency with which I have met this difficulty."

Great Scott! Talk about empiricism! Talk about restricting the practice of optometry to the oculists of Ohio, when one of the leaders makes such confessions of guess-work and carelessness! It is no longer a matter of wonder that the oculists need laws to force the public to patronize them. I appeal to the legislature to come to their relief.

Fifth, I am even more content to remain in my present position since the news comes to me within the past sixty days that one of the most eminent of all the New York ophthalmological eminences has declared himself "cured of all prism nonsense."

CHAPTER III.

Affections of the Eyes Commonly Called Diseases.

There are only two natural sources of disease: (1), the blood; (2), the nerves.

There are two subdivisions of each, viz.: In the blood, *Hyperæmia*, too much, or a congested state, causing a condition above normal, feverish; and *Anæmia*, a deficiency in quality or quantity, below normal, wasting. In the nerves, *Paralysis*, an interference with the circulation of nerve force, which may be temporary or permanent; and *Atrophy*, a condition of degeneration.

There are two classifications of diseases which affect the eyes: (1), Local; (2), General.

Local diseases are those which are confined to one district. General diseases are those which affect the entire system.

Local diseases of the eyes are affections of the lids, conjunctiva, lachrymal apparatus, cornea, sclerotic, choroid, iris, ciliary body, crystalline lens, vitreous and aqueous humors.

Among the most common of these are:

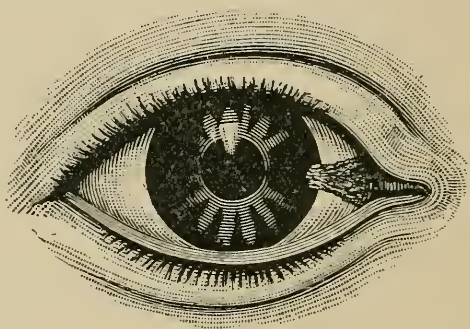
Inflammation of the lids and conjunctiva, which, speaking truly, are not diseases at all, in most instances. They are the effects of uncorrected errors of refraction. Of course, after it reaches the suppurative stage in one individual, it becomes infectious, and another may have it from that cause.

Growths upon the lids, such as chalazions, (tumors), and hordeolums, (styes), which are also usually the effects of errors of refraction.

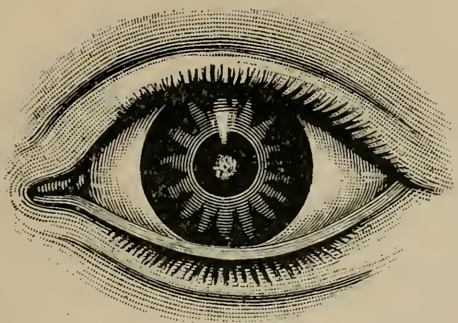
Inversion (turning in) of the edges of the lids from injuries, or eversion (turning out) from the same cause, or from relaxation of muscles in old age.

Keratitis, inflammation of the cornea, and Iritis, inflammation of the iris, also from errors of refraction.

Pterygium, a vascular thickening or growth of the conjunctiva, usually on the nasal side of the globe, extending toward the cornea. It should be removed, by operation, before it reaches the surface of the cornea, else it will impair vision.

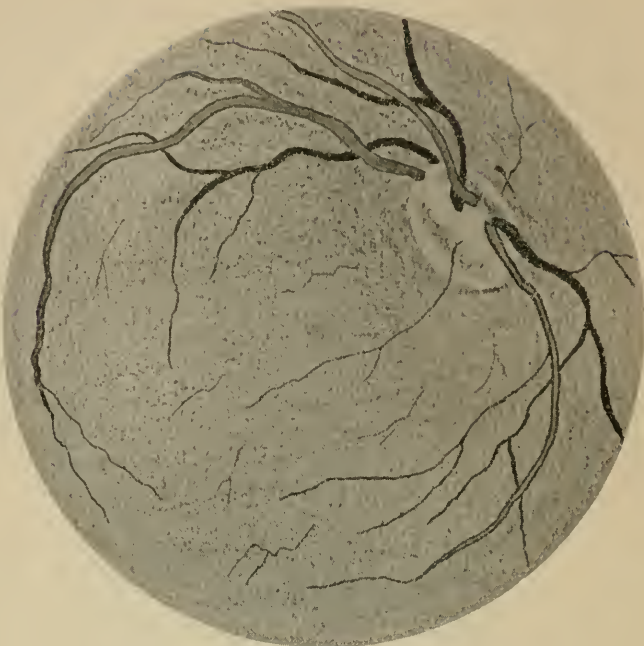


Cataract, an opacity of the crsytalline lens, due to traumatic injuries or to senility. When the opacity has enveloped the entire lens, so that vision is almost obscured, it is said to be " ripe," and ready for extraction. So long as the other eye is good, however, it is not advisable to operate, as the inequality of vision between the eyes will be too great to be comfortable.



Opacities of the humors usually float, and the patient will complain of seeing "black snow." My experience is these are caused by excessive indulgence in matter containing too much sugar, and abstinence from salt and acids.

Glaucoma, a disease in which the entire globe is affected, beginning, it is said, by eminent authorities, with increased tension, noticeable under pressure; the patient requires constantly increasing power of glasses for reading on account of the diminution of the power of accommodation, (the ciliary processes are supposed to be the seat of the origin of the trouble), lights have halos around them, the blood vessels appear to turn in at the edges of the disc when viewed with the ophthalmoscope, and the disk is of a greenish hue, hence the name Glaucoma (green). I have had one case which presented the so-called deadly characteristics of halos and the vessels turning in at the edges of the disk, but, as the individual was in the full vigor of manhood, and there was no increased tension, his error, 2.50 D hyperopia, was corrected and he is all right to-day. Still sees the



halos, but has a mania for looking at lights, which is enough to cause halos. The vessels still turn in at the edge of the disk, so I conclude it is an unusual case of "physiological cup," which even the glaucoma authorities concede to be harmless.

General diseases which affect the eyes may come from the blood or nervous systems. In the first instance, the blood supply may be impure, and obstructions occur in the circulation, causing congestion and even hæmorrhages, or it may be insufficient, and there be a lack of nourishment. In nephritis or diseases of other

organs, the sympathetic relation between all parts of the anatomy exhibits itself in the eyes by causing inflammation of the retina. This is called retinitis. It is not a disease, but a symptom.

Affections from this source are observed with the ophthalmoscope, for which purpose the direct method is the best.

Seat the patient in a slightly darkened room, back to the light, which should be a round burner, placed about two feet distant. Turn his head until the light reflects along the temple to the edge of the orbit, leaving the eye-ball in the shadow. Direct his attention to some object straight ahead.

The operator sits alongside the patient, but faces the light, holding the end of the handle of the instrument between the thumb and two first fingers, so it may be moved readily, and, letting the disk rest lightly against the brow and nose in such a position that the eye may see through the hole in the mirror, the light from the lamp is reflected from the mirror into the pupil, when a red reflex is seen. Following a direct line toward that reflex and getting as close to the examined eye as possible, the vessels of the retina will appear; the darker ones are veins, the lighter ones arteries.

Do not throw the light into the eye from squarely in front, but at an angle of about thirty degrees from the optical axis of the observed eye. Use the right hand and right eye for patient's right, and left for patient's left. Keep the unengaged eye open if possible, it will be more comfortable. The lenses in the instrument are to be rotated until one is found which affords the best view of the retina. About — 3.00 is required by beginners for eyes which are almost normal. This is to offset the observer's accommodation. If it requires a very strong + or — lens to secure a good view, the lens indicates approximately the amount of hyperopia or myopia, after deducting for one's own accommodation.

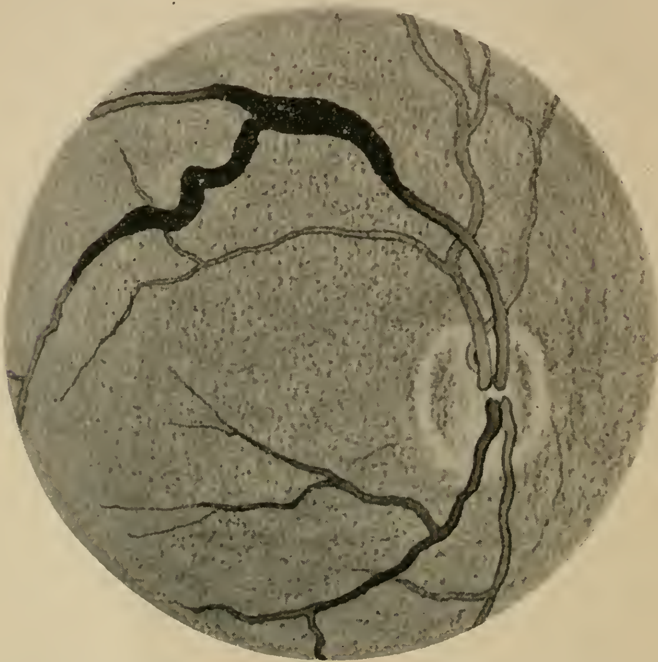
The operator should first familiarize himself with the appearance of the normal eye, (see cut). Note the general field around the

central disk where the vessels meet is even and passive in appearance, the edges of the disk (optic nerve entrance) clear, vessels uniformly decreasing in size as they extend farther from the entrance, the veins darker than the arteries, which is proper, because they carry the impure blood back to the lungs for purification, while the arteries are employed to bring the good blood out through the system after it has been renovated. The light streak in the arteries is merely the reflection of light along its axis, which is permitted by the transparency of the blood. Its absence in the veins is due to the opacity of the blood which absorbs the light.

Do not expect to see as much of the field at once as is shown in the cut. An area about twice as large as the disk is all that can be illuminated from one position, but a slight turn of the instrument brings other parts into view, and it is moved until the entire retina has been examined.

Nearly all beginners rely too much on the instrument, and, if they do not see the entire retina at the first attempt, grow discouraged. For eyes anywhere within 3 or 4 D of normal, the blank peep-hole is used, and when the observed eye is approached at the proper angle the red reflex and a few of the blood vessels will be seen. Keep the patient in that position and rotate the lenses until the one which gives the clearest view is found. For the purpose of studying diseases it is not necessary that the observer's eye be corrected, unless his error is so great he is unable to see anything distinctly. Usually beginners use their accommodation considerably, so about — 3.00 or — 4.00 will be required to offset it. All power above that may be considered myopia in the patient.

If the vessels are congested in places, as illustrated in the following cut, it is called a Thrombosis, (a clot of blood), and is caused by an



Embolus (plug) which obstructs circulation. If it occurs in an artery it will affect vision suddenly and it is liable to be permanent. If it is in the veins, they being somewhat larger, it may pass away under prompt medical treatment, with possible aid from massage of the eyeball. Or a hæmorrhage may occur, as shown in the next illustration, and, after a time re-absorption take place, and vision, which was lost, restored again.

If the vessels are thread-like, and the color of the arterial blood is paler than normal, while that of the veins is dark, but seems not to fill the vessels and shows a light streak, and the general appearance of the patient is corroborative of a lack of proper nourishment, it indicates disorder of the generative organs in females and functional derangement of the liver and digestive apparatus generally in males.

After the blood vessels, examine the general field of the retina, especially around the edges of the disk for inflammations and any other abnormalities. After once seeing the normal condition it is as easy to recognize retinitis as it is to know when the lids are inflamed. The first appearance is usually around the edge of the disk, and a slight degree may be caused by a cold, or over-work from an error of refraction, but the more intense exhibits mean organic diseases.

In females it is most commonly from ills incident to their sex, and in males the great majority are renal troubles. The commonest cause of female ills is hyperopia, and ignorance of the functions of their procreative organs and how to care for them.

It is to be hoped, for the sake of posterity, that the higher education of daughters, and sons too, will soon include a thorough knowledge of every function, and common sense enough to care for them. It would result not only in a higher state of physical health, but in moral elevation as well.

The commonest cause of kidney troubles in males, is excessive use of malt liquors, which not only overload the organs by the great quantities taken, but the chemicals used in their preparation have the effect of reducing their capacity.

In hyperopia the constant accommodative effort causes a sympathetic contraction of the sphincter muscles throughout the body, (and it must be remembered every opening in the body, large or small, is surrounded by such a muscle), among them that of the uterus, thus interfering with the menstrual function. This sets up a disturbance which is reflected back to the eye, causing further contraction of the muscles there, even to those surrounding the optic nerve at its entrance, with the result that the arterial circulation is cut off so blood cannot enter the eye, venous circulation is impeded so blood cannot

pass out, and the field around the edge of the disk becomes so irritated that the disk appears like a splash of cheap whitewash, tinted. The cut was drawn from such a case.

The Creator evidently intended only water to be used as a beverage, else there would have been an occasional river of beer or some other liquid.

The ophthalmoscopic appearance is very much like that shown in the last illustration. It is diffused over a larger field and does not appear quite so intense, except in advanced stages, when, in addition to the inflammation, irregular-shaped œdemic patches appear from which the circulation has been cut off by the swelling. This condition is said to be a sure indication of Bright's disease. If these appear black, as they will when the degenerated tissue disappears, showing the pigment layer, it is safe to predict early death. If your prediction fails, the patient is pleased, and if it is fulfilled your reputation is enhanced.

There are many diseases which will cause retinitis. I have only mentioned these because of their frequency. So, after finding the *condition*, consult the patient to find the *cause*. Hear his story patiently,ask questions,probe family history, etc., get the facts, and you cannot possibly fail in your diagnosis, if you do in treatment.

If, after careful examination of the vessels and tissue nothing abnormal is found, proceed with the visual tests. If vision is poor and cannot be improved to approximately normal, it must be the nerves which are affected. There is no other source left. If vision was lost suddenly, it is paralysis, and the application of electricity together with constitutional treatment and rest may restore it. If sight passed away gradually, it is atrophy, and, while the progress of the disease may be arrested, the dead nerves can never be revived.

The commonest causes of nerve troubles are excessive use of spirituous liquors and tobacco, diseases, such as scarlet fever, measles, typhoid, la grippe, and their ilk. But, as cited in reference to other affections, the specific cause may be located in any given instance by questioning the patient.

Treatment.

FIRST. Having discovered the cause of trouble, if it be from an acquired habit, such as liquor, tobacco, etc., order it stopped. If it be from a natural habit, such as eating and drinking the foods necessary to sustain life, or from excessive sexual indulgence, order it regulated.

SECOND. Correct whatever errors of refraction are found, and direct the patient, in plain terms, how to wear it, giving simple reasons therefor.

THIRD. If you are not a physician, and, in your judgment, medical treatment is needed, see that it is secured. The patient's family physician is the proper one to treat such cases, and it is right for you to send him a note or give him an oral statement of the conditions you have found.

CHAPTER IV.

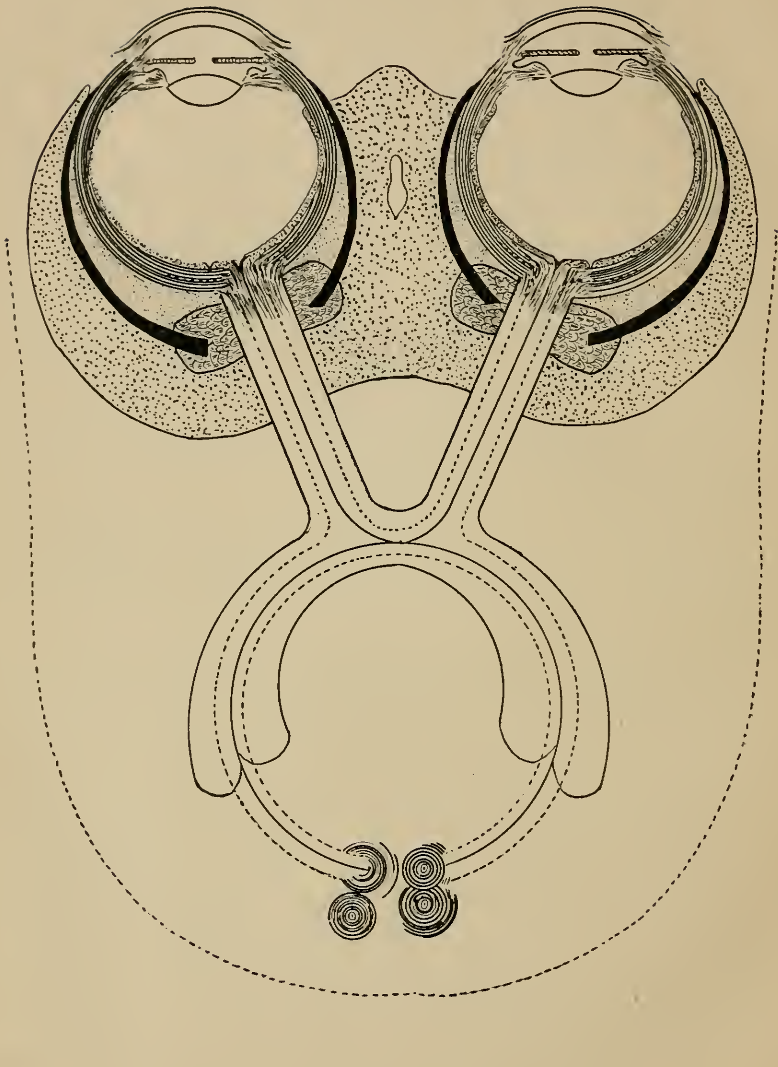
Anatomy and Physiology of the Eye and Its Appendages.

The orbits are the hollow cavities in the skull which contain the eyeballs, and afford protection from injury. They are lined with a fatty, fibrous, cartilaginous cushion called the Aponeurosis, from which, in the posterior portion arise the muscles which hold the eye in position.

The lids perform the office of shutters to the orbits excluding light and protecting the eyes from dust, etc.

The conjunctiva, or lining membrane of the lids, extends over the anterior surface of the globe, and, being lubricated from the Lachrymal Glands, affords two smooth surfaces which prevent friction in winking.

The eye-ball is spherical in form, with a projecting segment of a smaller sphere on its anterior surface, by means of which the refractive properties are increased, so that light will be focused on the retina. It is composed of three principal layers: (1), the sclerotic and cornea; (2), the choroid, iris, and ciliary processes; (3), the retina. These layers form two principal cavities; (1), behind the crystalline lens, filled with vitreous humor; (2), in front of the lens, filled with aqueous humor. The iris is suspended in the front cavity dividing it into two chambers, the anterior and posterior, which are connected by the opening in the iris called the pupil.



The cut illustrates the relative positions of the eyes, and the source of their nerve supply, showing why pains in the eyes are always referred to the back of the head. The sclerotic, choroid and retina are shown in their respective locations as the outer, middle and inner layers of the eye-ball. The dark lines represent the internal and external recti muscles, and, posteriorly, is shown the cartilaginous substance where all the muscles of the globe have their origin.

The globe and its contents form what is termed the *dioptric system*.

The dimensions of the eye are, antero-posterior diameter, .95 inch; horizontal, .92 inch; vertical, .90 inch. The optical axis is an imaginary line connecting the anterior and posterior poles, which are the geometric centers of the cornea and the retina. The visual axis is an imaginary line from the macula to the object observed, and crosses the optical axis at the optical center of the lens, so that in looking at distant objects the two eyes receive the same image without any effort at convergence.

The sclerotic is a dense, fibrous membrane, without nerves, and with few blood-vessels. It encloses about four-fifths of the globe, and the cornea the remainder. The latter is transparent and is of cellular structure; has nerves but no blood-vessels, except at the margin,where there is a narrow space plentifully supplied from capillaries from the ciliary processes. The sclerotic and cornea form a layer of protection to the more delicate inner coats.

The choroid, (sometimes called the uveal tract), is a vascular membrane, dark brown in color, and is attached to the sclerotic at the ciliary processes and at the optic nerve entrance. It is the layer of nourishment, carrying the blood and nerve supply of the eye. The ciliary processes are folded elongations of the anterior part of the choroid in which are located the suspensory ligaments and sphincter muscles which, with the zone of Zinn and crystalline lens, complete the mechanism of accommodation. The iris is a continuation of the choroidal coat and forms a curtain which regulates the amount of light admitted to the interior. It is formed form a combination of radiating and cirular muscles, and is colored by a layer of pigment cells, continuous with that pigmentary lining of the choroid which receives the light after it has passed the retina, on the same principal that the earth is utilized by telegraphers to "ground" electric currents to prevent burning out of instruments.

The retina is the optic nerve expanded into a membrane. Its function is to receive the incident rays and telegraph the impressions to the brain. It is composed of many layers, and is most highly sensitive in that portion in the vicinity of the posterior pole where incident rays from the pupillary space form images. At the optic nerve entrance there is no sensibility, and, under the ophthalmoscope it appears as a disk, almost white, and is seen a little to the nasal side of the posterior pole. It is the "blind-spot."

The aqueous humor is a transparent fluid, with a specific gravity about equal to distilled water, and fills all the space in front of the crystalline lens. It is a glandular secretion, related to the lachrymal apparatus, and if the cornea is punctured, allowing it to escape, it will refill the space in a few hours.

The crystalline humor, or lens, is a substance of peculiar formation. Although seemingly a liquid, it is of a striated composition of several layers and conditions of refracting and dispersing powers. The combination forming an achromatic, or, rather an aplanatic (meaning both spherical and chromatic aberration are corrected) lens. It is most probable here is the seat of color blindness, when the aplanatism is not complete. The lens is enclosed in a capsule and this is attached to a tubular structure, the zone of Zinn, which is attached to the ciliary processes. The lens has a natural tendency to contract peripherally, and expand along its antero-posterior axis, making it more convex, thus increasing its refractive power. This is assisted by a similar tendency on the part of the zone of Zinn, but the suspensory ligaments, having greater contracting power, pull outward on the combination and hold the lens in its thinnest form, until there is a demand for more convexity of the dioptric system, when the sphincter muscle receives an impulse from the third nerve and contracts, like a watch spring, thus overcoming the suspensory muscles to whatever extent the occasion demands. It is the loss of this impulse which is called *presbyopia.*

The vitreous humor fills the main globe of the eye and holds the choroid and retina in close contact with the sclerotic. It is a transparent gelatin-like substance, and is enclosed by a delicate membrane called the hyaloid, which forms a lining to the retina, and in case of hæmorrhages of retinal vessels, is useful in holding the extravasated blood in the tissue affording opportunity for re-absorption.

The blood supply of the eye comes from the ophthalmic artery, which is a branch of the internal carotid, from the common carotid, from the arch of the aorta. There are two main veins, the superior and inferior ophthalmic, which empty into the cavernous sinus, and also connect with the veins of the face, thus allowing free circulation.

The muscles of the eye-ball are six: four recti, the superior, inferior, internal and external, and two oblique or pulley muscles, the superior and inferior, which pass along the nasal side to a ligament, thence over and under the globe. The function of the muscles is to rotate the eye-ball in its socket.

The muscles of the lids are the orbicularis palpebrarum, corrugator supercillii, tensor tarsi, and levator palpebræ.

The cartilages of the lids are the superior and inferior tarsal. They give form and support to the lids. The outer angle of each is attached to the malar bone by the external palpebral or tarsal ligament, while the inner angles terminate at the commencement of the lacus lachrymalis, (the space next the nose where the tears find entrance to the nasal duct), and are fixed to the margin of the orbit by the tendo oculi.

The Meibomian glands are located in the tarsal cartilages, and correspond in length to the width of those cartilages. They are more numerous in the upper than in the lower lids and secrete a sebaceous matter which is exuded upon the free margins of the lids, preventing adhesion when they are closed.

The lachrymal glands are situated at the upper outer angle of the orbits and their secretions are carried away by many small ducts which lubricate the conjunctiva and pass away through the lachrymal canals and nasal duct at the inner angle (or canthus).

The nerves of the eyes are the 2d, 3d, 4th, 6th, and part of the 5th cranial. The 2d affords the sense of sight, the 3d operates all muscles except the superior oblique and external recti, which are supplied respectively by the 4th and 6th.

CHAPTER V.

Mydriatics and Myotics—Drugs which act on the Accommodation.

Mydriatics are drugs which paralyze the accommodation. Those commonly used are: (1), Atropine, an alkaloid of Atropa-Belladonna, or Deadly Night-shade; (2), Homatropine, a product of Atropine; (3), Duboisine, from Duboisia Myoporoides; (4), Hyoscamine, or Scopolamine, from Scopolia Japonica; (5), Daturine, from Daturia Stramonium; (6), Gelsemine, from Gelsemium Sempervirens; (7), Cocaine, from Erythroxylon Coca.

Those in most common use are Atropia-sulphate and Scopolamine. They are used in solution of 2 to 4 per cent. The objections to their use are: (1), the length of time required to secure complete mydriasis; (2), the discomfort to the patient from the effect on the general system which it enters *via.* the tear-duct through the nose and throat; (3), it does not keep longer than a couple of weeks; (4), the dose is unavoidably inaccurate as to strength.

The Homatropine combined with Cocaine, and put up in gelatin disks is the most satisfactory of all mydriatics, because, (1), the accuracy of the dose; (2), it keeps indefinitely; (3), it acts quickly; (4), there is absolutely no danger in its use.

The disks, as put up by Wyeth & Bro., and kept by all optical houses, are in bone boxes each containing fifty disks. The stock numbers of the ones most used are:

No. 338 Homatropine and Cocaine, $\frac{1}{50}$ grain of each in each disk. One disk in each eye, under the upper lid, (which should be everted and the disk placed on the conjunctiva, so it will be above the apex of the cornea), will smart slightly for a few moments, during which time the eyes should be kept closed; after twenty minutes the pupils will dilate, and in about one hour the patient will be unable to read ordinary print at any distance. The effects pass away in about twelve to twenty-four hours, and there are none of the after-effects which are so common in the use of the solutions.

No. 336 Homatropine $\frac{1}{500}$ grain, is used as the other; dilates the pupil for ophthalmoscopic examinations, and may be used on old people to enable the physician to examine cataracts in order to ascertain their condition.

No. 323 cocaine muriate, is a local anæsthetic, used to deaden the conjunctiva while foreign bodies imbedded therein are removed. Takes effect in about six minutes, and passes off in about twenty minutes; dilates pupil for several hours. As soon as smarting ceases after inserting, go to work on the object.

Myotics produce artificial stimulation to the sphincter muscles. Those most used are Eserine, Calabarine and Physostigmine, all Alkaloids of Calabar Bean.

No. 331 Eserine $\frac{1}{1000}$ grain to the disk is used as the others, except for the opposite effect. In some instances of iritis with spasm of accommodation there is danger of the iris adhering to the lens, and if it does, Atropine is used to pull it loose, alternating it with Eserine to prevent mutilation of the membranes. Again, in myosis, or enlarged pupil from inaction of the sphincter muscles of the iris, Eserine is used in the effort to stimulate it to action.

CHAPTER VI.

Color-Blindness, and a Comparison of the Tests Therefor.

This subject is one which has been widely studied and written upon; but, as yet, no one has reached conclusions susceptible of demonstration with satisfaction to all and the etiology is as obscure as that of the "expression" of the eyes.

One theory is that the retina possesses three sets of color-perceiving elements, viz: those for red, green and blue, or violet.

Another is that there exists in the retina three different visual substances, viz: red-green, blue-yellow, and white-black. It is claimed that one color of each pair is used up by the process of dissimilation and the other is produced by a sort of creative process called assimilation, that white corresponds to the process of dissimilation, and black to the process of assimilation; that for the two other pairs it cannot be said which color represents either process.

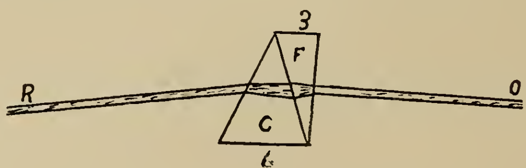
Another proposition is that we know everything by comparison with some other thing—a large man by comparison with what we know to be the average size, a red color by comparison with yellow, a black by comparison with a white.

All of these appear to me to be the same idea, expressed differently, the latter being rather more intelligible than the others. But just why or how the retina is able to produce the particular color for comparison is the unexplained feature. I know they say, and prove, that the presence of one color leaves an after-effect which produces the other, and upon this ground their theory, but why does it do so?

The series of colored plates on the following pages illustrate the facts. The reason for their existence is not so clear by any means.

I have a theory which I will give for what it is worth.

It is well-known that crown and flint glass, with approximately the same index of refraction, have decidedly different indices of dispersion, the last named having twice as much of the dispersive quality as the first. All high grade mathematical instruments utilize this property to overcome spherical and chromatic aberration. Before the discovery of the peculiarity of flint glass it was impossible to make lenses of higher magnifying power than about twenty-five diameters because of the diffusion of color over the observed field. In the chapter on "Laws of Refraction" the illustration was used which is here reproduced, and it was stated that it exhibited the principle upon which achromatic and aplanatic lenses are made.



The manner in which it is utilized is as follows:

A lens of, say, two inches focus is desired, and a biconvex crown glass of 40 D or 1-inch focus is taken for the nucleus, on one side is cemented a concave meniscus, or periscopic-concave flint glass lens of 20. D which neutralizes *half* of the refractive power of the other and *all* of its dispersive power, thus securing a + 20. D or 2-inch focus, without any dispersion. When it was found there was still a difficulty from the extreme edge rays focusing just a little sooner than those passing the main body of the lens, preventing a distinct image being secured, it was obviated by *dividing* the flint glass, putting — 10. D on each side of the crown.

Now, all authorities agree that the crystalline lens is constructed upon the same principle, and I believe it was done for the same purpose, for I have not found a single case of true color-blindness in which I was able to secure $\frac{20}{20}$ vision and they invariably had great errors of refraction.

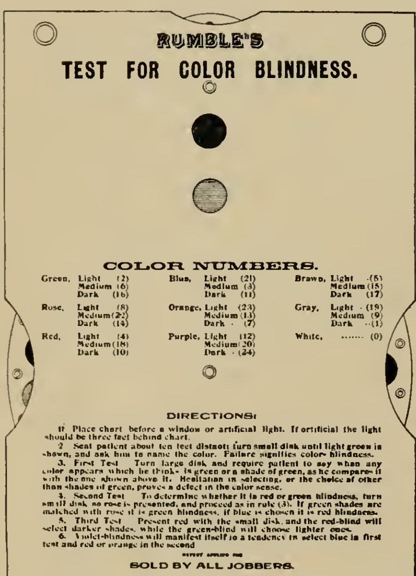
One may have an error of refraction without color-blindness, because the composition of the lens may be normal. And one may be color-blind from an abnormal consistency of the lens, yet have no error of refraction. Still his acuteness of vision will be below normal, and nothing will bring it up to the standard.

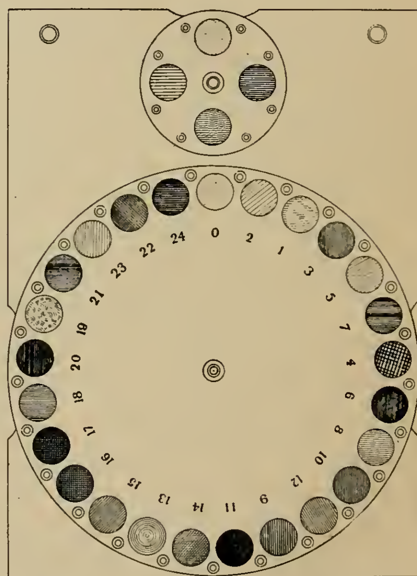
I am, therefore, of the opinion that the test for color-blindness is not complete without a test for errors of refraction, and if I find a seeming deficiency in the color-sense, yet vision can be brought to $\frac{20}{20}$, I pronounce it, not color-blindness, but color-ignorance. A number of experiments have convinced me that all such persons can be educated to match colors as well as anyone.

Of the methods of testing the color-sense the ancient one by Prof. Holmgren, of comparing skeins of worsted and the modern one devised by Prof. Rumble, are the only two in general use.

Of these two, the newer one is unquestionably superior because it can be used with equal facility day or night, while the other is practicable only in good day light.

The accompanying cuts show front and back views of the test, which is mounted upon a card 8½ x 12 inches in size, and of heavy, durable material. The colors are arranged on two revolving disks, and are of celluloid. The test colors, light green, rose and red, are on the small disk, together with white. Three shades each of green, rose, red, blue, orange, purple and gray, are attached to the large disk, which is revolved slowly, presenting the several shades, which are numbered, at the lower opening of the two shown in the upper cut for comparison with the test color shown at the upper opening.





The following form is used by many railroads for recording the results of the test. The name of the color submitted is not recorded in the first column until the test is over and patient gone.

Name of Patient, C. E. DAVIS.

Test Color Submitted.	Name Given.	NUMBER SELECTED TO MATCH.
GREEN	GREEN	12, 16, 11, 6, 3, 2, 21.
ROSE	RED	10, 8, 7, 22, 18, 14.
RED	RED	18, 14, 10, 4.

Reference to the Chart under head "Color Numbers" shows 2, 16 and 6 are green, while 11, 3, and 21 are blue, and 12 is purple.

In the second test "rose" was called "red" and of the colors matched with it 10 and 18 are red, 7 is orange, and 8, 14 and 22 are rose.

In the third test he named color properly and matched them without fault, except that he added dark rose to the collection.

According to article 6 of "Directions" this was a case of violet-blindness.

In cases where there is a reasonable doubt of true color-blindness, a statement should be made to that effect in the report, so that if the individual's pecuniary interests are involved he may have opportunity to practice with colors, and, if possible, thus remove the obstacle in the way of his employment. Careless examiners often commit grave injustice to persons in the employ of corporations, where a good color-sense is nccessary, and such carelessness deserves as severe punishment as would follow the passing of a color-blind person.

The cuts on the following pages are a preliminary test for color-blindness, and show the rapidity of color perception in a manner beyond question. The effects to the eye with normal color sense will be as follows:

Look at the eye of the figure for a short time, say half a minute, then cover it with a blank sheet of heavy white paper, and fix the gaze on one spot, and its complementary color will appear: If the figure observed is

Black, white will appear;
Red, green will appear;
Green, red will appear;
Yellow, blue will appear;
Blue, yellow will appear.

APPENDIX.

A Quiz Compend, Embracing the Principal Points of Practice.

Question. What is force?

Answer. It is that which causes or arrests motion.

Q. What is light?

A. It is a force, positive and negative.

Q. How many kinds are there?

A. Two, natural and artificial.

Q. What is meant by refraction?

A. The word "refraction" means "to break." The refraction of light is the deviation in its course a ray suffers in passing obliquely from one transparent medium to another of different density.

Q. What is meant by "index of refraction?"

A. It is the comparative rate of speed at which a ray travels in mediums of different density.

Q. Why do we take air as our standard of measurement of refraction?

A. Because it is the rarest medium, and is the one through which all light comes to us.

Q. What are three principal laws of refraction?

A. First, the deviation oblique rays suffer. Second, a ray passing a prism is broken toward the base. Third, in order to utilize refraction for optical purposes, we must have curved surfaces in order to get foci.

Q. What three things always accompany refraction?

A. Reflection, dispersion and absorption.

Q. What three things are necessary to illustrate refraction?

A. Two transparent mediums of different density and an oblique ray.

Q. What is a nodal point?

A. A center of curvature.

Q. What is a prism?

A. A wedge, of some transparent substance.

Q. How are prisms utilized in the formation of lenses?

A. They are used in multitudinous quantities, of different angles, and are arranged around a central point for sphericals, bases toward that point for +, and away from it for —, in such order that the result is a spherical curvature. For cylinders they are arranged on either side of a line, so as to form either + or — cylindrical curvature.s

Q. How many kinds of lenses are there?

A. Two, convex and concave, (+ and —).

Q. What are the general forms of lenses?

A. Spherical and cylindrical.

Q. What class of lenses form images?

A. Spherical.

Q. Locate the nodal points of a lens?

A. They are the points upon the principal axis where the secondary axial rays would cross did they not suffer refraction.

Q. Locate the optical center of a lens?

A. It is the point on the principal axis where the refracted secondary axial rays cross.

Q. Locate the principal foci of a + spherical lens, and state if they are movable or fixed?

A. They are the points on the axis, on either side of the lens, where rays are focused which were parallel to the axis on the opposite side. They are fixed.

Q. Locate the conjugate foci of a + spherical lens, and state if they are movable or fixed?

A. They are the points on the principal axis, on either side of the lens, where the object and its image are respectively located. They are movable, the position of the image being governed by the location of the object, hence the name "conjugate" which means "yoked together."

Q. What class of lenses have their conjugate foci on the same side of the lens?

A. Concave (—) spherical.

Q. What class of lenses form images reversed?

A. Convex (+) spherical.

Q. Why is this so?

A. Because the secondary axial rays always cross the principal axis at the optical center, and the law of conjugate foci brings rays from a point on one side of the lens, back to a point on the other side, on a direct line with the starting point and the optical center of the lens.

Q. How many ways are there of finding the location of the second conjugate focal point?

A. Two, one practical and the other theoretical. First find the refracting power of the lens, draw a plane through the first principal focal point, than draw a line from the object, on the axis, to the lens at some distance from the axis toward the edge, then draw a line from the point where the first line crossed the focal plane, through the optical center of the lens, then continue the first line beyond the lens parallel to the second until it touches the principal axis; this point is the second conjugate focus. The rule to calculate this, is: The first conjugate focal distance and the focal length of the lens being given, multiply them together and divide the product by the difference between them; the result will be the second conjugate focal distance.

Q. At what distance from a lens must an object be placed in order that its image will be formed at the same distance on the other side, and what will be their relative size?

A. At twice the focal length, and they will be of equal size.

Q. How many principal axes has a lens?

A, One, the line from one nodal point to the other.

Q. How many secondary axial rays are there?

A. All rays which cross the principal axis at the optical center are secondary axial rays, and they are innumerable.

Q. What is the peculiar difference between principal and secondary axial rays?

A. The principal suffer no refraction, while the secondary do; it is so little, however, it is not considered in calculation.

Q. What is the advantage of the metric system of numbering?

A. It simplifies calculations to mere addition and substraction

Q. What is a toric lens?

A. One in which the sphere and cylinder are both ground on one surface.

Q. What is an achromatic lens?

A. A lens composed of two pieces, one of crown and one of flint glass, the first being + and the second —; the latter one-half as strong in refracting power, but of equal dispersive power, overcomes chromatic aberration.

Q. What is an aplanatic lens?

A. It is similar to the achromatic one, except that the — lens is divided, one-half being placed on either side of the + with the re-result that not only the chromatic, but the spherical aberration is overcome and a fully corrected lens formed. They are used only in high power instruments.

Q. To what class of lenses does the dioptric system of the eye belong?

A. To the + class.

Q. What constitutes the dioptric system of the eye?

A. The cornea, aqueous humor, crystalline lens and capsule, and the vitreous humor.

Q. What is meant by static and dynamic refraction of the eye?

A. Static means natural, and is that condition which is present when the nerves and muscles of accommodation are at rest. Dynamic means force, and is the condition present when the nerves and muscles are active.

Q. What is the index of refraction of the eye?

A. Of the cornea and humors it is about 1.33; of the lens, about 1.42. They aggregate in calculation so nearly the index of glass, that for practical purposes, draw the perpendicular to the surface of the cornea where the incident ray strikes and calculate on the basis of an index of 1.50, ignoring the humors and lens.

Q. Why is the cornea necessarily a segment of a smaller sphere than the globe?

A. Because no globe with an index of refraction of less than about 2.00 will focus within its own circumference, hence the cornea is of sharper curvature to bring the focus of the dioptric system within the eye.

Q. Which meridian of the cornea has the sharpest curvature in the normal eye, and why?

A. The vertical, to give the effect of a + cylinder to act as a governor to the oblique muscles.

Q. What is an error of refraction?

A. That condition of the dioptric system in which the retina is situated in front of, or behind the focus of one or more meridians.

Q. How many kinds are there?

A. Two, Hyperopia and Myopia.

Q. Give some symptoms of each?

A. Of Hyperopia: frowning when looking at distant objects, vertical wrinkles on the forehead between the eyes, a flat face, with low nose-bridge, small eyes deeply set in the head, small pupils, conjunctivitis, headache, sick stomach, indigestion, constipation, piles, female disorders, almost all nervous affections, visions more acute than $\frac{20}{20}$. Of Myopia: large, full face, prominent eye-balls, high nose-bridge, large pupils, tendency to close the eyes when looking at distant objects, inability to see clearly at a distance, absence of hyperopic symptoms.

Q. Are these symptoms infallible?

A. Oh, no! Symptoms are only a general guide, and may fail completely. As a general rule they are pretty reliable.

Q. What is astigmatism?

A. It is a lack of spherical curvature of the cornea, one meridian having more convexity than the others, the one at right-angles to it having the least amount.

Q. In what part of the eye is it most frequently found?

A. In the cornea.

Q. Where else?

A. Occasionally in the crystalline lens.

Q. Does it change in amount?

A. It does not in the cornea, except in case of injury or corneal disease. In the lens it does, as age affects the power of accommodation.

Q. How many kinds of astigmatism are there?

A. Seven, viz: Normal, five kinds of regular, and irregular.

Q. How may irregular astigmatism be corrected sometimes?

A. By using stenopaic disks, or pin-hole disks, either alone or combined with lenses.

Q. What is a spasm of accommodation?

A. It is an involuntary action of the muscles, from nerve strain.

Q. How many kinds are there?

A. Two, Clonic and Tonic.

Q. Describe them?

A. Clonic is an intermittent action found in almost all young hyperopes and is overcome readily by fogging. Tonic is a permanent cramp, is always painful, and often requires atropia to subdue it, although a pair of + lenses of .50 to 1.00 D power, if worn constantly for a few days, may conquer it.

Q. How may spasm of accommodation affect the vision and the tests therefor?

A. It may conceal a portion of the amount of hyperopia, may make the eye appear emmetropic, and even cause it to simulate myopia, thus interfering with the test.

Q. What are some special indications of spasm of accommodation?

A. In testing, if patient sees better one moment than another, with the same lenses, it indicates clonic,and pain, with reduced accommodation indicates tonic spasm, showing that the muscle will neither relax or contract further.

Q. What is the difference between range and amplitude of accommodation?

A. The range is the difference between the far point and near point. Amplitude is the muscular effort required to adjust the focus of the eye to points within that range.

Q. Locate the far points and near points in emmetropia, hyperopia and myopia?

A. The far point in emmetropia is at infinity, in hyperopia it is beyond, and in myopia nearer than infinity. The near points in all of them are the nearest points to which they can accommodate.

Q. When would you prescribe a spherical, if the test called for a compound?

A. For temporary wear, if there is some doubt about the correctness of the test, or for persons who require a very strong sphere and weak cylinder. In the latter instance, because in grinding the sphere all on one side of the lens the aberration thus caused would counteract the benefit of the cylinder.

Q. When would you prescribe a cylinder if the test called for compound?

A. In compound myopia, or mixed astigmatism where the full correction gives $\frac{20}{20}$ vision, and the sphere is — .50, or less, we would prescribe only the cylinder, so long as accommodation remained.

Q. When would you prescribe a compound instead of a cylinder?

A. In simple myopic astigmatism, if the cylinder gave $\frac{20}{20}$ and accommodation is good we put + .25 or + .50 sphere in combination, reducing vision a little, but assuring ourselves we are not overcorrecting.

Q. What class of patients should wear glasses all the time, and why?

A. Those with an error of refraction. Hyperopes, to relieve nerve strain. Myopes, to improve vision.

Q. Who should wear them only for reading?

A. Emmetropes with presbyopia.

Q. Who may wear them for distance but lay them aside when reading?

A. Myopes of less than about 3.00 D. whose accommodation is growing weak.

Q. Under what circumstances would you prescribe + lenses for a myope?

A. If the myopia is less than 3.00 D and accommodation is gone, would give them for reading. In simple myopic astigmatism of .50 or less, would give + cylinder axis reversed.

Q. When would you give — lenses to a hyperope?

A. Never!

Q. What is the greatest danger in prescribing — lenses?

A. That we will make them too strong.

Q. What is most liable to happen in prescribing + lenses?

A. We will not make them strong enough.

Q. How do we calculate the nerve strain in emmetropia.

A. Add to the amount of accommodation in the two eyes, the amount of convergence which gives the total strain per second, then multiply by the number of seconds devoted to near work each day.

Q. How is the calculation made for hyperopia?

A. Add to the amount of hyperopia in the two eyes as much more for the strain involved through the recti muscles, and multiply by the number of seconds the patient is awake each day. Then add the strain of emmetropia to that and we have the total strain on the hyperope who does not wear glasses.

Q. How do we calculate the strain in myopia?

A. It is only approximate in this case, because of in-co-ordina-ion, but it would be safe to deduct the number of dioptres of myopia from the strain of the emmetrope.

Q. When there are conflicting symptoms in regard to nerve strain, or to errors of refraction, in which shall we place most confidence and why?

A. In those which indicate nerve weakness, or hyperopia, because we are then on the safe side.

Q. How many kinds of muscular trouble are there?

A. Two, cross-eyes and muscular insufficiency.

Q. What is their cause?

A. The first might be congenital or be the effect of accident or disease, or hyperopia; the second is caused by errors of refraction, ninety per cent. of which is hyperopia.

Q. How shall we treat them?

A. The first, by operation; the second by correcting the errors, thus removing the cause.

Q. Why not use prisms for muscle trouble?

A. Because it is foolish almost to criminality. If the cause of trouble is errors of refraction, and these are corrected, Nature will do the rest, and prisms only interfere with her.

Q. What is the cause of errors of refraction?

A. Over or underdevelopment of the eyes from improper nourishment, either during the period of gestation or during the first decade of life.

Q. Why do we see things which are not in themselves luminous?

A. By the light reflected from them.

Q. What is presbyopia?

A. Loss of accommodation incident to age.

Q. Is it the same in both eyes?

A. Yes, because their nerve supply comes from the same source.

Q. How much of it can one have?

A. Three dioptres.

Q. What is the difference between presbyopia and errors of refraction?

A. The first is the loss of a function, and the second are deformities.

Q. What is the difference between errors of refraction and muscular insufficiencies?

A. The first are deformities, and the second are weakness resulting from those deformities.

Q. If a patient needed different glasses for far and near work but would buy only one pair what should you do?

A. Refuse to have anything to do with the case until patient agreed to follow instructions.

Q. Does age have any influence in determining what to prescribe? If so when?

A. The age itself has absolutely nothing to do with prescribing. The effects of age do, but one person at sixty may not need as much assistance for presbyopia as another would at forty.

Q. What are the principle obstacles in fitting glasses?

A. An active accommodation and the idiosyncrasies of the patient.

Q. What is the cause of conjunctivitis and how shall we treat it?

A. Hyperopia is the commonest, a foreign substance under the lid, infection or from the use of intoxicants, etc., which interfere with the circulation. Treat by using antiseptic lotions such as salt water, correct errors of refraction and order rest for a few days.

Q. Explain the difference between objective and subjective tests; which is best and why?

A. Objective tests are those in which the errors are measured by reflection from the cornea or retina, and their correctness depends much upon the keenness of preception of the operator, with great liability to mistakes. Subjective tests are those in which the patient's preceptive powers are employed in determining the error, and as he has to wear the correction it is self-evident it is the best method.

GLOSSARY.

ACHROMATOPSIA—Total color-blindness.

ALBINISM—Absence of the layer of pigmentum nigrum in choroid.

ANÆMIA—A condition of wasting.

ANCHYLOBELPHARON—A stiffening of the eyelids.

ANEURISM—A wart-like dilatation of vessels.

ANISOMETROPIA—Unequal vision in one's two eyes.

ANOPSIA—Without vision.

AMAUROSIS—Obscure vision.

AMBLYOPIA—See Amaurosis.

AMETROPIA—Imperfect refractive condition of the eye.

APHAKIA—Absence of crystalline lens.

ARCUS SENILIS—Senile ulcer, degeneration of corneal cells forming gray crescent or circle at edge of cornea, mostly in old people; harmless.

ASTIGMATISM—Without a point. Irregularity of the curvature of the refracting media.

ASTHENOPIA—Fatigue of ocular nerves.

ATROPHY—Loss of vitality, wasting.

BINOCULAR—Two-fold vision. To see with both eyes at once.

BLEPHARITIS—Inflammation of the eyelids.

CANTHI (s, canthus)—Angles formed by the upper and lower eyelids, from the middle to either side.

CATOPTRICS—Laws of reflection of light.
CHALAZION—Tumor of the eyelid.
CHROMATOPSIA—Abnormal color sense.
CILIA—The eyelashes.
CILIARY BODY—Apparatus of accommodation.
COLLYRIUM—An eye-wash.
COLOBOMA—A mutilation.
CONJUNCTIVA—To join together. The transparent membrane which lines the lids and covers the front of the eyeball.
CONJUNCTIVITIS—Inflammation of conjunctiva.
CORECTOPIA—Pupil out of place.
COREDIALYSIS—A rupture of the iris.
CORNEA—Horny. The projection on the front of the globe.
CYCLITIS—Inflammation of the ciliary body.
CYCLOPLEGIA—Paralysis of the ciliary muscles.
DACRYO-CYSTITIS—Inflammation of the lachrymal sac.
DALTONISM—Color-blindness.
DIOPTRE—To see through; a unit of measure in optics; one metre.
DIPLOPIA—Double vision.
DYNAMIC—Force.
ECCHYMOSIS—Black eye.
ECTOPIA—Partial luxation of the crystalline.
ECTROPION—Eversion of eyelids.
EMMETROPIA—A perfect condition of the refracting media.
EMBOLISM—A rupture.
ENTROPION—Inversion of eyelids.
ENTOZOA—A wormlike parasite, which finds its way into almost any portion of the eye, and destroys tissue by causing small cysts.

ENUCLEATE—To remove.

EPIPHORA—Overflow of tears.

ESOPHORIA—Insufficiency of external rectus.

EXOPHORIA—Insufficiency of internal rectus.

EXOPHTHALMOS—Abnormal prominence of eye-balls. Graves disease.

FILARIA—A thread-like worm sometimes found in the cornea.

FORAMEN—A passage or opening.

FOSSA—A ditch.

FUNDUS—Bottom.

GLAUCOMA—Green; a disease of the ciliary processes and optic nerve.

GLIOMA—Glue.

HEMIOPIA—Half vision.

HEMERALOPIA—Day blindness.

HETEROPHORIA—An abnormal muscular condition.

HETEROPHTHALMOS—Congenital differences of color in the iris, or of two eyes.

HIPPUS—Alternate contraction and expansion of pupil.

HORDEOLUS—A stye.

HOROPTER—The field of vision included by both eyes at once, without moving.

HYALOID—Glass-like; a thin membrane which lines the inner surface of the eye.

HYALITIS—Inflammation of the vitreous.

HYPERPHORIA—Insufficiency of superior or inferior recti muscles.

HYPOPYON—An abscess from corneal ulcers.

INTRA-OCULAR TENSION—The degree of pressure from the fluids within the eye.

IRIDECTOMY—A cutting of the iris.

IRIDODIALYSIS—Separation of iris from ciliary body, as a result of blows.

IRIDODONESIS—Trembling of the iris.

IRIS (a rainbow)—The colored portion of the eye surrounding the pupil.

IRITIS—Inflammation of the iris.

KERATITIS—Inflammation of the cornea.

KERATOKONUS—Conical shape of the cornea.

KERATONYXIS—Puncture of the cornea.

LEUCOMA—White.

LAGOPHALMOS—Inability to close the lids.

LOCOMOTOR ATAXIA—Creeping paralysis.

MACULA LUTEA—The yellow spot, or point of sharpest vision.

MALINGERER—One who falsely pretends to have an incurable defect of vision, or other function, to excite sympathy or evade duty.

METAMORPHOPSIA—Distorted vision.

MIGRAIME—Sick headache.

MUSCÆ VOLITANTES—Floating specs in the eye.

MYDRIATICS—Drugs which suspend accommodation.

MYOPIA—To close the eye.

MYOTICS—Drugs which stimulate the accommodation.

NEBULA—A cloud.

NEURITIS—Inflammation of the optic nerve.

NICTITATION—To wink.

NYSTAGMUS—A jerking of the eyeballs.

NYCTALOPIA—Night blindness.

ŒDEMA—An exudation.

OPHTHALMIA—Inflammation of the eyes.

ORA SERRATA—Serated boundary. The circle of connection between the retina and ciliary processes.

ORTHOPHORIA—Normal muscular condition.

OPHTHALMOPLEGIA (*interna* and *externa*)—Paralysis of the sphincter muscles of pupils and ciliary.

PALPEBRÆ—The eyelids.

PANNUS—Corneal vascularization from long continued irritation.

PAPILLA—A nipple. The optic disk.

PHAKATIS—Inflammation of the lens.

PHLYCTENULE—A pimple.

PHOTOPHOBIA—Aversion to light.

PINGUECULA—A small elevation on the ocular conjunctiva; sometimes mistaken for petrygium.

POSTERIOR SYNECHIA—Adheson of iris to lens.

PRESBYOPIA—Old sight.

PTERYGIUM—A little wing. Is a hypertrophy of the conjunctiva and grows on sclerotic and cornea sometimes interfering with vision. May be removed.

PTOSIS—A falling of the upper lid from paralysis of the third nerve.

RETINA—A net. Formed by expansion of the optic nerve.

SCLEROTIC—Hard. The white of the eye.

SCOTOMA—Obstruction of vision from hemorrhages. Darkness.

STAPHYLOMA—A bulging projection. *Anterior*, comes after corneal ulcers, and is a bluish-white in appearance. *Posterior*, is a projecting backward of the posterior pole of the eye.

STRABISMUS—To squint.

STROMA—Bedding.

SUPERCILIUM—The eyebrows.

SYMBLEPHARON—Adhesion of ocular and palpebral conjunctiva, caused by *escharotics*, such as lime, ashes or other alkalies.

SYNECHIA—To hold together.

SYNCHISIS—To flow together.

TAPETUM—A carpet.

TENSION—The condition of an organ when under strain.

THROMBOSIS—A plugging of retinal vessels by blood clots. Sometimes causes hemorrhages which bring at least temporary blindness.

TRACHOMA—(Rough). Granular conjunctivitis.

TRAUMA—A wound.

TINEA TARSI—Eczema of border of lids.

UVEA—A bunch of grapes. The choroid, Iris and ciliary body.

VASCULAR—Pertaining to vessels.

VITREOUS—Glass-like.

XANTHELASMA—Yellow patches of fibrous tissue on the lids, mostly of women. Harmless, but may be removed.

XEROPHTHALMUS—Dry eye.