# PRINCIPLES AND PRACTICES

OF

# REFRACTION

AN ELEMENTARY TREATISE ON THE SCIENCE OF REFRACTION AS APPLIED TO "SIGHT TESTING"

INCLUDING

ESSAYS ON RETINOSCOPY, ASTIGMATISM, OPHTHALMOSCOPY, ASTHENOPIA, FRAME FITTING AND MUSCULAR INSUFFICIENCIES, ETC.

WITH

ILLUSTRATIONS

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*To the Graduates of the Canadian Ophthalmic College,*

This volume is dedicated in pleasant remembrance of the many happy hours of study passed together in the acquirement of the Optical Truths set forth in its pages, and to whose repeated requests for a non-technical work on refraction, "Principles and Practice" owes its existence.

*The Author.*

# PREFACE.

*"The misfortune of certain books is the killing work one has to do in condensing what the author took so much time to expand."*

*—Montesquieu.*

In issuing a new work on the principles of refraction and the methods of measuring and correcting errors of vision, I do not lay claim to any original theory, and possibly no section of the ground covered but has already been pretty well trodden, and by writers possessing in the eyes of the optical world a greater claim to distinction than myself.

It is not, however, with a view to contesting with them for the honors pertaining to original research that "Principles and Practice" is designed, but is rather an attempt at condensation and classification of generally accepted optical principles and above all an effort to provide for those possessing no technical education an easy method of attaining to a fair state of optical proficiency as applied to what is commonly known as "sight testing."

It is a well recognized fact that practically all the optical text books extant have been written by medical practitioners, and naturally they are too technical to be easy of understanding by the ordinary optical student.

I need, therefore, offer no apology for the minuteness of some of the descriptions offered, particularly in the lecture on refraction, which is the corner stone of optical proficiency, nor yet for the curtailment of some of the lectures—especially that on anatomy—where any excess of detail would only lead to confusion without materially aiding in the attainment of the object sought.

I have in each lecture endeavored to condense the essential facts into as short a space as possible, even at the risk of but partially covering the subject, as no one can possibly learn even this small section of optical science from a text book alone. I have assumed that the student is attending, or will attend, oral lectures where minute details will be illustrated and will require his "Principles and Practice" to prepare him for the lecture, and if it is to be of the greatest good it must be concise and must have the subject matter upon the surface and be absolutely devoid of padding.

This is the plan I have laid out and endeavored to live up to, and where important facts have been omitted from some of the lectures it has been done advisedly, and the missing information will be found in the supplementary lectures and essays in the latter pages of the book, where the student will probably arrive after completing his course of instruction, and when he has not only more time to study, but, I trust, more knowledge to understand them.—L.G.A.

# REFRACTION OF LIGHT

## LECTURE No. 1

VISION. Vision may be described as the transformation of surrounding illuminated objects into ideas containing certain information relative to the nature of these objects, and is brought about by the combined and harmonious action of the eye and the brain.

LIGHT. Light may be described as a force somewhat resembling electricity, inasmuch as it is a mysterious energy prodigious in its effects and, in the operation of its forces, shrouded in mystery.

For several centuries scientists remained divided into opposing schools on the theory of light. The one contended that it consisted of particles or atoms thrown out from luminous bodies with great velocity in all directions, and affecting the organs of vision somewhat in the same way as odors affect the olfactory organs. The opposing school looked upon light as a fluid or ether diffused through all nature, and in which waves or undulations are produced by the action of the luminous bodies in a manner similar to sound through the atmosphere. The latter has become the generally accepted theory, and for all practical purposes, so far as the study of light in relation to what is commonly called "refraction" is concerned, we can assume that the planets constitute the source of original light and that it travels in waves or undulations.

LIGHT RAYS. As has been stated, light travels in waves—the ripple that immediately commences to enlarge its circumference upon dropping a pebble in a smooth pond affording a perfect simile to the action of light—but for the simplifying of the subject for the purpose of elementary study, we look upon this mass of illumination as being composed of minute beams or streaks, which we call rays, and in studying the character and direction of these rays and the effect wrought upon them by various substances, we are able to appreciate the "theory of light."

All rays of light in leaving the point of propagation diverge in all directions and proceed at tremendous speed in straight lines, so that strictly speaking all rays in nature are divergent, but if the luminous point be located at a greater distance than twenty feet all rays proceeding from any one point and diverging so slightly that they are still able to enter the eye are so slightly divergent that we assume they are parallel, and for all objects beyond this distance—which is termed infinity—we have parallel rays, while from all points closer than twenty feet we would receive divergent rays.

Provided no obstruction by a different medium be encountered, rays of light once liberated and started in motion would continue their flight indefinitely with their direction unchanged and their speed unchecked. If, however, a substance of different nature to the atmosphere be interposed one of three changes would occur, namely, the rays will be either refracted, reflected or absorbed. If a transparent medium of different density to the atmosphere be passed through, they will be refracted, if a polished surface, such as is represented by a mirror, they will be reflected, and if any form of color they will be absorbed.

THEORY OF REFRACTION. It is entirely with the question of refraction that we have to deal in a study of this nature.

The speed of light has been proved to be about 200,000 miles per second. It will be readily understood that the speed of any moving body depends upon two conditions, the motive power and the degree of resistance.

Light, in passing through atmosphere, encounters the minimum of resistance, and upon passing into transparent bodies of different density it meets with increased resistance and consequently suffers a corresponding decrease in speed. If the ray, in meeting the surface of the denser transparent medium, comes in contact with it at right angles to its surface, no other effect than the decreased rate of travel is to be observed, and so far as vision is concerned no effects are noticeable. But if, in passing from one medium to the other it meets the surface obliquely, refraction takes place, that is, the ray will change its direction by bending toward the point that first came in contact with the denser medium.

If the surfaces of refracting medium be parallel, the ray will bend back again and resume the original direction on emerging into air.

The point where the rays enter the second medium is called the Point of Incidence and when it once more re-enters the air the Point of Emergence.

CAUSE OF REFRACTION. The reason of the change of direction as seen when the light meets obliquely the surface of a denser body is easily comprehended by means of the following illustration:—A detachment of infantry in line formation in marching at a fixed rate of speed will maintain a perfect alignment so long as each man makes the required number of paces in the allotted time, but should one flank or the centre man meet with some obstruction of such a nature that his speed is slackened while the remainder are marching at a greater rate, the inevitable result is that the line must converge or wheel on this pivot man.

Light in meeting a body of greater density obliquely decreases its speed only at the point of contact, other points still travelling in air at a greater speed and consequently will refract or change front in the direction of the first point of contact.

INDEX OF REFRACTION. The degree of refraction will depend upon the amount of obliquity and the difference in density. The ability of any substance to bend rays of light as compared with the standard air is called the index of refraction. The index of air is (1) one, while of crown glass, of which lenses for optical purposes are constructed, is 1.5.

COMPOSITION OF LENSES. For the purpose of refraction crown glass has been generally selected because it possesses less dispersive property in proportion to its refraction than any other transparent substance.

PRISMS. An optical prism is a three-sided body of glass, or other transparent substance, composed of a base and two sides inclining together and forming an angle at the apex. No two of its sides being parallel, it is impossible to pass light rays through a prism without undergoing refraction. The refraction by means of a prism is always towards its base, and as the eye has knowledge of the position of an object only by means of the direction the rays passed when they enter the pupil, it necessarily follows that in viewing an object through a prism its position is apparently changed in the direction of the apex.

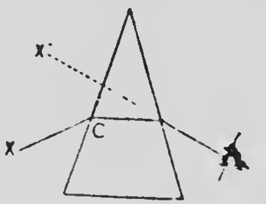



FIG. 1.

Rays of light from X. passing into prism at C. are refracted towards the base and the object is apparently seen at X'.

ANGLE OF DEVIATION. The intersection of imaginary lines drawn to the prism from where the object really is and where it appears to be forms the angle of deviation.

MEASUREMENT OF PRISMS. Three different methods have been employed in the measurement of prisms—Refracting Angle, Prism Dioptre and the Centrad.

Refracting Angle—Under this system the prism was numbered according to the number of degrees included in the angle at the apex.

Prism Dioptre—The Prism is numbered according to its refracting power, one which will so change the direction of light rays proceedir from an object one meter distant to just such an extent that the position of the object will be apparently moved exactly one centimeter towards the apex of the prism, would be the unit of this system, and termed a one-prism dioptre.

This system, which is in general use, has the great advantage of conforming closely to the metrical system of numbering spherical lenses, and greatly simplifies the calculations necessary in formulating the various sphero-prismatic combinations necessary in advance eye work.

The Centrad is based upon the same principle, with slight modifications, the difference being that the path over which the object apparently moves under the action of the prism is measured along a straight line in one case, while in the latter method its course describes the arc of a circle. The results are practically identical.

CONSTRUCTION OF SPHERICAL LENSES. This refractive power, as seen in a prism, of bending all rays towards the base or the thickest part, constitutes the fundamental principle upon which all optical lenses are constructed.

A spherical lens, so called because its surfaces are sections of perfect spheres, may be said to be composed of numerous prisms, and consisting of two kinds, convex and concave. The convex spherical lens having, as its name indicates, a convexly curved surface would have its thickest point in the centre and corresponding in its optical action to a number of prisms with their bases arranged around a common centre. All rays of light in passing through would bend towards the thickest part except the ray passing through this point, which is called the axis ray and undergoes no refraction.

OPTICAL CENTRE. The point of a convex glass at which it has greatest thickness is called the optical centre, and as at this point both surfaces are parallel there is consequently no refraction.

The concave glass being thinner at its centre all rays would diverge or refract towards the thickest part, which would be its edges. The optical centre of the concave lens would be its point of least thickness.

PRINCIPAL FOCUS OF A LENS. The principal focus of a convex lens is the point where parallel rays of light would meet after passing through and undergoing refraction, and its distance from the lens is called the focal length and depends upon the curvature of its surface. A plano-convex lens will have its focal length at a distance corresponding to the diameter of the circle of which its surfaces form a section, thus: if the curved line indicating the surface, on being continued would describe a circle of ten inches diameter, parallel r. ys of light on passing through would converge to a just sufficient amount to enable them to meet at a point on the opposite circumference, and would be called a ten-inch lens. The Principal Focus refers only to parallel rays.


FIG. 2.
A Bi convex spherical lens G. showing refraction of parallel rays of light P. focusing at B.

CONJUGATE FOCI. From all points within infinity, however, we would receive divergent rays, and consequently the point where these rays would meet would be farther removed from the lens, there being greater obliquity for divergent than for parallel rays. The closer the luminous point the greater the divergence and consequently a corresponding recession of the focal point. The various points where divergent rays would meet when proceeding from the different distances within infinity are called the Conjugate Foci. If the luminous point be located exactly at the focal distance light would pass out parallel and w[illegible] ever meet, but for all other distance betwe[illegible] the focal lengt[illegible] [illegible] infinity there would be a corresponding focus on the opposite side of the lens. If the luminous point be situated within the focal distance light will be so divergent that the refraction of the lens cannot overcome it, and will pass out still divergent but of lesser degree than before entering.

FOCUS OF A CONCAVE LENS. The focus of a concave lens is negative, as rays of light in passing through diverge, and, of course, can never meet. We find the focus by producing the divergent rays forward to a point in front of the lens where they will meet.

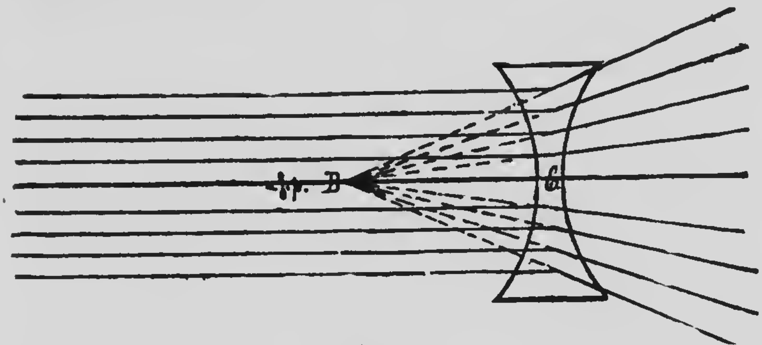


FIG. 3.

Diagram showing the refraction of a concave lens (C) and the negative focal point B.

B. is a luminous point situated at infinity, and the rays proceeding from it enter the lens C. and are diverged outwards. The focal point is the point B. where the diverging lines meet after being continued back through the lens again.

CYLINDRICAL LENSES. Cylinder lenses, so called from the nature of the curvature, are ground upon a cylindrical shaped shell, and their surfaces are accordingly convex or concave, as the inner or outer curve of such a shell is used. The size of the cylinder on which the glass is ground imparts to the lens its strength or refractive power. As in cylindrical shaped bodies there is one direction in which there is no curvature, there is consequently no refraction in this meridian, and rays passing through it would undergo no deviation.

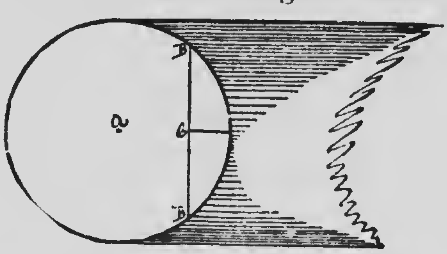


FIG. 4.

A. cylinder of glass showing section B. C. B. as used in cylindrical lenses.

All other meridians would refract towards the thickest part of the lens. The thickest part of a convex cylinder would correspond to the direction in which there was no curvature, and is called the axis of the cylinder. In a concave cylinder the thickest part would be along its edges.

A convex cylinder would refract light in such a manner that the rays would meet along a line corresponding in direction to its axis, but at the focal length of the curvature, of which its meridian of greatest curvature is composed.

A concave cylinder would act similarly, but the rays instead of meeting along the line would be diverged in opposite directions from the axis.

In the spherical lens we saw that it was practically composed of prisms around a common centre with their bases together in convex, and the apices together in concave.

The cylinder may be similarly described, but the bases and apices would be arranged along a common line—the axis of the cylinder.

The peculiar action of cylindrical lenses producing an apparent lengthening or shortening of the object alternately looked at through a convex or concave cylinder is best shown by the changed form of a square.

A convex cylinder with axis vertical will lengthen the horizontal sides producing a horizontal parallelogram; a concave similiarly placed will have the opposite effect.

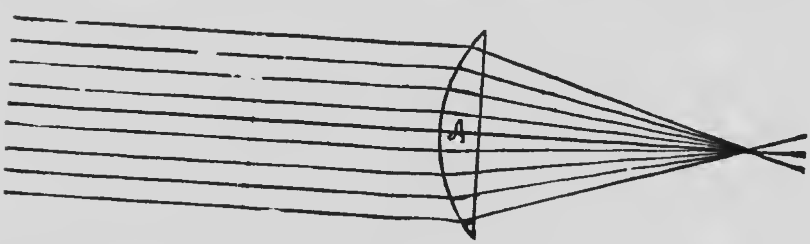



FIG. 5.

Fig. 5 represents the meridian of greatest curvature and shows its effects upon parallel rays.

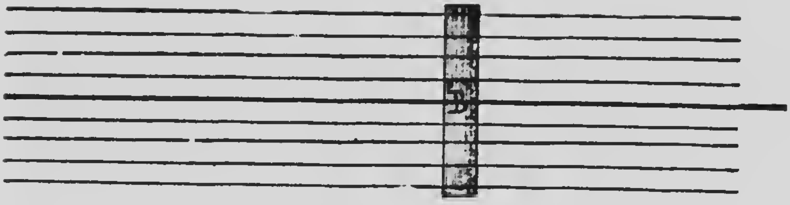


FIG. 6.

Illustrating the principal meridians of a cylinder.

Fig. 6 shows the plane meridian or axis with parallel rays passing through unchanged in direction.

## METHOD OF ANALYZING AND NEUTRALYZING.

It must be borne in mind that the effect of concave and convex lenses, whether spherical or cylindrical, is exactly of opposite nature, and therefore the combination together of a convex and a coneave of equal power would have the effect of entirely destroying the refractive power of both. This is called neutralizing and it is accomplished in the following manner :

If we wish to analyze a spectacle lens (we will suppose for the purpose of supplying a duplicate), we first find if it is spherical or cylindrical.

As we know, the latter have one direction in which there is no refraction, we rotate the lens, at the same time moving it up and down in front of the eye while looking intently at some near object. The effect of this up and down motion is that it gives to the object viewed through the glass an apparently similar motion. If the glass be convex the objects will appear to move in a direction opposite to that taken by the glass, while in concave it apparently moves with it. If the glass be plano, that is, has no curvature, there will be no motion imparted to the objects viewed through it.

If on looking through the lens we noticed objects moving opposite to its motion it would indicate a convex lens, and if this motion was the same for all directions it would be spherical in curve, and the concave spherical lens from the trial case that would stop all motion would indicate the strength of the lens.

But if in one direction there was no motion, while moved in all others objects moved with the glass, it would show a cylindrical lens of concave curvature and would require a convex cylinder of equal power with their axes parallel to neutralize.

A very simple plan for the analzying of the various forms of lenses met with in optical work is to memorize these three simple rules:

1st. Concave and convex cylinders of equal strength neutralize when their axes are at the same angle.

2nd. Two cylinders of equal strength and kind with axes the same double the power.

3rd. Two cylinders of the same kind and power with axes crossed at right angles form a spherical of same strength.

But as lenses are frequently constructed in which there is a combination of spherical and cylindrical curvature, there would be no direction in which there would be no motion, although a cylindrical lens, owing to the fact that the power of the spherical lens which is present in it would cause objects viewed through it to apparently move in every meridian.

In analyzing them we must, in addition to ascertaining whether the lens is convex or concave, find out first of all whether spherical or cylindrical—and by the term cylindrical I mean either a plain or simple cylinder in which one surface is plain and the other cylindrical as well as sphero-cylindrical—where one surface is spherical and the other cylindrical (sphero-cylindrical).

The following method will be found to be a simple way of ascertaining not only the presence of cylindrical power in a lens but also the power of each component part of the glass and the location of the axis of the cylinder.

All that is necessary is a trial case containing the various lenses and a protractor or diagram, in which the various meridians of the circle are marked like the spokes of a wheel and numbered from 0 to 180—that is just half the circle. Take the lens to be neutralized between the thumb and finger, and looking through it at a straight line (a window sash will answer), rotate the lens and notice if the section of the line seen through it rotates or remains stationary. If the former, cylindrical power is present; if the latter, the lens has no cylindrical power and is either spherical, plain glass, or prism.

Now, while moving the glass up and down while fixing some object through it, notice if the object apparently moves, if so, it proves a spherical glass, and the kind and power is found as already described. If no motion is noticeable it indicates plain or flat glass—neither convex or concave, although it may be prismatic.

To ascertain the presence and strength of prismatic power fix the eyes intently on a straight line—looking at it through the lens, of course—and care must be taken to look through the centre, and if the line appears broken in the section seen through the lens as compared with the remainder seen above and below the lens, prismatic power is indicated and the apex of prism is in the direction in which the section of the line appears misplaced.

The power of the prism is indicated by the prisms from the trial case, which, placed over the lens being neutralized, renders the line straight and unbroken. The prism from the trial case must be placed upon the lens with its base in the direction in which the line was misplaced.

A cylindrical lens is indicated by the rotating motion given to a line when looked at through the lens which is being rotated.

On continuing the rotating motion slowly it will be found that in two positions only does the line appear unbroken, in all others the line as seen through the lens is not continuous with the line as seen above and below. These two directions constitute the principal meridians of the cylinder, and are its axis and its direction of greatest curvature and are always at right angles to each other.

Having found one of these directions, draw an ink line across the lens corresponding to it, and another at right angles to it and another line through the horizontal length of the lens (we will designate the first lines as No. 1 and No. 2 and the horizontal line No. 3).

Now, if by means of the motion test just described we find that the lens is convex in the direction of the first two ink lines, we have but to neutralize with concave lenses from the trial case, which will show us the exact power of the lens in each principal meridian, and consequently the exact power of spherical and cylindrical present in the lens.

For instance, having ascertained and ink-marked the two directions we find in both of them, if the lens is moved up and down, that objects move in the opposite direction. This proves the lens to be convex in all meridians. We select a concave lens, of say 1.00 dioptre, and placing it on the lens repeat the motion test in the direction of one of the ink lines, when we find that no motion is now noticed. This means that in this direction the lens is 1.00 dioptre convex. (We will call this line No. 1.) We now repeat the test with the opposite ink line (called No. 2) and find that 2.00 dioptre concave lens destroys all motion, so we have 1.00 dioptre convex in all directions that is 1.00 dioptre sphere, and an additional 1.00 dioptre in one direction or 1.00 dioptre cylinder—the axis, of course, being in the direction of least power.

Now we have merely to place the ink-marked lens on the protractor with the line indicating its horizontal length (No. 3) corresponding to the horizontal line of the protractor, and the position of axis is indicated by the number of the meridian on the protractor upon which the ink line No. 1 is found to rest.

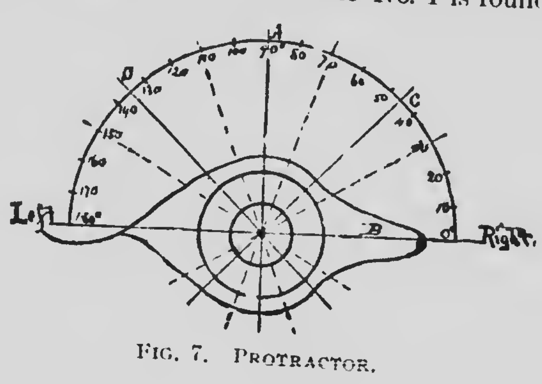



FIG. 7. PROTRACTOR.

THE VARIOUS FORMS OF CONCAVE AND CONVEX LENSES. Convex lenses are also called positive, converging and plus ( + ). Concave are known as negative, diverging and minus ( − ). Plus and minus are the terms in general use, and the kind of lens is indicated by the algebraic sign preceeding it. Thus, +4 meaning a convex of that strength while − would call for a concave.

There are six different forms or styles of spherical lenses, plano, convex and concave, in which one surface is plane, and the reverse curved, convex or concave.

Bi-concave and Bi-convex, in which both surfaces are equally curved. Periscopic convex and concave, one surface convex, while the reverse is concave. The concave surface always is placed towards the eye.

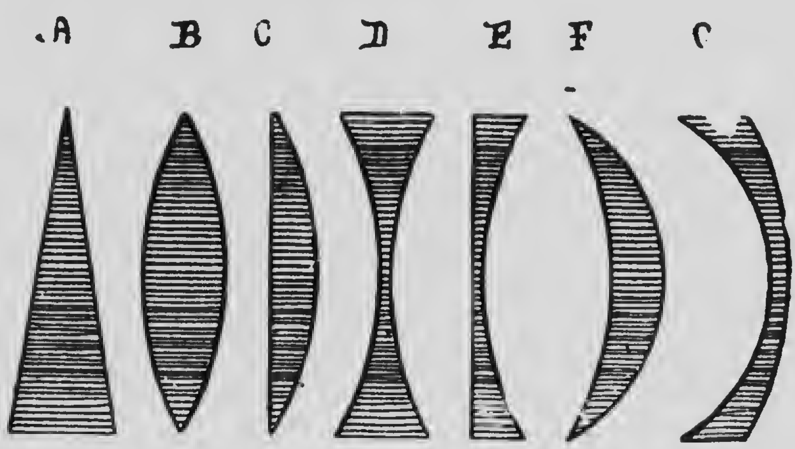



Fig. 8.

The several kinds of lenses used in refraction: A. Prism. B. Bi-convex. C. Plano convex. D. Bi-concave. E. Plano concave. F. Periscopic convex. G. Periscopic concave.

METRICAL SYSTEM OF NUMBERING LENSES. We have already shown the method of numbering according to their focal length, but for the purpose of uniformity, and also the easier to make mathematical calculations, what is known as the Metrical System has been generally adopted. This consists of numbering the lens by its refractive power instead of its focal length. For this purpose the term dioptre was adopted to indicate the unit lens, viz., a lens of (40 inches) 1 meter length, and as the greater the refraction the shorter the focal length, the one bears an inverse ratio to the other. For lenses of more than forty inches focal length decimals are used thus: .25, .50 and .75, indicating one-quarter, one-half, and three-quarters of a dioptre.

## COMPARATIVE TABLE OF INCH AND METRICAL SYSTEM.

| DIOPTRES | INCHES | DIOPTRES | INCHES |
|---|---|---|---|
| .0125 | 320 | 3.00 | 13 |
| 25 | 160 | 3.25 | 12 |
| .50 | 80 | 3.50 | 11 |
| .75 | 54 | 4.00 | 10 |
| 1.00 | 40 | 4.50 | 9 |
| 1.25 | 32 | 5.00 | 8 |
| 1.50 | 26 | 5.50 | 7 |
| 1.75 | 22 | 6.00 | 6½ |
| 2.00 | 20 | 6.50 | 6 |
| 2.25 | 18 | 7.00 | 5½ |
| 2.50 | 16 | 8.00 | 5 |
| 2.75 | 14 | | |

FORMATION OF IMAGES. It has been previously stated that light travels in diverging straight lines from the point of propagation, and in order to clearly understand the theory of the formation of images by convex lenses, it will be necessary to consider every object which is illuminated by artificial light or original light, as being itself a luminous body, every minute point of which gives off bundles of rays in which all the rays composing each bundle diverge fro the instant of issuing from each individual point. The light issue, in fact, may almost be said to represent the decomposition of the object, which practically takes the form of the rays themselves.

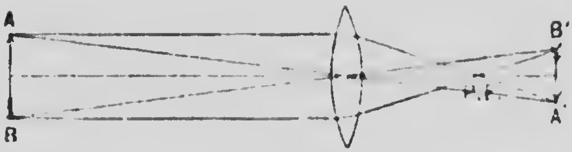



FIG. 9.

The formation of an image by means of a convex lens. A. B. is the object and A' B' the inverted image. The rays of light travelling divergently from A. B. are collected again by the convex lens and meet at A' B' thus producing a picture of the object A. B. in an inverted position.

If a convex lens be so placed that some of the rays from each bundle pass through they will, in obedience to the laws of refraction, so change their relative direction that although parallel or divergent before entering they will be convergent upon emerging, and ' ı the former case all the rays of which each bundle consists aı which proceeded from one point will, at the focal length of the ıens, once more reunite and form there a point, which will be the reproduction or image of the point from which the bundle of rays proceeded. Every other bundle being similiarly affected we would have all the points of the object reproduced in relative proportions, but in an inverted position, as the rays proceeding from the top of the object would, in passing through, pass downwards, and those from below pa sing upwards, crossing in the lens.

This reproduction is called the image, and its size depends upon the size of the object and its distance. The farther removed the object is the smaller will be the image.

VISION. When lenses properly arranged for this purpose, together with the necessary chemicals, are used, the process is called photography. When the eye is employed, the result is vision. The mechanical operation necessary to the collection of the rays being accomplished by means of the system of lenses of which this organ is composed, and developed through the instrumentality of the nervous system into an idea containing some information relative to the object from which the ray proceeded

As in photography the size of the image depends upon the distance at which the object is placed, the faıther removed it is the smaller will be the image, and consequently the object will be correspondingly reduced in size in our estimation.

REFRACTION OF THE EYE. As has been stated, refraction is the power which any transparent substance, by reason of its optical construction, possesses of bending rays of light in such a manner that the direction of travel is changed, and when the surfaces are spherically curved, with their thickest part corresponding to its geometrical centre, the resultant action is the bringing together of divergent or parallel rays, forming at the uniting point, or focus, a perfect picture of the object from which the light proceeded.

As we get farther advanced we shall see that the eye is composed of transparent substances of spherical shape, and that its action on rays of light is exactly in accordance with the laws laid down in regard to refraction by lenses.

Light in passing into the eye is therefore refracted to a focus, and consequently forms an image there of the object to which it is directed. This function is called the refraction of the eye, and is the first stage of vision.

ACUTENESS OF VISION. The acuteness of vision has been aptly described as "The ability of the intellect to interpret the image," to transpose this light impression into an idea containing certain definite information, so that it will be readily understood that the seat of vision is the brain and not the eye, that the mere fact of the collection of the light rays into an image or picture of the object looked at does not give us any information until it is acted upon in some mysterious manner by the nervous system. Just as in photography the mere posing in front of a camera does not supply us with a photograph. The sensitive plate first of all has to be conveyed to the dark room and there developed into the finished picture. So it is with vision, until the image be developed in the hidden recesses of the intellect it conveys no meaning to us.

VISUAL ANGLE. Rays proceeding from the extremities of an object and passing into an eye opened to receive them will intersect each other while passing through the eye from the front to the rear, that is the ray proceeding from the upper extremity will pass through in a downward direction while that from the lower end will take an upward course. The point where they intersect is called the nodal point, and the angle formed by the intersection is termed the visual angle. It will readily be seen that as these rays proceed from the extremities of the object, that the farther apart the extremities are, or in other words, the larger the object the larger the visual angle, also the closer we approach to the object the larger becomes the angle, so that the size of the visual angle depends upon the size of the object and the distance it is from the eye. The size of the image formed in the interior of the eye by means of the optical system will, of necessity, depend upon the size of the visual angle, as the greater this angle the larger the surface over which the picture is spread, and consequently the greater the dimensions of the object in the transformed idea in the intellect.

It has been found by experiment that a certain amount of space requires to be included in the dimensions of the image, in order that perfect development of vision may result. The mere fact of an object being exposed in front of an eye is sufficient to reproduce its image in the interior, but for subsequent nervous action necessary to develop the image into an idea, certain sized images are necessary. While we are unable to state what amount of surface must be included in the retinal image, we do know how large a visual angle is required to insure a perfect development of the retinal pictures.

The object must be of such a size and distance that rays from its extremities crossing in the eye from a visual angle of not less than five minutes (5").

Angles are measured in accordance with what proportion of a circle their sides would include: for instance, every circle is composed of 360 degrees; if divided into four equal sections by lines drawn at right angles to each other through the centre, each of these sections would contain one quarter of the whole circle, therefore, 90 degrees. If we sub-divide one of these into

90 parts, each one would be an angle of one degree, and wishing to still further reduce the size of the angle, we would divide each one of the sections into sixty parts, each one of which would contain an angle of one-sixtieth of a degree, or one minute. Minutes being the sub-division of degrees, five of these latter would be the size of the visual angle necessary for clearer vision.


Fig. 10.

Snellen's Test Type—Distance Chart.

TEST TYPE. As has been already stated, the smallest image which the average human eye is capable of developing into perfect vision must form an angle of five minutes at each nodal point.

In accordance with this established principle, test types have been constructed with letters of various sizes, each one of which, if placed at the distance which is indicated on the card, will form an angle of five minutes. If we know that an eye possessing normal vision can distinguish an object clearly—

therefore read letters—which form an angle of not less than five minutes, and we also possess a series of letters which we know will form an angle of exactly five minutes when placed a certain distance from the eye, we then have a positive rule of knowing the perfect or imperfect condition of the eye by its ability or non-ability to read the letters forming this angle of five minutes.

The Snellen's Test Type, such as is generally used, consists of several rows of letters of gradually decreasing size, each row being numbered to indicate the distance at which it could be read.

By means of the Test Type we readily measure the acuteness of vision or degree of sight which an eye possesses, and record it in the form of a vulgar fraction, having for its numerator the distance at which the type is placed, and for the denominator the number of the smallest line which it is possible to read; thus, if with the type twenty feet away an eye is able to read the line marked 20, vision would be normal and would be expressed 20/20. If the smallest line that could be read was marked 60, the acuteness of vision would be 20/60 or one-third of normal vision.

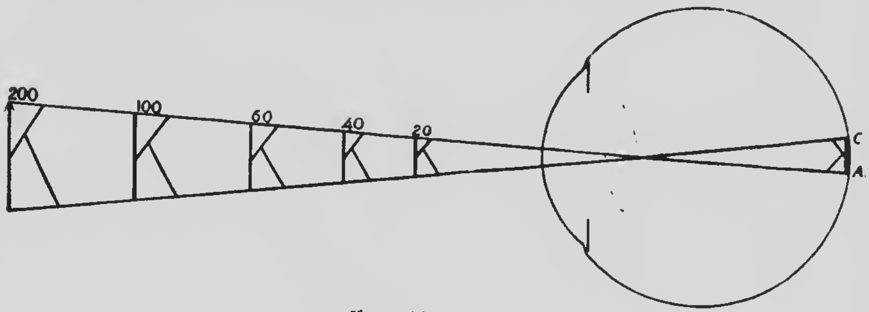



FIG. 11.

An illustration of the principle of the Snellen's Test Type, showing visual angle in relation to objects of different sizes at different distances. The various letters located at the distances marked 20, 40, 60, 100, 200, are seen to subtend the same angle.

SPHERICAL ABBERATION. Although it has been stated that the refraction of a spherical lens is the same for all rays of the same obliquity, this is true in a limited sense only. The axis ray passing through the optical centre undergoes no refraction whatever, as at this point both surfaces of the lens are parallel. The refraction gradually increases the farther we travel from the optical centre towards the edge of the lens, so that the peripheral rays (those passing through the portion farthest removed from the centre) would, as a result of this excess of curvature at the edges, focus sooner than the more central rays, consequently light proceeding from a point would not re-unite as a point, but as several points connected—practically a line—as the peripheral rays focusing closer to the lens than all others and the remainder meeting slightly farther back as they pass through a more central point of the lens. This is termed Spherical Abberation, and in the early days of telescopes and microscopes was the despair of scientists and opticians for years, as it practically prevented the use of lenses sufficiently strong or large to be of any service for the construction of powerful instruments. In lenses such as are used for spectacles, there is little inconvenience felt from Spherical Abberation, they being too small, and the curvature not great enough to cause any optical defect.

CHROMATIC ABBERATION. Light upon being violently refracted becomes decomposed into the various colored rays of which it is composed, as seen in the rainbow, being the result of the strong light rays from the sun, violently refracted by coming in contact with rain drops, which from their size and shape are very strong convex lenses. This phenomenon which is called Chromatic Abberation, while not entering into considera ion in spectacle lenses, was for over a century a positive barrier to all astronomical progress, as it rendered astronomical telescopes almost impossible as we understand them to-day. It was finally overcome by the invention of the achromatic lens, which instead of being composed of one piece of glass, as was customary, was constructed on a plan of the human eye, being composed of several pieces, of different indices of refraction, cemented together.

# ANATOMY OF THE EYE.

## LECTURE No. 2

Having in view the object for which this work was especially designed, viz. the arrangement of the necessary facts connected with vision in such a manner that they can be quickly learned and readily understood, the study of anatomy must necessarily be confined to a comparatively small section of the ocular system.

Fortunately, the amount of ground which it is necessary to cover to intelligently prescribe lenses is relatively very small, and in making no mention whatever in these pages of numerous portions of the anatomy of the eye, many of which are very beautiful, and likewise wonderful in their construction, I have done so advisedly, recognizing that they have, at best, but a relative bearing upon the question of refraction, and a knowledge of which, however satisfactory, is not by any means necessary to doing successful refraction work. But there is one feature to which I wish to draw special attention.

In these days, the intelligent optician is expected to know pretty nearly everything about the eye, and on account of the prevailing popular ignorance on the subject, plentifully trimmed with an unlimited amount of humbug, with which eye-work has been surrounded, he will be asked all manner of questions about it, and he will be constantly looked to for advice when the eye or sight becomes affected in any way. If he is able to meet the requirements in this direction, he will inspire his patrons with confidence in his ability to fit them successfully with glasses, without which small hope of successful practice in any profession is possible.

As before stated, the limits of this work scarcely permit more than a brief outline of the more important sections and appendages of the eye, just sufficient to form an intelligent idea of the marvellous ingenuity displayed in its construction, and to lay a sufficient foundation upon which to rest the more practical branches which are to follow.

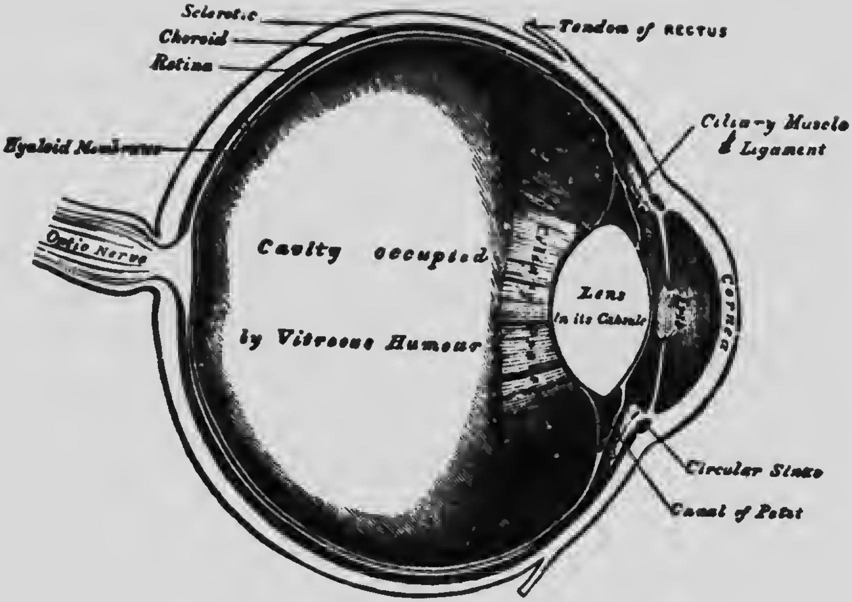



FIG. 12.

The Eye and its appendages.

The eye-ball is of spherical form (or nearly so) and its diameter is slightly less than an inch. It may be said to be composed of three coats or tissues of a membraneous nature, Sclerotic, Choroid, and Retina, closely adhering to each other, forming apparently one capsule, containing the humors—Aqueous, Vitreous and Crystalline Lens, or fluids, but possessing in their close unity each its own function and characteristic.

SCLEROTIC. The external coating, called the Sclerotic, is composed of a tough fibrous tissue, whitish in color (in children it is often so thin as to allow the underlying Choroid to show through, appearing then as bluish white. In the aged the Sclerotic is sometimes yellow—commonly known as the white of the eye) acting as an envelope and protection to the more delicate and sensitive parts within. From the nature of its construction, it is peculiarly adapted for this purpose, as well as that of maintaining the ball in its globular shape, and serving as a means of attachment for the muscles that control its movement.

The Sclerotic includes the rear five-sixths of this outer coat, and is not transparent, though possibly translucent. The transparent attachment occupying the remaining front one-sixth of the outer coat is called the Cornea which, from its nature and shape, serves the double purpose of admitting the light to the interior of the eye, by means of its transparency, and at the same time refracting it as the result of its convexly curved surface.

THE CORNEA has been aptly described as the "Object glass of the ocular camera," performing the same function, in reference to the Retinal image, that the camera objective does to the negative—being at this point that the first change in the nature of the in-going rays is made, the completion of which, in the one case is photography, in the other vision. The Cornea is practically a transparent continuation of the Sclerotic, but forming a section of a much smaller sphere, like the "bull's eye" on the old-fashioned "dark lantern."

CHOROID. The middle or vascular coat is called the Choroid, and, as the name implies, is principally composed of blood-vessels for the nourishment of the eye. It adheres closely to the inner surface of the Sclerotic, with its front section, Iris, hanging vertically some distanee behind the Cornea, acting as a curtain to "the window of the eye."

In addition to its net-work of blood-vessels it is plentifully supplied with pigment cells eontaining black or dark brown colored matter.

The function of the Choroid, in addition to its nutritive properties already mentioned, is to absorb, by means of its pigmentation, superfluous rays of light, some of which may possibly filter through the translucent Sclerotic. It is the absence of this pigment which constitutes the cause of the distressing blinking of the eyes when exposed to a strong light, so well marked in the Albino, with his pink eyes and colorless hair, who furnishes us an example of lack of development of the choroidal pigment.

PHOTOPHOBIA. The absence of choroidal pigment, which is termed Photophobia, renders the eye very sensitive to light, and is indicated by a feeling of discomfort and an inclination to close the eyes when exposed to a bright light.

Photophobia is relieved by the use of tinted lenses—preferably smoked—of the necessary degree of density to modify the light to the desired amount. Smoked lenses may be had either plano or ground to the strength necessary to correct any existing error of refraction.

THE IRIS or Rainbow, commonly known as the "color of the eye," is suspended across the eye like a curtain, with the circular aperture, the pupil, appearing more like a black spot than an opening immediately in the rear of the centre of the Cornea. This opening, which seems black simply because the interior is in darkness, is for the purpose of admitting light to the interior; the Iris, through the action of its Sphincter muscles possessing the power of contracting and relaxing, thereby regulating the amount of illumination admitted. In passing from a dark room, where the pupil would be dilated to its fullest capacity in order to secure the greatest possible amount of light, to the bright sunlight, where the pupil immediately contracts, protecting the eye from the excessive glare.

ATROPINE. The active principle of belladonna has the effect of dilating the pupil by temporarily paralyzing the muscles of the Iris and suspending accommodation by a similar effect upon the Ciliary Muscle. It is frequently used for giving an appearance of beauty to the eyes, and in ophthalmic practices for enabling the operator to more clearly observe the interior of the eye.

RETINA. The third and innermost coat, the Retina, is the most delicate, sensitive, and important of all the many wonderful sections of this wonder of creation. Composed principally of nerve cells, its function is necessarily nervous, the mysterious operation of which is usually a sealed book to the layman, and even to the expert anatomist it is frequently a foreign tongue.

The Retina may be said to occupy the same position in reference to the ocular system and vision that the sensitive plate does to the camera and the photograph. We may, for the sake of simplifying matters, look upon it as a chemically prepared plate, capable of receiving and retaining for a time, on its surface, images of surrounding objects under the focusing power of the lens system in front of it, of which the Cornea is the first. It is practically a continuation or expansion of the Optic Nerve, which, entering the globe of the eye at the rear, and spreading out over its inner surface, receives the light impressions and carries them to the brain, there to undergo that mystic transformation, of which we know nothing but its results—Vision.

YELLOW SPOT. The Macula Lutea (or Yellow Spot) is in the centre of the Retina, in the rear of the centre of the pupil, or nearly so. Here the sensitiveness of the Retina reaches its greatest development, and gradually decreases the further removed from this point. At this point is a round, elevated, yellowish spot, having a central depression at its summit. The Macula Lutea, commonly known as the Yellow Spot, is the point of acutest vision, the spot at which it is necessary to have the image found in order to secure the maximum of vision. Vision on the Yellow Spot is called direct vision. When the image falls on some part of the Retina more or less removed from it, the outlines may be distinguished, but the details are lost, and is known as Orientation or Indirect vision.

DIPLOPIA. Although each eye possesses its own complete set of organs, forming on each retina a separate image of the object looked at, under normal condition these two images are merged as one in the brain.

If, however, from any cause the two eyes are so directed in reference to the object looked at, that the images do not impinge on corresponding section of each retina the effect will be two objects are seen.

This act of seeing two objects where one only is looked at is called Diplopia.

OPTIC NERVE. In our understanding of the functions of nerves, we are apt to associate them with the sensation of pain, but in the case of the Optic Nerve, the only sensation of which it is capable is light, so that a blow which would agitate it would convey the impression of light flashes, and no doubt would account for the "stars" we perceive when receiving a violent blow on the head. It belongs to the class of nerves of Special Sense, carrying only impressions of light, as the Olafoctery carries only the impression of odor, or the Auditory carries only the impression of sound.

The Optic Nerve forms the means of communication between the seen and the unseen, as if it were carrying messages from the material world to the great unknown. It forms an essential part of the mysterious developing process like that to which a photographer subjects his negative in a dark room, converting it into a permanent, lasting reproduction of the original. The point of entrance of the Optic Nerve into the interior of the globe of the eye, is known as the "blind spot," or Optic Disc, from the fact that, at this point, the Retina is non-sensitive to light impressions, and an object so held that its image will fall upon the blind spot cannot be seen.

THE VITREOUS HUMOR occupies the rear four-fifths of the globular space contained within the tunics, and extends from the Yellow Spot forward to the Crystalline Lens. It is a perfectly transparent jelly-like substance, and is enclosed in a thin, delicate, transparent sack, called the Hyaline Membrane. The sole function of the Vitreous Humor seems to be that of maintaining the eye-ball in its globular shape, which it is well calculated to do, and at the same time possessing sufficient springiness to save the delicate organs from injury in case of shock.

THE CILIARY MUSCLE is situated at the junction of the Sclerotic Iris and Cornea. It is connected with the suspensary ligament in such a way that any contraction of the ciliary will produce a slackening of the ligaments and a consequent increase in curvature of the Crystalline Lens as seen in accommodation.

CRYSTALLINE LENS. The Crystalline is so-called from its striking resemblance to a bi-convex lens, both in appearance and function, it is located in the concave space immediately in front of the Vitreous. It consists of a highly elastic transparent capsule, filled with a transparent jelly-like substance, resembling in appearance the Vitreous.

It closely resembles a bi-convex lens in form, but with this difference, its surfaces are not equally curved, its convexity being greater on its posterior surface. It is suspended vertically in front of the Vitreous, and immediately in rear of the Iris, and is held in place by means of the suspensory ligament, is about eight millimeters in diameter and four in thickness (on an average) in the adult eye. In youth, the humor of which this lens is composed is soft and mobile, and readily forms to the changed shape of the capsule when acted upon by the ciliary muscle.

The eye possesses the power of tightening and slackening the tension of the suspensory ligament, thus causing a change in the convexity of the surface of the lens. This function is of the highest importance, and without a clear understanding of its operations, success in fitting cannot be obtained.

It must be borne in mind that the increase in curvature is not brought about by a direct effort of the ciliary muscle pulling its surfaces into a more convex form, but the lens should rather be looked upon as a hollow elastic ball, filled to the greatest degree of tension with its jelly-like contents, which, if unrestrained, would naturally revolve the lens into globular shape natural to its construction, but being attached by means of a string or ligament completely around its circumference in one meridian, and this string being drawn tight, the lens, from its mobility, naturally "gives" in the direction of the tension, and flattens correspondingly at right angles to it, in just the same manner that a soft india rubber ball will from the inherent elasticity of the material, and its contents—air—assume a globular shape, and, if stepped on, it flattens in the direction of pressure, and elongates reversely. So, in the lens, the suspensory ligament exerts a pressure, keeping the lens in a partly flattened condition, until the ciliary muscle, which is so constructed as to remove the tension exerted by the ligament, comes into action, when the lens, by means of the elastic properties of the capsule, and the force exerted outward by its contents, immediately assumes a greater convexity.

As the Crystalline Lens is the principal organ in the refracting system of the eye, it will be readily apparent that this spontaneous change in its power will have a momentous effect upon the focusing of light rays.

As already stated, the elasticity of the Crystalline Lens, and consequently its resultant increase of curvature under muscular effort decreases with advancing years, so that, what in youth may be perfectly normal, will, by reason of age, become for close range imperfect.

Aphakia is a term used to indicate the absence of the Crystalline Lens. This may be congenital, or as a result of operation.

To prove the presence or removal of the Crystalline Lens, a simple and effectual method is afforded by the "candle test." Hold a lighted candle close to and in front of the eye under examination, which acts as a mirror reflecting the flame. If the Lens is in position, three reflections will be seen, as the Cornea and front and rear surfaces of the lens each act as different mirrors, each at a different distance from the light, consequently the three reflections will be seen at equally varying distance from the flame.

The absence of the lens will be indicated by the presence of but one reflection.

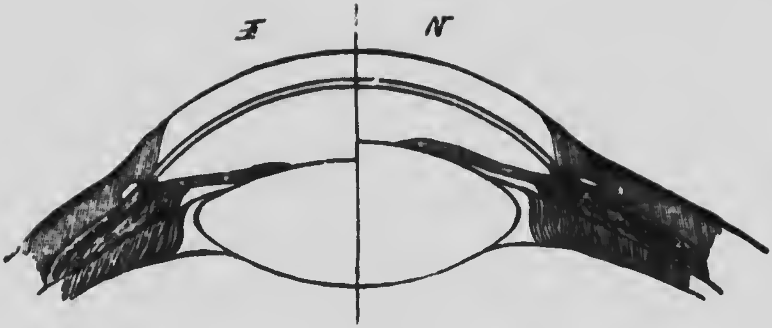



FIG. 13.

Sketch showing the mechanism of accommodation. One half the Crystalline Lens, N being accommodated for near work, and the other half, F, at rest, and adapted for distance.

CATARACT. An opacity of the Crystalline Lens, which in some forms gradually becomes cloudy, and frequently shutting out the entrance of light entirely, is called cataract. There are several forms of cataract, all of which usually attack persons of advanced age only. Cases of juvenile cataract are very rare. Cataract generally affects both eyes, but rarely simultaneously. The only relief consists in the entire removal of the Crystalline Lens, thus removing the obstruction to the admission of light.

AQUEOUS HUMOR. This is a thin, sparkling, transparent fluid, consisting of water completely filling the space in the eye-ball, between the Crystalline Lens and the Cornea, the Iris hanging vertically suspended in the Aqueous, and dividing the Aqueous Chamber into front and rear, the Aqueous flowing through the pupil from one to the other. The secretion of the Aqueous is very rapid, as the chambers refill in a few minutes if drained off through a puncture.

These Humors have an intimate communication with each other by means of very small vessels, or openings, known as Lymphatic Channels, through which the fluids in their interior are constantly changing, and are excreted in the form of tears. When an obstruction in these channels occurs, the tension is increased, causing a great hardness, which gives rise to the disease known as Glovcoma.

THE EYE-BROWS. The Eye-brows formed of muscle and thick skin, with a heavy thatching of hairs, afford protection to the eye from perspiration, which otherwise would become very troublesome.

THE EYE-LIDS. These consist of two thin moveable folds, entirely devoid of all fatty substance, and armed with long projecting hairs, which act as an advance guard to give timely notice of the near approach of a foreign substance.

The brilliancy of the Cornea is, in a great measure, due to the action of the eye-lids, which, plentifully lubricated by lachrymal secretions, constantly opening and shutting keeps moving any particle of dust from the Cornea, which would otherwise dim its lustre and impair its usefulness.

The Conjunctiva forms the Mucous Membrane of the eyes, completely covering the front part of the Sclerotic. It is a continuation of the Mucous Membrane of the throat, and is similarly affected under the influence of colds, etc. It is the inflamed condition of the Conjunctiva which gives the appearance of what is commonly called "blood-shot" eyes.

LACHRYMAL APPARATUS. The tears are secreted by the Lachrymal Gland, situated in a hollow excavation in the top of the orbit.

The Lachrymal Gland, together with the numerous ducts of which the tear system is composed, furnish a complete and truly wonderful example of miniature engineering, and constitute a system of water works and sewerage for the ocular system. The tears secreted in the Lachrymal sack act as a reservoir, and under the action of the lids in winking, are pumped out of the sack, and passing through the ducts, empty into the socket, and flowing around the front part of the eye-ball, carry with it all foreign substances which must of necessity lodge there, and passing out by means of the Lachrymal duct which empties into the nose, a constant system of lubrication and drainage is kept up, and the eye-ball maintained, and its multitude of movements performed without friction.

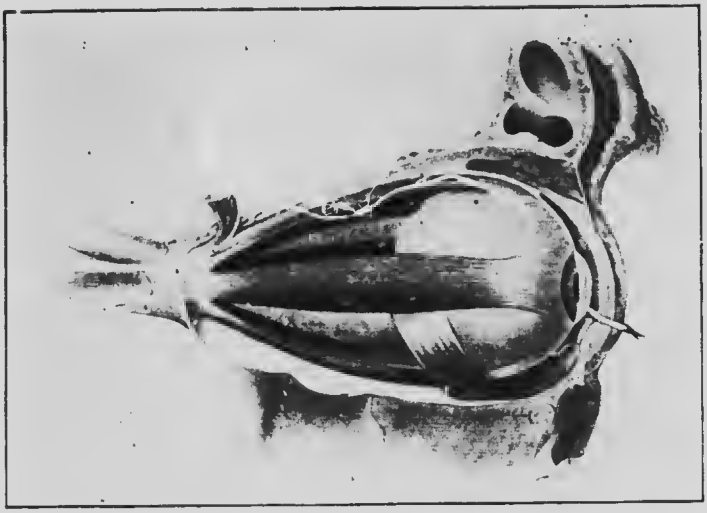


FIG. 14

THE MOTOR MUSCLES. B, Superior Rectus. C, Inferior Rectus. D, External Rectus. E, Internal Rectus. F, Inferior Oblique.

NOTE.—The Superior Oblique occupies a position opposite to the Inferior Oblique, and it is impossible to illustrate them both in the same cut.

THE MUSCLES. The Ciliary Muscle has already been discussed in reference to its connection with the Crystalline Lens. Its sole function is to bring about a relaxation of the suspensory ligament, thereby increasing the curvature and consequent refraction of the lens.

Sphincter Muscles are attached to the Iris, thus enabling it to increase or decrease the size of the pupil.

The eye-ball is rotated in various directions by means of the Motor Muscles, six in number—External Rectus, Internal Rectus, Superior Rectus, Inferior Rectus, Superior Oblique and Inferior Oblique. To possess a clear conception of the operations of the Motor Muscles, it must be borne in mind that the socket is a mere bony excavation in the skull, and that the eye-ball merely rests upon the floor of this cavity, securely packed and padded, it is true, with thick layers of fat, the Motor Muscles forming its means of attachment, one end of the Muscles being attached to the socket, and the other embedded in the Sclerotic. Now, it is very evident that the eye-ball being deposited in this cavity, with the centre of the pupil directed straight to the front, while all the muscles are relaxed, the eye maintaining its direction towards infinity without muscular effort of any kind, that being its passive normal condition, if any one of the Motor Muscles contract the ball will rotate in the direction of the contracted muscles.

The External Rectus is situated on the side of the Ball, and the eye rotates outward in obedience to its action.

Internal Rectus turns the eye in towards the nose.

Superior Rectus turns the eye upward.

Inferior Rectus rotates it downward.

Superior and Inferior Oblique are for the purpose of rotating the bal sideways in its posterior axis.

Two sets of muscles can be used in conjunction, turning the eye obliquely out, down, etc.

In a discussion of this nature no description of the nerves is necessary further than to state a fact which possibly is pretty generally understood, viz., that all motions of any kind of the limbs, or parts of the body, are accomplished by means of the muscles, but it must be remembered that the muscles possess no motive power of their own, they are merely the means of applying it, the power itself emanating from the brain, the means of communication being the nerves. An excellent illustration of the relation of the brain, nerves and muscles is furnished by the electric motor, the source of power representing the brain, the electric wires conveying the mysterious power act similarly to the nerves, by whose means the unseen energy is conveyed to that part in which the action is required.

The important point in connection with this principle is the fact that the Ciliary Muscle and the "Internal Rectus" are supplied simultaneously by the third cranial nerve, showing the intention of nature that these organs should act in harmony and unison.

# THE PHYSIOLOGY OF VISION

## LECTURE No. 3

As has been stated, images of external objects are formed upon the retina of the eye similarly to pictures in a photographic camera, and the eye, in so far as its dioptric system is concerned, is an optical instrument subject to the same laws of mechanics as other optical instruments. In the camera the first essential for a clear picture is that the instrument must be properly focused, that is, the sensitive plate for receiving the picture must be situated at the exact point where the light rays will unite after passing through the lenses of the camera, as here is the point where the image of the object is formed.

If the sensitive plate is too close or too far removed from the lens the outlines of the picture are blurred and indistinct, and the form and features of well known objects or persons are scarcely recognizable.

We have a perfect parallel in the human eye. If the retina is situated at the distance from the cornea corresponding to the focal length of the dioptric system, a clear picture of the subject looked at will be made here, and being conveyed to the brain by the optic nerve, we are able instantly to tell, as the result of education and comparison, the exact nature of the object looked at, but if the retina, from an abnormal lengthening of the diameter of the eye-ball, be situated farther away than the focus of the dioptrics, the rays of light having met at that point and crossed and met the retina while diverging, forming there a line instead of a point, and consequently the outlines of the object seen under these conditions would be distorted and indistinct.

Again, if the eye be shortened in its diameter, the rays upon entering the pupil are converging to a point will not have had sufficient distance to travel after meeting the cornea, and consequently will strike the retina while still in the act of converging, and again a blurred image will result.

From what has been said above, it will be readily apparent that eye trouble, as far as the dioptrics are concerned, is entirely a question of mathematics, and also that it is of two distinct forms, viz., that in which the diameter of the eye is too long and when it is too short. The exact nature and name, as well as sub-division of each kind will be considered under separate lectures.

EMMETROPIA. This is a term used to designate a perfect co-ordination between the refracting power of the dioptrics and the length of the eye-ball, an emmetropic eye being one in which parallel rays of light focus upon the retina, while the accommodation is at rest.

AMETROPIA. Ametropia is the opposite condition, and is a term used to designate an eye that is mathematically incorrect in its construction, and, of course, includes all forms of error which would cause an object to be incorrectly focused, either in front or behind the retina.

AMBLYOPIA. Amblyopia is a term used to indicate an impairment of vision, as a result of some imperfection in the construction or operation of the nervous function of the eye.

To differentiate between Ametropia and Amblyopia:—A condition under which perfect vision is unobtainable as a result of imperfect refraction, would be termed ametropia, while a perfectly formed image, as the result of a perfect refracting system, giving a faint impression to the intellect if conveyed through the medium of a faulty nervous system would be designated amblyopia.

The former being an error of refraction, is corrected by means of lenses which supply the necessary amount of refracting power, which is absent in the dioptries of the eye, while the latter is not subject to treatment by lenses, and consequently does not come within the province of the optician.

In the preceeding lectures we have studied the theory of light. We have carefully noticed its natural methods of motion and its speed.

The effect of the interposition of various bodies of certain curvature as seen in the optical lenses has been thoroughly discussed, and the resultant reproduction of the "image" as a result of passing light rays through a convex spherical lens has been clearly illustrated.

Our study of anatomy, though brief, has shown that the cornea forms a convexly curved surface, presenting in the normal eye a perfectly spherical or globular surface in all directions, so that rays of light proceeding from a luminous body of its front must fall upon this curved surface, and obeying the fundamental law of refraction, converge and meet at a point in the ocular system, situated at the focal length of the lens system of which the eye is composed.

We have studied the theory of the formation of images by means of convex lenses and noticed its parallelism in photography. It will be a comparatively easy matter, therefore, for the industrious student, if he understands these primal laws governing the refraction of light and also possessing a fairly intelligent idea of the anatomy of the eye as laid down in these lectures, to pass at once to a consideration of the physiology of vision—to complete a practical fact by the simple operation of uniting two theories.

The Cornea, as has been shown, acts as the objective, and collects upon its surface the rays proceeding from surrounding objects, and reproduces at its focal length (including, of course, the other lenses of which the eye is composed) the image or photograph of the object from which the light proceeded. The Retina, acting as a sensative plate, receives this light impression, which, by means of the optic nerve is conveyed to the brain, and mysteriously acted upon in such a manner that the resultant idea contains definite information relative to the nature of the object looked at. This is a vision. Not the unclosing of the eye-lids permitting light to fall upon the inner parts; not the changing of its direction by the refractive elements of the eye; not the act of conveyance of light impressions to the brain, these are all means to an end, but the knowledge acquired by these mears constitute what we call vision.

It will be quite apparent from the foregoing that the eye is not the seat of vision, but the brain, and consequently there must be a decided limit to the field of operations in which the application of spectacles can be used in restoring impaired vision. In the act of vision there are two distinct operations by means of entirely different sets of organs. First, there is the operation of refractive organs of the eye. This is purely mechanical, and as such is subject to the known law of mechanics. The light in passing into the eye is first of all refracted by the Cornea, and proceeding inwards through the Aqueous Humor comes in contact with the Crystalline Lens, when it is again refracted, and finally through the Vitreous Humor it reached the Retina in the form of an image or picture of the original object. Yet no vision, this is merely the first or refractive stage.

DIOPTRIC SYSTEM—The various organs necessary for the completion of the first stage of vision are collectively called the Dioptric System. They include the Cornea, Crystalline Lens, Aqueous and Vitreous.

NERVOUS SYSTEM—For the completion of the act of seeing, the nervous system of the eye conveys the impression formed upon the Retina by the Dioptric System to the brain, when the completion is brought about in the mysterious depth of the intellect. For the perfect fulfilment of the act of vision these two distinct conditions are necessary: First, a well defined image must be formed at the Yellow Spot. Secondly, the impression there formed must be conveyed to the brain.

Although the dioptric and nervous systems are entirely distinct, both in character as well as in their fields of operation, one is absolutely essential to the usefulness of the other, as no matter how accurate and perfect the photographic powers of Dioptric system, if the nervous communications fail to perform their functions vision is not possible. And in spite of the greatest activity in the nervous system, if the Dioptrics are imperfect, either in their transparency, thus preventing the passage of light, or if from being imperfectly focused a blurred image is formed, blindness, or at least imperfect vision must result.

Vision on the Yellow Spot is called direct vision, all other conditions when the object is situated obliquely, so that rays from it fall on parts of the Retina removed from the Yellow Spot, is called indirect vision.

In order to distinguish the details of an object clearly, direct vision is necessary, although we may at the same time, by means of indirect vision have a dim knowledge of the presence of surrounding objects.

ACCOMMODATION—In the foregoing remarks upon refraction as a means of securing images, it has been assumed that the rays enter the eye parallel, but as a matter of fact during the greater part of the time in civilized communities the eyes are directed to near objects, that is, at distances less than twenty feet.

It will be borne in mind that for all distances within twenty feet the rays meet the eye in a divergent direction, and require greater refractive power in order to still continue to focus on the Retina, and the nearer the eye approaches to the object the greater will the divergence be, and the consequent necessity for additional refractive power.

This increase of refraction in the eye is called Accommodation, and is accomplished by means of the Crystalline Lens increasing the convexity as a result of the force exerted upon it by the Cilliary Muscle, which acts in such a manner that it relieves the tension which the Suspensory Ligament exerts upon the Lens, which, relieved of the flattening pressure, immediately assume a more convex form as a result of its own elasticity. The increase in refraction required is in proportion to the amount of divergence which the rays possess, or, which is the same thing, the distance of the object from which they proceed.

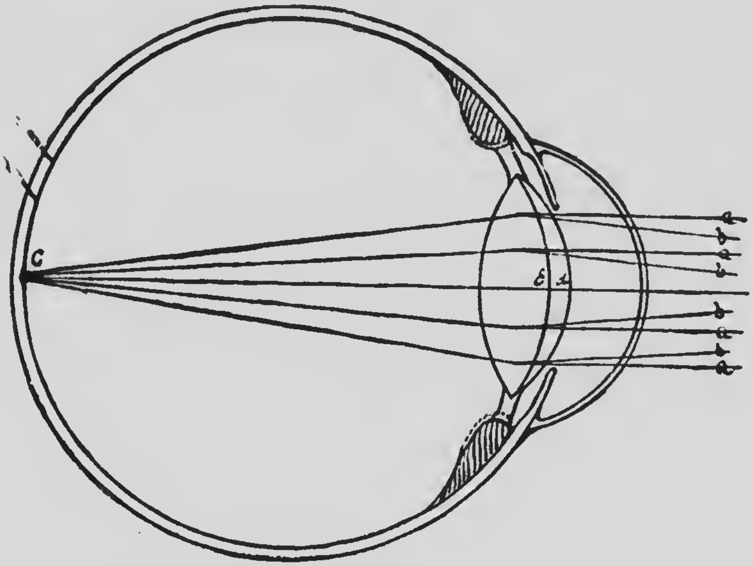


FIG. 15.

An Emmetropic eye with parallel rays a, a, a, a focusing on the Yellow Spot at "G" with no accommodation in force, (E) and divergent rays b, b, b, b, still focusing at "G" by means of accommodation D.

FAR POINT (PUNCTUM REMOTUM)—Far Point is that point proceeding from which, the rays will focus upon the Retina without the use of any accommodation. The Far Point, therefore, of the Emmetropic Eye is situated at infinity.

NEAR POINT (PUNCTUM PROXIMUM)—Near Point is the nearest point at which the eye can focus rays upon the Retina with the full amount of accommodation in force.

AMPLITUDE OF ACCOMMODATION is the difference in refractive power of the eye when adapted for its far point, with no accommodation in force, and when fully accommodated for its near point; in fact it is the total amount of accommodation which the eye is capable of exerting with its full muscular effort.

The Amplitude varies with age. A child of ten years having 14.D: year by year, however this amplitude decreases, until at the age of forty but 4.50 remains. Below will be found a table giving the amplitude at different ages:

| YEARS. | AMPLITUDE. |
|---|---|
| 10 years | 14.00 D. |
| 15 " | 12.00 D. |
| 20 " | 10.00 D. |
| 30 " | 7.00 D. |
| 40 " | 4.50 D. |
| 50 " | 2.50 D. |
| 60 " | 1.00 D. |
| 70 " | 0.00 D. |

Range of accommodation is the distance between far and near point.

Proof of Accommodation—By looking through a wire screen at a distant object it will be found that the object or the screen can be seen clearly alternately, but not simultaneously.

ACCOMMODATION NECESSARY FOR DIFFERENT DISTANCES—To find how much accommodation is required to focus rays upon the Retina which proceed from points within infinity, we have merely to divide the distance (in inches) into forty, and the result is the accommodation in Dioptres. For instance, to see an object clearly at 16 inches from the eye, $40 \div 16 = 2.50$ would be the accommodation necessary.

The effect of accommodation being to increase the refraction of the eye, the same results would accrue if an additional convex glass were placed in or in front of the eye.

When the Cilliary Muscle is entirely relaxed, and no accommodation used, we say the eye is at rest and adapted for its far point.

When fully accommodated it is adapted for its near point. and as the nearness at which we can focus objects on the Retina depends upon the Amplitude of Accommodation, we are able to exert, we can, by simply measuring the closest distance at which standard size type can be read find the Near Point. This divided into forty gives the amplitude of accommodation.

As age advances the muscular power diminishes, the lens capsule loses its elasticity, and the near point recedes in consequence.

CONVERGENCE is the ability to direct the visual axis of both eyes to a point within infinity, and is accomplished by means of the internal Recti Muscles.

The act of convergence is closely connected with accommodation, both the Internal Rectus and the Cilliary being supplied through the medium of the same set of nerves.

As accommodation is intended for looking at near points only, for which purpose convergence in like proportion is required, it is clear that we require increase of refraction for near points in exactly the same amounts as convergence is used.

METRICAL ANGLE.—Metrical Angle is the angle formed by the intersection of the visual axis and the median line, and we measure convergence in meter angles in proportion as we measure accommodation in dioptres—one dioptre of Acc., and one metre angle convergence being necessary to see clearly at 40 inches. 2 Dioptre Acc. and 2 metre angle of convergence for 20 inches, etc.

The object of the convergence is the directing of the Yellow Spot of each eye to the same point, so that rays proceding from any one point may fall upon identical parts of each Retina, otherwise two impressions would be received, and being conveyed to the brain separately by each eye, Diplopia would result.

DIPLOPIA.—Diplopia is the act of seeing two objects when one is looked at. Binocular vision is the simultaneous use of both eyes while maintaining single vision, and in order to enjoy it to its finest extent, it is necessary, not only that the convergence be normal, so that the eyes turn inwards in unison in order that the corresponding parts of each Retina receive the image, but also that the refraction of both eyes be approximately the same.

POSITION OF OBJECTS.—The senses acquire their information as to the position of an object entirely by the part of the Retina the rays image upon it. An image formed upon the lower section giving sure information that the object is above. If formed to the temporal side the object must be situated to the nasal side.

PIN HOLE TEST.—To ascertain whether imperfect sight is the result of Ametropia, and thus restored by lenses or by Amblypoia upon which lenses will have no effect, we employ the Pin Hole Disc, which is supplied with the trial case. The Disc consists of a black rubber disc with a small round hole in the centre, the effect of which is to close off all rays from entering the eye except the axis ray.

If vision being below normal is improved by means of the disc it implies Ametropia, indicating that the vision was imperfect by reason of the incorrect focus of the rays of light which are shut out by the disc.

If vision remains equally low through the disc as with the naked eye it would indicate Amblyopia, as defective condition of the nervous apparatus would not in any way be improved by excluding badly focused rays.

ANISOMETROPIA is a condition in which the refraction of the two eyes show a marked difference.

ASTHENOPIA—(Eye Strain).—A condition of fatigue in various parts of the ocular system, occasioned by some error of refraction or as the reflex of some disease or physical disability.

# HYPEROPIA.

## LECTURE No. 4.

As has already been stated, an Emmetropic eye is one in which parallel rays of light focus upon the retina without the aid of accommodation. Such an eye is the ideal eye, as such a condition is possible only as the result of perfect refraction, and provided the accommodation and convergence are normal, perfect vision will be possible at all distances.

In considering the Ametropic eye, viz.: one in which the refractive apparatus is not adapted for focusing parellel rays upon the retina, we have to study it under two distinct forms, viz.: When the eye-ball is so short that the focus falls behind the retina, and when, from its abnormal elongation, the focus is in front.

Hypermetropia is a condition of the eye in which the diameter of the eye-ball from the cornea to the Yellow Spot is shorter than the focal length of the dioptric system of the eye, and consequently parallel rays on passing into such an eye would not have converged sufficiently to have met at the Retina, the focus, if such a thing were possible, would be behind the Retina.

Images formed upon the Retina under this condition would be blurred and indistinct, and an object, although seen under an angle of 5″, would be unrecognizable.

The only means by which the vision of a Hyperope can be improved is through the aid of increased refraction, which will converge the light rays more rapidly, and thus move the focal point forward to the Retina. This is accomplished by means of a convex lens. Such a lens placed in a spectacle frame acts upon the rays of light convergently, thus partially performing the function of the dioptric system. As a slight amount of convergence having been given to the rays before meeting the Cornea, the eye is able to accomplish the remainder and so acquire an accurate focus.

The Hyperopic eye, however, possesses within itself a ready means of correcting any ordinary amount of refractive error by means of the accommodation, having the same effect as a convex lens in front of the eye, viz.: An increase of the refraction.

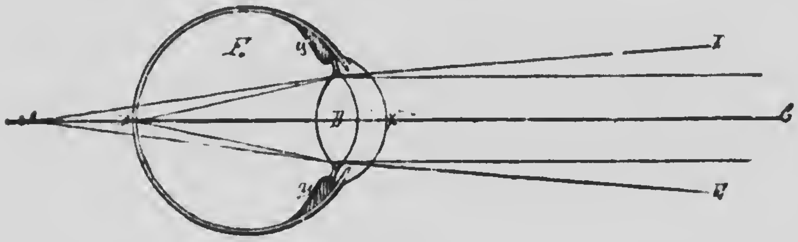


FIG. 16.

Diagram showing Hyperopic eye with parallel rays focusing behind the Retina, and convergent rays focusing on the Retina.

Many people go through life perfectly unaware of their Hyperopic condition, as a result of the assistance rendered by the accommodation, and were it not for the fact that accommodation was intended for use for near objects only, and that Nature rebels at the abuse of her laws, and visits the sins of the trangressor upon him, we might have but little cause for the correction of Hyperopia.

It has been shown in another section of this work how the convergence and accommodation are both designed for near work only, and being intended to work in unison, receiving their impulse for such work through the medium of the same set of nerves, consequently no effort of accommodation can be exerted without the equivalent amount of convergence following. Thus with 2. D. Hyperopia before he can see a distant object clearly must exert 2.00 D. of the accommodation, and the convergence acting simultaneously, his eye would turn inwards and fix a point twenty inches from the eye, which, of course, would prevent a distant object from being seen, as it would not while the eye was in this position fall upon the Yellow Spot. So the only means of obtaining clear vision is to accommodate 2.00 D., at the same time suppressing the converging muscles by an effort of the External Rectus.

Hyperopia is of two forms, Manifest and Latent. The accommodation being constantly used for both far and near points acquires a state of chronic contraction, and even when lenses are supplied to correct the Hyperopia, from long use refuses to entirely relax, and thereby prevents the total amount from being corrected. The amount it is possible to measure by lenses is called Manifest Hyperopia, the remaining portion, which is concealed by the accommodation being termed Latent. In young children it frequently happens that the full amount is latent, but usually only partially so, and with advancing age with its attendant loss of accommodation the Latent becomes more Manifest.

Atropine is dropped into the eye for the purpose of paralyzing the Ciliary Muscle, and thus permitting the measurement of Latent Hyperopia.

The Hyperopic eye of moderate degree with ample accommodation may have vision equally good with the Emmetrope, but it is secured at the expense of a constant use of accommodation, both for near and far points, and the evil effects of which will be considered under the heading of Asthenopia.

SYMPTOMS OF HYPEROPIA.—There is usually pain in the region of the eye, and necessarily in the eye-ball itself, but frequently extending to the temple and brow, and even the back of the head, and is often mistaken for neuralgia and muscular rheumatism.

The inability to maintain the use of the eyes for near objects for any length of time, without a feeling of drowsiness and an inclination to close the lids, constitutes an unfailing sign of Hyperopia, indicating the inability of the Ciliary Muscle to sustain the extra strain put upon it by reason of the Hyperopic condition.

APPEARANCE OF THE EYE IN HYPEROPIA.—Being an undeveloped eye it is usually set deep in the orbit, and of smaller dimensions than the Emmetropic eye, and frequently its brilliancy is less owing to excessive use of accommodation.

The pupil being smaller than in Emmetropia, the Hyperope requires a stronger light in order to secure a sufficient illumination of the retina.

Although the majority of Hyperopes will assert that their vision has always been good until some recent occurrence, such as sickness or an accident, it should be borne in mind that Hyperopia is a congenital disease and has always been present, but its presence has been concealed by an active accommodation which, as a result of some illness becomes weakened, and being no longer able to carry its double burden, the Hyperopia becomes suddenly manifest.

CAUSES OF HYPEROPIA.—Hyperopia is always congenital. The Hyperopic eye being an undeveloped eye, it is perfectly natural that in new born infants the eye should be like other organs, but partially developed, and consequently Hyperopic.

Development is usually rapid at first, and the infant Hyperope as the eye-ball becomes elongated becomes Emmetropic, as the anterior-postero length of the balls becomes equal to the focal length of the Dioptric system of the eye. Those in whom the process of development still continues after this point is reached become Myopes.

RESULTS OF UNCORRECTED HYPEROPIA.—The effects as seen in uncorrected Hyperopia appear in several different form of inconvenience or discomfort, and the old adage pertaining to the practice of medicine "that disease usually attacks the weakest part," holds good in relation to Hyperopia. There are, of course, multitudes of uncorrected Hyperopes not even conscious of the possession of any eye defect whatever, as their general condition of robust health permits the excessive use of accommodation without apparent fatigue, after having acquired the habit of using accommodation and convergence in unequal amounts.

There are others who in this effort of disassociation of accommodation and convergence lose control of the converging muscles (Internal Recti) and develope an internal squint, which can only be relieved by the removal of the cause, viz., the correction of the Hyperopia.

Those cases in which the ciliary muscle escapes control produce ciliary spasm, in which we find Hyperopia overcorrected by accommodation and a condition of artificial Myopia existing, which, upon examining by subjective methods will show poor distant vision, which will be found to be still further impaired by plus lenses and to be restored to 20/20 by minus lenses.

It is clear, however, that no concave lens can prove permanently satisfactory, as while it gives normal vision it compels a continuance of the muscular spasm, and would be intolerable after a few hours.

This troublesome affection, which is discussed at greater length under the heading of Simulative Myopia, can only be relieved by weak convex spherical lenses gradually increased from time to time as the spasm relaxes.

There are others of the Hyperopic class who, having successfully accomplished the disassociation of accommodation and convergence and become expert in the use of the former without the latter, and showing no signs of squint or spasm, do so at the cost of perpetual pain and strain, the external symptons of which are headache, neuralgia, irritation of the eye-ball and lids, and the various conditions of discomfort as seen in Accommodative Asthenopia, and which will receive fuller treatment under that head.

The fact that Hyperopia requires accommodation for distant vision to the extent of the Hyperopic error, and, of course, the additional amount necessary for the various distances inside infinity, will account for the fact that many Hyperopes, in seeking relief, complain of near vision only being difficult or painful, as it is under the excessive strain necessary to close points that the nervous system first feels the effect, but when the distant vision is corrected no difficulty is experienced at near points.

ESTIMATION OF HYPEROPIA.—An eye that sees equally well or better by the aid of a plus glass (at the distant type) than with the naked eye is a Hyperopic eye. The acceptance of a convex lens for distant vision is proof positive of Hyperopia, as under no other conditions is it possible to do this. If the vision is already normal the strongest glass with which it remains normal is the measure of the Manifest Hyperopia. The Latent, of course, cannot be measured without the use of Atropine, and, if measured, cannot be corrected.

It is important to remember in the dagnosis of Hyperopia, that the existence of perfectly normal dista t vision does not exclude it, as all young Hyperopes can exercise sufficient accommodation to correct any ordinary degree of Hyperopia, and it frequently happens that the degree of sight possessed by an uncorrected young Hyperope of moderate degree is even better than normal (20/15). This is not by reason of any higher refractive excellence than that possessed by the Emmetrope, but possibly the result of a keener perceptive faculty of the retina.

Considerable difference of opinion exists as to the most desirable method of treating Latent Hyperopia. Some authorities maintaining that an overcorrection of the manifest error should be supplied with the object of inducing a relaxation of the accommodation, and thus bringing out and allowing of correction of the greatest possible amount of the Latent.

This plan, while excellent in theory, is inadvisable in practice, as the lenses causing discomfort, few children will persevere in their use, and thus they defeat the very object for which they were prescribed.

Instances will be found among children in which the whole amount is Latent, in which case but little headway can be made, as no plus lens is accepted, and there is nothing for the optician to do but to coax a relaxation by weak plus spheres, which, while uncomfortable at distance, can be readily worn for near work.

# MYOPIA.

## LECTURE No. 5.

Myopia is a condition of the eye in which parallel rays focus in front of the retina.

The distance through the eye-ball from the centre of the cornea to the yellow spot is greater than the focal length of the dioptric system. An object situated at infinity would be imperfectly seen by such an eye from the fact that the refraction of the eye is in excess of what is required to focus rays from infinity, and, possessing no power to reduce the refraction abnormally, the Myope has no means of correcting his Ametropia after the manner of the Hyperope. The refraction of the Myopic eye being too great for parallel rays, it is only adapted for divergent rays.

There are, therefore, two ways in which an object can become distinctly seen by the Myope.

If we move the object closer to the eye than infinity, the rays proceeding from it will strike the cornea divergently, and the focus falls correspondingly farther back; or by means of a concave lens in front of the eye.

As we saw, while studying the theory of refraction, the nearer the object approaches to the lens the farther removed in proportion will the focal point be, so in the case of the Myope we have merely to approach the object until the rays have sufficient divergence to enable their focus to fall upon the retina.

The higher the Myopia the closer to the eye will this point be. This point will be the far point of the Myopic eye, and is always at a finite distance.

This accounts for the fact of Myopes being able to see clearly at near point, but having very low distant vision.

As Myopia is a condition of excessive refraction, we can, by the application of a minus lens, neutralize this surplus, and so render them capable of seeing clearly objects at infinity. As has been stated, a Myopic eye is capable of focusing only divergent rays, and by placing a concave lens in front of the eye, parallel rays proceeding from an object situated at infinity are refracted divergently before entering the cornea, and a focus on the retina thereby secured. Myopia is essentially an *attache* of civilization, being the result of continuous use of the eyes for close distances, and though rarely congenital is undoubtedly hereditary.

CAUSES OF MYOPIA.—The most prominent causes then of Myopia are heredity and the excessive use of the eyes for near work at a very early period in life, and more particularly the practice of sending very young children to badly lighted schools with inadequate seating accommodation. The seats being constructed for larger pupils the reading matter is necessarily very close to the eyes of small scholars, and the excessive convergence thus demanded subjects the soft, yielding coats of the young eye to a continuous strain in turning the eye inward. This continual strain eventually produces an elongation in the ball, which is in itself Myopia, and demanding more convergence still, the tendency is to increase the elongation and consequently the Myopia. Thus may Myopia, in a double sense, be said to breed Myopia.

Imperfectly lighted school-rooms will necessitate the children holding the type very close in order to secure large retinal images to compensate for the indistinctness, and hence the tendency to Myopia is again present.

When Myopia is once established, some of the conditions which combined to produce it are no longer present, thus the accommodation is used less or not at all, and since accommodation and convergence are associated through the medium of this single nerve supply, the Myope frequently finds it easier to give up convergence and to use one eye only for near vision, and in a short time the convergence becoming more difficult is altogether lost, and an external squint or Strabismus is acquired.

The intervention of squint usually precludes any further progress to the Myopia, as the convergence being gone the cause of the increase is removed.

Myopia is also prevalent during the first stage of cataract, the chemical change taking place in the crystalline lens, inducing a softening and extension of the lens.

The importance of preventing the increase of Myopia in young persons, by the removal of all conditions likely to cause it, should be borne in mind by all opticians.

MALIGNANT MYOPIA.—When Myopia is above 6.00 D. it is called malignant, and is positively dangerous, as the excessive convergence used in uncorrected Myopia of high degree has a tendency through a constant straining of the muscles which are attached to the choroid to increase the length of the ball, thereby increasing the Myopia. When this occurs it is called progressive Myopia, and having once started upon the increase, the ruin of the ocular system is usually a matter of time, the continued muscular pressure causing a bursting of the tunics at the rear of the ball, and is then known as Posterior Straphaloma.

Estimation of Myopia.—The concave lens that will give to parallel rays the exact amount of divergence necessary to enable the refractive power of the eye to focus them upon the retina is the measure of the Myopia, or, in other words, the minus lens that will give to parallel rays the same divergence as if they proceeded from the far point.

The difficulties peculiar to the correction of Myopia are the liability to overcorrection, and the disinclination of the Myope to wear a correction for near work.

Myopia is recognized by the fact that distant vision is *always below normal*, and is improved by the aid of a concave spherical glass, but as the vision would remain equally high under small amounts of overcorrection, owing to the fact that the patient would use his accommodation to neutralize the amount of overcorrection, great care must be used to avoid supplying a lens which causes this condition.

It must be remembered that the presence of Myopia is indicated by the condition of low distant vision rendered higher by concave lenses, and consequently the degree of error must be measured by the improved vision secured by each successive strength of glass which is tried, and under no condition are we to prescribe a glass unless it has enabled the Myopic patient to read some letters which with the preceding weaker lens he was positively unable to read or incorrectly named.

We are, in no case, to accept the patient's assertion that any glass "is better" than the preceding one, but to form our judgment and base our conclusion only on his ability to read some certain letter or letters with the present lens that it was found impossible to accomplish with the preceding weaker number.

The difficulty in inducing Myopic people to wear a correction while using their eyes for close points is easily accounted for by the fact that the near vision of such people is far better without the correction, as the Myopia at a close point acts as a magnifier, and objects are magnified to such an extent that the retina, having become accustomed to the consequent large images, does not readily conform to normal conditions entailed by the corrections, and is unable, sometimes, to tolerate the smaller though natural images produced through the aid of the correction lens.

The difficulties connected with the correction of Myopia are increased by the fact that a great majority of Myopic eyes are Amblyopic, and normal vision is impossible even with a perfect correction, and in the anxiety to secure perfect vision there is a tendency to overcorrect.

RESULTS OF UNCORRECTED MYOPIA. In no form of Ametropia are the results so far reaching and of such a serious nature as in Myopia. Posterior Staphaloma, or bursting of the eye tissues at the rear. Detachment, also hemorrhage of the Retina and a predisposition to cataract may be mentioned as among the graver forms of disturbance which are directly traceable to uncorrected Myopia in addition to the commoner disarrangements of muscular balance, Muscular Asthenopia, Diplopia, Squint or Strabismus.

SIMULATIVE OR ACCOMMODATIVE MYOPIA. This is a false condition of apparent myopia, which will have to be guarded against with great care, or the inexperienced optician will find himself supplying concave glasses to Hyperopes.

It has already been shown that Hyperopia is a condition in which the focal point being located behind the Retina, and being uncorrected by a plus lens, the victim does not wait to secure an artificial lens but immediately corrects his Hyperopic error by means of his accommodation, but as Hyperopia is present even when distant objects are viewed and accommodation and convergence are so produced by the harmonious action of the ciliary and internal recti muscles it is a matter of difficulty to accommodate without at the same time converging, and it will readily be understood if convergence is used while looking at a distant object it will be either impossible to see it or it will be seen double.

The difficulty experienced in acquiring the habit of using convergence and accommodation in unequal amounts usually produces one of three results. Either the Ciliary or the internal rectus escape control, or the patient avoiding this does so by a supreme and constant effort and at the cost of comfort.

The first condition has already been referrred to as Squint, the last will be discussed later under the heading of Asthenopia. The second condition constitutes Ciliary Spasm.

SYMPTOMS OF MYOPIA.—The prominent eye-ball, while not necessarily an indication of Myopia, is usually so, as the ball from its elongated form is pushed forward and consequently a greater portion of the sclerotic becomes visible.

EXCESSIVE PUPILLARY WIDTH is a frequent accompaniment of Mypoia, inasmuch as many cases of Myopia are induced by the excessive convergence entailed by a pair of eyes abnormally far apart.

DIVERGENT SQUINT is in most cases caused by Myopia, and when found Myopia is presupposed.

SUBNORMAL DISTANT VISION is always present in Myopia, and consequently inability to clearly recognize distant objects may be accepted as a fairly reliable symptom.

ABNORMAL NEAR VISION.—Close objects are clearly seen, but the range over which this occurs is necessarily limited, and the near point is closer than in Emmetropia.

Now, according to the average text book, the symptoms of Myopia are plain and easy to recognize, but I think this statement should be amended to read: "The symptoms of Myopia are easy to produce, and the greatest care and judgment is necessary to disclose the real and the apparent condition."

First of all we have genuine Myopia, but "overcorrected," and by the term overcorrected is meant, not only those cases in which the actual amount of error present has been overcorrected, but those malignant cases in which a "full correction is an overcorrection."

There are two ways in which a real "overcorrection" can be supplied. First, by relying upon the patient's description of his sensations instead of by actual progress made in deciphering the letters on the test card, and, secondly, by omitting the binocular test with plus lenses after full correction has been placed in position.

The very natural anxiety of young opticians to do the very best that can be done is frequently the cause of supplying a "too full" correction in malignant Myopia.

I need scarcely point out that Myopia of a high degree, having been for years uncorrected, has performed the work usually devolving upon the ciliary muscle, and the eyes, when used at close points, are performing perfectly without the aid of accommodation, the natural result of which is that the malignant Myope is devoid of any development of ciliary, and, if occasion arise which calls for what in the Emmetrope would be a natural exertion of accommodation, fatigue and discomfort will be the inevitable result.

This is just the situation in maligant Myopia fully corrected. It presents the spectacle of a baby muscle carrying a man's burden.

There is another feature in the correction of high Mopia which is worthy of attention, as a prolific cause of Eye Strain. I refer to retinal rather than muscular conditions.

The retina of a highly Myopic eye must certainly have existed in a blissful condition of inertia. Being deprived of distinct images during the whole time that the eyes are not directed to an exceedingly close point, this means that the retina and optic nerve and that mysterious dark room apparatus that convert the retinal images into ideas are for the greater part of the time inactive.

Now, the old adage that a certain nameless gentleman "finds some mischief still for idle hands" may be equally applicable in a certain sense to idle retinas. Or, more correctly speaking, the retina being idle, or being used for near objects only, loses its aptitude for work at distant objects, but the nerve force, the energy, without which the human body, which is the embodiment of miraculous motion, becomes but nerveless clay, is directed into other channels where it can be more profitably employed.

The sudden and full correction of the malignant Myope restoring the acuteness to normal conditions produces on the retina an endless succession of distinct images. No matter whether the eyes be directed to infinity or to the Near Point there is no escape from the duty devolving upon it to assist in conveying these newly-acquired sensations to the developing stage in the recesses of the brain.

What more natural than a retina after long years of indolence should feel fatigued at the sudden imposition of severe exertion. This is surely as rational here as if applied to physical exercise in any of the parts of the body.

The retina, accustomed to a life of indolence, now has to perform a laborer's work, and fatigue and strain, headache and sometimes nausea are the complaints received concerning the effect of a full correction which restores normal vision to the malignant Myope, and, as few people can know what constitutes perfect vision and everyone realizes the presence of discomfort, an undercorrection for malignant Myope should be generally considered a perfect correction, at all events it is the safer and more generally acceptable one.

This view is further strengthened by the fact that in those cases where the Myopia has gone uncorrected for years, and Amblyopia is present to a large degree, and a very moderate degree of visual acuity is therefore all that can be got, that a full correction can be worn without discomfort, as the indolence in which the retina has long existed has had the effect of permanently deadening its sensibility, and no matter how perfect the correction, activity sufficient to cause mental fatigue is impossible.

ESTIMATION AND CORRECTION OF MYOPIA. The weakest concave glass that gives the most vision is at once the measure and the correction for Myopia.

# ASTIGMATISM.

## LECTURE No. 6.

Astigmatism is of two kinds, Regular and Irregular.

IRREGULAR ASTIGMATISM consists of a general irregularity or non-symmetrical formation of the Cornea. There is no correction for it, and relief is impossible.

REGULAR ASTIGMATISM may be described as that condition of the eye in which the rays of light, in passing through the Dioptric system, do not focus at one point, but constitute a series of focal points, corresponding to the different curvatures of the various meridians.

It will be apparent that from the definition that in Astigmatism that the Cornea is not spherical in form, but elliptical, the various meridians having each different degrees of curvature.

In studying Astigmatism we consider only "the meridian of greatest curvature" and "the meridian of least curvature." The two are known as the Principal Meridians, and are always at right angles to each other.

In the foregoing it has been assumed that Astigmatism is entirely Corneal, that is, that the malformation is of the Cornea only, and not extended to the Crystalline Lens.

Reference is made, however, by all writers on the subject, to a condition of Lenticular Astigmatism, implying an elliptical lens. I scarcely think this is the case, but am inclined to believe that the comparatively small number of cases of Lenticular Astigmatism met with is owing to a misplaced rather than mis-shapen lenses.

This is quite easy to understand if we experiment with a spherical glass, by looking through it obliquely at an object, when it will be found that a cylindrical effect is experienced. So, likewise, it may be easily possible for the Crystalline Lens to be set obliquely behind the pupil, thus causing the same result as if the cylinder glass were placed in front of the eye.

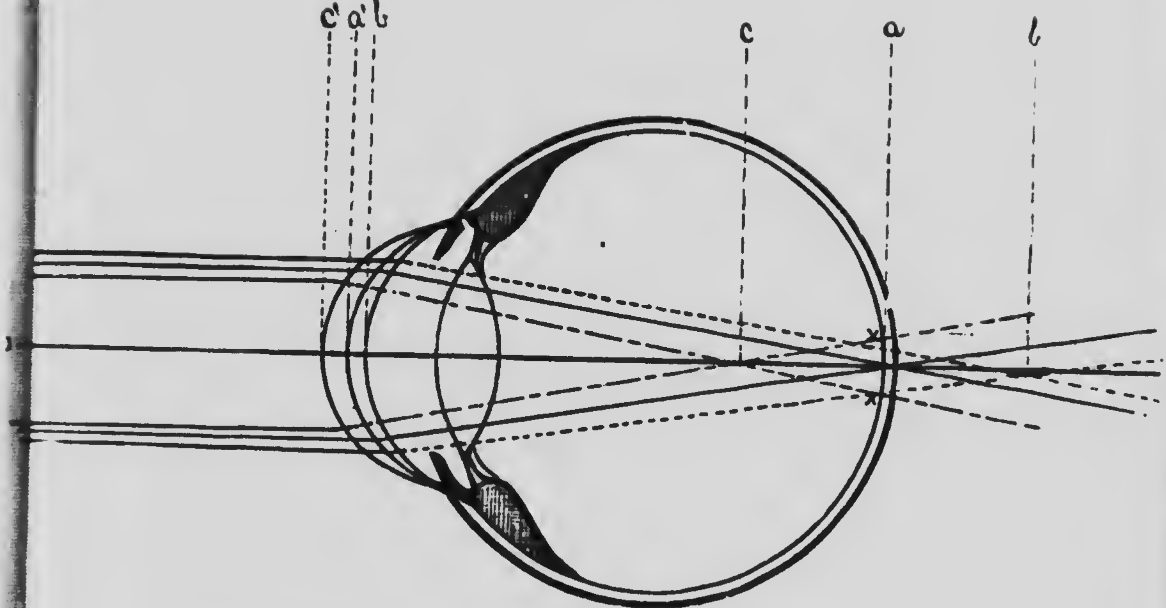



Fig. 17.

Diagram showing the relative positions of the focal points in Simple Hyperopic and Simple Myopic Astigmatism.

A′ represents the Emmetropic meridian with its focus upon the retina at A.

B′ represents the other principal meridian in Hyperopic Astigmatism with its focus behind the retina at B.

C′ represents the other principal meridian in Simple Myopic Astigmatism with its focus in front of the retina at C.

For all practical purposes, however, we can assume all Astigmatism to be entirely dependent upon the curvature of the Cornea, and is in proportion to the excess of curvature or want of curvature of the Principal Meridians as compared with the curvature required to focus parallel rays upon the Retina.

CAUSES OF ASTIGMATISM. Astigmatism is usually congenital, and, as a rule, hereditary. It may be present as the result of accident to the Cornea or an operation such as Sclerotomy. Some authorities claim that Muscular Imbalance is a fertile cause of Astigmatism, as the result of the unequal pressure existing in different meridians.

While it is stated that the normal eye is spherical in shape, it is a statement that requires qualifying. A slight difference is found in the radii of curvature even in a perfect Emmetropic eye, the Vertical Meridian being very slightly more curved than the horizontal. It is quite natural, then, that where the difference is sufficiently great to cause Astigmatism that the Principal Meridians lie somewhere near these two directions, with the verticle being that of the greatest and the horizontal the meridian of the least curvature.

When this condition is found it is called Astigmatism with the Rule, and the opposite Astigmatism against the Rule. This would mean that as a rule the Vertical Meridan has a stronger refracting power than the horizontal, a difference of one millimeter in the radii, causing about 6.00 D. difference in refraction.

SYMPTOMS OF ASTIGMATISM. Among the prominent symptoms of Astigmatism of high degree is a general want of symmetry in the features, the nose either shows a lateral curve or possibly a bony projection, or in some instances one eye is slightly higher than the other or at a greater distance from the centre of the forehead.

In reading the test types the head is generally tilted over at an oblique angle, and during the process of reading the card this angle is frequently changed as difficulties in deciphering the letters are encountered

The Astigmat also has a pronounced tendency to miscall many letters which, under the distortion incidental to Astigmatism, assume other shapes.

VARIETIES OF REGULAR ASTIGMATISM. Astigmatism is of five kinds, Simple Hyperopic, Compound Hyperopic, Simple Myopic, Compound Myopic, and Mixed.

Simple Hyperopic Astigmatism is a condition in which one Principal Meridian is Emmetropic, having its focus upon the Retina while the other one is Hyperopic, with its focus behind the Retina.

A spherical convex that would bring the latter forward to the Retina would at the same time carry the Emmetropic Meridian forward and make it Myopic. It requires for its correctio convex cylinder of sufficient strength to correct the Hyperopic Meridian, having its axis corresponding in its direction to the Emmetropic Meridian.

Compound Hyperopic Astigmatism, or Simple Hyperopic Astigmatism combined with Hyperopia, is a condition in which the whole refracting surface is too flat, and the various Meridians focus behind the Retina, but at different distances. In its correction a convex spherical is used of the required strength to correct the Meridian of greatest curvature, which of course has its focus nearest to the Retina, combined with a convex cylinder to correct the remaining meridian, the axes parallel to the Meridian of greatest curvature, that is the least Ametropic Meridian. This glass is called a sphero-cylinder, and is made by grinding a spherical curve on one surface and a cylindrical one on the converse.

Simple Myopic Astigmatism is a condition similar to Simple Hyperopic Astigmatism with the exception of the location of the Ametropic Meridian, which in this case is Myopic and has its focus in front of the Retina, the other Principal Meridian, of course, has its focus upon the Retina.

It is corrected by means of a concave cylinder of sufficient strength to reduce the refraction of the Meridian of greatest curvature to that of the Meridian of least curvature. To affect this the axis would be placed at right angles to the former Meridian.

Compound Myopic Astigmatism. Myopia combined with Simple Myopic Astigmatism, is a condition in which all Meridians focus in front of the Retina, but one principal Meridian more than the other.

It is corrected by a concave sphere of sufficient strength to correct the Meridian of least error combined with a concave cylinder, the exact power necessary to correct the refractive error remaining uncorrected in the opposite Meridian, the axis in all cases being at right angles to the Meridian to be corrected by the cylinder.

MIXED ASTIGMATISM. As the name implies, Mixed Astigmatism is a combination of Hyperopic and Myopic Astigmatism, one principal Meridian, that of least curvature, focusing behind the Retina, while the other has its focus in front.

Mixed Astigmatism is corrected by three different forms or combinations of lenses.

FIRST. By Cross Cylinders, in which a convex cylinder of the requisite strength to correct the Hyperopic Meridian is ground on one surface of the glass, while the reverse side is occupied by a concave cylinder to the amount of the Myopic error. The axes of the two cylinders are, of course, at right angles to coincide with the relative position of the Principal Meridians.

For example. A case of Mixed Astigmatism with 1.00 D. Hyperopia in the Horizontal and 2.00 D. Myopia in the Vertical Meridian would be corrected by +1.00 Cyl. axis 90 ⊂ -2.00 Cyl. axis 180.

SECOND. By correcting Hyperopia with plus spherical combined with minus cylinder, the power of which is equal to the sum of Hyperopia and Myopia combined, having the axis at right angles to the Myopic Meridian.

The above case would be corrected as follows: +1.00 Sph. ⊂ -3.00 Cyl. axis 180.

THIRD. Correct Myopia with minus spherical combined with plus cylinder, the power of which is equal to the sum of the error in both Meridians combined—the axis of cylinder placed at the Myopia Meridian.

The above case would be corrected as follows: − 2.00 Sph. ⊃ + 3.00 Cyl. axis 90.

The Cross Cylinders being more expensive and no more satisfactory, the two latter methods are usually employed.

ASTIGMATISM WITH THE RULE. As has already been stated, there is a predisposition in all cases of Astigmatism to an excess of curvature in the Vertical Meridian, so that Myopic Astigmatism is usually in the neigborhood of this Meridian, while Hyperopic Astigmatism is usually horizontal or thereabouts. This condition is called "Astigmatism with the Rule," and when the opposite is the case it is known as "Astigmatism against the Rule." This will explain how it is that the axes of plus cylinders are usually set somewhere near 90 and minus cylinders usually have their axis at 180.

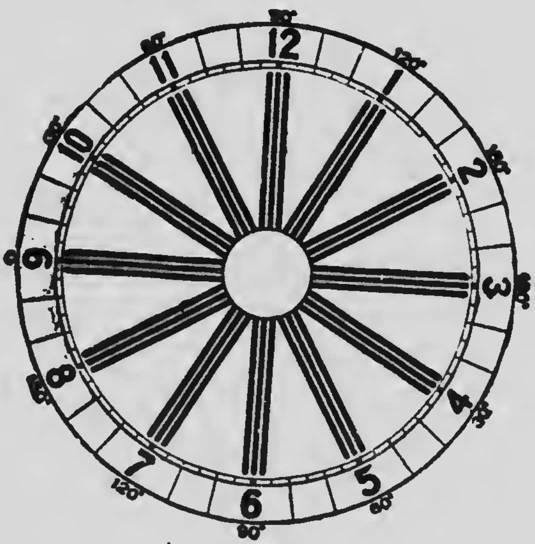



FIG. 18.
Clock Dial Chart for Detecting Astigmatism.

DETECTION AND DIAGNOSIS. The detection of Astigmatism is by means of radiating lines. For this reason test-cards have been used of different forms, all of which, however, are composed of lines radiating in the various Meridians of the circle, and the presence of Astigmatism is indicated by the ability to distinguish lines in some directions more clearly than in others. The directions in which the lines appear most distinctly being the meridians of Astigmatism, the correcting cylinder would, of necessity, have its axis placed at right angles to this Meridian. The most satisfactory arrangement in the matter of Astigmatic cards consists of four square groups or blocks of lines, each group representing the four principal directions, viz.: horizontal, vertical and the two obliques, one at 45° and the other at 135°. The advantage of this card lies in the fact that the grouping of the lines is far more effective on the sight than single lines.

The Ophthalmometer is also used for diagnosing Astigmatism. It consists of an arrangement of prisms combined with a telescopic tube, by which the curvature of the Cornea is measured in its various meridians, the difference between the greatest and the least representing the Astigmatism. This, of course, means Corneal Astigmatism.

STENOPAIC SLIT. This consists of a round metal disc with a narrow slit across it, and when placed in the trial frame in front of the eye it permits vision through one Meridian of the eye only, and, on being rotated, exposes the various Meridians in succession, and thereby permits the separate measurement of the refraction of the Cornea.

In cases of Mixed Astigmatism it is found to be of great assistance, but the successful optician does not rely upon any one method, but uses several for the purpose of verification. It is not the intention here to give the various methods in detail, but to illustrate the physiological condition of the eye in Ametropia and Emmetropia, showing the optical principles involved in the correction, but leaving applications of these principles to a future lecture.

There is one important feature in connection with the consideration of Astigmatic cases, which the young student will do well to recognize at the outset, viz.: that the discomfort experienced as a result of Astigmatism is not at all in proportion to the amount of error. In fact, it bears the reverse ratio, as we find invariably the smaller the error the greater the eye-strain and discomfort, and consequently anything above mediocrity in eye-work is only possible by close attention to small errors.

A MERIDIAN. By the term Meridian, as applied to the eye, is meant the several directions across the surface of the Cornea, corresponding to degrees of longitude on the earth's surface.

In numbering the Meridians a quadrant scale is used extending over half a circle, and consequently containing 180°, as seen on the celluloid semicircular strip of the trial frame accompanying all trial cases. The Horizontal Meridian extending from zero on the right to 180° on the left, and is known as either .O or 180, the vertical being at right angles, or just half way, is the 90° Meridian.

THE PRINCIPAL MERIDIANS are the two Meridians of greatest and least curvature, and are located at right angles to each other, so that having ascertained the position of one the other is found by adding or subtracting 90 from the number of the degree representing it.

For instance, one principal Meridian is at 40° the other will be at 130°,

The Asthenopic symptoms are somewhat similar to those of Hyperopia, indicating a condition of fatigue produced by constant strain in the effort to secure perfect vision.

DIFFICULTIES TO CONTEND WITH IN THE CORRECTION OF ASTIGMATISM. Astigmatic corrections present two distinct forms of difficulty, those inseparable from all forms of eye examination as met with in testing, and those conditions of discomfort and strain which are frequently produced by wearing a perfect correction, and which are the visible signs of the efforts the Astigmatic eye is making to adapt itself to the changed conditions created by the correction.

The difficulties peculiar to the successful diagnosis of astigmatism are largely individual in their nature, and there is little to be told in a treatise of this kind that will aid the optician in evading them. They must be encountered in actual practice, and the solution of each worked out on its own merits in the light of sound optical principles, but no absolute rule can be applied to the whole.

The occasional mis-statements in regard to the appearance of the Astigmatic lines are to be accounted for either by a misunderstanding of the questions submitted or to a want of retinal perception, and possibly in some instances to freaks of accommodation.

The occasional reverses met with in process of examination should not upset the faith of the young graduate in the soundness of the accepted optical doctrine, but should merely teach him self-reliance and the impossibility of mere text-book optics when applied to actual practice.

So in case a certain line has been selected as the brightest on the chart, and the patient has stated that plus lenses improve the dim lines, but on proceeding with a plus cylinder with axis at right angles to brightest line no progress is made, but rather a worse condition is produced, and finding on investigating that a minus lens restores the symmetry of the chart, we have only to conclude that one of us was mistaken, ourselves or the patient, it does not matter which, and proceed to the completion of the test.

The occasional freaks of imagination or accommodation, as indicated by the variable colors which the lines of the chart assume during the diagnosis are to be disregarded, and the regular routine followed of increasing the strength of the cylinder in the effort to overcome the preponderating brightness of a certain line.

In low degrees of Hyperopic Astigmatism, it sometimes happens that through involuntary action of accommodation no difference is noticed in the radiating lines of the chart, hence these amounts may be overlooked. This can easily be overcome by placing a weak convex spherical glass in front of the eye under examination, thus relaxing the ciliary and allowing a measurement of the existing error.

Passing to the second condition, under which difficulties are encountered in Astigmatic corrections, we have to face the fact that glasses which, according to all the laws laid down in text-books, were correctly fitted, and have been instrumental in largely improving the vision, are unacceptable, owing to a feeling of discomfort and strain experienced in wearing them.

Now, here we have a condition in which low visual acuity is restored to normal through the medium of glasses, which must be presumed to be correct in order to accomplish this, and a condition of eye-strain prevailing as a direct result of wearing glasses which are acknowledged to be a correction for the refractive error.

Let us see how it is possible to restore vision at the sacrifice of comfort.

In Astigmatism, owing to the fact that one certain Meridian has a greater curvature than any other, the cornea, in addition to its converging power, may be said to have a prismatic power, the Meridian of greatest curvature being its base, and consequently there will be an inclination of the retinal image of an upright object where Principal Meridians are oblique to tilt over from a vertical position, in the direction of the meridian of greatest curvature. As this would cause distortion and possibly Diplopia—especially if the Astigmatism in each eye was at a different angle—the oblique muscle, by an effort of contraction, rotates the eye-ball on its antero-posterior axis in the direction necessary to restore the retinal images to an upright position.

That this can be done is easily proved by a similar action of the recti muscles, when a prism of weak power is placed before the eye, the inevitable result of which we know is to change the direction of the visual axes in such a manner that they impinge on non-corresponding sections of each retina, but if we experience Diplopia at all it is only momentarily as the recti muscles contracting, rotate the ball until the images correspond and no distortion or Diplopia is experienced.

The oblique muscles perform a similar function in uncorrected Astigmatism.

The continual use of the oblique muscle for the purpose of maintaining erect images under oblique Astigmatism, naturally develops one particular oblique in excess of its opponent, producing a condition in which it is difficult, sometimes impossible, to entirely relax it and permit the ball to assume its normal position of rest.

When the correcting cylinder is applied, the tilting of the image is prevented by it, and consequently there is no occasion for an effort of the oblique as before, but being from long habit of contraction unable to entirely relax the eye-ball is rotated, and the now upright image is rendered oblique in the opposite direction unless the opposing oblique exert a restraining effort and prevent it.

It is the continuance of this effort by the undeveloped muscle in checking a shortened robust one that produces the feeling of strain complained of, and which exhibits the phenomenon of eye strain under perfect correction.

There is no method of removing this feeling of strain except by perseverance in wearing the correction, as the discomfort is owing to the fatigue of the hitherto undeveloped oblique muscle being called upon to maintain a continual check upon the opposing oblique to prevent it rotating the eye-ball as hitherto.

The continuance of the effort will in most cases result in developing a condition of balance between the two obliques with a consequent acquisition of perfect comfort. In some cases, however, where the Astigmatism has been for years uncorrected and the conditions of unequal balance are very pronounced, great difficulty will be found in inducing the patient to persevere with the correction, and a partial correction will have to be supplied which while giving less vision allows more comfort.

RELATIVE POSITION OF ASTIGMATISM IN THE TWO EYES. Astigmatism usually is found in corresponding directions in each eye. If one is vertical, so will the other be also; when one is found to be Astigmatic horizontally, both will usually be the same. When Astigmatism is oblique the direction of Principal Meridians will not be the same, but will generally be at the same angle with the horizontal, thus if Astigmatism is at 20° in right eye, that means that that Meridian is 20° from horizontal, and the left eye being the same would be at 160. The Astigmatism in the right eye points up to the right at an angle of 20° with horizontal line, and that of left eye points up to the left at a similar angle.

ANISOMETROPIA IN ASTIGMATISM. Anisometropia is a condition of Ametropia, in which the amount of error in each eye is of different amount. The generally accepted rule in Anisometropia is that in supplying a correction a difference of more than 2.00 D. cannot be accepted with comfort. Thus, if right eye be Hyperopic 1.00 D. and left eye Hyperopic 4.00 D., we could not fully correct the latter, as the great difference in the image formed by the two lenses would cause Diplopia. We would, therefore, according to rule prescribe + 1.00 for right eye and + 3.00 for left eye.

This rule will have to be modified in actual practice, as it is frequently found that some can accept a correction containing a larger difference while others will not tolerate any difference whatever.

A troublesome case of non-symmetrical Oblique Astigmatism having been fully corrected and vision restored occasions discomfort, and patient returns complaining that glasses cause a feeling of strain, and in spite of continued perseverance small progress seems to be made. If, in addition to radical difference in location of axis of cylinders, there is a difference in amount of Astigmatism for each eye, the burden of the correction will usually be intolerable, and it is well to reduce the correction to even amounts.

# PRESBYOPIA.

## LECTURE 7.

Presbyopia may be described as that condition in which, owing to loss of accommodation, the near point has receded beyond eight or nine inches.

It will be noticed by this definition that Presbyopia affects the vision for near distance only.

It is, in fact, not an error of vision or disease of the eye, but a physiological change peculiar to everyone at a certain time of life.

In referring to the mechanism of accommodation, we notice that the amplitude of accommodation depended solely upon the age, the amount decreasing year by year until in extreme old age absolutely no accommodation at all is found.

The near point has been described as the nearest point at which the eye can focus an object with all the accommodation in force.

The Emmetropic eye in viewing an object located at infinity would use no accommodation whatever; but if the object is brought nearer than 20 feet, accommodation is required in proportion to the distance. The closer the distance the greater the amount required. To calculate the amount of accommodation necessary for any given distance we have merely to divide the distance (in inches) into forty. An object of 20″ distance would require 2 D. accommodation, and at 8″ 5 D. would be required.

Presbyopia would, therefore, naturally be expected at that time of life when the amplitude is less than 5 D. A reference to the age table of Donders would show that this occurs at the age of about forty.

Presbyopia, therefore, is the loss of power necessary to see near objects, and is clearly indicated by the efforts those suffering from it make to read or pursue any vocation requiring the use of the eyes at close points.

In reading, when in the early stages, the type may appear clear at first, but becomes gradually indistinct as the accommodation refuses to sustain the strain necessary to focus at the point at which the reading matter is held, and to relieve this strain the type is pushed further away, giving momentary improvement, until the Ciliary Muscle still tiring, a further removal is made, when having arrived at a distance beyond which the type is constructed for, viz., the distance at which the letters will form an angle of 5″, the type is again blurred.

We have here two horns to the dilemma. If the type is approached it becomes blurred, by reason of the inability to sustain sufficient accommodation to focus on the Retina, and if removed to a distance at which the accommodation can focus, the letters form a visual angle so small that no distinct vision is possible even with a perfect focus.

As Presbyopia is a loss or want of refractive power, so its correction is necessarily an addition of refractive powers, that is a convex spherical lens.

As Presbyopia is a condition in which the nearest point of distinct vision has receded beyond eight inches, its presence is assured by the fact that certain type of a standard size cannot be read at this distance.

SECOND SIGHT. Instances are occasionally met with in which, after wearing a Presbyopic correction for years, during which period it has been utterly impossible to see at near points without them, people of advanced age suddenly find themselves able to see for near and far points without glasses and unable to do so with the glasses they have hitherto worn.

The name of Second Sight has been bestowed upon these cases, and they are frequently looked upon as miraculous. The conditions are merely the result of approaching cataract, which in its early stages acts upon the capsule of the lens—hardened and non-elastic with age—in such a manner that it becomes soft and elastic once more and consequently restores accommodation, whose loss was occasioned by this hardening process peculiar to advancing years. An eye so affected eventually loses its sight as the cataract matures.

CAUSES OF PRESBYOPIA. As Presbyopia is the condition consequent upon loss of accommodation we have to seek for the cause in occasion of lost accommodation.

In discussing anatomy and physiology we saw that accommodation was produced by the action of the ciliary muscle upon the Crystalline Lens which removed the flattening pressure exerted upon it by the suspensory ligament, thus allowing the pressure from within, acting upon the elastic membrane comprising the capsule, to force it to spring out and assume a form of greater convexity, thus increasing the refractive power of the eye.

We have seen that advancing age even in youth affected the inherent elasticity of the lens capsule, thus preventing it from responding as fully as formerly to ciliary action.

This loss of elasticity increasing year by year until finally so little accommodation is left that the eye cannot focus at a distance of eight inches when Presbyopia is said to be present.

It should be clearly understood that Presbyopia does not affect the distant vision, as an Emmetrope will frequently retain perfect distant vision even in extreme old age, where every vestige of accommodation is gone, consequently glasses supplied for the correction of Presbyopia are acceptable for near work only and will be useless at distance.

When distance glasses are necessary as well as Presbyopic correction they are sometimes prescribed in one of the various forms of bifocals which is composed of a glass with the upper part of suitable power for distance, and the lower section of the increased strength necessary for near work.

SYMPTOMS OF PRESBYOPIA. The necessity of holding the type at a greater distance from the eye than has always been customary, and the total inability to see it clearly at a close point, with an inclination always to seek for a bright light to read by, constitute never-failing symptoms of Presbyopia, and always produce the complaint of fatigue if reading is continued.

The latter symptom is, of course, identical with that of Hyperopia, as in fact the refractive conditions are the same, but that of Hyperopia is a defect that is felt at all distances while Presbyopia is detrimental t[illegible] although the symptoms are similar and [illegible] a + lens) no mistake is possible, as H[illegible]finity while Presbyopia is found by [illegible].

DIAGNOSIS AN[illegible] As Presbyopia is a condition in which the [illegible] beyond eight inches, to ascertain if it is [illegible] to find the near point. This we do by the aid [illegible] card and tape line, finding the closest point at wh[illegible] small type can be read, and measuring with rule or tape, when if it is at eight inches or closer no Presbyopia is present, but if this point is farther removed than eight inches Presbyopia is indicated, and the greater the distance the higher the amount.

The correction is always the weakest plus sphere that will restore it to eight inches.

In making the test for near point it is important that the card should be held close to the face, several inches inside the near point, where, of course, it will be found impossible to read it, and withdrawing it slowly have the patient read it immediately it becomes sufficiently clear. This will be the near point. This distance in inches divided into 40 will give the amplitude of accommodation, which, subtracted from 5—the amount necessary to focus an object at eight inches—will give the amount and the strength of the lens necessary to correct the Presbyopia.

It is important in finding the near point with card and rule that the card be held inside the P. P., and slowly withdrawn until the point is reached, and not started outside the P. P. and approached towards the eyes, as the patient will stop reading long before the actual near point is reached, and the amount of Presbyopia indicated will be erroneous.

Great care should be exercised to avoid an overcorrection, as the inclination of all Presbyopes is to secure large images, which are only possible by extra strong lenses, allowing them to hold the type at short range. Glasses fitted thus will be highly satisfactory at first, but will surely be returned in a few days with the complaint that they "strain the eyes."

Additions for Presbyopia will have to be made in cases of Simple and Compound Astigmatism as well as in Myopia, occasionally, though, the Myope when Presbyopic merely removes the distant glasses for reading, thus giving the necessary increase in refraction.

It will be noticed that the Myope's distant glasses will be weakened for reading, and the Hyperopic increased in power.

The following examples of Presbyopic combinations will make this clear:

An Emmetrope, whose near point is at 20" would require, according to the foregoing rule, nothing for distance and + 3.00 Sph. for reading. Thus 40 + 20 = 2.00, 5.00 - 2.00 = 3.00.

A Hyperope who is wearing distant correction of + 2.00, and whose near point is 11", would require for reading + 1.50 in addition to the distance glasses = + 3.50. Thus 40 ÷ by 11 = 3.50 (about), 5.00 - 3.50 = 1.50, 1.50 + 2.00 = + 3.50.

One who is wearing for distance a simple cylinder, say + 1.00 Cyl. axis 90, and whose near point is 40", would require for reading + 4.00 combined with + 1.00 C. axis 90, written thus: + 4 00 S. ⊃ + 1 00 Cyl. axis 90.

Thus 40 divided by 40 = 1.00; 5.00 - 1.00 = 4.00, which being a spherical lens and the distant glass a cylinder, their powers cannot be added, but the two separate lens combined in one lens—spherical on one surface and cylindrical on the other.

If sphero-cylinders are necessary for distance, and additions are necessary for Presbyopia, the spherical power only is changed, the power of the cylinder remaining the same for near and far.

Thus, if + 1.00 S. ⊂ + 50 Cyl. axis 90 be the distant correction, and the near point 13", we have merely to add to the spherical power ( + 1.00 ) a plus spherical of the required strength, which in this case will be + 2.00 ( 40 ÷ 13 = 3.00; 5.00 - 3.00 = 2.00), and the reading glass will be + 3.00 S. ⊂ + 50 C. axis 90.

If Myopic glasses are worn fo distance, and we wish to correct the Presbyopia, we, while adding the necessary plus glass to the distance correction, in reality subtract that amount from this power, as a convex glass combined with a concave will neutralize the power of each.

Thus, a Myope of 6.00, finding reading impossible with this correction, seeks a correction for his Presbyopia. Finding his near point at 14", you would add to the distant correction +2.25 S. (40 ÷ 14 = 2.75; 5.00 - 2.75 ÷ 2.25) - 6.00 Sph., with + 2.75 Sph. added to it, would make - 3.25 as + 2.75 would neutralize this amount of - 6.00, leaving the balance - 3.25 for reading.

In the above examples I have selected cases from all the different forms of error, and with practice with the lenses from the trial case no difficulty should be experienced in fitting Presbyopia, no matter what error of refraction it is combined with; for it must be borne clearly in mind that no correction for Presbyopia is attempted until any existing error of refraction is corrected, and with this correction on all cases becomes Emmetropic and subject to the same calculations.

We have stated that the correct lens should be of just sufficient strength to restore the near point to eight inches, but it must not be inferred from this that t. reading distance is eight inches. If care is taken in using the reading card, eight inches is the nearest point it is possible to focus an object by the use of all the accommodation and the lens prescribed combined, but not more than one-half the accommodation can be used continuously, so that in relaxing this amount the reading distance would recede to about 14 inches, which would give the best results.

Overcorrecting in Presbyopia is not only bad optometry, but bad business, as the strain on the convergence is positively harmful, and the loss of revenue entailed by supplying glasses powerful enough to correct the Presbyopia for the next five years, instead of requiring them to be exchanged for stronger ones every year or two, is certainly a poor business transaction.

EXCEPTIONS TO EIGHT INCHES AS AN ABSOLUTE RULE. The selection of eight inches as being the point beyond which a recession of near point shall constitute Presbyopia, is a point upon which many opticians differ.

In practice it will have to be considered as being the best distance that experience could select, but not be adhered to invariably, as in measuring the near point, and supplying glasses that will restore it to eight inches, we do not calculate upon the Presbyope holding the type at such a close point, but assume that he will relax at least one-half of his accommodation, thus receding the type to the generally acceptable reading distance of 14″ or 16″.

For instance, on measuring we find near point ten inches, thus indicating amplitude of 4.00 D. and Presbyopia of 1.00 D., and on supplying a glass of this strength the near point is brought to eight inches by the use of all the accommodation (4.00 D. and +1.00 spherical lens), but upon using only half the total accommodation (2.00 D.) combined with the Presbyopic correction, we have a total of 3.00 D., and focusing of course 13″.

But in advanced age, where we have found amplitude is not more than about 1.00 D., if we supply 4.00 D. according to rule to restore P. P. to eight inches, the relaxation of even the total amplitude would not enable us to focus clearly outside ten inches, consequently with a Presbyope advanced in life, and amplitude of accommodation passed below 2.00 D., it is not advisable to fit strictly up to the rule, but undercorrect at least 1.00 D.

While the ability to accommodate for 8″ would establish the absence of Presbyopia, and would be sufficient reason for refusing to prescribe glasses for near work, under ordinary conditions, exceptional cases will be found in which the patient, while perfectly able to accommodate momentarily to this distance, is unequal to the strain of accommodating for twice the distance continuously, and consequently such people, if engaged in any pursuit in which their eyes are directed to close points a greater part of their time, will suffer from eye strain and will require glasses, as if actually Presbyopic. Cases of this kind are usually the result of illness or general debility.

Those whose occupation demands that the type be held at a greater distance than 14″ or 16″, such as preachers and public speakers, when notes are used which usually rest on a pulpit or table at least 20″ or 24″ removed from the eyes, would find it utterly impossible to see at this distance if Presbyopic and corrected by lenses up to 8″, as they would be unable to relax sufficient accommodation.

The usual practice is to have the notes typewritten or manuscript, in which the characters are sufficiently large as to form the necessary visual angle at the distance at which they are used, and to supply an undercorrection for the Presbyopia.

Glasses supplied for this purpose will, of course, be unsuited for the ordinary reading distance, for which purpose a second pair will be required.

GLAUCOMA — ITS RESEMBLANCE TO PRESBYOPIA. Glaucoma is a fatal disease which frequently attacks the eyes of people in middle life, and as it appears about the Presbyopic age, and is characterized by certain symptoms resembling those of Presbyopia, it is sometimes confounded with it by young opticians.

Glaucoma is a condition in which the drainage system, called the filtration angle, is by some means stopped up, and the secretion of aqueous humor contained in the eye-ball becomes overcharged and a condition of extreme tension exists, which, unless speedily relieved by surgical treatment, results in the total loss of vision.

One of the prominent symptoms of Glaucoma is loss of accommodation, as seen in the necessity for increased strength of reading glasses, and in this it resembles Presbyopia, but while in Presbyopia the loss is gradual and slow, requiring about 1.00 D. every five years, in Glaucoma it frequently requires this much in as many months.

Rapid increase then in Presbyopia is to be looked upon with suspicion. With a little experience the optician can learn to recognize between normal and abnormal tension. The normal eye, when pressure is exerted upon it, will "give," but the Glaucomatous eye will be hard and firm, and when this condition is present, together with the necessity for rapid increase in strength of reading glass, the case should be referred to the oculist.

In concluding the lecture on Presbyopia, I would remind the young and aspiring optician that, although it is apparently the simplest form of eye error met with, it is a great mistake to treat it carelessly. Imperfectly corrected Presbyopia will produce equally disastrous results as those of any other form of error improperly fitted, and as the Presbyopic cases are by far the most numerous, the chances of error in the aggregate are proportionately large.

# METHOD OF TESTING.

## LECTURE No. 8.

Presuming that the student clearly understands the principles as laid down in the previous lectures, he will experience little difficulty in applying them to the correction of defective sight, which is the "Be all and end all" of optical instruction.

There are two distinct methods of testing the vision, Subjective and Objective.

The first of these includes all systems of measuring the refraction by means of questions applied to the patient, by which diagnosis is based upon the information received, while in the Objective method the knowledge is based upon phenomena presented to the observer's eye, without any aid from the patient. There are, of course, various instruments in use in operating under either method, but the trial case constitutes the final test in all cases, and it is this method, therefore, that will be discussed here.

For this purpose a trial case is neccessary, containing plus and minus lenses, both cylindrical and spherical, and a trial frame to place them in position before the vision.

The patient is seated at twenty feet distance from the trial card, which should hang vertically at right angles to the line of vision.

'Tis well for the young optician to cultivate a habit of observation in regard to the external symptoms of "eye error." The full, prominent eye, pushed rather forward into prominence by reason of its abnormal length, may indicate Myopia. If, in addition, the patient habitually holds objects close to his eyes to distinguish them, and in looking at distant objects partially closing the eyes in the attempt to secure better vision, possibility becomes certainty.

A small, deep sunken eye, accompanied by a complaint of inability to sustain near vision for any considerable length of time, betokens Hyperopia, while the Astigmat often possesses the same want of symmetry in his features that interfere so seriously with vision when found on the Cornea.

The manner also in which the test card is read frequently affords a fair index to the error of refraction, especially Astigmatism.

The Myopic vision is, of course, below normal, and no effort at his command can improve it one iota. He, therefore, reads down to a certain point readily and correctly, but no effort can produce any improvement. The Hyperope, however, hesitates frequently, and exerts a supreme effort of the accommodation to decipher some letters more intricate than others, but the Astigmat plunges through recklessly, hesitating at nothing, but miscalling several of the letters, and occasionally holding his hea[illegible] sideways to bring into use some particular meridian more co[illegible]ct in its refraction.

[illegible]hese are mere landmarks, however, to guide us in a pre-[illegible]nary survey, and it is not to be supposed that they take the [illegible] the optician's "Theodolite and chain"—the trial set and [illegible] by which correct distances and calculations are obtained.

[illegible]eneral success in refraction work is only to be obtained by [illegible]stematic effort and close attention to detail, nothing must b[illegible]ken f[illegible]r granted," everything must be proved.

[illegible] sligh[illegible]ariation of the well-known legal axiom will afford a [illegible] rule [illegible]work by, viz., "Consider every patient guilty of Hy[illegible]il proved innocent"

[illegible] your practice by classifying your cases under two distinct [illegible]ds, "Those who require glasses because they cannot see, and those who require them because they cannot rest."

This really means the two great classes of eye patients, Asthenopic and non-Asthenopic. In the latter case they have plodded along without glasses as long as sufficient vision is present to enable them to perform their accustomed vocations, sometimes thinking they are discriminated against by Nature in not possessing the normal amount of vision, or, at least, having less than their friends, but in other instances not realizing that they are any different to the rest of mankind.

These cases are simple, as the landmarks are so plain that the merest tyro would stumble on something that would improve vision, even though he possessed little knowledge or experience Everything that will improve vision is a correction to him. He knows nothing of 20/20. He is easily satisfied, provided he sees better than before.

The Asthenope, however, is frequently a hypochondriac. He is constantly suffering from a form of nervous trouble, his temper is affected more than his vision, and he is hard to please, because his very condition makes him distrustful of his fellow men, and he is compelled to take his glasses on trust. I mean he trusts that they will help him. The effect is not instantaneously effective as in the other class. His sight is probably perfect already, and any beneficial effect to be derived must necessarily be the work of time, and will depend upon his faithfulness in wearing the correction. I need scarcely say, that in these cases no amount of error should be considered too small for correction, particularly in regard to Astigmatism.

A careful comparison of Asthenopic cases establishes the fact that the amount of discomfort is in the opposite degree to the amount of error, that is, the smaller the error the greater the Asthenopia, and a noted English oculist, who has been highly successful in treating Asthenopic cases, claims to have found that the worst cases of discomfort were caused by one quarter dioptre of Astigmatism, and were wholly relieved by the application of the necessary cylinder.

The optician, therefore, who begins his professional career by disregarding low Astigmatism as too insignificant to notice, throws away the more lucrative part of his practice, and is doomed to failure as a refractionist.

We begin by asking our subject to read the letters on the card, noting carefully any that may be miscalled, but in no case prompting him, as they afford excellent material on which to watch the effect of our efforts at correction.

If 20/20 is read, Myopia is excluded, and the case is either Emmetropia or Hyperopia, and the former is excluded by the acceptance of a plus glass.

If, therefore, he reads 20/20 without any lens, and a +.25 spherical placed in front of this lowers vision, Emmetropia is assured, but if with it he sees equally well as without, Hyperopia is proved, to correct which we have merely to increase the strength to the strongest convex spherical lens with which he can see as distinctly as with the naked eye, this glass would at once be the measure and the correction for the Hyperopia.

It will be seen from the above that Hyperopia does not necessarily lower the vision, as in youth, while the amplitude of accommodation is sufficient to correct the error and leave enough for use at nearer distances, no defect of vision is noticed, and the enquiry for glasses is with a view to relieving the Asthenopia, which is generally present under the unnatural use of the Ciliary muscle.

The method of correction is the same in either case, the only difference is in detail, as in the young Hyperope vision is perfect without glasses. We therefore do not look for improvement, but supply the strongest plus glass that will still maintain 20/20 vision. In the case of the older patient the vision is below normal, because the accommodation is insufficient to correct the Hyperopic error, and the vision has first to be restored to 20/20 by a plus lens, and the strongest number supplied that this vision can be maintained with, otherwise distant vision is being maintained partially at the expense of the accommodation, which is particularly what has to be guarded against.

If vision is below normal and is rendered worse by a convex glass (weak), we try the effect of a weak concave, and if improvement is noticed, Myopia is assured, and in its correction we apply concave spherical glasses of increased strength, noticing particularly that each succeeding glass gives better vision than the preceding number.

Just here is where the young optician is apt to err in deciding just what constitutes improved vision, and unless the following rule in this matter is rigidly adhered to, failure is imminent. "A glass can only be said to improve vision when with it the patient can read some letters on the trial card that were miscalled or confused without it."

The patient's statement of "that is better" is to be disregarded, and the strength increased only when the previous one has given improvement according to the foregoing rule.

The correction, therefore, for Myopia is the weakest minus glass that gives the best vision.

If vision is low, and neither plus nor minus sphericals give any improvement, or at best, but partially restore the vision, we would place in a trial frame the strongest plus or the weakest minus sphere that secured the greatest amount of vision, and direct the patient to look at the Astigmatic Chart, and decide if all the radiating lines are equally distinct and black, or if there are some that are more conspicuous for their distinctness.

If the latter is the case, on locating the brightest one we direct the attention exclusively to the one at right angles to it, which, of course, is dim and indistinct.

Holding a weak plus sphere in front of the eye, we enquire if it renders this set of lines clearer or more dim. If the former, Hyperopic Astigmatism is present, and we select a convex cylinder of sufficient strength, so placed in the trial frame that its axis is parallel to the blurred lines, which will render all lines alike.

An overcorrection is proved by the fact that the lines which without the glass are the most indistinct are with it the clearest seen. If a convex sphere renders the blurred line still more dim, we assume Myopic Astigmatism is the cause, and apply a minus cylinder, with axis corresponding to the dimly seen lines, or at right angles to the brightest section, and the correct strength would be indicated by the fact that all lines were seen alike.

Each eye is tested separately, of course, the eye not under examination being covered by the black disc from the trial case.

Having examined each eye, both eyes are uncovered, and if the correction is perfect, and no Amblyopia is present, vision will be restored to 20/20.

We next measure the near point with the distant correction on, and if this is found to be within eight or nine inches the glasses are suitable for all distances, near and far, but if it be further removed than this distance Presbyopia is indicated, and additional glasses are necessary for reading purposes only.

The amount necessary to add to the distant glasses to correct Presbyopia is calculated by the following method:

With the distant glasses on we measure the near point with the reading card and tape line. This distance, divided into forty and subtracted from five, will be the approximate correction required. This is to be added, of course, to spherical power of distant correction.

These would be suitable for reading purposes only, the weaker pair being necessary for distance.

The above rule is based upon the assumption that it is desirable to restore the near point to eight inches.

There are, of course, occasions, such as with preachers and public speakers, in which a greater distance for near vision is desired, when it will be necessary to supply a weaker correction, giving poorer vision at close range, but better at longer distance.

An excellent method of refracting young persons, when accommodation is likely to be active and interfere with accurate diagnosis, is by means of what is known as the "fogging system." This method is based upon the well-known fact that Myopes do not suffer from ciliary spasm, and the accommodation is usually dormant.

The fogging system consists merely in making every case Myopic by overcorrection with plus spheres, and working backwards with minus spheres over it until a correction is reached. This plan, to give the best results, must be correctly used, and not, as is sometimes done, by removing the lens that causes the overcorrection and substituting weaker ones, as each time the glass is removed the accommodation is unrestrained and trouble will ensue. Either minus lenses should be used over the plus fogging lens, gradually increasing their strength until a correction is reached, or, if the fogging lens is changed for a weaker one, the latter must be in place before the former is removed.

In young Hyperopes, considerable more of the error is manifested by this method than were weak plus spheres used and gradually increased up to a correction.

PRESCRIPTIONS—WRITING AND RECORDING. It would almost seem as if nothing could be said upon the simple matter of copying on to the blanks provided the necessary data regarding the description of glasses and frame required.

'Tis a fact, nevertheless, that a large percentage of the prescriptions received by dispensary houses are more or less defective.

It is not at all an uncommon occurrence to receive prescriptions without any signature attached, and the only means of identification being the post-mark and the hand-writing, and as many opticians use printed envelopes supplied by dispensary houses, and the post-marks are usually inelligible, these waifs and strays accumulate in prescription houses a lasting monument to the ignorance and carelessness of the refracting optician.

Omissions of sign or axis to the cylinder render the prescription useless, and the prescription clerk is frequently left to guess at the material of frames.

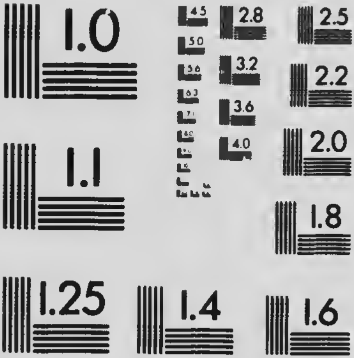
If scientific diagnosis and accurate frame fitting are essential to success in optometry, correct prescription writing and recording is scarcely of less importance, and there can be little hope of success where prescriptions are not recorded and carelessly written so that their meaning has to be surmised.

Some form of record book for recording each case in detail and a book of prescription forms is necessary.

The record should contain all the particulars of each case, the age, family history, symptoms, visual acuity, with and without glasses, the correction, and a copy of the prescription furnished and the price charged.

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



DATE__________

NAME__________

ADDRESS__________

AGE__________ OCCUPATION__________

SYMPTOMS__________

| | ACUTENESS OF VISION WITHOUT GLASSES | | | | CORRECTION | | | ACUTENESS OF VISION WITH GLASSES | |
|---|---|---|---|---|---|---|---|---|---|
| | Date | Binocular | Monocular | | Sph | Cyl | Axis | Monocular | Binocular |
| TEST 1 | | | R | | | | | | |
| | | | L | | | | | | |
| TEST 2 | | | R | | | | | | |
| | | | L | | | | | | |

HETEROPHORIA__________ PRESBYOPIA__________

| RETINOSCOPY | | | | |
|---|---|---|---|---|
| | R | | | |
| | L | | | |

PRESCRIPTION FURNISHED No__________

| | | SPH. | CYL. | AXIS | PRISM | BASE |
|---|---|---|---|---|---|---|
| FAR | R | | | | | |
| | L | | | | | |
| NEAR | R | | | | | |
| | L | | | | | |

| CAT NO | STYLE OF FRAME | EYE | P D | N H | CREST | BASE | SPECIAL |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

REMARKS__________

CHARGES__________

FIG. 19.

Ophthalmic Record Book.

Designed by the author.

All subsequent changes and modifications, and the reasons for making them, should be noted, and, particularly where Presbyopic corrections are made, the date of any changes should show on the record.

In writing prescriptions, if possible, use the printed forms provided, and write only one prescription on each form, and do not write anything else on it. Never mix letters and stock orders all in one communication.

If spherical lenses only are required, fill out the space provided for them, with the strength wanted, prefixing the algebraic sign to show whether convex or concave, also state size of eye and whether rimmed or rimless.

If cylinders are wanted, the space set apart for them should be filled out and the degree of the axis given. The same applies to sphero-cylinders, and in case prisms are wanted, in the plain or in combination, each space should be filled out, without the use of ditto marks.

If frames are required, it is best to quote catalogue number whenever possible, as this indicates material, quality, and style in the shortest possible space.

If a spectacle, give all the necessary measurements, as shown in the lecture on frame fitting. If eyeglasses, it is best to use a fitting set and quote the set number, always giving size of eye and material in addition.

If rimless are desired, it should be clearly stated, as it is customary to assume that rims are wanted, unless instructed to the contrary.

In calculating on size of lenses, bear in mind that rimless lenses are larger than the equivalent number in rimmed, as the latter is the size of inside of eye while the former is that of the outside edge.

All prescriptions should be numbered and written in duplicate, for verification in case of dispute, and should contain the name of the patient, date, and all the necessary particulars, written as plainly as possible, and the meaning should be made so clear that there can be no two opinions as to what is intended, and where several prescriptions are mailed at once the signature should be attached to each one.

| | LEFT EYE. | | | | | RIGHT EYE. | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | SPHERICAL | CYLINDRICAL | AXIS | PRISM | BASE | SPHERICAL | CYLINDRICAL | AXIS | PRISM | BASE | |
| FAR | | | ° | | | | | ° | | | FAR |
| NEAR | | | ° | | | | | ° | | | NEAR |

**FRAME**

**SPECTACLES.**

Style of frame ..........

Material ..........

Pupilary distance ..........

Height of bridge ..........

Width at base of bridge ..........

Position of bridge (Backward ..........
(Forward ..........

Size of Eye ..........

**EYE GLASSES.**

Style of frame ..........

Material ..........

Pupilary distance ..........

Thickness of nose at base of guard ..........

Thickness of nose at top of guard ..........

Inclination of guard ..........

Material of guard ..........

Size of Eye ..........

Special Instructions ..........

FIG. 20.

Diagram of ℞ form in common use.

# FRAMES AND FRAME FITTING.

## LECTURE No. 9.

### INTRODUCTION.

In the preceding lectures, while treating on the subject of lenses, I have shown that the optical centre of a lens is that point at which its two surfaces are parallel, and consequently the point at which light will pass through without undergoing any refraction, and, furthermore, it is the only point of a shperical lens where this is possible.

The visual axis has been described as a line or ray of light passing from the object looked at through the centre of the pupil to the yellow spot.

It is, of necessity, the means by which we know the direction in which the object is located, as it is in a direction corresponding with the visual axis.

If the visual axis undergoes any change of direction before reaching the eye, the position of the object from which it proceeds will be apparently changed; this is easily illustrated by viewing an object through a prism.

The visual axis, in passing from the luminous point to the yellow spot, through the centre of the pupil, can only deviate from a straight line under the influence of some refracting body, such as a lens.

If glasses are worn then, they have, in addition to their function as a correction of any error of refraction, the added power of affecting the apparent locality of the object looked at.

If, as has been shown, the optical centre is the only point of a spherical lens that will not refract a ray of light, and that light, in passing through all other points, is refracted towards the thickest part, and the visual axis being nothing more nor less than a ray of light, it necessarily follows that, unless the optical centre of the lens exactly corresponds to the centre of the pupil, the visual axis will be deviated from its straight course in passing through the lens, and, instead of impinging upon the yellow spot, will reach some other section of the retina, the consequence of which would, theoretically at least, be Diplopia, or, avoiding this by a constant contraction of one of the motor muscles, the result would inevitably be muscular Asthenopia, a condition probably far more intolerable than that which the glasses were designed to relieve.

It is important, then, that the lenses should be so placed before the eye that the optical centres of the eye and the lens exactly coincide.

There are two ways in which the want of coincidence could be brought about, viz., by reason of a decentered lens or by an ill-fitting frame.

In the present lecture, I propose to discuss the question of frame proportion or disproportion, and will leave the question of lenses to a subsequent lecture.

There are two distinct types of frame used as a means of holding the correcting lenses in position, the *Spectacle* and *Eye-glass.*

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# PART I.

## SPECTACLES, AND HOW TO ADAPT THEM.

The spectacle frame, from a purely scientific point of view, as a means of securing the desired position of lenses, with the least amount of inconvenience and discomfort, is certainly the ideal contrivance. Unfortunately, the traditions associated with the wearing of spectacles are objectionable to many, especially the members of the fair sex, as being formerly associated only with Presbyopia, or old sight—they are an unwelcome reminder that we are no longer as young as we once were. Hence, it is difficult to prevail upon young people to wear them.

It is advisable, however, in all cases where the features are not adapted to the comfortable wearing of eyeglasses, to endeavor to supply spectacles.

The various parts of a spectacle are temples, bridge, eyes, end pieces, screws and dowells.

The temples are the pieces that extend along each side of the head, and hold the frame in position.

Fig. 21.
Riding Bow.

Fig. 22.
Straight Temple.

There are two distinct types of temples, Riding and Straight, the former being of fine wire, curved to hook around the ear, and the latter of stiffened, heavy wire, usually half-round, which is curved to fit closely to the head, but are not hooked, as in the riding temple.

The Cable temple is a modern, improved form of riding temple, and is constructed of a fine coil or spiral, which is slipped over the usual fine wire of the riding temple, thus giving it more substance and, therefore, less liability to cut, while, at the same time, possessing more elasticity.

The Half-riding temple is a compromise between the straight and the riding temple, being constructed of fairly strong wire and fitted closely to the head, and the ends being slightly hooked, so as to engage the ears, and thus hold them in position.

A standard R. B. temple is 6 inches in length, laid out straight.

A standard Straight temple is 5½ inches in length.

The Bridge is the connecting link between the two eyes, and it is the most important part of the frame, as, by means of it, the frame is adapted to various sizes and shapes.

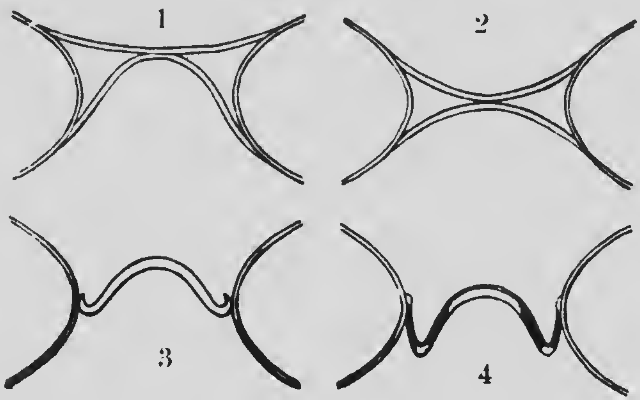


FIG. 23.

Four of the Leading Styles of Spectacle Bridges.
No. 1, "K;" No. 2, "X;" No. 3, Common (C); No. 4, Saddle (SS).

There are many styles of bridges—Saddle, Snake, Hoop, Arch, Common, "X," "K," etc., but the Saddle (SS) and the Common (C) are the only two forms in common use.

The saddle bridge is always supplied with a riding temple frame, and the straight temple is usually fitted with a "C" bridge.

The advantage of the "SS" bridge over the "C" lies in the fact that the former can be adapted to various dimensions without materially altering the shape of the arch of the bridge.

The hoop bridge is used where the distance between the eyes is small, and the nose is broad and requires all the space possible between the lenses.

The "X" bridge is reversible, being used either way, and its only use is in connection with lenses supplied after an operation for cataract, where one eye only is of use, and requires a distance and a reading lens.

The "X" frame is supplied with the distance correction in one eye and the reading lens in the other, so that the wearer, in using his eye for distance, has his distance lens in front of the good eye, and, in close work, he merely has to turn his frames upside down, bringing the reading lens into position.

The "K" bridge is a modification of the "X," and the Snake, of the Saddle.

The saddle bridge is composed of the arch or crest, by which is meant the hooped centre section that conforms to the contour of the nose, and the legs or extremities by which adjustments are made.

The eyes are the oval sections of grooved wire to contain the lenses.

Eyes are of various sizes, No. 1 being the standard size, and the larger sizes being numbered 0, 00 and 000, while the smaller sizes are 2, 3 and 4.

The eyes are usually oval in shape, but occasionally are made round for shooting, when a large, vertical range of vision is wanted, and horse-shoe eye, for use with colored lenses for protection from strong light.

Half eyes are supplied for presbyopic corrections, enabling the wearer to look over the frames for distant vision, and through them for near work. This form of frame is called "A Clerical," from the fact that they were first designed for preachers who required a correction for presbyopia in reading their texts or notes, and desired to be rid of it when looking at their congregation

The end piece, or joint, is the name given to the small block of metal at the outside end of the eye, and containing the screw or dowell, and into which the temple is jointed.

The screw is for the purpose of opening the eyes to admit the lens, and, when screwed up, to hold it in place.

The dowell is the technical name for the rivet that holds the temples attached to the end piece.

Spectacleware is usually constructed of steel, alumnico (a nickel alloy), gold filled and solid gold.

Gold is the ideal metal, as it possesses springiness and life to a higher degree than any other metal.

Gold filled, as now constructed, furnishes an excellent substitute for solid gold, possessing the color and finish, but lacking in the elasticity.

Steel is capable of a high temper, giving the necessary spring, but its usefulness is impaired by its liability to rust.

Alumnico and all nickel alloys furnish a fine-looking, non-corrosive frame, but they are always soft, and easily lose their shape.

The same description and terms apply to rimless spectacles as I have already given above.

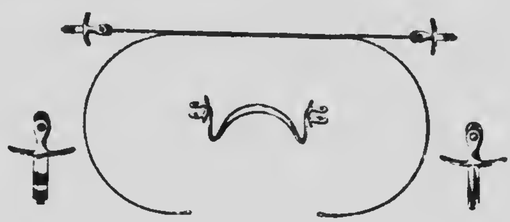


FIG. 24.

Rimless Spectacle Mountings.

Having decided that the correction is to be supplied in the form of spectacles, it remains for the operator to see that the frame selected possesses the necessary dimensions to bring the lenses into the proper position in relation to the lines of vision.

In order to secure a scientifically correct adjustment, and at the same time permit of the highest degree of comfort to the wearer, the spectacle frame must coincide in its various measurements to that of the face it is designed to fit.

The facial measurements are as follows:

Pupilary Distance (P. D.) being the distance between the centres of the two pupils. Nose height, being the elevation of the ridge of the nose above the horizontal line which passes through the centres of the pupils, the thickness of the nose at base, and the temple width or distance through the head at the temples. To coincide with these facial dimensions we have similar terms referring to frame construction.

A spectacle frame is measured for pupilary width—distance from centre of right eye to centre of left eye. Height of bridge—distance of inside of crest above pupilary line. Base width—distance across the inside of the arch. Position of crest—the position of top of arch in relation to the plane of the lenses and temple width—the distance between open temples one inch above the joint.

In measuring a spectacle frame a chart constructed for the purpose is necessary, which by placing the frame upon it we see at a glance the various dimensions according to the scale accompanying it.

The position of crest cannot be measured [illegible] and has to be estimated, but it is but a simple matter [illegible] a few weeks practice will enable the novice to calculate [illegible] nicety the exact position, merely by looking across the fron[illegible] noticing if the crest projects forward or backward of [illegible] of the lenses, and calculating the distance in sixteent[illegible] meters

It must be remembered that in this, as well as ca[illegible]tions for height of bridge, that the lower surface of bridge, wh[illegible] the nose will rest when the frame is in position, is the [illegible] to reckon from.

The following diagram will explain the method of mea[illegible]ing a spectacle frame:

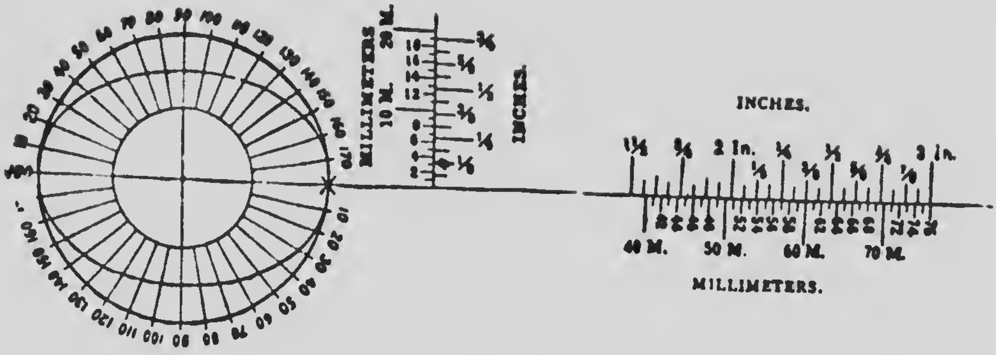



FIG. 25.

In measuring a spectacle the frame must be true, or false measurements will result.

TO MEASURE THE PUPILARY WIDTH. Place the frame on the chart with the right end of left eye (that is the point at which the bridge is soldered) exactly over the "X" that marks the intersection of the circle, the oval, and the horizontal line and the P. D. will be indicated by the figures at the right-hand end of right eye at the point where the end piece is soldered to it.

The figures above the line are in sixteenth inches, and in millimeters below the line.

THE HEIGHT OF BRIDGE is shown by placing the frame on the chart with the horizontal line running through the centre of each end piece, and the bridge resting upon the vertical scale. The figures to the right being in sixteenth inches and those to the left in millimeters.

In adapting a spectacle frame to the face the following points are to be considered: The distance between the centres of the two eyes of the frame is to exactly coincide with the distance between the pupils of the person who is to wear it. This is called the Pupilary Distance, commonly abbreviated P. D. The height of the bridge is to be just sufficient to allow the frame to rest at such a height that the eyes looking straight to the front look through the centre. If the distance between the centres of the frame be $2\frac{1}{2}$ inches, and the patient's P. D. is but $2\frac{1}{4}$ inches, it will be apparent that the centres of the lenses will be, each one, $\frac{1}{8}$ inches farther apart than the pupils of the patient, consequently, in wearing a frame of this proportion, the patient would be looking through the lenses $\frac{1}{8}$ inches from the centres, and, if the lenses were 4.00 D. in strength, this would be equal to a prism of about 1½ degrees, a condition which the eye could not tolerate for any length of time.

From this it will be noticed that there are four ways of decentering by means of a misfit frame:

A frame which is too wide in the P. D., one that is too narrow, and when the bridge is too high, and when it is too low.

It must be borne in mind that a bridge that is too high has the effect of throwing the lenses too low, and when the bridge is low the lenses will be high.

By observing, then, the question of P. D. and nose height, we can secure perfect fitting in regard to centers, but, in addition to this, we have other considerations but little less important.

The position of the lenses, in regard to their distance from the cornea, depends entirely upon the position of the crest or top of the bridge as compared with the plane of lenses.


FIG. 26.


FIG. 27.

The method of adjusting the lenses to the necessary distance demanded by the prominence of the eyeball and length of lashes.

In Fig. 26, the eyes are deep-set, as usually is the case in Hyperopia, and the bridge is set out from plane of lenses, allowing the lenses to set in close.

In Fig. 27, the eyeball is prominent, as generally found in Myopia, and the bridge crest is set behind plane of lenses, thus throwing the lenses clear of the lashes.

The ideal position to have the lenses, from a purely scientific point of view, would be touching the cornea, but, as this is an impossibility, the next best place is as near as we can place them, without coming in contact with the eye lashes.

A spectacle frame will have to be constructed according to the prominence of the eyeball and the length of the eye lashes.

A full, prominent eye and long lash will necessitate the crest being adjusted back of the plane of lenses, in order to throw the lenses further away, while the small, deep-sunken eye, with its overhanging brow, will require the bridge set forward, to allow the lenses to set in close.

Bear in mind you cannot, with comfort, change the location on the nose where the frame will rest, as nature provided a suitable spot for this purpose at the junction of the nose with the brow, consequently any scheme calculated to alter the proximity of the lenses to the face must necessarily imply an alteration of the plane of the lenses in relation to the crests of the bridge.

To bring the lenses closer to the face, the crest must be forward; to throw the lenses away from the lashes, the crest must be backward.

A frame which is correctly centered, and the crest adjusted to the right position, will insure perfect results optically, but there are other points, which are almost as important, in relation to the comfort of the wearer, which is, after all, the grand object of the correction, and in no particular can a perfect correction be so easily marred as by carelessness in adapting the base width of the bridge to the size and shape of the nose.

A spectacle frame that is supported in its entire weight at one point, and that point the sensitive bone of the nose, will surely be uncomfortable, and is positively unsightly, likewise a nose, that is ⅞ inches in thickness at its base, which is forced into the bridge of a spectacle frame ¾ inches in width, is a sore spot to the wearer, and is bound to prove one to him who fitted it, also.

The bridge should conform to the shape of the nose, and the weight consequently divided over all the wearing surface, instead of concentrated in one spot.

The next point to notice is the temple width, that is, the distance between the temple of frame where they rest against the side of the head.

If they are so narrow as to cut into the flesh like a wrinkle, they will be uncomfortable and unsatisfactory, and if they are so wide that a clear space on each side of the head intervenes between it and the temples, the frame will be very unsteady. The ideal frame just touches the temples, but does not press.

The temple width can be easily adjusted by filing the small stop-piece on the end of the temple, thus allowing it to incline outward to the required amount.

Riding temples should be curled to conform to the curvature of the ear, in order to distribute the pressure, just as in the case of the bridge.

Straight temples are held in place merely by the pressure they exert on the head, and, consequently, are unsuited for rimless work.

The modern spectacle bridge is constructed of a broad band, the under surface of which, instead of being flat is convex, so that it is adaptable for noses of various inclinations. Occasionally exceptional cases will be found in which the sharp edge of the bridge rests on the nose, instead of the convexed surface; the result, of course, will be an uncomfortable frame, and, possibly, abrasion of the skin. This difficulty can be obviated, in a measure, by bending the bridge back and up when the lower edge cuts, and down and forward in case the upper edge is pressing on the nose.

Of course but slight adaptation can be made in this way, without materially altering the height of the bridge and position of the crest, so that it may be necessary to order a frame especially constructed with the bridge at the required angle. Almost any alteration can be made successfully, provided a frame is selected that will permit of the change in height and position and still be of the required dimensions.

An ingenious method of estimating the angle of the bridge has been designed by Mr. Jerry Britton, of Montreal, of which an illustration is given below.

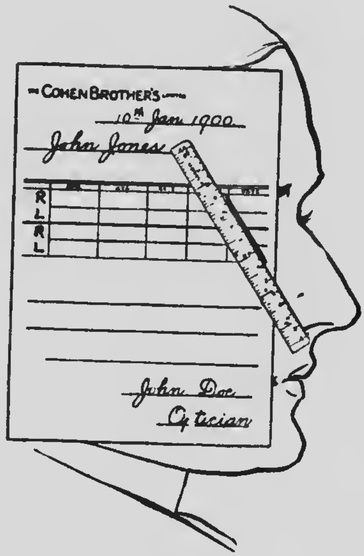



FIG. 28.

The prescription form on which the correction is written is held in a vertical position beside the face of the patient, and a small optician's rule is placed on the paper, but projecting over the front edge and adjusted parallel to the nose. A line drawn on the paper along the edge of the rule will necessarily be at the same angle with the edge of the paper as the nose of the patient is with his face.

Several instruments for the purpose of securing facial measurements have been invented and marketed, but they are generally unsatisfactory. The trial frames accompanying the trial case are graduated with a view to showing the various dimensions, but the eyes of this frame being large, it is impossible to say when the patient is looking exactly through the centres, and any mechanical contrivance, even although giving measurements fairly correct, usually produce a frame having the appearance of a "ready-made," unless the optician possesses considerable experience, and is able to supply almost by instinct some of the minor details.

The common-sense method is that of measuring a face for a spectacle frame with a spectacle frame, and for eyeglasses with an eyeglass. For this purpose fitting sets are arranged containing from one to four dozen frames, each one being different in some of its measurements to that of any other contained in the set.

A fairly complete set is composed of three dozen, and are of the most convenient form in ordinary steel frames, fitted with half riding temples and glazed with plano lenses, and marked with crossed lines intersecting at the centres and having the P. D. nose height, position of crest, and base width etched upon the lenses.

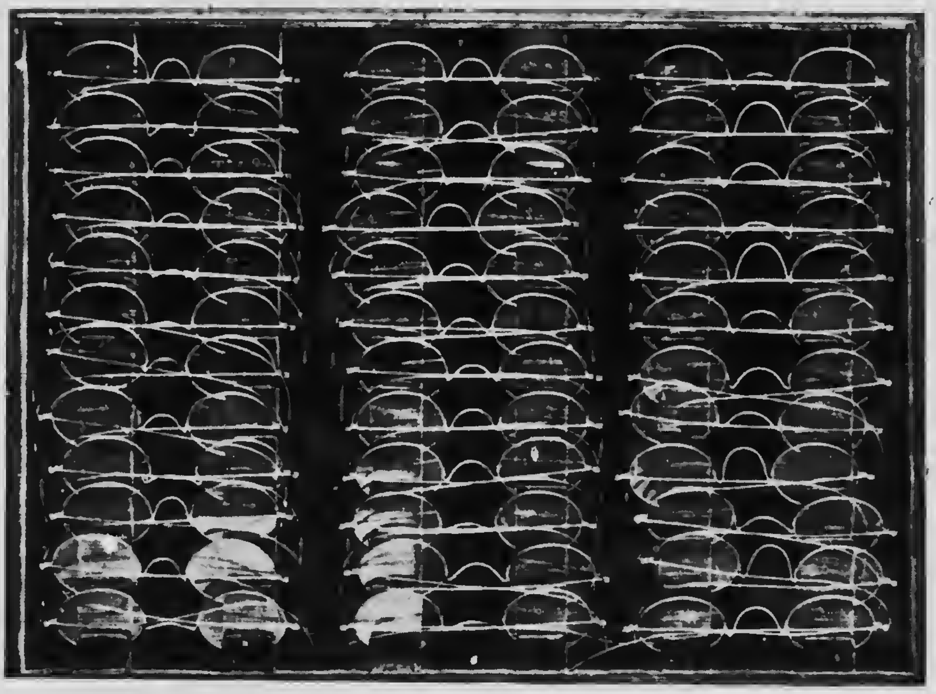


FIG. 29.
Set of Fitting Spectacles.

With this set it is a simple matter to select a frame that is of correct proportions, and we have merely to copy from the etching on the lenses the dimensions of the frame required. In out of the way measurements it may occasionally be found impossible to find all the measurements desired by means of one frame, but in this event several may be used, selecting one for P. D., another for nose height, etc.

While No. 1 is the standard size of eye, it is well to study cosmetical effect, and supply 0 or 00 eye where the face is large, even although the P. D. may be quite ordinary.

Not merely is it imperative that the modern optician should be able to select a frame of the proper dimensions, but it will often be necessary, when time is an object, to adapt a frame of certain dimensions to a face requiring slightly different ones.

For instance, where a frame of $2\frac{1}{2}$ P. D., $\frac{1}{8}$ height, $\frac{1}{16}$ forward with $\frac{3}{4}$ base is required, and the nearest at hand is $2\frac{1}{4}$ x $\frac{1}{8}$ x $\frac{1}{16}$ x $\frac{3}{4}$, and no time is allowed to have a frame made, the competent optician should be able quickly to adapt it to the required dimensions, without disturbing the shape and fit of bridge, by merely bending the legs of the bridge outward, thus increasing the distance between centres.

In a like manner the P. D. can be reduced by bending the legs inward, and the base width increased by spreading the arch, but the last operation would at the same time increase the P. D., which can be again reduced by means of the legs of the saddle.

But little change can be made in the position of crest, as in bending it backward or forward the edge, instead of the broad, flat surface, would rest on the nose, causing discomfort and abrasions.

So, likewise, a thorough understanding of the theory of frame fitting would enable the optician to straighten and true up a frame that is resting in an improper position upon the face.

Occasionally cases are met with in which the eyes are not located at equal distances on each side of the nose, in which event one leg of the saddle will have to be longer than the other, in order to bring each lens accurately before each pupil. Bony projections and malformations of the nose will also have to be dealt with in the same way, making one side of the arch a different curvature to the opposite side as the case may require.

A spectacle which is tilted up at one side so that one eye is higher than the other is usually faulty in the temples, which will be found not parallel. A right temple bent upward will drop the right eye lower than the left one. A frame in which one lens is closer to the eye than the other will be also imperfect in the temples. Examination will usually show that the temple on the eye that rests too closely does not open as wide as on the other side, and the difficulty is removed by filing the stop piece on end of temple until both temples are set back to the same extent.

The uncomfortable pressure of the riding temples on the back of the ear is usually the result of the temples being curled up too short, or a faulty curve of the hook, which should conform to the shape of the ear.

The substitution of a cable temple will sometimes be advisable. A sharp bend in the temple will always give trouble.

In supplying riding temples, care should be used, not only in adapting them in their curvature to the shape of the head and ear, but that they be just of sufficient length to pass around the ear and have the ball at the end rest in the space behind the lobe, and, in cases where the distance to the ear is abnormally long, so that the ball of the temple does not reach to the required point, a longer temple should be supplied, either 6½ inches or 7 inches, and, when this distance is unusually short, a 5 inch or 5½ inch temple should be used.

Where frames are intended for reading purposes only, it is necessary to have the P. D. slightly less than for distance, and the height of bridge greater, thus bringing the lenses closer together and lower, to conform to the changed position of the eyes in reading.

It is sometimes advisable to supply angular joints to reading frames, thus throwing the lower edge of lenses in close to the eyes, preventing the wearer from looking underneath them.

Grab Fronts or Grabs are sometimes used instead of bifocals when corrections for Hyperopia and Presbyopia are worn.

They are in the form of a regular spectacle front, with hooks at each end for the purpose of attaching them to the front of the spectacle containing the distance correction.

The Grabs of course are fitted with the Presbyopia correction only, so that when in position the strength of the two pairs are combined.

Fig. 30.

Grab Front.

A careful attention to details in frame fitting will greatly assist in the achievement of generally satisfactory results in refraction work, as being instrumental in carrying out scientifically the intentions embodied in the prescription.

A well fitted frame constitutes a lasting advertisement of competency. as everyone can see it and know whether it fits and whether or not it is becoming in style.

In fact the correct and comfortable fit of the frame is every bit as important as the correctness of the diagnosis of the error of refraction.

# PART II.

## EYE GLASSES, AND HOW TO FIT THEM.

Eyeglasses to the optician, if he be but imperfectly equipped in knowledge, stock and appliances, are a genuine "bugaboo," and he almost comes to dread the appearance of a comely female for eye examination lest she demands eyeglasses, irrespective of her nasal claims to recognition.

Many opticians spend half their time convincing their customers of the necessity of glasses, and the other half persuading them not to wear eyeglasses.

This is not as it should be, and is one of the evils growing out of our "short term schools," as the time is so limited that the student devotes his energies to the technicalities of refraction work, looking with disdain upon the apparently simple matters of distance and adjustment incidental to facial fitting.

The fact is, that the correct and harmonious fitting of eyeglasses is just as much an art, and as such, has to be learned, as the correction of errors of refraction is of science, and the student too often looses sight of the fact that his efforts at frame fitting and adjusting will, to a certain extent, make or mar his refraction work.

The problem to be faced at the outset is just this: the wearing of spectacles has been for so long associated with the advance of old age that young and attractive females, whose stock in trade consists largely in youthfulness and good looks, are not going to submit to any such badge of old age as a pair of spectacles.

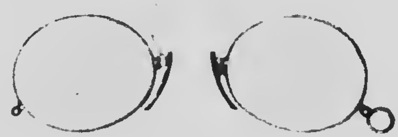


FIG. 31.
Fox Eyeglass. The most popular style of modern eyeglass.

If you expect to attain to more than mediocrity, then you must attack the eyeglass question, and until you can adjust them to any face that can retain this form of spectacleware, you must not consider yourself a master workman in eyeglass fitting.

A thorough familiarity with the names and uses of the various parts composing an eyeglass is absolutely necessary.

The parts are handle, blocks, eyes, stud or post, guard, spring, screw and hanger.

The guard is the most important part of the eyeglass, as upon it depends the clinging powers of the frame. The stud is the small post to which the guards are attached. The spring connects the two eyes, and is made in several shapes, which are usually distinguished by the catalogue number, but the high-arched form is commonly called a "hoop," while the low spread shape is called "square." A spring curved forward in the centre is known as a Grecian, while those bent suddenly forward at the posts are "tilted." "Reduced" is the name given to those in which the centre is narrower than the ends.

The studs are made of different lengths to secure different P. D. measurements, and are numbered A, B, C, D and E, B being standard, and the succeeding letters representing 1 m/m extension. An "A" post is an abnormally short post for use where very narrow pupilary width is wanted.

The handle on the modern eyeglass is a small neat ring, just large enough to receive the cord.

The law of first importance is the law of gravity. You cannot achieve any success if you have your guards do the gripping below the centre of gravity, as the dead weight of the frames and lenses will topple them over on the most perfect nose.

The guards should do all their work above their own centre, the lower half merely resting against the side of the nose to maintain the frames straight and rigid.

Another objectionable result of a neglect to do this is seen in the appearance of wrinkles down the nose and face continuous in line of contact of the guards.

It is scarcely necessary to state that wrinkles are no more acceptable than spectacles.

Eyeglasses cannot be fitted on paper. You may take the facial dimensions very accurately, P.D., thickness of nose at base and crest, and height of nose, and the result may easily be a perfect misfit, as your figures make no calculation on the bony malformations which all noses, especially Astigmatic cases, are subject to.

Fig. 32.
Eyeglass Fitting Set.

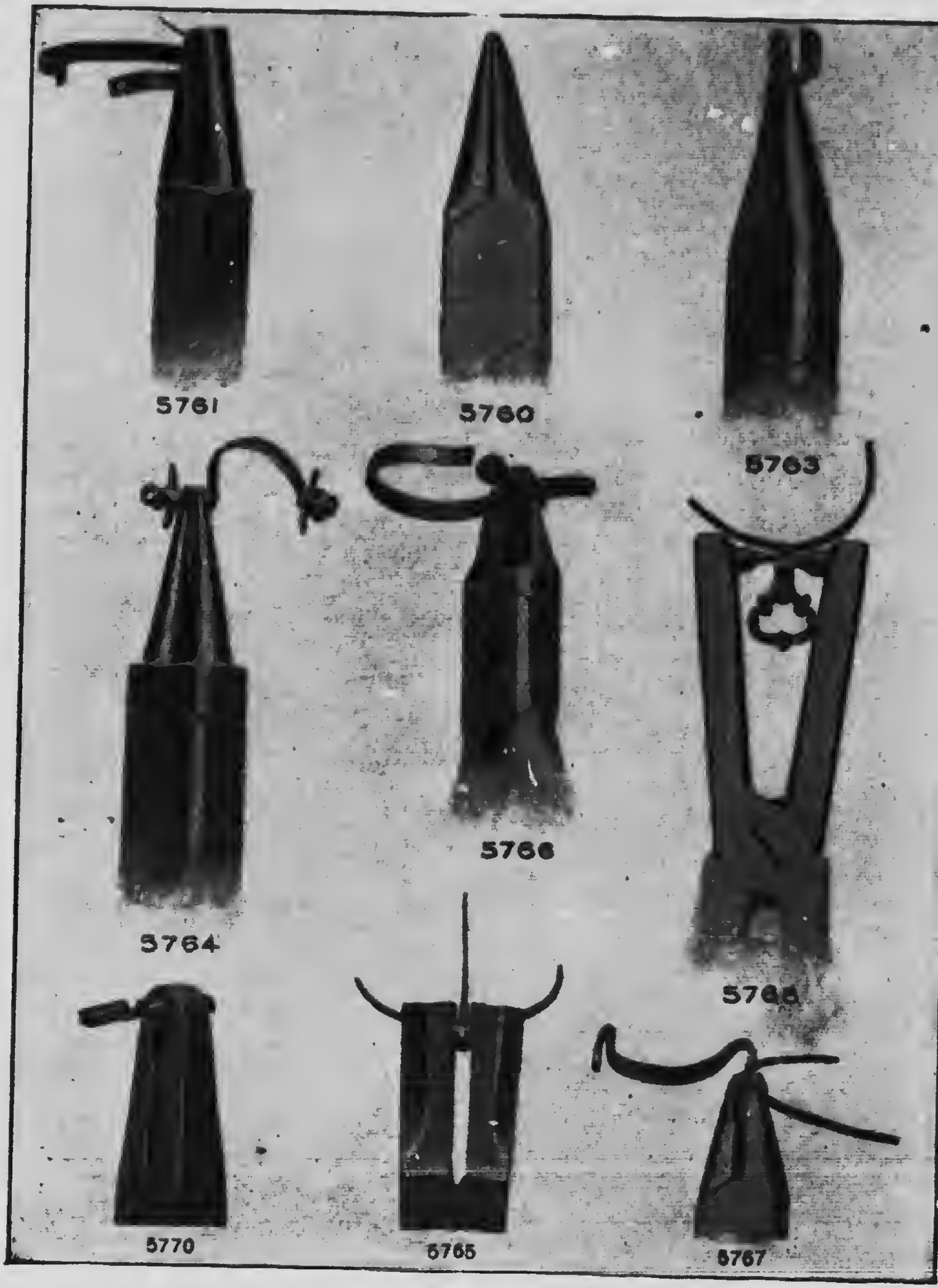



FIG. 33.

Complete set of Adjusting Pliers, by which it is possible to convert a Frame from one measurement to another, and also necessary in truing up Eyeglasses and Spectacles.

Fig. 33—5761—Concave Pliers for adjusting the spring of Eyeglass. 5760—Flat Pliers for grasping the Bridge and End Piece for adjustment. 5763—Pointed Pliers for adjusting Spring, Bridge, or Guards. 5764—Round Nose Pliers adapted for the Shanks of Bridges. 5766—Stud Pliers for grasping the Posts of Rimless Eyeglass while adjustments are made. 5768—Screw Extractor for removing rusty Screws. 5770—Guard Pliers for curving and straightening Guards. 5765—Truing Pliers for truing Spectacle Joints. 5767—Soldering Pliers for holding parts of Spectacles together while being soldered.

A perfect fitting eyeglass is only possible by means of an assortment combining all the leading styles of guard, spring and post, and even with this equipment the optician must be an adept in the use of the pliers. Guards are usually convexed on their gripping surface, but there are many noses that require the surfaces concave, and in most instances when this is necessary the curves vary on each surface, and the guard must be adapted accordingly.

[illegible] le it is necessary to effect the gripping almost entirely above the centre of guard, the more th[illegible]ht can be distributed over the whole length the greater comfor[illegible] he less liability to complain. The reason of this is evident, as the greater the surface to spread the pressure over the greater the power to stand it.

This is one of the reasons why an eyeglass in which the posts are set above the pupilary line are usually more comfortable than those of the regular pattern post which are set lower. The higher the posts are set the greater the amount of the guard that is above the centre of gravity, and consequently the more gripping surface available on them, thus making the pressure less severe and fit more secure.

Never attempt to fit an empty frame, as anyone can wear an eyeglass in this condition if the spring is strong enough. You can neither tell whether the guards are of such a form that the complete frame will remain secure, nor can you determine accurately the correctness of the position of the lenses in reference to the lashes

Fig. 34.

Various lengths of Offset Posts, used for throwing the Lenses farther away from the Eyes.

The method of setting the lenses at a greater distance than usual is by means of offset posts, but with every millimeter you give to the offset you are adding to the tendency to fall off, as you are again interfering with the centre of gravity in another direction, and as the weight of lenses is placed further out from the point of contact of the guards so will the weight be multiplied by the length of the offset.

In cases of large pupilary width, use large eyes as much as possible to secure the necessary width rather than extension posts, as not merely is the frame more rigid and exempt from vibration, but the post is not as conspicuous in using the eyes for close reading distances.

In using Grecian springs it is important to remember that the frames do not spread out right and left exactly in the same plane in which they lie when closed, but incline always towards the direction in which the spring is curved, consequently in truing up allowance must be made by having the outer ends of the lens inclining backwards, so that the whole eyeglass describes the section of a circle, and as the lenses are spread, in adjusting to the face, they assume a correct position with both lenses parallel.

One of the chief difficulties in eyeglass fitting is the tendency to "cock up" at the outer ends of the lenses.

This may be owing to faulty spring, guards or nose, or all of them combined.

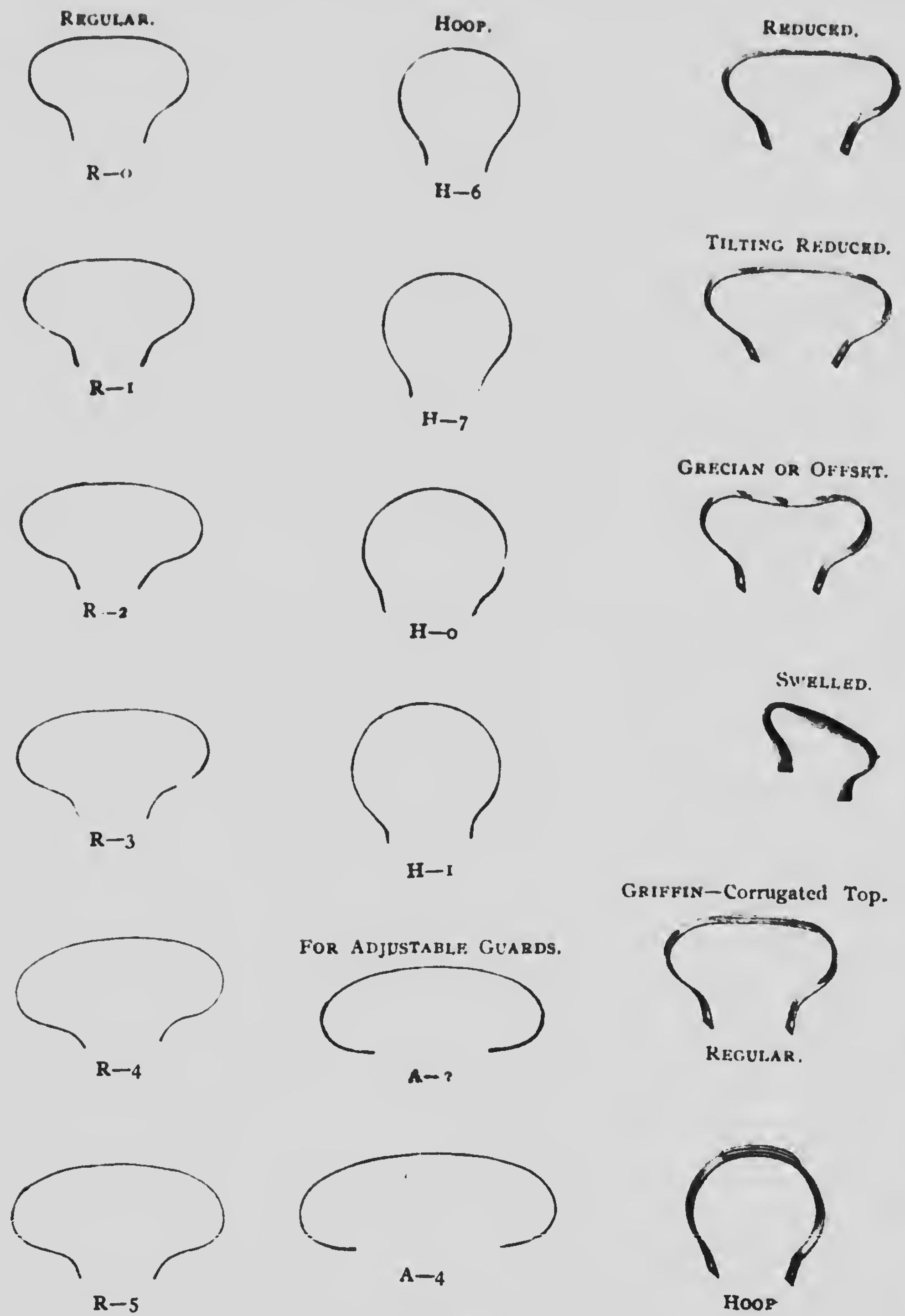



FIG. 35.
Assortment of Springs in common use.

Fig. 85—R-0, R-1, R-2—Different length Square Springs for use on Offset Eyeglasses. H-6, H-7—Standard Hoop Springs for Offset Eyeglasses. H-0, H-1—Extra long Hoop Springs. R-3, R-4, R-5—Square Springs of standard and extra length, for use in connection with Stationary Guard Eyeglasses. A-2, A-1—Standard and Long Spring for adjustable Eyeglasses.

A spring too short or too suddenly bent at the post, a guard with the lower ends too close together, or a malformed nose, with uneven bony protuberance, will always produce this.

From this it will be readily apparent that a "cocked lens" does not necessarily require a longer spring to rectify it. A slight bend of the spring, at the point where it enters the slot of the post, will throw the outer ends of the lenses down. The same effect can be produced by bending the shank of the guards in such a manner that the lower ends are more widely separated.

It is entirely a matter of experience and judgment to know which operation should be performed, as although either method would throw the lenses into correct position when on the face, only the correct method would have them straight also when not being worn. In short, the spring should be bent or a longer one supplied, when the nose is too thick to permit the glasses to rest in position without uncomfortable pinching, but the change should be made in the shape and position of guard or guards when the bone of the nose is of unnatural shape and proportions.

The old adage that "there are other ways of killing a cat besides hanging" is particularly apt as applied to eyeglass fitting, for while the bone of the nose, at a point close to its junction with the frontal bone, is the generally accepted correct position for the guards to grip, there are many cases in which there is practically no bone there, or at most a slight ridge or "kopje," which no eyeglass, even with the tenacity of the modern Boer, could be expected to hold.

Cases of this nature have to be treated differently, the gripping being done by sectional guards, in which the clinging process has to be done on the loose skin covering the upper section of the nose, with an independent lower section of the guard resting on the bone to maintain the correct position.

If, as frequently happens in cases of this kind, where the bridge of the nose is depressed the forehead is prominent and protruding, provision will have to be made with a Grecian spring, which, instead of joining the two lenses in a plane continuous with that of the lenses describe a crescent forward, thus allowing the protruding frontal bone to extend forward of the plane of the lenses.

Neglect of this will mar the best efforts, as, no matter how firmly gripped, the lenses cannot assume an upright position, and must of necessity topple forward.

There exists considerable difference of opinion among experts as to whether the best results are to be obtained with a stiff spring, adjusted so that very little "spread" is made in wearing it, or with a light spring, set close, so that a large "spread" is used. My own method is with stiff springs, set so that very little bearing down pressure is exerted upon the guards. This undoubtedly ensures greater comfort but requires greater exactness in adjustment.

Fox.

Empire.

Champion.

7½ Anchor

0 Anchor.

Lasso.

In the matter of style of guard, no specific advice can be given, as a guard that is perfect for one case may be useless for another, so that the best guard is the guard that fits comfortably and holds securely in the case for which it is intended.

Generally speaking, the best all round guard is the one that will permit of the greatest degree of adjustment. The "Fox" guard is the father of all guards, and was a great advantage over all previous efforts. Its great weakness is its total want of adjustability. It cannot be adjusted at all.

The Anchor is very similar to the Fox, with the addition of an independent arm fitted with a pad.

This form of guard is useful in M-shaped and hollow bridged noses, when the gripping has to be done on the skin and the position maintained by an independent pressure on the bone.

One of the results of defective fitting is the appearance of abrasions at the gripping points.

These usually are the aftermath of shell-faced guards, where care has not been used to present the rounded surface to the point of contact.

Many opticians make a rule of always using cork facings in order to avoid these sore spots, but the fact is, cork facing will produce sores of greater magnitude than shell, owing to the fact that in hot weather the cork absorbs the perspiration, and the dust adheres to them and remains a constant source of irritation, grinding the skin by constant friction.

Shell guards, properly fitted, with the sides rounded off and carefully faced so that they do not bear in the flesh, will give perfect comfort, and will permit of the greatest adaptability.

Some people, in selecting eyeglasses, express a preference for a certain shape of spring, but the experienced optician will consider the spring as much a part of his prescription as the lenses, and use the style best adapted to each case.

The general appearance can be largely improved or marred by the kind of spring selected. The effect of a large round face can be considerably toned down by means of a high hoop spring, while the low square spring would exaggerate the lateral proportions of the face to a ridiculous degree.

Long, narrow, attenuated faces can be transmogrified by the use of wide low springs on eyeglasses with prominent handle.

These may seem small points, but they are the ear marks of the competent optician.

Considerable trouble is experienced in the use of rimless glasses by people with heavy, overhanging brows and deep set eyes, as, in setting the lenses close to the lashes, the upper section comes in contact with the brows, and the warmth of the body communicates itself to the lens, which becomes misty.

It can be overcome by making the lenses D shaped instead of oval, the upper edge being the straight line. If a fairly secure fit can be accomplished, it is advisable to supply rimless eyeglasses without handle or chain, as the additional weight is a disadvantage. A hole bored in the lens and a silk cord affo the greatest protection.

It is, of course, unnecessary to warn Canadian opticians of the ill-effect of folding-up eyeglasses, as this is so well recognized here that eyeglasses are no longer made in this country with the necessary catch for folding. In England, however, they still consider it of more importance to fold the lenses over each other when not in use, in the same manner that their forefathers did, than it is to have lenses that can be seen through.

If you are not as competent in eyeglass fitting as you are in refracting, do not add to your refracting equipment one cent's worth until you have brought yourself, at least, to an equal state of proficiency in fitting.

If you have intentionally slighted this feature of optical training, under the impression that it was of secondary importance, you cannot undeceive yourself too quickly.

The public may frequently be in ignorance as to whether your glasses have been a perfect correction, but they do not long remain in ignorance of comfort and elegance, or the absence of these essentials in the means you employ to supply your correction.

# A STUDY IN LENSES.

A lens has been described as a transparent object so formed that it will reflect light rays.

The refractive power of a lens will depend upon two conditions, the degree of density of the material of which it is constructed and the obliquity of the angle of incidence.

A few years ago spectacle lenses were constructed largely of so-called "pebble" or Iceland Spar, as the refractive power, or rather index of refraction, was high and the material was hard, rendering the surface cap le of accepting a very high polish and not easily scratched.

Of late years the quality of the pebble has greatly deteriorated, while that of glass has equally improved, until to-day practically all the lenses used in spectacleware are made of glass.

Assuming, therefore, that all lenses are made of glass with the same index of refraction, the difference in refraction in the various strengths is a question solely of shape, or, technically speaking, curvature.

Lenses for the correction of visual errors are either spherical or cylindrical, and are made with their surface either convex or concave.

Spherical lenses are so called because their surfaces are sections of spheres, and are ground to the required curvature by means of cast-iron plates, called "shells," which, being turned by means of automatic lathes to the required curvature, are covered with hot pitch, into which the rough piece of glass is stuck, and, after cooling and hardening, this shell is attached to a shaft which revolves it sl wly, and a second shell, concaved to fit the desired convexity of the glass to be ground, is attached to a second shaft, and resting on the glasses in the first shell they are, by means of emery sprinkled over them, ground to the curvature of the grinding shell.

They are afterwards smoothed and polished with fine emery and rouge.

In bi-convex or bi-concave both surfaces are equally curved. In plano-convex or concave one surface is flat and the other possesses all the curvature.

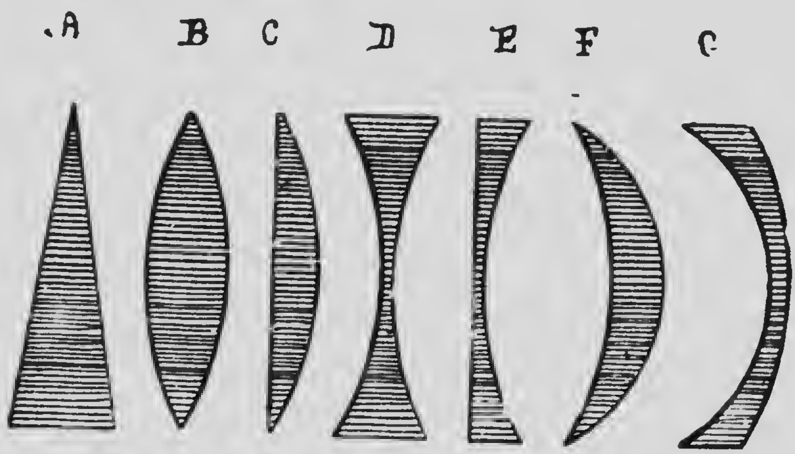



FIG. 37.

A Prism. B Bi-convex. C Plano Concave. D Bi-concave. E-Plano Concave. F-Periscopic Convex. G-Periscopic Concave.

Periscopic lenses have a combination of convex and concave curvatures,

In the Periscopic Convex the inner surface consists of a concave curvature, which in standard American lenses is always the same (1.25) curve, no matter what the strength of the lens, and the front surface convex. Consequently, the front surface will always be of a curvature representing 1.25 D. greater than the total refraction of the lens, as this amount is required to neutralize the reverse curvature of the inner surface.

In Periscopic Concave Lenses the front surface is always 1.25 convex, and the inner surface over curved to the same amount. The Concave surface is always placed towards the eye.

It is claimed for the Periscopic lens, which is the form in general use, that it affords a wider field of vision than either Doubles or Planos.

Lenses, as already stated, are of two kinds, Convex and Concave, and are known by various other names, Positive, Converging, and plus (+) being used to indicate Convex, and Negative, Diverging and Minus (–) meaning Concave.

In Canada the algebraic signs + and – are generally used prefixed to the number indicating the power of the lens.

For many years lenses were numbered according to the inch system, by which method the power of a lens was indicated by the number of inches in its focal length, but this method being complicated where mathematical calculations became necessary as well, owing to the fact that the length of the inch varies in different countries, the metrical system has of late years come into general use.

By this method the refracting power of the lens and not its focal length is indicated by the number used. The unit of the metrical system is 1.00 dioptre. A glass whose focal length is one meter (40″) and the fractional parts indicated by .25 .50 .75, just as in the decimal currency.

The proportion between the refractive power of a lens in dioptres and its focal length in inches is in an inverse ratio, the higher the refraction the smaller the focal length, for instance, 1.00 dioptre equals 40 inches; 2.00 dioptre equals 20 inches.

To measure the strength of a spherical lens we require a selection of lenses comprising the various numbers in convex and concave.

We must first know whether the lens to be measured is plus or minus. This we ascertain by fixing the eye upon some object and interposing the lens move it up and down, and it will be noticed that if the lens possesses any refractive power the object will apparently move as we move the lens.

If the lens be convex the object will apparently move to the opposite direction to the movement of the lens, but if concave the motion is in the same direction.

We then select from the trial case a lens of opposite kind, and placing it over the lens being measured, the movement test is repeated, and finally we find a lens which combined with it neutralizes all motion in the object viewed. The power of the lens from the trial case will be the strength of the lens under measurement, but of opposite kind, one being plus, the other minus. This is called neutralizing when referring to spherical lenses, and analyzing in reference to compounds.

The size of a spherical lens is necessarily limited by its power, for as the surfaces are sections of circles it is evident that a lens whose surfaces are sections of a certain sized circle cannot be constructed of a greater diameter than the circle itself, and even then would be too bulky for use.

This feature, of course, will not be apparent in spectacle lenses, as their size is always below the required limit, but in reading and magnifying glasses it will always have to be considered.

Cylindrical lenses, now so extensively used in the correction of Astigmatism, are of comparatively recent invention. As implied by their title, they are of cylindrical form, being ground on a cylindrical shaped shell, just in the same manner as spherical lenses, with the exception that the motion of the shell in grinding instead of being rotary is lateral.

It must be clearly understood that the refractive power of a lens depends upon the curvature of the surfaces or the angle at which the surfaces form with each other.

The spherical lens being curved equally in all directions as a section of a globe will refract equally in all meridians. The cylinder has, of course, one direction in which no curvature exists, consequently it has no refraction or power in this meridian.

This absence of curvature can be easily illustrated if we observe an ordinary iron column of a building. It will be seen at a glance that it has no curvature towards the length of the column.

The cylinder is a glass ground on this column and consequently identical with it in form, and in one direction has no curvature whatever.

This plain meridian is called the axis of the cylinder, and all other meridians are curved differently, those nearest the axis slightly, and that at right angles to it possessing the greatest curvature of all. It is from the curvature of this meridian of greatest magnitude that the cylindrical lens takes its strength. For instance, if a cylindrical lens is ground upon an iron column of 20″ diameter, the focal length of meridian of greatest curvature would be at 20″, and it would be a 2.00 D. glass. One principal meridian would have no curvature and consequently no focus or refraction, and the others of different foci up to 20″—the glass is numbered according to the power of the greatest meridian.

Cylinders are either plano or compound. In the former one surface is plano or flat, and the other cylindrical.

In compound or sphero-cylindrical, the one surface is spherical in shape, the other cylindrical. It is thus a combination of these two forms of lenses.

To neutralize a plano-cylinder we have first to locate the direction of its axis. This we can do by means of the motion test referred to in neutralizing sphericals.

The object moving the same direction as the lens indicates concave and the opposite convex, and no motion at all indicates no refraction.

So, if the object viewed moves with the motion of the lens refraction is proved, and we merely rotate the lens in our fingers while continuing the motion test, and if the motion continues the same in all meridians it is spherical, but if in one direction there is no motion the glass is cylindrical, and the direction of " no motion " will be its axis.

It will be readily apparent that a sphero-cylindrical lens will produce motion in all directions, owing to the presence of the sphere in its composition, but as the speed of the motion will be greater the stronger the lens, consequently in the direction of the greatest power of the cylinder (that is, at right angles to its axis) the motion will be greatest.

A simpler plan is to fix the eye upon a straight line (a window sash will serve the purpose), and interposing the lens to be measured rotate in front of the eye. If spherical the line will remain straight while the glass is rotated, but if cylindrical it will rotate with the glass.

The line, as seen above and below the glass, will be continuous with the section seen through the glass only when the line is parallel or at right angles to the axis of the cylinder. In all other positions the line will be apparently broken at the boundaries of the glass.

Having located, by this method, the two principal meridians, and marked them with an ink line, we have merely to neutralize the motion with the trial lenses in these two directions.

The least amount being the power of the spherical lens, while the difference in power in the two principal meridians will represent the strength of the cylinder, while the degree of its axis is located by means of a protractor, showing the different degrees of the circle.

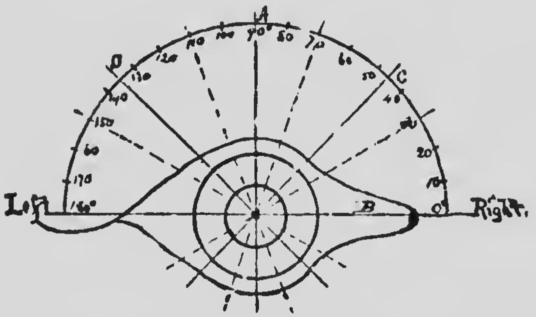



FIG. 38.
Protractor for locating Axis of Cylinder.

The power of a lens can be quickly measured by means of lens gauges which indicate upon a dial the degree of convexity or concavity of their surfaces.

Prismatic lenses have no focus, and consequently are not used in correcting errors of refraction. The power of a prism consists in apparently changing the position of the object looked at, and as the muscles are used for the purpose of directing the eyes to the object when they are defective, and perform these functions with difficulty, we prescribe prisms to bring the object to where the eyes can be directed with comfort instead of undergoing the discomfort of bringing the eyes to the object.

It will be very evident, therefore, that if the muscles being defective, and the act of directing the eyes to the object being an operation involving pain and discomfort, and which is relieved by the use of the prism bringing the object to a point of rest, that if the muscular condition is normal and a prism be placed before the eyes, displacing the object, it will necessitate a constant effort on the part of one of the muscles to keep the eye directed to the new position.

We have already described a prism as a three-sided figure consisting of two sides, a base and an apex, the two sides inclining together and forming an angle at the apex, and that light in passing through refracts towards the base or thickest part.

It is merely the fact of difference in thickness that produces the refraction. Any transparent substance of different density to the atmosphere will cause refraction if in one place it is thicker than in others, a convex lens being thicker in its centre, light refracts towards this point, while in the concave it refracts away from the centre.

A spherical lens then, if so placed that its optical centre (the thickest part, if convex) is not in front of the centre of the pupil, will in addition to its function as a spherical glass, with power to magnify or diminish, posseses that of a prism, and will change the direction of the light rays, passing into the eyes in such a manner that the object will appear to change its position until the muscles are brought into operation and once more restore it.

Spherical lenses are sold in stock quantities, and are graded in price, presumably according to quality. All the various qualities are ground from the same stock, the first quality of finest lens being the survival of the fittest. Scratches, chips and imperfections in shape, edge or centre, furnishing the reason for consigning them to the various inferior grades.

The most serious defect, and the one least conspicuous to the inexpert, is the imperfectly centering or decentred lenses, a condition in which the optical centre is not in the middle of the lens. The optician who prescribes a lens of this kind for Hyperopia is condemning his patient to carry the burden of a prism regardless of his muscular condition.

Spherical lenses are sold in stock quantities, and are made interchangeable in size in order that they may be mounted in interchangeable frames.

In ordering edged lenses, unless special size is mentioned, it is always assumed that No. 1 is required, and orders are filled accordinly, without question.

It should be clearly understood that while the same method of indicating the sizes of rimless lenses is used, that the sizes do not coincide, as a one-eye rimless lens is the size of the OUTSIDE of a rim of a one-eye frame, while the one-eye edged lens is necessarily the size of the INSIDE of the rim.

## DIMENSIONS OF INTERCHANGEABLE LENSES.

| NO. | | RIMMED. | RIMLESS. |
|---|---|---|---|
| 1 | Standard - - - | 36.5x27.5 m/m | 37x28 m/m |
| 0 | 1 size larger than Standard, | 37.8x28.8 " | 38.5x29.5 " |
| 00 | 2 " " " " | 39.7x30.7 " | 40x31 " |
| 000 | 3 " " " " | 40.9x31.9 " | 41x32 " |
| 2 | 1 " smaller " " | 35x25.5 " | 36x27 " |


Fig. 89.

Lenses for rimless purposes are usually selected from somewhat thicker stock than edged lenses, in order to insure greater bearing surface on the screws.

Rimless glasses are extensively worn, owing to the fact that they are inconspicuous, and larger lenses can be used than is possible with rimmed goods, thus giving a larger field to vision without destroying the proportion essential to perfect cosmetic effect.

Lenses are made of colored glass, either smoke, blue or pink, for the relief of Photophobia. These are made in six shades, numbering from No. 1, which is the lightest, to No. 6, the darkest.

In smoke tint a special dark shade called "electric" is made for use in connection with electric lighting plants, or occupations where a very strong light is necessary.

Lenticular Lenses are of recent invention, and are made either in concave or convex. In the convex form they consist of a circular plano convex disc, of the required strength, and of about 7/8 inch diameter, cemented on a plano lens; while in the concave a plain slab of glass is used, of about one-half the thickness required to grind the lens required in the ordinary form. In the centre of the glass a circular concave disc is ground of the required curvature.

Lenticular Lenses are, of course, only advantageous when they are of strong power, such as for cataract, or high myopia. They are very light in weight and neat in appearance. The central part of this lens—that is, the disc—is, of course, the only part that possesses the requisite amount of curvature, but as in the ordinary lens, when the curvature is spread over the whole surface of the lens, the periphery is useless owing to aberration, so that this curtailing of the field is not a disadvantage peculiar to the Lenticular Lenses.

Bi-focal Lenses are constructed with a view of affording the advantages of perfect adaptation of one glass for near and far work.

They are of four distinct types, Solid, Split, Perfection and Cement.

These four are alike in principle, but different in d 'ai' In all of them the lower portion of the lens, through which the light rays from near objects must pass in entering the eye, is of stronger refractive power than the upper part, through which distant objects are viewed. Solid Bi-focals are constructed of one piece, which is first ground to the power necessary for reading and near work. The lens is then attached to the shell, and the upper section ground to the curvature required for distance. The prismatic effect introduced in grinding the upper section to the refraction required is so great as to destroy their usefulness. The shape of the reading section, which is an inverted crescent, is also inconvenient.

The Split Bi-focal consists of the half of a complete glass, suitable for reading, combined with half of the distance glass. While not as objectionable as the solid form, they are by no means a satisfactory lens, and have fallen into disuse.

Cemented Bi-focals are the most common form of double vision glasses, and are made by cementing onto the lower section of the distance glass a thin wafer, possessing the necessary additional power for reading. This wafer is usually made crescent shaped, but can be made to any design required. Canada Balsam is used in cementing, and the prismatic feature is avoided by decentring the wafer a like amount in the opposite direction, one prism thus neutralizing the other.

The only objection to this form is their liability to blister, that is, the wafer becomes slightly detached with a sudden jar, and adn the air between the two surfaces, and interferes with the ..nsparency. They are, however, easily repaired.

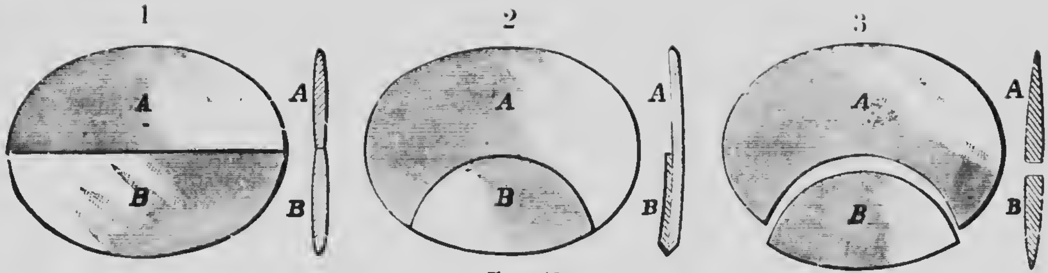



Fig. 40.
Bi-focal Lenses. 1-Split. 2-Cemented. 3-Perfection.

As the cement bi-focal has become a staple article among opticians, a brief description of the method of making and repairing will be useful and interesting.

In making a new lens, the main lens of the required strength for distance is cut to the proper size, but not ground (edged). The wafer, of the strength necessary to increase the power of the distance glass to the strength required for reading, is placed on top of it with one drop of Canada Balsam between them. With a pair of blunt tweezers, the two pieces are held in the flame of an alcohol lamp or Bunsen burner until the cement boils freely. In cooling off, the wafer is adjusted in place, and the air bubbles squeezed out, and the whole is edged to the required size, and the surplus cement cleaned off in methylated spirits.

It will, of course, be readily apparent that, in order to effect an invisible joint between the two surfaces, they must be exactly corresponding curvature, in order that they may closely attached.

In Periscopic Convex Lenses, the inner circle is always − 1.25, so that the wafers are necessarily + 1.25.

In Cylindrical Bi-focals, one surface is plano, and consequently requires a wafer with a plain surface.

In Sphero-Cylindrical Bi-focals, the wafer has to be specially ground to fit the curvature of each glass. This will account for the large cost of the latter as compared with the former.

In repairing Cemented Bi-focals, the lenses are warmed in the flame, and the wafer pushed off, and both sections thoroughly cleansed in alcohol, and recemented as in the case of a new lens.

Care must be used in cementing on the proper side.

Perfection Bi-focals are made from two distinct lenses, one adapted for distance and the other for reading.

From the lower half of the distance lens a crescent-shaped section is cut out and the edge ground smooth, and a corresponding piece cut from the centre of the reading glass is fitted to it.

These two latter forms of Bi-focals give good results, and are perfectly satisfactory.

The general objection to Bi-focals is, that in going upstairs the eyes are turned down to see the position of each step, which is located probably four or five feet away, but the lower section of the glass is adapted for reading distance (say 16 inches), and consequently the stairs are indistinctly seen, and the wearer is liable to stumble. This, while a disadvantage, is very much less so than that of having to constantly change one's glass for distance to reading, and can be easily overcome by learning to use the stairs without looking at them.

The Coquille Lens is usually a smoke or blue-tinted glass curved to the form of a shell, from which fact it takes its name. They are worn as a protection from the sun or snow, and are made in two ways.

The ordinary Coquille, such as is commonly sold for the purpose, is a cheap affair in which the pieces of glass are pressed up while hot, and consequently are full of optical imperfections.

The ground Coquille is made from a thick block of glass in which the shape is formed by grinding. Their expense prevents their coming into general use.

Shooting Lenses (Diaphram Lenses) consist of either white or colored lenses in which a circular disc of about five-eights of an inch in diameter is left transparent, the remainder of the lens being frosted.

These lenses, as the name implies, are used for target shooting, for the purpose of curtailing the field of vision and thus enabling the marksman to concentrate his sight upon the target.

Toric Lenses are of recent invention, and their cost has hitherto prevented their general use.

They embody the optical principles of a sphero-cylinder, but the whole of the compound curvature is ground upon one surface. A slice cut from a wedding ring would illustrate the form of a convex Toric Lens.

Cross Cylinders, now so little used, unite in one lens two cylinders with their axes at right angles.

Prescriptions calling for Cross Cylinders are usually reduced to their sphero-cylindrical equivalent, which are made lower in price and afford the same refraction.

Cross Cylinders are reduced according to the following rule: Use a spherical of the same power as a plus cylinder in the combination, with which combine a minus cylinder, whose power is the sum of the two cylinders, having its axis placed the same as the minus cylinder in the original cross cylinder. Thus, the following Cross Cylinder + 1.00 C. axis 90 ⊃ − 2.00 S. axis 180 reduced = + 1.00 S. ⊃ − 3.00 C. axis 180. These can also be reduced by substituting a minus sphere and continuing with a plus cylinder, the power of which is the sum of the two original cylinders, the axis the same as the plus cylinder.

In this method, the foregoing example would reduce to the following sphero-cylinder: − 2.00 ⊃ + 3.00 axis 90.

Sphero-Cylindrical combinations are of three forms + ⊃ +, − ⊃ −, and + ⊃ −. When the sphere and cylinder are of the same sign that is, + ⊃ +, or, − ⊃ −, it is already in its simplest form, and no reduction is possible; but when + ⊃ −, or, − ⊃ + is met with, unless the cylindrical power is greater than that of the sphere, the formula is not in its simplest form and will reduce to + ⊃ +, or, − ⊃ −, whichever kind the spherical is.

A formula of this kind will reduce by the following rule: Subtract the cylindrical form from the spherical, which will give the correct spherical power with the same sign as the original sphere. Combine with this the original cylinder with sign and axis changed, thus: +1.00 S. ⊃ -.50 Cyl. axis 180 is subject to reduction by this rule +1.00 - .50 equals +.50 ⊃ +.50 axis 90.

The following three rules will, if thoroughly understood, enable the optician to solve the most complicated problem in reduction.

1. Plus and minus cylindricals of the same strength, and axis the same degree, neutralize each other, thus: +.50 C. axis 180 ⊃ -.50 axis 180 = plano.

2. Two cylinders of the same strength and kind, and axis at same degree, double their power, example: +1.00 C. axis 180 ⊃ +1.00 C. axis 180 = +2.00 C. axis 180.

3. Cross Cylinders of the same kind and strength equal a spherical of the same strength and kind, example: +1.00 C. axis 90 ⊃ +1.00 C. axis 180 = +1.00 sph.

# RETINOSCOPY.

## (THE SHADOW TEST)

Retinoscopy is the method of diagnosing errors of refraction by means of light reflected into the eye, by which the various conditions of Ametropia are indicated by a different appearance and motion of light and shadow effect as the mirror is rotated.

Retinoscopy has been so simplified of late years, and its value becoming better appreciated, it has at length become the most popular form of objective test.

Retinoscopy has come into general use by opticians because its successful practice, while requiring high mechanical skill, demands little or no scientific knowledge. It is not even necessary to understand the scientific principles underlying it, if one can quickly recognize a rapidly-moving shadow, and remember that moving in a certain direction indicates Hyperopia and in the opposite direction Myopia.

As a means of arriving at definite results with illiterate people and children, it is unequalled, and in discerning the presence of spasm. without the aid of a mydriatic, it is invaluable.

Another point in which it appeals to the rank and file is in the matter of expense, as it is possible to conduct experiments in Retinoscopy, and to arrive at a fair state of proficiency, at an outlay of five or six dollars, and, as it is more of an art than a science, but little instruction is necessary, as expertness comes from practice not preaching.

The Retinoscope consists of a circular mirror from ¾ inches to 1½ inches in diameter mounted in a metal rim and having a handle attached.

In the centre of the mirror the silver is removed, leaving a round peep hole of 2 or 3 m/m in diameter. The mirror may be either flat or concave, but as the former has come into general use it will be sufficient to discuss that form only.

Thorington's Retinoscope, which has become quite popular recently, consists of a circular $\frac{3}{4}$ inch mirror, mounted on a metal back $1\frac{1}{2}$ inches in diameter, thus giving the advantage of the small mirror in the interests of scientific exactness and the convenience of the large disc, which more easily adapts to the eye in operating, as its edge can rest against the side of the nose and thus steady it.

The small mirror, while more difficult to manipulate in the case of a beginner, gives much better results when one becomes expert.

The handle, of rubber or ivory, is jointed for covenience in packing, and the sight hole is now usually made by removing the silver instead of perforating the glass.

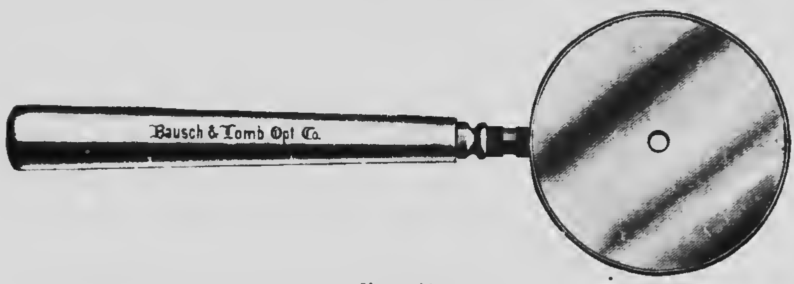



FIG. 41.

Hand Retinoscope, with plane mirror.

In the practice of Retinoscopy, in addition to the mirror, a properly arranged light, and lenses for measuring the error are necessary, as well as some form of dark room.

The room should be entirely darkened and the light—of which an argand burner with oil or a Wellsbach gas light are the best—so arranged that it can easily be adjusted to the desired position.

FIG. 42.
Bracket suitable for oil or gas, and capable of universal adjustment.

FIG. 43.
Asbestos Chimney with adjustable diaphram opening.

The flame should be enclosed in an asbestos chimney, constructed with a circular apperture capable of adjustment—either by means of a series of variated holes or by the use of a diaphram shutter. The light should be placed about six inches to the left front of the operator, and the patient seated forty inches away directly in front, and it is important that the observer's eye, the patient's eye and the light be at exactly the same elevation, so that the control of the illumination becomes much easier. This can be done by means of the adjustable bracket referred to and the use of adjustable elevating chairs for patient or operator, or both.

The patient should be cautioned not to look directly at the mirror, but just past the head of the examiner into the darkness, thus avoiding a natural tendency to accommodation in looking at a near object.

It is advisable to have the trial frames in position, and a plus lens, sufficiently strong to fog all accommodation, before the eye not under examination. Having arranged the patient at 1 metre distance as comfortably as possible, to avoid any movement during the examination, the light is brought down into position as close as possible on the left front, and the Retinoscope, held in the right hand, is placed in front of the right eye, pressed up tightly against the brow and nose to hold it steady, and the light from the opening in the chimney, shining across in front of the observer's left eye, strikes the mirror and is reflected back and illuminates the face of the patient with a bright, round spot, everything else being entirely dark.

If the mirror is now slowly tilted back and forwards in a horizontal plane, the illumination on the patient's face will move in accordance with the direction in which the mirror is facing. As the rotation is from right to left, the illumination takes the same direction; and likewise when the mirror is moved from left to right the movement of the illumination is the same. The small patch of light moving across the face and around the room, and always followed by the darkness as it is moved from place to place, and the darkness, or "shadow," as it is termed, always rushing in behind and moving in the same direction to take the place of the spot just vacated by the light.

The principal point to note in this preliminary observation is that what is commonly known as the "shadow" is merely the boundary of the light, and as the light changes its position as the mirror is tilted, this boundary between light and darkness moves in relation to it and always follows the light, and consequently always moves in the same direction as the mirror is tilted.

Now, in directing the motion of the mirror so that the illumination falls directly upon the pupilary area, it penetrates the interior of the eye and lights up the retina so that a bright red glow (the Fundus) is discerned, and continuing the motion of the mirror the illumination passes out of the eye and the "shadow" or darkness takes its place.

It is the manner in which this shadow takes possession of the spaces in the eye just vacated by the light that we gather all our information in Retinoscopy.

In Hyperopia the movement of the shadow upon the retina is the same as on the wall or across the face – always following the direction of light; but in Myopia the motion is in the opposite direction. Thus, if the mirror is rotated from right to left across the face and, falling on the pupil, illuminates the retina and continuing passes across it, and the shadow still follows in the same direction across the retina and face, Hyperopia would be indicated.

If, however, upon the illumination falling on the eye the shadow moves across from the opposite direction, Myopia is present.

The method of measurement is simple, as we have merely to place the correcting lenses in front of the eye until the motion is neutralized. The safer plan is, if the motion is in the same direction as the mirror, to place in the trial frame a plus lens just strong enough to produce the reverse motion and subtract ¼ dioptre from it, thus giving the exact correction.

If the motion is against the mirror, a concave lens will be necessary, and the strength ascertained in the same manner.

To this lens, when making examinations at one metre, must always be added a – 1.00 D. to compensate for the distance, as the conditions described are natural to infinity, but examination at that distance is impossible, owing to the minuteness of the phenomena presented.

In examinations, therefore, at one metre, unless the glass which neutralized the motion is greater than + 1.00 D., Hyperopia would not be present, and if this glass be exactly + 1.00 D. Emmetropia, and if + 50 Myopia of ½ dioptre would be shown.

The movement of the mirror should be as slow as possible, in order to allow the best opportunity of seeing the motion of the shadow.

This motion will be found to vary in speed according to the degree of error, being slower for high amounts and becoming more rapid as a correction is approached.

Astigmatism is indicated by the fact that in tilting the mirror in different meridians the motion is greater in one than in others, also when the tilting does not correspond to one of the principal meridians the motion of the shadow will be found to be in a different plane to that of the mirror, and will take an oblique direction towards one of the principal meridians.

The edges of the illumination will also present a different appearance in Astigmatism to that of other forms of Ametropia, as in Hyperopia and Myopia the illumination is circular, and the boundaries present a crescent-shaped picture, while in Astigmatism the illumination presents more the appearance of a broad band of light with straight edges, the long direction being the meridian of Astigmatism.

Fig. 44.
The band of light as seen in Astigmatism.

In the diagnosis of Astigmatism with the Retinoscope it is necessary to locate the principal meridians by means of the oblique movement of the shadow referred to, or by the straight edge of the illumination, and neutralize the motion by lenses in these two meridians only.

If one principal meridian (say 45) already shows no motion, proving it Emmetropic, or, more correctly speaking, if it requires just +1.00 s. to neutralize motion which after allowing −1.00 for the 1 metre distance would show Emmetropia, while the opposite meridian requires +3.00 to neutralize, we would have the following formula: +1.00 s. ○ +2.00 c. axis 45 ○ −1.00 s. equals +2.00 c. axis 45, showing Simple Hyperopic Astigmatism.

If in both meridians the motion is with the mirror, and above +1.00 D. is required to neutralize the least error, it would indicate Compound Hyperopic Astigmatism.

The same method of diagnosis would apply to Simple and Compound Myopic Astigmatism The meridian of least error being corrected by a spherical of the desired strength, and the opposite meridian by a cylinder, the strength of which is always the difference in error between the two principal meridians.

Mixed Astigmatism is present when the movement is with the mirror in one principal meridian and requires more than + 1.00 D. to neutralize it, and is against the mirror in the opposite meridian.

The two meridians are located as in every other form of Astigmatism, and the error in hyperopic meridian corrected by a convex sphere, which, while it corrects the hyperopic meridian increases the error in the myopic meridian, which is afterwards corrected by a minus cylinder with its axis located at the hyperopic meridian.

It is also possible to diagnose each meridian separately by correcting the hyperopic error with a convex cylinder with its axis in myopic meridian and power sufficient to neutralize the motion of shadow, and diagnose and correct myopic meridian in a similar manner by the aid of concave cylinder axis in the hyperopic meridian.

This form of correction would call for cross cylinders, which are little used and are usually reduced to their sphero-cylindrical equivalent, which would be the formula arrived at by the method of first illustration.

One of the difficulties incidental to Retinoscopy in the simple form described is in the application of the trial lenses to ascertain the amount of error, as being seated at 1 metre distance from the patient, the examiner has to rise and discontinue his examination with each change of lenses, and to the novice it is like beginning over again to lose the "reflex" after once having secured a clear view.

Several contrivances have been put in practice for containing the lenses in a handy form so as to remove the necessity for this interruption. A hand Skiascope is sometimes used, which consists of metal or wooden frame with a handle, and containing a double row of lenses convex in one row and concave in the other which the patient holds in front of his eye as directed, the convex, if Hyperopia is shown, and concave in Myopia, and sliding the frame up or down as directed the different lenses are brought in front of the eye.

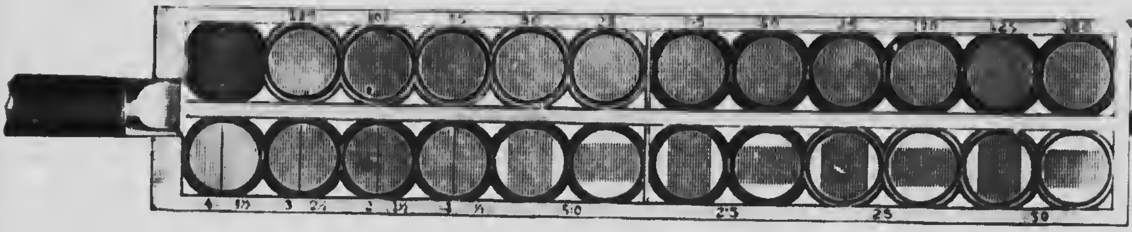


FIG. 45.

Hand Skiascope, for use in connection with the Retinoscope.

A somewhat similar device is also used mounted upon a stand and containing the lenses in a wheel, which is revolved in front of the patient's eye by means of a rod held by the examiner.

THE GENEVA RETINOSCOPE overcomes the difficulties pertaining to dark room and Skiascope, as the metal tube through which the patient looks is a perfect dark room, and the Skiascope wheel contains all the lenses necessary to the various corrections. This instrument is fully described in another chapter.

The Axonometer is a useful adjunct for giving the degree of the principal meridians in Astigmatism. It consists of a black disc with a circular aperture about the size of the iris, and having a white line drawn through the centre from one point on the circumference to a point opposite and terminating in an arrow point.

The Axonometer is placed in the trial frame in front of the eye under examination, and in Astigmatism is revolved until the arrow corresponds to the direction of the Astigmatism, when the degree of the meridian can be read from the quadrant scale on the trial frame as indicated by the arrow point.

Irregular Astigmatism presents appearances which are somewhat confusing to the novice, but what is called the "scissor movement" is one of the most pronounced features.

In this form of Astigmatism the illumination is interfered with by dark spots, and the patches between them show motion, in various directions.

The "scissor movement" is the name given to the motion of the bands of light which under the tilting movement of the mirror approach and recede like the opening and closing of a pair of scissors. It is, of course, impossible to effect any accurate diagnosis of this form of error.

Conical Cornea is to be recognized by the indication of high Myopia in the centre of the cornea and lessening rapidly towards the edge, where in most cases motion with the mirror is found.

In beginning the practice of Retinoscopy the student should use a Schematic Eye, constructed of metal or cardboard, and presenting all the appearances of the human eye under examination.

The Schematic Eye is formed of two tubes telescoping into each other, the rear end of one containing a lithograph picture of the retina and the front end of the other containing a powerful convex lens, to represent the cornea, the other two ends being open. Along the outer surface of the inner tube a scale is placed marked zero in the centre and reading both ways in dioptres. When the tubes are so adjusted that the rear end of outside tube is at zero on the scale the eye is set at Emmetropia and in examining with the Retinoscope all the phenomena of an Emmetropic eye are presented.

By sliding the tubes in farther the various amounts of Hyperopia are secured, and pulling them out Myopia is produced.

FIG. 46

Schematic Eye, for practicing Retinoscopy.

In the practice of Retinoscopy no difficulty will be experienced, with the great majority of cases which present themselves, in securing an accurate diagnosis without the use of any mydriatic, provided the eye not under examination is fogged with a strong convex lens, although the best results of fogging are only to be secured in some such contrivance as the Geneva Retinoscope, when the eye under examination is in darkness and the one carrying the fogging lens is in the light.

# OPHTHALMOSCOPY


FIG. 47
Loring Ophthalmoscope.

There are two distinct uses to which the Ophthalmoscope is put: to measure the refraction, and for the purpose of examining the pathological condition of the eye and its many parts.

Previous to discussing the methods employed in the use of the Ophthalmoscope as a refracting instrument, I would state that I do not consider it at all adapted to the use of the optician for this purpose, as it is difficult to master, and even in the hands of an expert the results are only approximate and can be much more quickly and accurately secured by the Retinoscope.

There are two methods of measuring the refraction with the Ophthalmometer, the direct and the indirect method. In the indirect method the light should be placed beside and slightly behind the eye under examination, in order that the eye itself may be in darkness, and the light falling upon the mirror in the hand of the operator, who is seated about two feet from the patient, and holding the Ophthalmoscope directly in front of the patient, before and close to his own eye, reflects back the light into the eye of the patient, and looking through the sight-hole is thus able to view the interior of the eye, which is no longer a dark chamber but brightly illuminated, and the pink background of the retina clearly visible.

FIG. 48

Ophthalmoscopic examination by direct method.

We now look for the optic disc, and not the yellow spot as many beginners imagine. Having located the disc, which in Emmetropia is round, and has the appearance of a pale moon among fiery clouds, we interpose the convex lens, which accompanies the instrument, which, being held between the thumb and the forefinger of the hand not in use, is brought down in the line of vision, and at about its own focal length from the patient's eye. Upon seeing the disc clearly through the lens, we move it—the lens—backwards and forwards, closer to and farther from the eye.

FIG. 49

Ophthalmoscopic examination by indirect method.

If the eye is Emmetropic the size and shape of the disc will remain the same, no matter where the lens is held.

In Hyperopia the disc appears larger than in Emmetropia, but diminishes in size as the lens is withdrawn.

Rapid diminution denotes high degree and slight change low degree.

In Simple Hyperopic Astigmatism the disc diminishes in one principal meridian, but remains stationary in the other. The meridian of Astigmatism is, of course, indicated by the direction in which the change occurs.

In Compound Hyperopic Astigmatism the disc diminishes in all meridians, but in one more than in the opposite. The meridian of greatest error is indicated by the direction of greatest motion.

In Myopia the disc is smaller than in Emmetropia, but increases in all meridians as the lens is withdrawn. Rapid increase indicates High Myopia In Simple Myopic Astigmatism the disc increases in the direction of the Astigmatism only, while in the opposite meridian its size remains fixed.

In Compound Myopic Astigmatism the disc increases in all meridians, but in the meridian of greatest error the increase is more rapid than in the opposite one.

In Mixed Astigmatism, one meridian increases while the other decreases.

Now, if the above method of diagnosis is clearly understood, the means of correction will suggest itself.

In Hyperopia the disc is seen to decrease under the motion of the lens, so that we have merely to bring the necessary plus glass in the Ophthalmoscope in front of the sight-hole to stop all change in the size of the disc, and the glass is the measure of the Hyperopia.

The same results are obtained in Myopia by the use of a minus sphere. In Simple Astigmatism the degree of error can be estimated by the strength of the lens necessary to neutralize motion in the direction at right angles to that in which there is no motion.

In Compound Astigmatism the meridian of least error is measured first, and the glass required to do this represents the spherical power of the correcting formula, while the cylinder is represented by the glass necessary to correct meridian of greatest error, or, more strictly speaking, the amount left uncorrected by the glass that corrected the meridians of least error.

In Mixed Astigmatism it will require a plus glass to correct one meridian and a minus lens in the reverse.

By the direct method the operator is seated in front of patient with his right eye opposite the right eye of the patient when examining that eye, and his left eye opposite the patient's left eye, when that eye is under examination.

With the Ophthalmoscope in position, and at a distance of about ten or twelve inches, the fundus is located, and then the eye is approached as closely as possible. The closest distance at which the fundus can usually be seen is about two inches from the observer's eye.

If the observer, being Emmetropic, or rendered so, looks through the sight-hole and sees the fundus distinctly, the patient is either Hyperopic or Emmetropic, and upon turning on a weak plus glass, if the fundus is seen less distinctly Emmetropia is proved, but if it is equally or more distinct, Hyperopia is proved, and the strongest plus glass with which it can be seen distinctly is the measure of the Hyperopia.

If the observer cannot see the fundus clearly it is usually Myopia, and the weakest concave glass that renders it perfectly distinct is the measure of the error.

Astigmatism is recognized by the fact that the retinal vessels, which branch out in all directions like the lines on the astigmatic chart, are more clearly seen in one meridian than others.

If the vessels in the vertical meridian are seen distinctly through the weakest convex glass, while the horizontal vessels are rendered indistinct by it, there is Hyperopic Astigmatism in the horizontal meridian, and the axis of the correcting cylinder would be vertical.

If the vessels in the vertical meridian can be seen through a convex glass of certain strength, and those of the horizontal meridian through a stronger one, it indicates Compound Astigmatism The greatest error being horizontal, the axis will be vertical.

Myopic Astigmatism is diagnosed in the same manner, but with the substitution of a minus lens for a plus.

In the Mixed Astigmatism none of the vessels are seen distinctly, and require a plus glass to render them distinct in one meridian and a minus in the other. In correcting, the axis of cylinder would, of course, be at right angles to the meridian they are designed to correct.

It will be seen from what we have stated above that the measurement of the refraction by means of the Ophthalmoscope is theoretically a simple matter and easy of understanding, but unfortunately in actual practice it is entirely the reverse. In fact, as an instrument for the optician's use its value is practically destroyed by the fact that without the use of atropine no reliable results are obtainable. By the indirect method not only do we find the results impaired by the accommodation of the patient, but that of the observer lends an added degree of uncertainty to what is already little more than guess work. We can, therefore, consider this method of measuring the refraction generally unsatisfactory, under the best of conditions, but in the case of opticians with limited practice, and without the use of atropine, entirely unreliable and unsatisfactory.

A knowledge of the foregoing facts has probably been largely instrumental in deterring opticians generally from learning and practicing the use of the Ophthalmoscope, as its uselessness as a refracting instrument seems to have prevented many from appreciating its value as a means to acquiring general knowledge regarding the symptoms of health and disease, which are an open book to the ophthalmoscopist, whether doctor or optician.

I am not advising in favor of the optician prescribing for diseased conditions of the eye, but I desire on the contrary to have him by his knowledge of diseases to avoid prescribing, not merely for disease, but in prescribing glasses at all for an eye in a diseased condition.

By the term disease I refer, of course, to pathological conditions, not errors of refraction.

By the use of the Ophthalmoscope for this purpose we learn to detect a condition indicating disease in just the same manner as the dealer in precious stones decides upon the value of gems, simply by means of comparison. By continued practice in examining stones of the highest value he learns to recognize the condition of color, fire and cutting that constitute the highest type of gem, and the ophthalmoscopist, by continuous practice in the examination of eyes of healthy normal conditions, learns to know their general appearance, and consequently is able to recognize an abnormal condition when it presents itself.

There is one important feature as an indication of health or disease which the ophthalmoscopist attaches great importance to, viz., the color and appearance of the retina and optic disc, and the difficulty lies largely in deciding just when the slight blurring has passed the border of health and entered that of disease. Just as the jeweler finds it difficult to state when a stone is of perfect color and when a defect of this kind brings it under the heading of "off color."

It will be seen that the line of demarkation between health and disease is as faint as the division between the east and the west.

Basing our judgment upon the color of the interior of the eye, it is important to know that this color depends upon conditions other than that of health and disease.

The color of the hair and the complexion vary largely, and we are affected by the amount and color of the pigment, and it is, of course, but natural to expect this same variation in the complexion of the retina, so that while a rosy pink tint is a general indication of health, and a departure from this appearance an indication of disease, this statement is subject to qualification by the complexion of the patient, for while the normal retina in a person of light complexion is bright rose color, in a negro it would be nearly purple, so that what would be an indication of disease in the former would be a normal condition in the latter.

The macula, while occupying the most prominent position in the retina, is the most difficult to distinguish, and no blood vessels are visible. It is situated directly in the line of vision 2 m/m to the temporal side of the optic disc, and slightly larger than the disc. In shape it is an irregular oval, with its long diameter horizontal.

The color is darker than the rest of the fundus and shades off into an orange-red color. The macula is frequently surrounded by a halo, which is due to reflection and must not be considered an abnormal condition.

The optic disc is situated slightly to the nasal side of the central axis of the eye, and is circular, or nearly so, in shape, and size about 1.75 m/m diameter.

The disc is sometimes slightly oval anatomically, and care must be taken not to mistake this for Astigmatism.

The diagnosis is easy, if we remember that in the indirect method, as we move the objective lens back and forth, the disc in Astigmatism changes its shape and size, while the disc is actually oval in shape it will remain in this form under all corrections.

The disc is easily seen with the Ophthalmoscope, as its color is decidedly lighter than the rest of the fundus, and it will be found that the color varies in different parts of the disc. We sometimes find a slight depression or cupping of the disc, even in health, and which is distinguished from that of glaucoma by the fact that it does not include the whole disc.

The margin of color around the disc is known as the Choroidal Ring.

In examining the cornea, the objective lens used before the mirror will enable the observer to detect any foreign substance or the presence of ulcers.

Conical Cornea can be also detected by this method.

Corneal opacities will appear as black spots on the fundus, and are recognized as corneal by making an oblique examination.

The various abnormal conditions of the aqueous dependent upon iritis may also be readily detected in this manner.

The examination of the lens is somewhat difficult without atropine, but frequently a good clear view is obtained.

An opacity in the lens will show, as in corneal opacities, as a dark spot in the fundus. and is separated from atropy of the retina by the following method :

Having excluded the lens and retina by oblique illuminations, and finding no corneal opacities, we next make direct illumination and bring them into view, consequently they must be located in the lens or retina.

We now cause the patient to look downwards, and, as the ball rotates, the opacity of necessity changes its position, and if on the lens, which is located in front of the centre of rotation, it will, of course, move downward with the cornea and other parts so situated, but if upon the retina the movement is upward, as it is situated behind the centre of rotation.

While any opacity found in the lens is usually an indication of the presence of cataract, an exception is occasionally found in the effects of iritis, which leave spots of pigment attached to the anterior surface of the lens.

There are various forms of cataract, all of which can be readily diagnosed by the aid of the Ophthalmoscope.

On examining the vitreous the chief indications of disease are loss of transpa·ency and diminished consistency.

In case of extensive hemorrhage no reflex of the fundus can be obtained at all.

Floating particles are occasionally met with in the vitreous, and are easily detected as the eye is rapidly rotated. They usually appear as black spots, but one variety is sparkling like tinsel.

With the exception of hemorrhages these particles do not usually cause serious discomfort, seeming to be more or less disturbed by eye strain and allayed by the correction.

Changes in the condition of the choroid may be easily detected by this method. Choroiditis, or inflammation of the choroid, being the most common form of disturbance, and is recognized by pink and yellow spots distributed over the fundus.

Choroiditis is common to malignant Myopia resulting from the thinning of the coats under the stretching process constantly going on. Retinal imperfections are quickly recognized by changes of color, and while the optician can familiarize himself with the appearance in health and disease, he, of course, could not diagnose between the many forms of retinal disease without familiarising himself with the nature of the disease to which the retina is subject.

Retinitus—the most common form—is indicated by hemorrhages and white patches and fullness of the veins. The white patches, which are of irregular shape, are usually seen in the neighborhood of the disc.

Retinitus is associated with disease of the kidney and other physical disabilities, so that the optician can only view it as an interesting study, not as a prospective customer.

It will be seen from what has been said that the Ophthalmoscope as an instrument for measuring the refraction, or as a direct means of supplying glasses, is not adapted to the optician, but as a method of acquiring useful information it is invaluable, and its importance has undoubtedly been overlooked by most opticians.

# INSTRUMENTS FOR MEASURING THE REFRACTION.

## INTRODUCTORY.

The necessity for some instrument for measuring the refractive error in addition to the trial case is a much vexed question among young refractionists.

There are instruments without end upon the market, and only two distinct reasons for using them.

They are advisable either as an aid to securing the most perfect results in diagnosing errors of refraction, or as an advertisement to attract attention or inspire awe in the bosom of the prospective customer.

If the latter feature is the sole reason in purchasing, and the optician has no knowledge of its use or faith in its usefulness as a means of diagnosing, it matters little which one is used, probably the largest and most impressive would give the best results.

As to the justification for this use of instruments, it is possible that much could be said on both sides, but after all has been said on the question of professional morals and etiquette, the fact remains that people insist upon a certain amount of "fuss," and will go where it is offered.

A prominent oculist, for whose opinion I have the highest respect, refused for many years to invest in an Ophthalmometer, as he frequently affirmed that its "results were only approximate, and he could get that with trial lenses." Finding a new instrument of this kind in his office upon a recent visit, I enquired his reason for this change of front. He stated "that he had not changed his opinion, but that his patients commented upon the absence of this test, and expressed the opinion that his charge should not be so high as those who made the Ophthalmometer test."

He now has all the instruments he has room for, and charges accordingly.

The principal reason for the general dissatisfaction expressed by those who have some auxiliary test lies in the fact that there is not enough behind the instrument and too much in front of it.

Too much is expected from the instrument itself, and consequently not enough trouble is taken to become proficient in its use.

By no other conclusion can the perfect results of certain instruments in the hands of one optician and failure in the hands of others be accounted for.

Every optician has come across a case some day that vanquished him, and he concludes his means of performing his work are inadequate, and like the lover that has just been jilted, he is "caught on the rebound" by some advertisement or salesman of the many instruments, and he rushes at his recent reverse under the firm conviction that it will be easy going for him now, and expects the machine to supply the information he lacks, regarding possible pathological conditions or muscular complications, and being again disappointed he, in one sweeping condemnation, consigns it and all other "eye machines" to perdition.

The fact is, instruments do not supply the place of knowledge or experience, they only emphasize the absolute necessity of these essentials.

They cannot do more than furnish the optician with the means of traveling to a certain destination by a different route to that furnished by the trial case, and if this terminal is the same, or nearly so, by both routes, the diagnosis must be pretty accurate, but if the instrument is expected to convey him to certain points, all other roads to which have been found closed, he will meet with disappointment and failure.

If an instrument, then, is to be of the greatest practical use to the optician, it would appear that in its operation it be as different as possible from the trial lenses, in fact, it should be some form of objective test, such as Retinoscopy, either in its crude form, or, better still, by means of the excellent aids to be furnished by the Geneva Retinoscope.

The Ophthalmometer of Javal, in any of its numerous models and modifications, affords positive information of this kind, and the one objection raised against it is that its scope is too limited. A prosperous optician—or one who expects to be—should not consider three or four instruments (thus including the best of each style) too much of an equipment. The oculist and dentist, to secure and maintain a connection, are compelled to have an equipment many times as costly as this, and possibly their uniform success is due to the fact that they rarely attempt to practice without it.

The opticians of to-day, generally speaking, have secured their optical knowledge at a very small outlay, and, as a consequence are apt to conduct their business upon the same plan, hence the tendency, as seen at present, to evade what in other lines of business are considered legitimate and necessary expenditures.

In arranging their finances, they plan to do without every possible "extra," in a species of false economy, instead of estimating the possible returns to be reasonably expected from a judicious outlay for such instruments as will assist in increasing their trade.

It is a remark common to the better informed and somewhat disappointed optician that "the fakir and pedlar usually has all the machines on the market, and rarely pretends, excepting to his customers, to understand their uses."

Admitting this to be true, it is only another reason why the competent and legitimate optician should employ them, for if the ignorant fakir, with nothing but his instruments and impudence as his stock-in-trade, can conduct a successful optical business, how much more reasonable it is to expect that one with the necessary knowledge—and the instrument—should do better still.

The same thing applies to the furniture and fittings of the optical room.

Many prominent opticians are content to have their test card on their show case, and the trial case on any article of merchandise in the store, and their examinations are conducted in the midst of a miscellaneous collection of persons and things, and then wonder why the fakir with no knowledge of optics but an intimate aquaintance with human nature should do all the optical work in the locality.

When approached upon the subject he usually hides behind "professional ethics," states "that he can do good work without instruments and fine trimmings, and does not wish to be placed in the same category as the fakir opposition."

Surely this is a false position, as whether we wish to be compared or not with these gentlemen, we certainly are (by the public) and not at all to the advantage of the optician in circumstance similar to those quoted.

The possession of a fine and varied assortment of instruments, the neat and tasty arrangement and furnishing of the optical room, the attendance of a neat and well dressed operator has nothing in it of quackery; it is a most natural compliment to pay to the intelligence of your patrons, and they are quick to appreciate it wherever it comes from.

The fact that the fakir with his "show rooms and machines can only attract custom and cannot satisfy and hold it," does not weaken the case I have made, but rather strengthens it, nor does it improve the position of the slow-going legitimate optician who is in opposition.

Do not for a moment imagine that those who have been attracted by the display, and supplied with glasses and found them useless, will turn naturally to the antiquated optician, they generally look elsewhere and find another attractive optical concern, and they may at length find one of the "legitimate competent opticians," who has learned something from a study of the fakir.

The hair-splitting argument that "the display of instruments —many of which the optician does not place implicit confidence in—are used principally for display, is quackery," is only begging the question, as both in the matter of honesty and optics you will be judged by your results, and, if these are honest and satisfactory, the display of instruments as an attraction is no more to be condemned than the making of elaborate window displays in watches and jewelry, for the purpose of attracting customers who otherwise might drift by your door into that of some less honest merchant than yourself. This seems more like philanthropy than roguery.

## THE TRIAL CASE.

A good trial case should contain a complete assortment of spherical and cylindrical lenses, both convex and concave, together with a set of prisms ranging up to 20°, a selection of tinted lenses, the usual assortment of disc , both stenopaic, pinhole and plain, and a pair of adjustable trial frame and one pair of plain frames.

FIG. 50.
Institute Trial Case in Oak Box.

The essential point in connection with the selection of a trial case is that, while a complete case is desirable, absolute accuracy in the grinding of lenses is imperative. The young optician, therefore, will do well to have this fact in mind in buying his first trial case, and to insist upon having the highest quality obtainable, even if unable to procure a complete set.

There are two distinct forms of ring used for containing the lenses in trial cases. The old model, or Natchet, is made of brass stamped up in one piece, and having a flange upon which the lens is fitted and the metal burnished over to hold it in position. The modern ring is made of steel and finished with a joint and screw just as in spectacles.

FIG. 51.
Natchet Trial Ring.

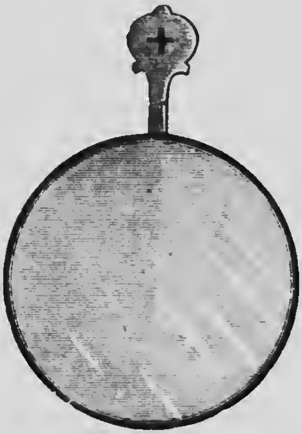


FIG. 52.
Screw Joint Trial Ring.

The latter is preferable as being more easily held in position, and in case of breakage a new lens is easily inserted, while in the Natchet ring it is impossible to remove and substitute a new lens. The rings are usually finished white for use with the convex lenses and gold plated for concave, thus permitting of ready distinction. In the Institute ring the algebraic sign is cut in the handle, and in both forms the strength of the lens is stamped upon the handle.

Trial lenses are commonly made in two sizes, $1\frac{1}{2}''$ and $1\frac{1}{4}''$, the former being in general use.

The important point in regard to the spherical and cylindrical lenses contained in the trial case is accuracy of focus, and exactness in centreing. While the prism should be carefully marked for position of base.

The trial frame is necessarily a matter of opinion, and each optician has his own particular preference. The best trial frame, however, is the one that possesses the greatest adjustment and is lightest in weight. The temples should be adjustable for length—the Wells' patent are the best form—also the height, width, and distance out and in must be capable of ready adjustment, and the quadrant scale be printed on celluloid to render it easily deciphered. The scale should read from right to left on both eyes to correspond with the method in use all over the American continent.

FIG. 53.
Popular form of Trial Frame.

On English and European frames there appears to be no standard rule for the construction of these scales, and we find them numbering from zero on the left to 180 on the right on both eyes, also numbering from the inner side outwards—that is, the right eye would number from right to left, and the left eye from left to right—others are numbered on both eyes from left to right, while to further complicate matters others are numbered each way from the vertical meridian.

In this latter form the vertical meridian is placed at zero, and the meridians outward are numbered 10 T., 15 T., etc., (T. for temple) while those inward have the letter "N" (Nasal) affixed to the number of each meridian.

This fact will account for apparent errors sometimes made in filling prescriptions of this kind, when no diagram is given showing direction of axis.

The uses of the several discs have already been referred to, the pinholes for tests for Amblyopia and the stenopaic for Astigmatism. In using them the countersunk surface should be placed nearest the eye, thus allowing the light to spread out slightly after passing through.

The Maddox Rod is for use in connection with examinations for muscular unbalance, and may be either red or white.

The Chromatic Disc is sometimes included in trial case outfits, but it is of doubtful use as giving but indifferent results in practice, although theoretically of great scientific value.

FIG. 54.
Chromatic Disc.

The chromatic test is based on chromatic aberration in which the light is broken up into different colors, and these various colored rays are differently affected by refracting media, thus in passing into the eye they would focus at different points, and in looking at a flame through the disc it would assume different colors in accordance with the condition of the refraction.

Placedo's Disc was formerly used in diagnosing Astigmatism of the cornea. It consists of a circular disc, containing alternate rings of black and white with a central aperture and mounted on a handle. On looking through the sight-hole at the cornea the examiner sees the rings reflected thereon, but in Astigmatism the shape is elliptical, the directions of greatest length indicating one principal meridian. The correction of course would be the glass that would convert these elliptical figures into circles.


FIG. 55
The Prisoptometer.

The Prisoptometer is the invention of Dr. Culbertson, and consists of a metal frame furnished with set screw for the purpose of attaching it to the table, and containing two prisms so arranged that in looking through the peep-hole at the white round disc that hangs as a target at about 20 ft. distance, the patient sees the disc doubled, and in Emmetropia the edges of the two discs are just tangent while the prisms are revolved through all the different meridians.

In Hyperopia the two images of the disc are separated, and the plus lens placed in the clip over the peep-hole that bring them in contact, represents the error and its correction.

In Myopia the discs are seen overlapping, and the correction is the concave lens that places them in a tangent position.

Astigmatism is indicated by the fact that as the finger attached to the prism is revolved the two discs revolving around each other describe an elliptical course being closer in one meridian and more separated in others.

In simple Hyperopic Astigmatism, the edges of the two images will just touch when the finger points to the Emmetropic meridian, and most widely separated at right angles to it. The convex cylinder placed in the clip with axis at Emmetropic meridian that will render the discs tangent in all meridians will be the correction.

Simple Myopic Astigmatism is diagnosed in the same manner excepting that the Astigmatic meridian shows the discs overlapping and a concave cylinder is used in the correction.

Compound Astigmatism is diagnosed in the same manner by finding the position in which there is least separation or overlapping and correct it with a sphere, then rotate the finger to opposite meridian and correct with a cylinder. The two lenses thus employed would represent the sphero-cylindrical correction necessary, and the position of the axis would be indicated by the position of the pointer.

Mixed Astigmatism is shown by a separation in some meridians and an overlapping in others. The point at which the greatest amount of separation occurs represents one principal meridian, and the one at right angles to it the other one.

Correction is made by placing a convex sphere in the clip of the strength necessary to bring the discs together in the principal Hyperopic meridian combined with a concave cylinder to give similar results in the Myopic meridian. The axis of the concave cylinder will always be in the Hyperopic meridian.

## THE OPHTHALMOSCOPE

The Ophthalmoscope consists of an oblong concave mirror with a central peep-hole of 2 or 3 m/m diameter pivoted at each end and mounted upon a metal disc, to which the handle is attached.

On the reverse side of the metal disc, a wheel with a milled edge and containing several numbers of convex and concave lenses in rotation, is pivoted in such a manner that by rotating the wheel by means of the milled edge each lens in succession is brought in front of the peep-hole of the mirror.


FIG. 56

The Ophthalmoscope.

The instrument is used in connection with a specially arranged light in a dark room and the mirror reflects the light into the patient's eye, and the operator looking through the peep-hole is able to recognize the presence or absence of disease by the appearances presented.

As a means of estimating the refractive error, the Ophthalmoscope is of only secondary importance, although it is still used for this purpose by a few old-school practitioners, but its principal value lies in its use in connection with the study of pathological conditions.

The uses of the Ophthalmoscope have already been described in another section of this work.

## THE OPHTHALMOMETER

The Ophthalmometer of Javal and Scheotz is an instrument by which the presence of Corneal Astigmatism is easily and quickly recognized objectively.

There are several variations of the Ophthalmometer in use but the same principle is embodied in each.

The instrument consists of a telescope containing a Nichol prism, mounted upon an adjustable base and surrounded by a dome shape reflector, inside of which are two mires at equal distance on each side of the telescope tube.

In rear of the reflector a dial containing a quadrant scale is attached, and pivoted to the tube is a pointer which, as the former is revolved, passes through all the meridians indicated upon the scale.

The mires are of translucent material, and are illuminated by means of small incandescent lamps enclosed behind them.

Attached to the tube, within easy reach of the operator, is a geared wheel which communicates with the prisms on the inside of the tube, and by means of which the prisms are moved along the tube bringing them closer to or farther removed from the eye under examination, and containing on its outer circumference a scale showing the radius of curvature of the cornea.

FIG. 57

The Ophthalmometer.

Directions for making examinations: The patient is seated in front of the instrument (an adjustable stool or chair being the preferable kind of seat) and the head placed in proper position, by raising or lowering the chin rest until the the upper bar of head rest is placed just above the patient's eyebrows, and the eye not to be examined is covered with the blind. See that eyes of patient are level, as this affects the accuracy in obtaining axis.

The patient is then directed to keep the head upright, and to look steadily into the opening of the tube—eye wide open.

The operator adjusts the instrument for height by means of the screw-post, then obtains a clear image of the mires by the focusing adjustment, then turns the tube horizontally slightly to right or left until two images of the mires are seen in close proximity and equally distinct. An outer image may be seen on either side of the field of view, but these are always widely separated from the inner ones, and are to be disregarded.

The instrument is now revolved until the long meridian lines of the images show a single straight and unbroken one. If there is no Astigmatism this condition will be seen at all axial positions, if Astigmatism, at but two positions.

An axis having thus been obtained, the graduated wheel on either side of the tube is revolved until the shorter lines or spurs of the images also unite, forming a perfect cross with the longer ones, and the adjustable hand or pointer on left-hand graduated wheel placed coincidentally with the stationary one, this being the first or primary position. You now rotate the instrument 90 degrees, when the long narrow axial lines will again be in alignment without further adjustment. Again the short lines or spurs are brought together to give the image the form of a perfect cross (the secondary position), and the variation of curvature of cornea is recorded between the two pointers in dioptres and fractions thereof.

If the actual radius of corneal curvature is desired, it may be read on the outer face of right-hand wheel (the red figures) in millimeters and fractions thereof.

Determination of axis. For convenience, there are two axis pointers provided, one at right angles to the other, so that when the reading at one meridian has been taken the instrument may be readily turned to the opposite one by moving either pointer to the position on the scale previously occupied by the other.

The corneal curvature is always measured in the meridian indicated by the left-hand pointer, therefor the axis of the correcting lens is to be applied at the angle of least variation from normal as indicated by the left-hand pointer, or of greatest variation as indicated by the right-hand pointer.

## GENEVA RETINOSCOPE

The Geneva Retinoscope furnishes a simple and convenient method of applying the most valuable of the objective tests.

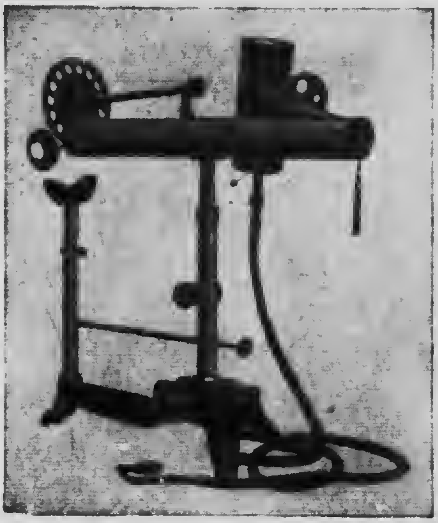


FIG. 58

The Geneva Retinoscope.

The instrument consists of a nickel-plated tube, mounted upon a plain or adjustable base, with attachments for raising and lowering, and a chin rest to hold the head in position during examination. To this main tube an auxiliary tube is joined at an angle of about 45 degrees, at the end of which the illumination is placed inside an asbestos chimney furnished with a diaphragm shutter to regulate the size of light opening.

The light passing down this tube strikes the mirror, which is pivoted at one end of the main tube, and is reflected back through it into the patient's eye at the opposite end.

Pivoted outside and on the top of the main tube, near the end at which the patient's eye is fixed, are two wheels containing convex and concave lenses, by a combination of which all the numbers up to and including 8.00 can be placed in front of the eye by simply turning a thumb-screw attached within reach of the operator. On the end of the tube to which the mirror is attached a quadrant scale is attached, and a small pointer protruding from the mirror on the opposite end from the handle passes over it as the mirror is rotated through the different meridians.

Either electric light or oil can be conveniently used for illuminating purposes, and by its use the necessity for a dark room is removed and the principles of retinoscopy applied in the simplest form possible,and the actnal refractive condition revealed without the assistance of the patient.

## DE ZENG SELF-LUMINOUS RETINOSCOPE.

This is a recent invention of Mr H. H. De Zeng, and is an exceedingly ingenious method of applying the storage battery to retinoscopy.

The instrument is but little different to the ordinary retinoscope with the exception of the position of the mirror which is placed at an oblique angle.

The wires communicating with the battery pass through the handle and are attached to a miniature incandescent lamp enclosed in a barrel which is pivoted to the frame, holding the mirror in such a position that the light passing through a condensing lens in the mouth of the tube strikes the mirror at a convenient angle and is reflected back into the patient's eye.

Fig. 59.
De Zeng Luminous Retinoscope.

The advantages claimed for this method of applying the light is, that being attached immovably in the required position in relation to the mirror, the difficulty of controlling the light—which is a stumbling block to young practitioners—is obviated, and the whole attention is free to devote to the study of the phenomena presented.

## THE OPHTHALMIC CABINET.

The cabinet is a convenient form of holding and showing the type.

The body is made of wood and contains eight cards, including letters, astigmatic, ignoramus and muscular tests.

The cards contain an eyelet at the top to which a cord is attached, which passes up to and along the ceiling to a point behind the operator where they are attached to a series of hooks.

By simply releasing any cord the card to which it is attached can be lowered, and when finished with can be restored to its place.

The advantage possessed by the cabinet over the loose cards is in the ease with which each card can be placed in position and quickly changed.

The exclusion of the lines not required is also an advantage ... of time in preventing a repetition of letters already ...n.

The preservation of the cards from soiling and tearing is ... feature peculiar to the cabinet.

## GENEVA LENS GAUGE.

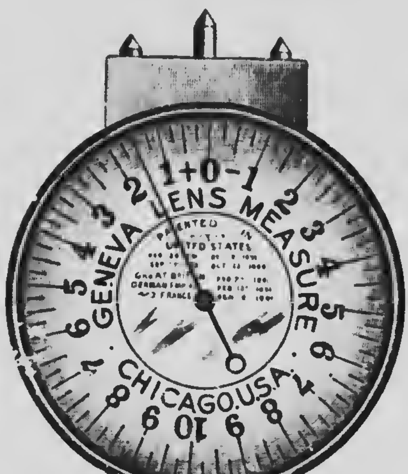



FIG. 60.

Geneva Lens Gauge.

Although not an instrument for measuring the refraction, the lens gauge is so intimately connected with sight testing that we offer no apology for including it in this article.

The lens gauge consists of three steel points projecting from the body of the instrument, two of which are fixed and the centre one resting at its upper end against a bar which is connected with a rack and pinion controlled by a hair spring.

The pinion is pivoted in the centre of the gauge, and the upper pivot projects through the centre of the dial and receives the finger which revolves around it.

In pressing the lens down upon the three steel points the centre one is pushed down until the glass rests upon the two fixed points.

If the glass is flat the centre point will be pressed down level with the other two, and the finger revolving as the rack is acted upon by the bar will point to zero.

If the lens is convex its centre will force the centre pin below the level of the other two, and the finger rotate to the plus side of the dial and indicate the degree of convexity.

If the lens is minus the centre pin will not come down to the line of the other two, and the finger will remain on the minus side of the dial and indicate the degree of concavity.

In measuring cylinders the lens is rotated on the points, and when the three points meet the glass in the direction of its axis the finger will point to zero, but as it is rotated the finger will gradually rotate towards plus or minus until the points are at right angles to the axis, at which point the power of the cylinder will be indicated. As the rotation is continued the finger will recede back to zero.

## THE PHOROMETER.

The Phorometer is constructed for attaching to wall bracket or stand, and contains two cells in each of which rotates a 5 degree prism, each cell has a border of teeth, and a small gear wheel between the two transmits the movement from one to the other.

A quadrant scale is marked around the edge of each from zero in the centre each way to 10 degrees.

In use the prisms are set exactly vertical, and the object viewed through them will be doubled, and if any insufficiency of the lateral muscles exists the objects will not be exactly vertical, in which case the prisms are revolved until they are brought vertical, when the kind and amount of error is indicated upon the scale.

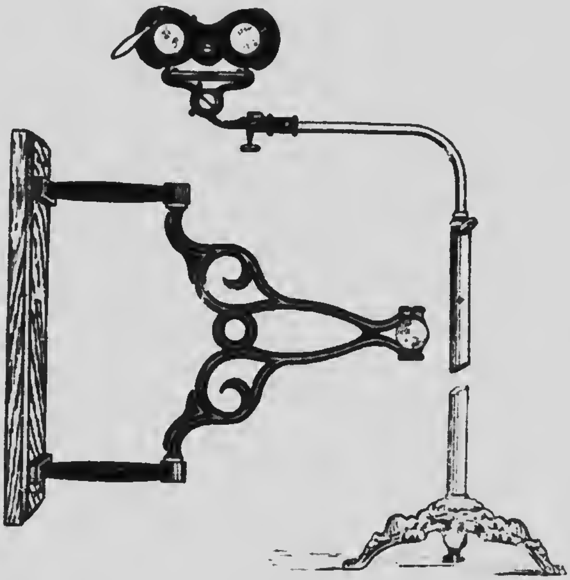


FIG. 61.

Phorometer.

Since this work has been in the hands of the printer an improved method of practicing with the Ophthalmoscope has been devised and patented by the Geneva Optical Co., of Chicago.

The improvement consists in a telescopic tube attached to the Geneva Retinoscope, by which the process of examination is greatly simplified, and what was by the old method a matter of great skill requiring many months of patient practice, is now readily accomplished in a few hours.

FIG. 62.

New Geneva Retinoscope.

The instrument is illustrated above and is so simple in construction and operation as to require but little description.

The light, which may be either gas, oil or electricity is attached near the mirror, and the telescope tube through which it is reflected acts as a dark room, and the convex lens mounted in it greatly magnifies the image and renders examination of the retinal vessels an easy matter.

The patient's head is held in position by an adjustable rest and the telescope brought into position and focus by means of set screws. By holding the finger up as a target and directing the eye toward it the whole of the interior can be explored as the finger is slowly moved about to different positions.

To opticians who have experienced the difficulties inseparable from the old method of using the hand instrument without a dilated pupil the "Geneva" will undoubtedly prove a boon indeed.

# ASTIGMATIC VAGARIES.

Astigmatism has been described as a condition in which the rays of light passing through the various meridians of the cornea focus at different points according to the various curvatures possessed by those different meridians.

The theoretical correction of Astigmatism is a simple matter by means of cylinders possessing the same characteristic of curvature, so that it is hard to account for the difficulties experienced by young opticians in the diagnosis and correction of this most common form of eye error, save upon the assumption that Astigmatism, while it is a mathematical error in the construction of the eyeball, and as such subject to mathematical calculations in its correction, possesses certain aberrations that frequently render an individual case a law unto itself, and render it absolutely impossible to secure satisfactory results in the refracting room solely by the aid of theoretical knowledge however sound, and an advanced arithmetic.

The fact that the optician of to-day depends so much upon subjective methods, and has not arrived at an advanced stage of proficiency in some of the various forms of objective testing, is largely responsible for this condition of affairs, as in the former method not only are we harassed by the many difficulties presented by accommodative complications, but we are in a measure brought down to the same level as our patient in the matter of intelligence.

It is a fact well recognized by experienced opticians that by this method the results achieved in complicated cases are largely proportionate to the intelligence of the patient.

Another point of difficulty is found in the means employed for subjectively detecting the presence of Astigmatism. I refer to the clock dial or similar form of astigmatic chart. The presence of Astigmatism is ascertained not so much by what the patient sees as by what he does not see, and consequently the information is of a negative quality.

The same objection does not apply to subjective testing for Hyperopia and Myopia as letters are used, and we know positively whether they can be seen distinctly by the fact that they can or cannot be correctly named. Not so with the astigmatic test by means of radiating lines, as the comparative distinctness is partially a question of actual defect and in part of mental diagnosis on the part of the patient to ascertain for himself actual comparative conditions of the various lines, and the resulting sensations have to be clothed in words before the conditions are presented to the examiner, so that it is small wonder if error creeps in.

Many refractionists in examining with the trial case for Astigmatism use nothing but the regular Snellen type, with cylinders placed in the frame and rotated before the eye through the different meridians, while the attention is directed to the letters on the card.

This method may be satisfactory when other corroborative tests are used, but otherwise it would be considered a slipshod way of diagnosing, although it may be resorted to in extreme cases and where the patient's visual accuity and intelligence are both of low order, and approximate results are all that are expected.

Another difficulty associated with the subjective diagnosis of Compound Astigmatism is the extreme difficulty in estimating the correct proportions of spherical and cylindrical power of the correcting formula. That this is not at all an imaginative difficulty is proved by the fact that it frequently happens that prescriptions for compounds supplied by different oculists and opticians while having the same axis will vary in relative power of sphere and cylinder. One prescribing say +1.00 sph. ⊃ +50 cyl., while another gives +75 sph. ⊂ +75 cyl. A trial usually shows results identical both in the appearance of the radiating lines and in the degree of vision obtained, and is accounted for by the fact that a slight amount of accommodation may interfere with a full correction of Astigmatism, and also the same result brought about by a slight overcorrection of the Hyperopia when the Astigmatism is of this variety.

In the correction of mixed Astigmatism the same difficulty is present—the vision is necessarily below normal, and while one or two plus or minus spheres of succeeding strength may be tolerated no decided improvement is accomplished with either. And as the correction is always a combination of plus and minus it becomes often a matter of difficulty to decide the relative amounts, as unless a full correction of the Hyperopic error is supplied it will be impossible to get perfect results from any minus cylinder that may be combined with it.

Again in mixed Astigmatism, where the Myopic and Hyperopic error is about equal in degree, it frequently happens that in process of examination, after having ascertained that neither plus or minus spherical gives any decided improvement, or possibly but a slight improvement secured with a weak number of either, that the spherical lens is removed from the trial frame and the attention directed to the astigmatic chart with the result that the patient can discern no difference in the radiating lines, all appearing equally blurred, the lines in one principal meridian being indistinct because their focus is in front of the retina and the other principal meridians focused an equal distance behind it so that the result is general indistinctness of all the lines.

Again, the young optician well grounded in theoretical optics but with his experience ahead of him, has a case presented to him in which the complaints are of asthenopia entirely, and an examination discloses perfect visual acuity without lenses and the weakest plus renders the letters on the distance card less distinct, and a reference to the astigmatic chart discloses no Astigmatism as the patient declares that they are all equally distinct.

And yet, in spite of these tests carefully made, Astigmatism is frequently found in just the quantities most liable to cause acute asthenopia.

Now here is a formidable list of Astigmatic Vagaries, any or all of which may be encountered in the course of ordinary practice, and calling for something more than the rule of thumb method in vogue with a certain class of opticians, who are theoretically well posted and who are anxious to do sound and accurate refraction work. In fact, so contrary to book rule do these cases often prove that many well schooled students in starting to practice become discouraged and jump at the conclusion that Astigmatism cannot be consistently corrected by means of the knowledge or appliances at the disposal of the optician, and send all Astigmatic cases to the oculist under the impression that atropine, or the knowledge and use of drugs may avail.

To these I wish to say emphatically that neither atropine or any other drug, or the knowledge of anatomy supposedly possessed in a higher degree by the oculist than by the optician, can avail in the successful diagnosis of errors of refraction, and the solution lies solely in the knowledge begotten of experience, guided by sound technical training and applied in the light of common sense.

Let us glance over the points already enumerated and consider the means most generally employed in arriving at the true refractive conditions when employing subjective methods only.

Undoubtedly the first point raised, the intelligence of the patient and the examiner's dependence upon it, is at once a bar to universally correct work by this method, but it is possible to get results generally satisfactory by holding its weak points in view and devoting the attention particularly to them and by carefully avoiding the practice of doing routine work and "fitting by the book."

If most of the mistakes made are traceable to lack of intelligence and consequent misunderstanding between patient and examiner, the most natural method of avoiding the mistake is to conduct your examination on a plane to which the intelligence of each patient can fairly be supposed to have access. Working on this basis, the first care on the part of the examiner would be to have his questions thoroughly understood, and secondly, to assure himself beyond a doubt that the patient is telling the whole truth without exaggeration or concealment.

These two conditions may seem a'most ridiculous to the casual reader, but will be appreciated by the practical student.

For instance, in the regulation method of using the astigmatic chart almost the first question asked by many opticians is "Which lines do you see the most distinctly?" or "Do any of the lines appear brighter than the remainder?" Both of these questions as quoted are improper and are a fruitful cause of error.

By asking which line is the most distinct we imply that there is a difference and suggest this fact to the patient, so that acting on the power of suggestion it is a simple matter in the case of weak-minded people to instantly discover a difference in distinctness and thus lead to the application of cylinders, or at least cause confusion and disappointment to examiner and patient.

The objection to the second question lies in the liability to a misunderstanding of the most important word in the question —the word "brightest"—and upon the correct interpretation of which the success and accuracy of the whole test depends.

Of the many definitions of the word "bright" one that is generally accepted is "of bright color." Now, an astigmatic person in comparing the radiating lines of the astigmatic chart, and asked to select the brightest one, would with this understanding of the word select the dimmest lines, as the effect of the dimness peculiar to lines seen under astigmatic conditions is to render black lines grey, and certainly grey is a brighter col r than black. So here we have as the result of a mutual misunderstanding the patient stating in good faith the very opposite of what is actually the case.

Coming to the second point, it would seem almost incredible that one coming for professional assistance would wilfully throw obstacles in the way of a successful diagnosis, but it is a part of the history of refraction that astigmatic people seem to feel the effect of their assymetrical defect even into the very marrow of their disposition and temperament. They are a nervous, uncomfortable, asthenopic, and to a certain extent cross-grained section of humanity, and the excitation of their resentment even by innocent mannerisms may render it almost impossible to extract the facts from them even with a forcep.

This section of the genius Ametrope is amenable only to a specie of optical equipment not acquired in the schools nor in the clinics—tact. Higher optical knowledge and greater expertness in the reduction and assimilation of complicated formula avails not in cases of this kind. The only knowledge that is of great service is that of human nature, just as in the case of a successful lawyer. It is not a profound knowledge of law that enables a member of the bar to extract the truth from an unwilling witness, it is knowledge of human nature, and the swift insight into the weaknesses as they are presented, that enable him to extract answers and sift out the true from the false.

As such an one would coax or force an answer and then proceed to secure an unconscious denial, so does the pastmaster in the science of refraction dig pitfalls for the deceptive patient.

For instance, a certain line being declared the clearest a plain glass being interposed producing a marked change proves the presence of a decided antagonism in the patient.

Other cases show a decided inclination to give you the answer that your manner would seem to indicate, that you expect regardless of the actual condition.

The experienced optician will bear me out in the correctness of these statements, and the novice will see in them the explanation of some of the Astigmatic Vagaries, to which he has been a victim.

The difficulty experienced in securing the correct proportion of sphere and cylinder is in part overcome by the use of a cross cylinder in proving the test.

An ordinary trial ring mounted with +50 cylinder combined with -50 cylinder with their axes at right angles, held over the correction in the trial frame while the attention is directed to the letters, will increase the refraction in one principal meridian and decrease it in a corresponding degree in the other, and will be of great assistance in adjusting closely the proportions of spherical and cylindrical error.

In the case of mixed astigmatism the better plan is to work out the hyperopia first by plus spheres and the astigmatic chart.

Take a case in which the usual subjective test has shown the vision to be considerably below normal and the application of a weak plus sphere while not positively refused is merely tolerated and, so far as the patient is able to judge, does not improve the vision, neither does it lower the visual accuity. If a succession of stronger plus spheres are applied they are quickly rejected without improving the vision. This condition, while indicating hyperopic conditions, shows conclusively that it cannot be simply hyperopia or the visual accuity would at once improve with each succeeding number of plu. power applied. If minus spheres are applied the result is nearly the same, a few succeeding weak numbers are tolerated without causing any pronounced improvement, and then the vision rapidly decreases with any further increase of power.

The toleration of a plus sphere without producing any improvement in a low visual accuity would therefore indicate either simple hyperopic or mixed Astigmatism, and the same conditions being repeated with a minus sphere would exclude the former and almost prove the case to be Astigmatism of the mixed variety.

Now, if in proceeding with the regular routine of subjective testing we bring the astigmatic chart into use, and find no difference in the various meridians, if the student has profited by what has just been said he will not pause in doubt, but proceed to correct the hyperopic error by plus spheres, and will instantly discover that although with the naked eye no difference in the radiating lines was discernable, owing to the fact that one principal meridian hyperopic, say one dioptre, and the other one myopic to the same amount, that one particular line or set of lines is more distinct, and if the increase of plus sphere is kept up this line will increase in distinctness as the opposite one becomes less and less clear, until finally the clearest lines will begin to lose their clearness and become dim. This will prove the overcorrection of hyperopic error, and the previous lens to that which produced the overcorrection would be the measure of the hyperopic factor in the astigmatic condition present.

It is an easy matter now to combine with this glass a minus cylinder, with its axis at right angles to the clearest line, of just sufficient strength to render the lines of equal distinctness, when the vision will be found to be restored to normal conditions, unless some amblyopic condition exists.

The remaining point raised is one that will frequently appear in young astigmats of low degree and active accommodation. The conditions are as follows: The complaint is asthenopia and usually the accommodative form is indicated. Subjective test shows vision to be normal, and the weakest plus sphere is instantly refused, and the most careful examination with the astigmatic chart fails to disclose any Astigmatism, and the usual muscular tests show orthophoria.

Under routine methods the examiner has exhausted his resources, there is nothing remaining for him to try but what he has already tried, and herein lies his way out of the difficulty. The fogging plan should be carried through the astigmatic test, when it will be found that in a case of this nature, when no difference in the lines is noticed with the eye unassisted, a difference is instantly noticed when a weak plus sphere is placed in front of the eye under examination.

We will suppose that having found this to be the case and +.50 sphere brings out the vertical lines the clearest and -.25 cyl. axis 180 in combination with it once more renders the lines equally distinct. Now here we have a condition in which no Astigmatism was indicated because all lines were equally distinct, and the same case with a cylinder and still having the astigmatic chart equally clear in all meridians. There is no question as to which is the real and which is the apparent condition, as unless Astigmatism was actually present no sphere would produce a difference in clearness of the lines and no cylinder could possibly produce a uniform appearance.

On returning to the type on the distance card, we usually find that while without any glass 20/20 was possible, with the the correction on that presumably corrected an error of refraction vision is lower probably 20/30 or 20/40. If now a -.25 sphere be superimposed upon the previous correction vision will instantly rise to normal, and the correction would be + 50 sph. ⊃ – 25 cyl. axis 180 ⊃ – 25 sph. = + 25 sph. ⊃ – 25 cyl. axis 180 = + 25 cyl. axis 90, which usually gives perfect vision and relieves the asthenopia.

A moment's consideration will reveal the true condition and the cause of the apparent one.

With one-quarter dioptre of simple hyperopic Astigmatism the focus of one principal meridian is on the retina and that of the other one-quarter dioptre is in rear, and with the slightest possible degree of accommodation these two focal points are brought forward one-eighth dioptre, thus transforming the case into one of mixed Astigmatism with 1/8 dioptre in each meridian, with the two points equally in front and in rear of the retina, and the appearance of the chart would be symmetrical, just as we find in real mixed Astigmatism, with equal amounts of each form of error

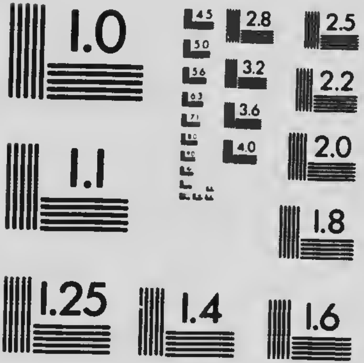
The application of + 50 sph. instantly relaxes the accommodation and brings the focal points forward in front of the retina, one a quarter dioptre and the other one-half dioptre, and the real difference in radiating lines is readily apparent. The vision is lowered owing to the fact that even when the correcting cylinder is applied the total focus is one-quarter dioptre in front of the retina and instant relief is afforded by – 25 sphere.

After all has been done that experience and knowledge can suggest, there still remains certain cases in which it is utterly impossible to secure complete uniformity in the astigmatic chart, and these will usually show with the ophthalmometer more or less irregularity of the cornea, and is impossible of correction.

With this exception there is no valid reason why Astigmatic Vagaries should not be controlled, but it must be remembered that they are the children of misrule and are not in subjection to law, and must be met on their own ground with each case a law unto itself.

MICROCOPY RESOLUTION TEST CHART

(ANSI and ISO TEST CHART No. 2)



# AMBLYOPIA.

Amblyopia is a term with which the but recently graduated optician is familiar, but he is wont to dismiss the conditions signified by the term as something with which he has nothing to do, and consequently need not devote time to investigating

Amblyopia means, literally, weak or dull vision, but is generally restricted in its application to partial defects of acuteness, with little or no ophthalmoscopic change.

Amaurosis, a term of similar meaning, is generally employed to indicate a more advanced condition of blindness without visible changes, while papilitus and atrophy, both indicating imperfect sight, not dependent upon ametropic errors, in which certain changes are visible to the observer.

Amblyopia may arise from several different causes Amblyopia Exophopobia is that form of the disease which is the result of a suppression of the image in squint.

This habit of suppression of the image, found in the squinting eye, is acquired for the purpose of preventing the obnoxious effects of diplopia, and once acquired remains permanently, and, in accordance with Nature's inexorable mandate, that "an organ subjected to idleness loses its usefulness, rapidly loses its power of receiving or transmitting light impressions."

Amblyopia, as seen from the foregoing, is a deteriorated condition of non-sensibility in the retina, or some similar defect of the optic nerve, and may be present with or without the presence of Ametropia.

Amblyopia may be induced by a defect in the retinal image as seen in maligant Myopia, or high degrees of Astigmatism or Hyperopia. Under these conditions, the retina is not able to perform its natural functions, owing to the fact that these images are never sufficiently clear to permit of retinal activity.

In some of these cases it happens that the best correction that can be obtained fails to give perfect vision, as the sensibility of the retina has already departed, although if glasses are supplied early in life the defect is frequently overcome and a restoration effected as a result of the active use to which the retina is once more subjected.

Unless the Ametropia is corrected by glasses early in life, no hope of the cure for Amblyopia is to be expected.

Occasionally we find, in making examination for glasses, that the sight of one eye is practically nil, and often the fact is entirely unknown to the patient, who, on being informed of the fact, usually affirms that it must have happened recently, and possibly attributes it to some recent illness. As a rule, however, it may be accepted as a fact, that the loss of sight has been gradual, and is due to the suppression of the image from some cause; but at rare intervals cases are found in which the loss of sight has been sudden and complete, and due to a form of paralysis of the optic nerve. Sometimes this will yield to proper treatment, but frequently no relief can be secured and the blindness remains permanent.

Toxic Amblyopia, or "smokers' blindness," is a more common and deadly form of lost sensitiveness, as its approach is gradual and insiduous.

"The acuteness gradually fails with little or no accompanying pain other than frontal headache accompanied by nervousness and sometimes loss of sleep and appetite. Few opthalmoscopic changes are noticeable; possibly the disc may be congested and hazy. The defect of sight as described by the patient is "Mist". The pupils show no particular change, save perhaps a sluggish tendency."

The degree of sight for different sections of the retina will be found to be very irregular and variable, and color blindness will be discovered by one of the usual tests.

The patients are, of course, usually males and smokers, frequently drinkers as well. Nettleship, from whom I have quoted, states that he attributes the cause to tobacco, and a discontinuance of it offers the only possible hope of recovery.

Occasionally the disease is found in females or non-smoking males, in which cases it is a hereditary form of the same affection. The chances for recovery are good if the failure of sight has been rapid and the case is taken early.

Hemmopiá is another form of Amblyopia, in which the loss of vision only extends over half the visual field, it is frequently caused by detachment of the retina, sometimes only one quarter of the field is lost, and the dividing line between light and darkness clearly marked. In this form of Amblyopia the optic disc usually shows little change.

Hysterical Amblyopia, or, as it is sometimes called, Hysterical Eye, is an affection of somewhat complex nature, and so closely connected with malingering or feigned blindness as to have frequently been confounded with it.

Drs. Oliver and Noyes, in the celebrated work on the eye, attribute this form of Amblyopia to "disturbances and disorders of the intrinsic and extrinsic muscular systems."

It is characterized by no marked ophthalmoscopic change and marked lowering of the central vision and a diminished light sense and a contraction of the field of vision for colors. Also accommodative Asthenopia, spasm of the Iris and ciliary muscles, monocular Diplopia, paralysis of the extrinsic muscles and unequality of the pupils.

Amblyopia with the above symptoms has been known to follow a blow on the eye.

Nettleship says: "True Hysterical Amblyopia seems allied with Asthenopia, in which Photophobia irratibility and want of endurance of the ciliary or internal recti muscle is present, acuteness of sight being nearly perfect and refraction normal."

Of the retinal conjunctival and muscular factors any one may be more marked than the others, and it would seem that given a certain state of the nervous system, which may be described as impressionable, and overstimulation of any one of them is apt to set up an over-sensitive state of the other two. All the symptoms are increased after exercise and vary considerably with the general state of health.

Night blindness (Nyclalopia) may be included in the list of Amblyopias. It is caused by prolonged exposure to strong light thus exhausting the sensibility of the retina. It is usually to be found with cases of scurvy. Sleeping in the bright moonlight will frequently cause it to appear. The fact that in certain countries, where the Lenten festival is religiously observed, it is very prevalent at that season, would imply that a lowered physical condition had something to do with it.

A prominent external symptom of night blindness is seen in the appearance of two little films or scales on the conjunctiva at the inner and outer border of the cornea.

The disorder usually subsides by protecting the eyes from strong light and restoring the tone of the system by nourishing food and tonics.

Micropsia is an affection of the retina by which objects appear diminished in size, and is owing to a diseased condition of the retina by which the rods and cones pertaining to a certain section are spread over a larger surface, thus giving the impression of reduced size.

Muscae Voilitantes refers to the annoying presence of small particles floating in the vitrious and producing the effect of moving bodies in front of the sight. They are not serious, and when caused by Myopia, as frequently happens, are usually relieved by the correction.

Color blindness does not seem to be common in this country, but whether from the absence of the malady or the scarcity of information and means of diagnosing, I am not prepared to state. In England, applicants for positions in the navy or railway service are required to pass an examination for color blindness, and it is found that about 4% are affected. It consists in an inability to distinguish certain colors, and is presumed to arise from some defect of the retina, the exact nature of which has not been clearly shown.

In addition to the various forms of Amblyopia described, many of which may appear as a disease or a symptom of disease, an amblyopic condition may be present as the result of the misuse or overuse of various drugs, and many diseases of parts of the body far removed from the seat of vision may have their reflexes in errorsof refraction as well as diminished acuteness of retinal perception. Among these no affection more surely affects the acuteness than Diabetes and Bright's Disease. In the former the optic nerve becomes affected. It is frequently referred to as Diabetic Amblyopia. The defect varies from a slight diminution of acuteness to complete blindness, and a considerable defect of sight may be present in cases in which the disease which caused it has apparently made little headway.

From the many forms of Amblyopia referred to, and the connection between them and the conditions of serious bodily infirmity, which have been pointed out, it can readily be seen that the serious student of ophthalmic science will find in every case of Amblyopia a problem worth studying and an object lesson in advanced optometry, and a careless passing by of cases so affected will be far less likely to occur with a knowledge of the importance of Amblyopia than would be the case if we merely consider it as "something not subject to correction," and I am convinced that a course of ophthalmoscopic study once inaugurated, it will be found quite as interesting as instructive.

# CILIARY SPASM.

Spasm of Accommodation or Ciliary Spasm has been described as an abnormal or involuntary contraction of the ciliary muscle, similar in some respects to the common cramp, such as attacks one when plunged into cold water when in a heated condition.

It will readily be seen that its effect upon the refraction of the eye is to increase it so that an emmetrope would be artificially myopic, hyperopia would be relieved and in many cases would become myopic, while myopia would be increased by its presence, and as the victims have no knowledge of the unnatural use to which the ciliary is subjected, its presence becomes a factor of no small importance in the success or failure of the refracting optician

A Spasm of Accommodation may be either clonic or tonic. In the former case it is produced only under the influence of fixation, a desire for distinct vision, or certain causes which excite the sensibility of the eye, while it ceases as soon as that organ is in respose. In the case of tonic spasm it is permanent and yields only to a mydriatic. Clonic spasm is undoubtedly a very common form of eye trouble in young persons, increasing the refraction and making out of many hyperopic cases artificial myopes. This spasmodic contraction of the ciliary is usually insignificant as it ceases at the same time as fixation and disappears with advancing years, and it is only in cases of Asthenopia that we are called upon to make the examinations which finally reveal its presence.

If for no other reason than for the instant detecting of clonic spasm, retinoscopy should be employed by every optician who expects to make a professional success of optics.

As stated, the clonic spasm ceases as soon as the eye is at rest and no attempt is made to observe anything, and employing the retinoscope under these conditions we are able to diagnose the refraction and ascertain the error, if any is present.

If upon making the usual test with the trial lenses, we find the refraction noticeably greater than with the retinoscope, that is, find the amount of hyperopia less, or even find myopia indicated we would have sure proof of the presence of clonic spasm.

The tonic spasm presents features that place it outside the scope of the optician and transfers it to the category of medicine, and we need not take time here to dwell on it further than to illustrate a ready method of diagnosis and brief description of its characteristics.

Landolt states that it is difficult to state exactly the cause of tonic spasm, "but it is probably the result of a lesion of a muscular tissue, or is produced by irritation of the motor nerves," which, in commonplace language, simply means that the ciliary muscle, similarly to all other muscles of the human system, is depending for its motive power upon a nervous edict from the brain; that the third nerves being the means of communication, some foreign cause creates a state of excitability in this set which causes it to give to the ciliary muscle the same action as if the intellect had so ordered.

Let me illustrate this point. Suppose you have an electric door-bell which rings upon a button being pressed, which so acts as to close the circuit and make a continuous channel for the electric power to pass on its route, of course affecting the mechanism of the bell in such a way as to cause the clapper to vibrate and consequently ringing the bell. Now, the same result will follow if by any means the wires are short circuited, that is, if another piece of wire should become entangled in such a manner as to join the two main wires. The power is there and is accidentally applied, as in the tonic spasm the power is there and is applied without any intention upon the part of the intellect to so use it, and, unlike the clonic form, it remains constantly in use and does not cease with fixation.

We are only able without the use of atropine to decide upon tonic spasm by means of its effect upon amplitude of accommodation, as we know what amount of accommodation should be present at different ages, and consequently in measuring the PP.

with distant vision normal—with glasses, if necessary—we are able at once to see if a proportionate amount is present according to age, and if not we would suspect spasm. For instance, a person of 20 years should have amplitude of 10.00 D. and PP. in Emmetropia would be 4 inches, and finding a case of this age in which amplitude was only 6.00 D. we would expect spasm 4.00 D. Of course the same results are to be expected in paralysis of ciliary, as that would lessen the amplitude in exactly the same way, but with but little practice you can readily differentiate between them, as spasm carries with it a contracted pupil, while in paralysis it is dilated.

In the tonic form considerable pain in the ciliary is felt, and a common symptom is an abnormal secretion of tears. The acuteness of vision is nearly always diminished, frequently simulating myopia, and is very changeable. The presence of a slight convergent squint would add to the proof. The common nerve supply of the ciliary and internal recti would account for spasm in case of muscular errors.

Having by any of the foregoing symptoms and methods of examination established the presence of spasm, it is easily classified with the retinoscope, and, if found to be of tonic spasm, we can only resign the case to the oculist.

In your regular practice of refraction you have come across cases in which the refraction, as measured from time to time, shows results which are greatly at variance, and some of you have doubtless pursued your studies far enough to know that this is a fairly accurate indication of the presence of spasm, but if you stop there you have no results. You must diagnose and classify, and if tonic let it go, but if clonic it is open to your efforts.

My own custom was for years, when engaged in doing refraction work, to order for all cases of tonic spasm, irrespective of any error of refraction as indicated by trial lenses, sufficiently strong convex lenses to blur the distant vision. These, of course, it was not possible to wear constantly, but by undergoing slight inconvenience they can be worn part of the time for distance, and constantly for reading, and the longer they are worn the less discomfort there is felt in wearing them, as their effect is to induce a relaxation, as the only means of obtaining clear vision. If a record is kept of these cases—and you cannot hope for practical results unless you do so—it will be found that subjective tests made previously will reveal more myopia, or less hyperopia, than one made after a course of training by means of a convex glass. I have even found the application of a weak convex lens instantly beneficial in diagnosing low amounts of astigmatism, presumed to be present, but which it was found to be impossible to disclose by the ordinary methods, they evidently being hidden under a mild form of spasm of the ciliary, which prevented the visual accuity from being affected, and also maintains the symmetry of the astigmatic chart, which under the blurring effects of the convex overcorrection blurs only such lines a correspond to the emmetropic meridians, and leaving bright the lines indicating the meridian of astigmatism. If there is no astigmatism present the lines will blur simultaneously.

Ciliary Spasm has been found to be present as the result of a slight abraision of the cornea.

Reflex irritation of the ciliary nerves from some disease possibly far removed from the seat of vision.

Various inflammatory affections of the eye, such as Conjunctivitis Keratitis, Episcleritis, Blepharitis, and it is also found in connection with an overworked condition of the retina.

A marked symptom of spasm is the diminutive pupil together with the variation of the acuteness of vision under different examinations.

The manner in which the test type is read should put you on your guard in regard to spasm, as while not constituting an absolutely reliable test, it will in many cases lead you to pause and investigate further before giving a correction.

Indications of the condition are to be noticed in the peculiarities incident to the various forms of ametropia in the manner in which the test type is read.

A hyperope, if he have ample accommodation, will read it off as readily as an emmetrope. Myopia, of course, precludes the possibility of normal vision, and the myope will read with a fair degree of certainty down the card to a certain point, but beyond that he can make no attempt, while the astigmat will dash through the letters regardless of results, making few pauses and miscalling most of the letters. Unlike the myope, they do not seem blurred to him, but have taken on other forms under the distorting effects of the elliptical cornea. But the spasmodic individual is usually a backward, undecided sort of a subject, reading the various lines with considerable uncertainty, and at one moment showing visual accuity in excess of what you presently find it. His style is like his condition—spasmodic.

These symptoms being present, you would not be justified in ordering glasses while the refraction was in this condition. In the absence of atropine you will find the persistent application of a convex lens to exert a relaxing influence upon the cramped condition of the ciliary, but, as before stated, you must learn to distinguish between clonic and tonic, as you but waste your time experimenting on the latter form.

To sum up the conditions and methods of treatment, we have to look for spasm with an abnormally small pupil, when the method of reading test type is indicative of this condition, and we are sure of it when repeated examinations give variable results.

We are able to diagnose and classify by means of retinoscopy.

Bear in mind that a discrepancy between amplitude of accommodation, as found with the tape measure and the age table of Donders, is sure indication of spasm or paralysis, and its diagnosis is by means of the pupillary aperture.

Now as to treatment. For tonic nothing can be done other than a long course of treatment with atropine, and also medical treatment with a view of removing the cause.

With the clonic form you cannot fail of at least partial correction if you persevere in the use of plus lenses, increasing the strength from time to time as your examinations show you the spasm yielding to treatment.

# ASTHENOPIA.

Asthenopia has been described as a group of symptoms indicating a condition of fatigue of the ocular muscles.

In its primary stages it is merely a question of rest and relief from the burden causing the fatigue, and which may either be an error of refraction, heterophoria, or disease of some of the vital organs.

When it is of long standing its effects are far reaching, and become complicated with nervous affections, and it is difficult to estimate just where they end and to what degree they are capable of relief, even when the correction is applied.

Asthenopia has been differently classified by different writers. Hartridge speaks of it as Accommodative, Muscular and Reflex. Thorrington, substitutes Retinal for Reflex, while Drs. Oliver and Noyes in their exhaustive treatise classify it into Ametropic and Heterophoric, these terms, of course, indicating conditions dependent upon errors of refraction and imbalance of the motor muscles respectively. This list may be advantageously amended to include them all, viz., Accommodative, Muscular, Reflex and Retinal.

Accommodative Asthenopia, as the name implies, is a condition in which the organs of accommodation show fatigue as the result of some unnatural strain being put upon them, and is always more or less associated with Hyperopia, Hyperopic Astigmatism or Presbyopia, and relief is usually secured by the correcting lens without much trouble.

The symptoms of Accommodative Asthenopia are frontal headache—especially after using the eyes for near work—the pain may even extend to the neck and shoulders.

The degree of discomfort experienced is not at all in proportion to the amount of Ametropia, as more frequently the worst cases of Asthenopia arise from the smallest possible amount of error and as frequently the extreme cases of ametropia produce no Asthenopia whatever. This may possibly be due to the fact that with a slight amount of Hyperopia or Hyperopic Astigmatism, the focus of the light rays is nearly upon the retina, and a slight amount of accommodation continuously exerted practically corrects the error and produces perfect vision, while in ametropia of the higher amounts no effort can effect a correction and the patient learns to recognize objects even although imperfectly focused, and thus while possessing a lower degree of visual acuity is comparatively free from Asthenopic symptoms.

From this it will be apparent that in the treatment of patients afflicted with Accommodative Asthenopia no amounts of ametropia are to be considered too small for correction, and even in many cases—notably those where a slight spasm of accommodation is present—the error will not at first be apparent, and when discovered will at first accept with difficulty the correcting lens.

Marlowe, a noted English specialist in eye work, states that in five hundred cases of Accommodative Asthenopia he found 50% caused by hyperopic astigmatism of less than ½ dioptre, and of these 80% were relieved by the correcting lens.

Another cause of Accommodative Asthenopia is found in partial or complete paralysis of the ciliary muscle, and while in these cases immediate relief is obtained only by means of plus lenses for near work, it is always advisable to send them to the oculist for treatment, as the cause can then be investigated and in many instances removed, and permanent relief secured.

In some instances persistent Accommodative Asthenopia is present, and no relief secured by the correction of the ametropia. These affections are undoubtedly reflex in their nature, and can experience but little benefit at the hands of the optician.

Another feature of this form of Asthenopia, which is a source of considerable trouble to the optician, is the fact that complications incidental to muscular imbalance may be associated with the hyperopic error that causes the ciliary fatigue, and occasionally we find the heterophoria of such a nature that any correction applied for the relief of the hyperopia and its attendant ciliary fatigue only increases the agony by adding to the burden already being borne by a weak recti muscle.

This would be the case where we have hyperopia with its attendant Accommodative Asthenopia and also insufficiency of the internal rectus; as in supplying the plus correction for the hyperopia we would in bringing the near point closer but increase the amount of convergence necessary for near work. We would thus relieve the ciliary at the expense of the internal rectus, and the second condition would be more intolerable than the first, and no relief for the ciliary by plus lenses can be obtained until the muscular trouble is relieved by the aid of prisms or tenotomy.

Muscular Asthenopia is a condition of fatigue of one or more of the motor muscles, and may be caused by errors of refraction or be present in emmetropia.

A preponderance of any one muscle over its opponent will furnish sufficient cause for Muscular Asthenopia and when not complicated with any form of ametropia its relief is affected by means of prisms in moderate cases, and by tenotomy in those of a more severe nature.

Muscular Asthenopia due to insufficient convergence associated with myopia, is usually relieved by the myopic correction, but if associated with hyperopia correction is impossible except by muscular treatment.

Conversely insufficiency of the externals finds ready relief in hyperopia by the spherical correction, but in myopia the strain is but increased by the minus spheres that correct the refractive error.

The distinguishing symptoms of Muscular Asthenopia are ocular pain, tenderness of the eyeball, and in many instances where the internals are affected the pain can be located at the inner side of the eyeball, and in extreme cases dimness of vision and diplopia are the attendants of this painful affection.

The treatment has already been given in another lecture on Heterophoria, by means of prisms either for exercise or for wear, and the optician will find these cases so closely allied with and dependent upon the general health that he will do well to keep in touch with the family physician.

Retinal Asthenopia, while closely allied to Accommodative Asthenopia, is distinct inasmuch as one is fatigue of the ciliary muscle and the other exhaustion of the retina or, perhaps more correctly speaking, the nervous system of the eye.

It is merely a question of overuse of the eyes, and demands rest and tonic.

Accommodative Asthenopia may be present as the result of overwork, but is relieved by using plus glasses to take off the strain on accommodative, but plus glasses would not relieve the strain consequent upon over-work of the retina, and the two conditions while produced by the same cause could not find relief by the same means.

Reflex Asthenopia is a condition of pain and discomfort in the ocular system, arising from causes entirely removed from the eye or its appendages.

Bright's disease is a prolific cause of Asthenopia in its most severe form.

Certain forms of indigestion will also produce feelings of discomfort and it is only when the optician has carefully examined every imaginable cause of error without arriving at the true cause, and prescribed glasses for any error found and still finding the discomfort continues, that he begins to seriously consider the presence of the reflex action of physical disabilities of which he knows nothing, and for which he cannot prescribe even if he did.

It is well, therefore, in all cases of Asthenopia, especially where no immediate progress is made by glasses, to inquire into the conditions of the general health, and in case of ill-health to delay further efforts of relief until the physician has brought about an improved condition.

The connection between nervous complaints and eye error is so close that it is often difficult to decide which is the cause and which the effect, and consequently cases of this nature are better in the hands of the oculist, who is competent to study and prescribe for both conditions, than divided between a general practitioner and an optician.

Asthenopia, in addition to the particular causes already referred to, is undoubtedly largely dependent upon climatic conditions and habits of a people.

The inhabitants of tropical countries are of necessity, as a result of their environment, an indolent people and do not indulge in strenuous exercise, either mental or physical, and for a great part of the year merely vegetate. All the inhabitants being controlled by conditions over which they have no control, there is but little competition, and but little inducement to nervous tension that in more temperate climates is peculiar to modern nations in their effort to secure a share of the world's commerce.

The necessaries of life are ready to hand. The fruit and vegetable production of tropical countries being ample for the necessaries of life and capable of being produced with little effort, the inhabitant of the tropics is a stranger to the anxious struggle that is ever present in colder climates

With the question of a livelihood always before them, education as a means of acquiring it is always a matter of serious consideration, and the child of the frigid and temperate zone is almost from infancy preparing for the struggle for existence, and not merely is the actual strain upon organs of sight consequently much greater than in climates where a ready-made livelihood is at hand, but the drain upon the nerve supply is enormous, and has undoubtedly much to do with the presence of Asthenopia.

This view is much strengthened by a consideration of the conditions existing in England and America.

In England, although the proportion of Ametropes is larger than in America, the percentage of people wearing glasses is considerably smaller, and those in England who do wear them are to a large extent Myopes, while in America by far the larger proportion are Hyperopes and Hyperopic Astigmats.

The reason for this is not far to seek. The English have for so long been at the head of all commercial enterprise that they have as a nation ceased to worry about it, taking it as a matter of course that they are bound to get their share both individually and collectively, and the business man does not, as we do, rush after business, but waits for it to come to him. His nervous energy is not concerned in what we call "hustling" for trade, and the effect is seen in his freedom from nervous affections, as, although ametropic to a greater degree than the people of the American continent, the English wear glasses less owing to the absence of asthenopic symptoms.

A case in point will illustrate the far-reaching effect of the nervous excitement which is characteristic of new world countries, and which seriously affects the condition of the eyes in relation to Asthenopia.

A case which came to me a few years ago for examination, and which had already been treated by two of the leading Canadian oculists, disclosed a considerable amount of mixed astigmatism and severe Asthenopia. The patient was a girl of sixteen, with a highly nervous temperament, and the various glasses prescribed, while giving fairly good vision, were always more or less unsatisfactory in the matter of comfort. Without glasses the patient could not read or perform any of the ordinary duties without the greatest degree of discomfort, amounting even to nausea. Four years ago the patient was sent to England to complete her education, and, although applying herself with the greatest diligence, she felt no ill effects, and before completing a year in her new home had discarded glasses entirely and continued to do without them during the four years she was there, but upon returning to her home in Canada, and, although her studies were completed, and she had comparatively little necessity for use of the eyes for near work, she was compelled to resume her glasses within a period of six months.

A second case that came under my notice is very similar. A young girl attending a local academy was brought to me for examination and disclosed considerable hyperopic astigmatism, and intense pain as the result of her studies. She was ultimately sent to England to complete her studies, and in a recent visit stated that she had entire freedom from asthenopic pains during her sojourn there, but felt symptoms of their return after being home for three months.

These instances of actual experience show how difficult it is for an optician, however well equipped, to prescribe for cases of this kind with any positive assurance of success, and the experienced optician will do well to undertake them with a reservation, and when found complicated with nervous or other diseases to resign them at once to the oculist.

# MUSCULAR ANOMALIES AND THEIR EFFECTS.

A great deal on this sensational order has been written on the subject of the cure and relief of disease by the application of lenses.

In this, as in almost all branches of original research, certain writers have been to the front with startling theories and original propositions. That many of these have been sensational and preposterous few will deny, but all of them have contained the same germ of truth, and it is unfortunately owing to the tendency of these writers to exaggerate in the main that the profession has been slow to accept them.

Probably no section of optometry has been the subject of greater difference of opinion than the question of prisms and their application.

Prisms have at times been "fashionable" among "the profession," and again at others have sunk into disrepute, so that their employment, in the form of a "fad," has undoubtedly deterred many conscientious opticians from thoroughly investigating the question and has assisted in prematurely condemning the use of prisms as "quackery."

In the light of recent investigations, however, it is safe to affirm that the prism has its legitimate place in the appliances available in the practice of modern optometry.

Is it not sufficient for the successful practitioners to state that they "succeed without the use of prisms, and "they never have any dissatisfied customers."

The fact remains that a certain percentage of eye trouble is due to muscular imbalance, and if you do not meet with it someone else does.

There are numerous instruments available for determining the presence of heterophoria, and they are generally simple in construction and easy of operation. The great trouble lies in the fact that many of those who do make heterophoric examinations, in every case, do so in a perfunctory way, and with little faith in the measures they are taking, and less care to insure accuracy in results.

I wish to state here that examinations for muscular defects made in this perfunctory manner, or, in fact, examinations with only a partial knowledge of the accepted theories of muscular imbalance, is time wasted, and glasses prescribed under these conditions are more likely to prove a burden than a relief.

It is, of course, impossible in an article of this nature, to attempt to teach the science of higher prisms, and it is not my intention to attempt to more than point the way.

The important fact to lay to heart is, that all eyes have a tendency, in a greater or less degree, to imbalance, just as all eyes are more or less ametropic.

Many eyes, however, possessing considerable defects in their refractive condition still possess perfect acuteness and an utter absence of asthenopia.

Likewise many a case of heterophoria exists in which no positive eyestrain can be found.

The question then naturally arises, shall we interfere in cases of this nature and attempt to rectify visible errors while not finding any ill-effects of that error? It is probable that right here is the strongest argument against the practice of optometry by opticians.

The far-reaching effects of eyestrain cannot be measured with the optometer and test case.

They extend through the entire system, and according to the most advanced authorities, no disease of organs, the most remote from the organs of vision, can be said to be beyond the the reach of uncorrected eyestrain. To what extent many of these remote—and some of them deadly—diseases are caused by eyestrain, it is impossible for the optician to judge, possessing no training in anatomy or the diagnosing of disease, and scarcely possessing the right to ask questions of his patient concerning its nature and symptoms.

There is no question, however, on one point, an optician, however well qualified in his profession, has no right to attempt a diagnosis of this kind nor to undertake the care of the disease, but no one will question his right, nay, his duty, to diagnose errors of refraction and heterophoric conditions and to use every means in his power to rectify them, leaving the results as shown in the improved physical condition to the physician, whose business it is to report thereon.

Professor Ranney, one of the greatest of modern authorities on this branch of eye work, claims to have established beyond a doubt that many so called incurable diseases, such as diabetes, Bright's disease, St. Vitus' dance, etc., may be, and in his experience have been, caused by uncorrected errors or muscular imbalance, or both, and that he has secured relief in a great many cases, and a complete cure in others, by the removal of the cause.

It is not to be understood that the cause is direct, but rather that the persistent strain on the nervous system by a defective ocular system reduces vitality of the whole body to such a low ebb that disease finds a welcome abode in any organ already predisposed, and its natural powers of resistance weakened by enervation.

To fully understand this theory it is necessary to remember the conditions under which we contract disease.

A constitution, with the powers of resistence weakened, falls an easy victim, while others escape. So it is in the cases referred to. Disease, a foe to nature, is always making efforts to effect a lodgment in parts the most susceptible, and a dissention from within reducing the defences below their normal condition offers an easy access to a foe from without.

If this theory be accepted the field of labor opened up to the optician is practically limitless, and certainly furnishes a convincing argument for the higher education of those engaged in optometry and an additional reason for safeguarding the privileges of the profession.

The eyeball is deposited in the orbit and surrounded by a cushion of fatty tissue, and attached to it are the motor muscles, six in number.

The motor muscles consist of four recti or straight muscles and two oblique.

They are as follows: Superior Rectus, Inferior Rectus, Internal Rectus, External Rectus, Superior Oblique, Inferior Oblique.

With all the muscles in a normal condition, and entirely relaxed, the eye is directed to infinity, and is "at rest."

In the act of directing the visual axis to any point within infinity the internal recti are contracted, thus rotating the eyeballs inward. In the act of retiring them to infinity the externals are used.

In looking upward the superiors would be contracted while the inferiors would direct the vision downward.

The oblique muscles are used for rotating the ball around the antero posterior axis.

Superior rotates the upper section of vertical axis inward.

Inferior rotates the upper section of vertical axis outward.

Adduction is a term used to indicate the power of the internal.

Abduction refers to the external.

The movement of the eye in an oblique direction is accomplished by means of the combined action of two or more muscles exerting a force from different directions, the ball takes a course between them.

For instance, in looking obliquely up and out the superior and external would be exerted, producing motion in a direction midway between the two muscles.

It will be easily understood from the foregoing that each muscle has its opponent, the external and internal opposing each other, also the superior and inferior and the two obliques, and that parallelism of the visual axis of the two eyes without muscular effort is only possible when the opposing muscles exactly balance each other, as it is evident that if one preponderated the eye would turn towards it unless restrained by its opponent.

Orthophoria is a term used to indicate a condition of perfect balance between all the motor muscles.

Savage says: "This condition in the strictest sense includes the idea that the extrinsic muscles have all been perfectly developed, that each has its correct origin, pursues its proper course through the eye, and is rightly attached to the globe."

Heterophoria is a term used to indicate a condition of unbalance among the motor muscles, the tendency being for the eyeball to rotate towards the preponderating muscles, thus demanding constant restraint on the part of its opponent.

The various forms of Heterophoria are as follows: A tendency to turn in is called Esophoria; a difficulty in converging is called Exophoria: an inclination upward is called Hyperphoria, and a tendency downward is called Cataphoria.

There are also complications of the oblique muscles with any of the above which would occasion Eso Cataphoria, Eso Hyperphoria, Exo Cataphoria, Exo Hyperphoria.

Heterophoria affecting the oblique muscles is known as Cyclophoria. When the inferior oblique is affected, producing a tendency of vertical axis to rotate outward at the top it is known as Plus Cylophoria, and where the tendency is for them to converge it would be Minus Cyclophoria.

It is evident from what has been stated that Heterophoria in any of its forms is a condition in which a certain muscle is working at a disadvantage as compared with its opponent.

This may be owing to difference in size and strength, or it may be owing to certain forms of malformation in which one muscle is attached more forward or backward of the opposing muscle.

In the latter case, although of equal strength, the one inserted forward will, as a result of the leverage thus acquired, produce more motion with less exertion.

It must be borne clearly in mind, however, that the preponderance of any muscles, from whatever causes, in Heterophoria rarely produces an actual deviation of the axis, owing to the fact that the opposing, and presumably weaker, muscles exerting a continuous check by means of constant contraction, holds the eyes in position, thus preventing diplopia and squint.

It must also be clearly understood that the unnatural strain to which the weaker muscle is subjected, demands a tremendous amount of nerve impulse to be constantly supplied for that purpose, and if we consider this impulse as so much motive power —electricity, if you will—and that all the organs of the body depend upon a certain supply in order to perform their allotted function, it is easy to understand that a shortage is likely to prevail somewhere if one set of organs is consuming an abnormal amount. This shortage would mean inability to act and consequently the form of disease natural to the inaction of any particular organ. If this theory is correct it is not difficult to imagine that the condition of muscular error, demanding an unnatural supply of nerve force, can easily be the indirect cause of many forms of disease and discomfort even in organs entirely remote from the organ of vision.

In the various forms of Heterophoria mentioned the terms Pseudo and Intrinsic are used to differentiate between a real condition of error in the construction or anatomy of the muscle and a condition of faulty action of a perfect muscle owing to interference in the nerve supply usually dependent upon some error of refraction.

For the testing of Heterophoria several appliances have been provided, from the simple prism to the phorometers of different designs.

In using the prism test we simply place a prism from the trial case of sufficient strength over one eye—the other being uncovered—and direct the attention to a small gas or candle flame. The power being just sufficiently strong to cause Diplopia two images of the flame are seen, one above the other if the prism is base vertical and no Heterophoria is present, but if the internals and externals do not balance the eyes will rotate either out or in, according to which ever muscle preponderates, and a consequent change in the apparent position of the two images, as if the internals preponderate, the eyes rotating inward, the image as seen by the right eye will appear more to the right, and consequently will no longer appear exactly above the other image as seen with the left eye. This condition indicates Esophoria.

If the image as seen by the right eye is to the left of the one seen by the left eye the externals preponderating have turned the eyes outward, indicating Exophoria.

In a like m the prism is used base out or in and lateral Diplopia is caused vith both images on the same plane in Orthophoria, but one elevated or depressed in Hyperphori taphoria.

The prism necessary to restore the images to the lane is in all cases the measure of the Heterophoria.

FIG. 63.—Maddox Rod.

The Maddox Rod and other similar appliances are used in the same manner, the object being to destroy binocular vision by reason of the transformation effected in the appearance of the object as seen through the rod as compared with vision with the naked eye, so that the vision of the two eyes is thus entirely disassociated.

The flame, as seen through the Maddox Rod, assumes the appearance of a long band of light, which in Orthophoria, with the rod horizontal over right eye, runs vertically through the centre of the flame, but in Esophoria is to the right of it and Exophoria to the left of the flame.

With rod on right eye vertically the band of light is seen extending horizontally through the flame, but in right Hyperophoria, when the right eye has turned upwards, the band will be seen below the flame, while in right Cataphoria it will appear above.

The degree of error, of course, is indicated by the prism necessary to compel the band of light to pass through the flame, which would be accomplished in Esophoria when the Maddox Rod is in front of right eye by holding before the left eye a prism base out of the strength required to bring the flame as seen by left eye over to the apparent position of the bar of light as seen by right eye, and in a like manner through all the various forms of Heterophoria, which is a very simple matter if we remember that the object will always appear to move towards the apex of the prism.

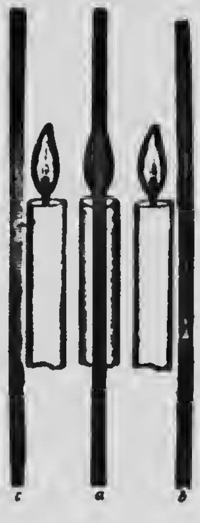


FIG. 64.

FIG. 65.

Fig. 64.—The Maddox Rod as applied for insufficiency of the external and internal muscles.

In fig. 65 the appearance and relative positions of the flame and the bar of light is shown.

A. shows the bar passing through the flame as in Orthophoria.

B. The bar is seen to the right of the flame, and with Maddox Rod on the right eye indicates Esophoria.

C. The bar shown to the left of flame indicates Exophoria.

Fig. 65.—The Maddox Rod as applied for testing the superior and inferiors.

A. Orthophoria with the bar passing through centre of flame.

B. Hyperophoria with the bar below the flame.

C. Cataphoria with the bar above the flame.

Another very simple test for the presence of Heterophoria —though not of the amount—is the cover test.

This is done by simply excluding the vision of one eye by means of the black rubber disc from the trial frame, and have the patient fix the uncovered eye upon some object at distance. This eye will immediately turn in the direction of the object designated, while the other eye excluded from action will turn in unison if Orthopaic, but if Heterophoria is present—as there is no possibility of binocular vision—will turn towards the preponderating muscle. The movement of the eye excluded from vision can be discerned moving towards the stronger muscle as the other eye fixes the object.

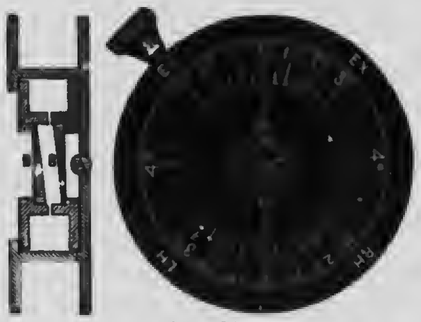


FIG. 66.

Prince's Phorometer.

The Phorometer, however, is the most reliable instrument for conducting heterophoric tests, and by its aid the various forms of muscular error are quickly and accurately diagnosed.

Much has been written and said upon the causes of Heterophoria, but after all has been said we have generally to look for the origin in one or more of the various errors of refraction, and for this reason any attempt to correct Heterophoria by prismatic correction or exercise, until any existing error of refraction has been corrected and had reasonable time in which to produce results, is bad practice, unless the Heterophoria is of such a form that the correction for the Ametropia will necessarily increase the muscular imbalance, in which case the latter must be ignored for the present and the muscular correction proceeded with immediately.

The symptoms of Heterophoria are those generally common to Asthenopia, viz.: Headache, pain in the region of the orbit and brow, and possibly extending to the back of the head, and the headache of Heterophoria is distinguished from those incidental to stomachic ailments by reason of the fact that in the latter one usually awakens in the morning with the sufferings present, while in the former rest has enabled the nerve supply to become recharged, and it is not until the eyes have again been subjected to unnatural strain in the effort of vision that the pain once more returns.

Headache not present upon waking, but ensuing upon the use of the eyes for close work, is usually that of refractive error, while the Asthenopia resultant from the use of the eyes at distance is nearly always Heterophorie.

Asthenopic symptoms, resulting from the use of the eyes in a bright, strong light, may be attributed to paralysis of the sphincter, which suffers in the prolonged effort of contracting the pupil.

But it must not be overlooked that the regulation sick headache, which is the invariable result of stomachic disorders, may have its original cause in errors of refraction or Heterophoria, or both.

Drs. Savage and Ranney, who have investigated muscular anomalies with marked success, both emphasize the connection between muscular errors and many serious ailments which have long baffled the skill of the medical practitioner.

There are two distinct methods of treating muscular errors, either by supplying for regular wear prisms with the base over the defective muscle, or by means of gymnastic exercise by means of prisms, with the base over the preponderating muscle.

By the latter method prisms of just sufficient strength to cause Diplopia are placed with apex in front of defective muscle, which thus puts a strain on this muscle, but by a supreme effort this muscle is made to contract and overcome the power of the prism and fuse the two objects seen, when the frame containing the prisms is raised and the muscles relax, and, on dropping the frame in place again, the object is again doubled and the act of fusion is again repeated. Thus, by repeated exercise of this kind, while increasing the power of the prisms used from week to week, the defective muscle becomes developed, and in favorable cases it is possible to produce a condition of preponderance in the originally defective muscle.

In case, however, the muscles are faulty in their attachment to the eyeball, little or no headway can be made with the use of prisms, and the only relief is by means of tenotomy.

In the correction of vertical errors—Hyperphoria and Cataphoria—Savage insists that the whole of the correcting prism should be worn before the defective eye and not divided between the two eyes.

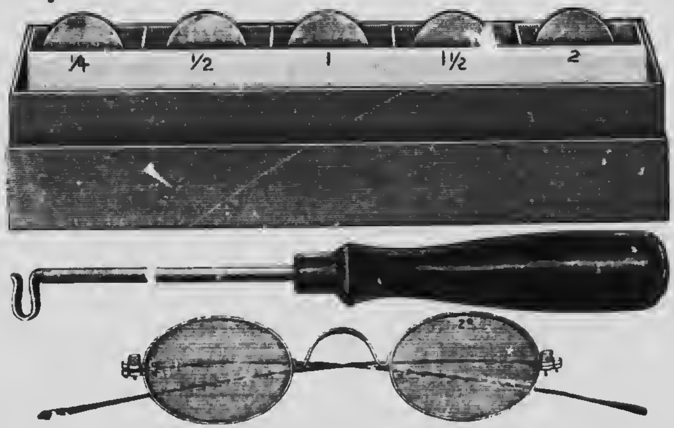



FIG. 67. Heterophoric Prism set for the practice of rhythmic exercise.

Regarding the correction of muscular insufficiencies by gymnastic exercise with prisms its inventor says:—

" While rhythmic contraction and relaxation regulated as to intensity and time will develop any one of the recti muscles, as is developed the biceps of the blacksmith's arm, the writer would not be understood as believing that one of these muscles can be developed out of a low state of weakness into a high state of strength. There are cases of Exophoria that will remain Exophoria still, in spite of the long-continued rhythmic and graduated exercise, and these cases, to be cured at all, must be cured either by partial tenotomies alone or by those supplemented with rhythmic exercise. The same may be said of Exophoria and Hyperphoria. Only low degrees (not more than 6°) of lateral Heterophoria can be converted, by rhythmic exercise alone, into Orthophoria, the higher degrees can be corrected by partial tenotomies, shortenings and exercise combined. While, in suitable cases, the aim of partial tenotomies and shortenings should be to approach Orthophoria, yet the greatest care should be exercised not to go beyond the " balance " line. The safest thing is to leave, for correction by exercise, some of the original condition."

Any one of the recti and either of the obliques weaker than its opposing muscle, the difference in corresponding strength not being too great, may be developed by rhythmic exercise into a state that will enable it to work harmoniously with its fellow.

In attempting correction by this method then, it is useless to waste time on any case in which the error is above a certain quantity.

In Exophoria 6. D. has been found to be the maximum degree with which satisfactory progress can be expected. In this form of Heterophoria it is the internals that are defected, and the exercise is of such a nature as to put the necessity of strenuous action upon the convergence, just as the physical director will order the wrist machine for strengthening the power of the forearm.

Having ascertained the degree of Exophoria by any of the reliable methods given, a pair of prisms, base out, are supplied just strong enough to cause Diplopia, which by an effort of the internals is overcome, and upon raising the frame containing the prisms this muscle instantly relaxes, and upon dropping the frame into position again Diplopia once more appearing, the internals are again called into action, thus developing and strengthening them by continual use in contracting and relaxing.

The progress made will be clearly indicated by the fact that a prism that used yesterday to cause Diplopia is useless to-day, owing to the fact that the increasing power of the internals enables them to instantly overcome the effect of the prism the moment it is placed in position and without conscious effort. The prisms will have to be increased in power as this happens until it is found by actual measurement that Exophoria no longer exists.

The exe has to be regularly practiced once or twice a day during periods of five or ten minutes.

Esophoria is a condition of preponderance in the internals, and consequently it is the externals that have to be exercised.

Prisms ranging from 1 to 3 are used in the same manner as already described in Exophoria, but in the present instance the bases are inward.

In Hyperophoria and Cataphoria the condition of weakness is in the inferior rectus, and one of the exercise prisms is placed, base up, over the eye found to be Hyperophoric, and the other, base down, over the opposite eye which, of course, is equally Cataphoric.

Weak prisms, not more than 1 or 2, are required, and the exercise must be continued and conducted as in the forms of error already described.

For the detection of insufficiencies of the oblique muscles the Maddox double prism is used when the phorometer is not available.

FIG. 68.
Maddox Double Prism.

One eye being covered with the opaque disc and the double prism base vertical in front of the other (the right) a card containing a horizontal line is used as a target at about eighteen inches distance. The horizontal line, under the effect of the prism, is instantly seen double with the two lines exactly parallel.

The opaque disc is then removed from the other eye and a third line will be seen between the other two, and if the obliques are harmonious it will be parallel to the first two lines, but if any insufficiency exists it will appear tilted up or down.

If the middle line appears tilted down on the right the left superior oblique is insufficient as compared with the left inferior oblique. With the left ends of middle and lower line converging insufficiency of the left inferior oblique is indicated.

The same method is applied to the right eye by placing the double prism over the left eye.

Cyclophoria—a condition of error in the oblique muscles—is of two forms. Plus when the vertical axis inclines outward at the top as a result of preponderating superior oblique, and minus as seen in the inclination of the vertical axis at the bottom owing to preponderating inferior obliques. Savage's method of the correction of Cyclophoria is by means of cylinders, usually + 1.50, placed before each eye, that it will demand action on the part of the defective muscle to prevent distortion and maintain binocular vision.

To understand the principles involved in this method it is necessary to be thoroughly familiar with the condition existing in Cyclophoria, and the effect of a cylinder upon the position and principal direction of the retinal images.

In Plus Cyclophoria the superior obliques preponderating theoretically rotate the eyeball down and out thus causing the vertical axis to separate at the top. This, if actually occurring, would produce either distorted objects in a slanting outward direction or Diplopia, either of which condition producing discomfort or strain, is prevented by the restraining power exerted by the opposing weak muscle, which is thus kept constantly in a state of contraction at the cost of comfort and health.

The effect of a cylinder placed in front of the eye, in addition to effect upon the refraction, is of prismatic nature, the light rays deviating towards the bases of the prisms of which a cylinder may be said to be composed. In the case of a plus cylinder this would be represented by its axis.

The optical effect of this is that retinal image of an upright object would be tilted over towards the direction of the axis if it were set obliquely.

Here, then, we have exactly the condition produced in Cyclophoria, so that it is very evident that if we place the cylinder in such a position that it will necessitate an effort of contraction upon the weakened muscle, thus applying to the obliques the same theory of development by exercise that has already been described in reference to the recti muscles should secure similar results in regard to muscular development.

It is obvious, of course, that a cylinder so applied is not for constant wear, and it is not intended in any way to correct any error of refraction, but is used merely as an exercise for a few minutes at a time at repeated intervals.

In case of Oblique Astigmatism the wearing of the correction will frequently fail to give satisfaction when complicated by oblique muscular trouble, and relief will usually be experienced by throwing the axis of cylinder over in such a position that it does the work hitherto done by the defective muscle. This position, while producing comfort, will scarcely give as high a degree of visual acuity, and the safer plan is to tone up the weak muscle by exercise previous to supplying the correction.

Referring again to the question of Esophoria, it has already been stated that this form of Heterophoria is of two kinds, Intrinsic and Pseudo.

In the former kind the cause is to be found in the fact that the internals are either too strong, too short, or are attached too far forward, or that the externals are abnormally long or weak or attached farther back than the internals. A mal-attachment also of the superiors, where this attachment is to the nasal side of vertical meridian, would necessarily create a tendency to Esophoria, and destroy the balance between internals and externals by the added weight of the superiors inwards.

Another cause for Esophoria is also to be found in a condition of abnormal enervation in nerve centres that supply the impulse to the internals, thus causing abnormal action on the part of these muscles.

Pseudo Esophoria is a fictitious condition depending upon the conditions of the ciliary muscle and its relationship to the internal rectus through their common nerve supply, and is the usual accompaniment of Hyperopia when the balance between accommodation and convergence had necessarily been disturbed, and the cause of the tendency over convergence is on account of the nerve impulse necessary to accommodate being unconsciously supplied also to the internals.

Thus we have a condition of Esophoria, or a tendency to overconverge, without, in any way, having a preponderance of muscular action inwards.

It is self-evident that no treatment or correction for this is necessary as the correction of the Hyperopia will at once do away with all abnormal enervation, both ciliary and internal.

Savage particularly emphasizes a curious fact, when read in the light of the average text book, the medical authors of which, while claiming to write for the laymen and anxious to receive their financial support, always have this stereotyped sentence inserted somewhere in every chapter: "No test can be in any way reliable unless atropine has been administered."

Savage's concluding sentence to one of his best articles on Heterophoria reads as follows: 'All tests for lateral Heterophoria are wholly unreliable within the first few hours after eyes have been brought under the influence of a mydriatic."

Exophoria, the tendency of the axes to intersect further away than the fixation point or possibly to diverge is a condition of preponderance in the externals and, like Esophoria, is intrinsic and pseudo.

In the intrinsic form an actual condition of preponderance in the externals in exactly the same manner as has already been shown in reference to the preponderance of the internals in Esophoria.

The tests for this form of muscular imbalance have already been given, and the means of relief either by prisms worn with their bases out or by means of gymnastic exercise by prisms with their bases in.

Pseudo Exophoria is usually associated with Myopia, or it may be present as the result of an abnormal development of the ciliary muscle.

If associated with Myopia it will be found only in near tests, as Myopia uncorrected demands little or no accommodation for near distances, consequently little or no nerve impulse is generated, and as the two functions of accommodation and convergence have a common nerve supply it is clear that a tendency to underconverge will be experienced.

The same reasoning applies to condition of abnormal development of the ciliary, as when directing the eyes to a close point under these conditions the act is accomplished by the use of an abnormally small amount of nerve impulse, and consequently a weak impulse to converge, thus allowing the externals to preponderate.

Pseudo Exophoria is indicated by the fact that the distant test shows Orthophoria, while the near test gives Exophoria, or when Exophoria is present at both points less for far than near points.

The tests and treatment have already been noted, and, while no correction would be necessary for Pseudo Exophoria associated with Myopia or Myopic Astigmatism other than the correction for the error of refraction, and in some cases associated by exercise, when an abnormal development of the ciliary muscle occasions it, relief would seem possible only through operation or persistent exercise with a view to producing in the internals a similar condition, thus "forcing a balance."

It is well to remember that in Exophoric conditions, when associated with Hyperopia or Hyperopic Astigmatism, will not permit the acceptance of the correction, as any plus correction would but increase the necessity for convergence, which is already in difficulties owing to the insufficiency of the internals.

The great difficulty lying in the way of all forms of gymnastic treatment for muscular anomalies as practiced by the optician, the process even under favorable circumstances is tedious and the results uncertain, and depends as much upon the hearty co-operation of the patient as upon any technical knowledge possessed by the optician, and in the event of the former failing to faithfully carry out instructions in exercising, no headway is made.

Another feature not without considerable importance to opticians as now practicing; very few are able to collect any fee for professional services, and the patient usually demands an estimate for glasses before placing the order, and usually expects a "no cure no pay" guarantee. It is easily seen that the actual value of the glasses is the smallest item in cases of this nature, and it is utterly impossible to fix a proportionate charge before undertaking the work, and no one would think of guaranteeing perfect results.

# COLOR AND COLOR VISION.

The phenomenon of color and its interpretation in the act of vision has long remained one of the mysteries of optical science as applied to eye work, and the various hypotheses that have been advanced at different times by the most eminent investigators are still little more than plausible theories, and have never yet been demonstrated to be absolutely true.

It may seem, therefore, somewhat presumptuous to attempt to elucidate a complicated question of this nature in an elementary optical treatise, but I would merely point out that it is not my intention to attempt here to solve the mystery of color and color sense, but merely to transcribe into simple English some of the theories that have come under discussion.

What is known as the "Young-Hemholts" theory has received the greatest measure of support, and it is pretty generally accepted as being the correct solution, but, unfortunately, it has not hitherto been found possible to demonstrate its absolute soundness.

Young's theory, which was the first to possess any scientific value, was as follows: "It is certain," said he, "that we can produce a perfect sensation of yellow and blue by a mixture of green and red light, and of green and violet light. There are reasons for supposing that these sensations are always composed of a combination of separate sensations. This supposition at least simplifies the theory of colors, we may therefore accept it with advantage until such time as we shall find it incompatible with some phenomenon. We will, therefore, consider white light as composed of a mixture of three colors only—red, green and violet."

Tschering, in his reference to color in his book "Physiologic Optics," says regarding this theory: "We suppose each nerve fibre of the retina composed of three fibres of the second order, each of these fibres would be provided with a special terminal organ (a photo-chemical substance) and also with a special central organ. An irritation of the first fibre would produce a red sensation, and an irritation of the second fibre a green sensation, and an irritation of the third a violet sensation. These three are termed principal colors. An irritation of the first two fibres would produce yellow, etc. An irritation of the three produces white, and the absence of all irritation produces a sensation of black.

Hemholtz, while agreeing in the main with Young, argued that each color irritated all three fibres at once, but some in a greater degree than others, and the resultant color sensation would be in accord with which ever nerve fibre was most affected.

It will be seen from this that the retina is supposed to possess a form developing faculty, and a color perception power, for which purpose it may be said to be composed of a set of nerves which are susceptible to form and another set susceptible to color, and that the latter, like the fo ner, have their infinity situated in the brain, so that while the retinal image by means of the former produces in the mind ideas and information concerning the size, shape, etc., of the object looked at, the latter clothes it in tints in accordance with the manner in which they are affected by the preponderance of the effect on the various nerve fibres that respond to the different colors of which light is said to be composed.

Thus it will be understood that color is merely a mental sensation and has no actual existence, and that objects appear red, blue, green, etc., because the chemical nature of their exterior is such that all but a certain portion of the light is absorbed, the remainder being reflected back enters the eye and, acting upon the particular nerve fibre that responds to the particular portion of the light ray which it represents, the color sensation is thereby produced.

This theory will not be difficult of comprehension if we bear in mind the results following the violent refraction of pure white light by means of a powerful prism. If we place such a prism in a dark room without a particle of color on its walls, and being entirely divested of any furnishings whatsoever, and admit a ray of light through a small opening so that it will pass through the prism in passing in, the result will be that on the perfectly colorless wall appears a succession of illuminated sections of different colors, so that it is evident that the effect produced is in the light itself and its effect upon the organs of sight and not by any artificial change in the wall itself.

This would prove either that the light is broken up into several parts each possessing a different tint, or that if these broken parts are really colorless that they are different from each other in some vital essential, inasmuch as they affect the retina and intellect in such a manner that they are to the person who views them to all intents and purposes really colored.

The acceptance of the Young-Hemholtz theory accepts the latter hypothesis and also accounts for color blindness—that is the inability to correctly distinguish colors—by the supposition that the nerve fibres which produce certain color sensations are imperfect or absent absolutely.

# GLOSSARY.

AXIS.—One of the principal lines through the centre of a figure. In a cylinder lens it is the plain direction.

AXIS RAY.—The ray that passes through the optical centre of a lens and which is not refracted.

ATROPINE.—The · ive principle of Belladona.

AQUEOUS HUMOR.—The fluid contained in the front chambers of the eye.

APHAKIA.—The absence of the crystalline lens.

AMETROPIA.—A condition of imperfect refraction.

AMBLYOPIA.—Imperfect · ision not caused by any error of refraction.

ACCOMMODATION.—The act of increasing the refractive power of the eye by means of the crystalline lens.

ASTIGMATISM.—A condition in which the various meridians focus at different points.

ANTERO-POSTERIOR.—From front to rear.

ANNISOMETROPIA.—A difference in the refractive conditions of the two eyes.

ASTHENOPIA.—(. . e strain) A condition of pain and fatigue in the eye or its appendages.

AMPLITUDE.—Amplitude of accommodation, the total increase possible by means of the full use of the ciliary muscle.

BLIND SPOT.—(The point of entrance of). The optic disc.

CATARACT.—An opacity of the crystalline lens through discoloration of its contents.

CATAPHORIA.—Imperfect condition of the superior rectus.

CENTRAD.—Unit of measurement of prism.

CONVERGENT.—Coming together.

CYLINDER.—A lens ground on a cylindrical shape form.

CHROMATIC ABERRATION.—The decomposition of light into colors by means of violent refraction.

CORNEA.—The transparent section of the outer coat of the eye

CHOROID.—The middle coat of the eye.

CRYSTALLINE LENS.—The principal organ of refraction in the eye.

CILIARY MUSCLE.—The muscle that controls the crystalline lens.

CONVERGENCE.—The act of turning the visual axis of both eyes to a point closer than infinity.

DIOPTRE.—The unit of the metric system of measuring lenses, its focal length being 1 metre.

DIPLOPIA.—Seeing two objects when one only is looked at.

DIVERGENT.—Rays are divergent when they are travelling away from each other.

DISPERSIVE.—Applied to refraction—the act of breaking light into its elementary colors.

DEVIATION.—Changing direction.

EMMETROPIC.—A condition of perfect refraction.

FAR POINT.—(Punctum Remotum). The point at which an eye can see clearly without any accommodation.

FOCUS (Principal).—The point behind a convex lens where parallel rays will meet after being refracted.

FOCI (Conjucate).—Th various points behind a lens where the light proceeding from the various points within infinity would meet after passing through the lens.

GLAUCOMA.—A disease of the eye which causes severe tension, and usually results in the loss of sight unless speedily relieved.

HYPEROPIA.—A condition of refractive error in which the focus parrallel rays is behind the retina.

IRIS.—The vertical section of the choroid.

INFINITY.—A distance of 20 feet or beyond.

LACHRYMAL GLANDS.—The system by which the tears are generated.

LUMINOUS.—Pertaining to light.

LATENT HYPEROPIA.—The amount of hyperopia covered by accommodation and incapable of measurement without atropine.

METRE.—A term of lineal measurement—about 40 inches.

MACULA LUTEA (Yel w Spot).—The point of greatest sensibility on the retina.

METRICAL ANGLE.—The angle formed by the intersection of the visual axis and the median line.

MEDIAN LINE.—An imaginary line running from a point midway between the eyes to infinity.

MERIDIAN.—A direction across the cornea passing through the centre.

MINIMUM.—Least.

MAXIMUM.—Greatest.

MEDIUM.—A body or substance.

MOTOR MUSCLES.—The muscles by which the eyeball is moved in various directions. They are as follows: External Rectus, Internal Rectus, Superior Rectus, Inferior Rectus, Superior and Inferior Oblique.

MYOPIA.—A condition of refractive error in which the focus of parrallel rays is in front of the retina.

MALIGNANT MYOPIA.—When Myopia is of a high degree (6.00 or more) it is said to be malignant.

NEUTRALIZE.—To place convex and concave lenses of equal power and opposite kind together.

NODAL POINT.—An imaginary point situated just in front of the rear surface of the crystalline lens where the visual and optic axis cross.

NEAR POINT (Punctum Proximum).—The nearest point possible to focus an object with all the accommodation in force.

OPTICAL CENTRE.—The point of extreme curvature in a lens.

OPTIC NERVE.—The nerve that conveys the light impressions from the retina to the brain.

OPTIC AXIS.—An imaginary line drawn straight from midway between the yellow spot and optic disc through the centre of the pupil.

OPTIC DISC.—The point at which the optic nerve enters the int[illegible]r of the eye.

OBLIQUE.—[illegible]er than a right angle.

**Pysiology.**—The science treating of the natural action of the various organs of the body.

**Point of Propagation.**—The point from which the light proceeded.

**Parallel.**—Running in the same direction.

**Prism.**—Three-sided figure of glass consisting of a base and two sides.

**Protractor.**—A diagram containing the various degrees of a circle. Used for locating the axis of a cylinder.

**Peripheral.** Near the periphery or circumferance of a circle.

**Photophobia.**—Intolerance of light.

**Posterior Staphaloma.**—The bursting of the eyeball at the rear; usually the result of Progressive Myopia.

**Progressive Myopia.**—A condition in which Myopia is increasing.

**Principal Meridians.**—Directions of greatest and least curvature.

**Presbyopia** (Old Sight).—A condition in which near vision is difficult or impossible owing to loss of accommodation.

**Retina.**—The inner and nervous coat of the eye.

**Refraction.**—The act of bending or turning aside.

**Spherical Aberration.**—The blurring caused by the imperfect focusing of a spherical lens owing to the fact that the central portion of the lens do not refract as much as the parts nearer the edge.

**Suspensory Ligament.**—The ligament which controls the action of the crystalline lens.

**Sclerotic.**—The outer coat of the eye.

**Spherical.**—One of the forms of lenses so called because its surfaces are sections of spheres.

**Strabisimus** (Squint).—A want of parallelism in the visual axes of the two eyes.

SIMULATIVE MYOPIA.—A condition of spasm of the ciliary muscle, which overcorrects a hyperopic condition and renders the eye temporarily myopic.

SOCKET.—The bony ledge in the skull containing the eyeball.

SPHINCTER MUSCLES.—The set of radiating muscles that control the motion of the iris.

VISUAL ANGLE.—The angle formed by the intersection of lines drawn from the extremities of the object looked at to the eye.

VISUAL AXIS.—An imaginary line drawn from the object looked at to the yellow spot.

VITREOUS HUMOR.—The jelly-like contents contained in the rear section of the eyeball.

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