# MANUAL OF INSTRUCTIONS

FOR THE GUIDANCE OF

# ARMY SURGEONS

IN TESTING THE RANGE AND QUALITY OF VISION

OF RECRUITS,

AND IN DISTINGUISHING THE CAUSES OF

# DEFECTIVE VISION IN SOLDIERS.

BY

SURGEON-GENERAL T. LONGMORE, C.B.,

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PROFESSOR OF MILITARY SURGERY AT THE ARMY MEDICAL SCHOOL;
CORRESPONDING MEMBER OF THE SOCIETY OF SURGERY OF PARIS;
ETC. ETC. ETC.

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*Price One Shilling.*

## PREFACE TO THE SECOND EDITION.

THE Manual, of which this is a revised edition, was written in the year 1862, in accordance with a request from Sir James Gibson, then Director-General of the Army Medical Department, that I would prepare a concise and simple guide for the practical examination of the conditions of vision of recruits and soldiers, as there were not at the time any works giving satisfactory information on the subject generally accessible to army medical officers. I undertook the task with diffidence, as I had previously given little more than ordinary attention to this subject. The special importance of visual diagnosis in military practice had made itself obvious owing to the interest which had been excited on questions connected with accuracy of shooting at the Hythe School of Musketry and elsewhere, and to the frequency with which army medical officers were referred to for opinions on matters relating to conditions of eye-sight in consequence. I therefore devoted all the attention to the subject which the time left at my disposal by other duties enabled me to give to it with a view to comply with the Director-General's request; and having completed the manual, it was printed under the direction of the War Office in the year 1863.

During the following year the researches of Professor Donders which had first placed the knowledge of the accommodatory function of the eye on a really scientific basis, and the whole subject of the optical examination of the eye with particular regard to variations in its refractive qualities, were published in a complete form by the illustrious Professor of Utrecht in his great work on the "Anomalies of Accommodation and Refraction of the Eye;" and this work, concurrently with its appearance in the Dutch language, was brought within the reach of English readers by the labours of Dr. Moore of Dublin, under the direction of the New Sydenham Society. The little manual that I put forth in 1863, has been out of print for about seven years past, and I have been repeatedly asked to prepare a second edition; but with the great work of Professor Donders above mentioned, and other important works on ocular diseases by eminent ophthalmic surgeons, available for study, I have hitherto declined to comply with the request. It continues, however, to be urged upon me, on the pleas that the manual, in consequence of its concise form, is useful as a help to the candidates for commissions in the army and navy medical services who have to study optical diagnosis with particular regard to the specialities of military circumstances and requirements during the courses of instruction at the Army Medical School, and that it also has some advantages for others who have not time to study larger and more advanced works on the subjects embraced in it, and I, therefore, though somewhat reluctantly, now yield to the request.

The objects and scope of the manual were fully explained in the introduction to the first edition, and some extracts from it are inserted as they will obviate the need of fresh remarks on this topic.

*Netley, October* 1874.

## EXTRACT FROM THE INTRODUCTION TO THE FIRST EDITION.

THIS Manual or Aide-mémoire is published with the object of supplying a want which has been felt by many army medical officers since the introduction of fire-arms with graduated aims. The general use of the rifle in the army has rendered a high degree of visual accuracy on the part of the soldiers for whom these arms are destined a matter of imperious necessity. The quality of eyesight which was good enough to meet the demands of the old smooth-bore musket is by no means sufficient for a weapon which has a range of nearly a thousand yards, and which, to be of service, demands that the soldier who uses it shall have a clear perception, and shall correctly judge the distance, of any object of the size of a man at any position up to that extent of range. It becomes the duty of the medical officer to determine whether the power of eyesight in a recruit is adequate to meet the new demand thus made upon this function by the combatant officer. The determination of the question is readily arrived at if the vision be normal, or if it be abnormal to an extreme extent; but there are many intermediate degrees of defect, and many peculiar complications, which require no little nice discrimination and accuracy of observation in practice to distinguish and define. These difficulties become increased when there is either an unwillingness to assist the surgeon, or positive attempts to deceive him, on the part of the person under examination. It is hoped that the materials in the following pages may be useful in saving time and showing the means of obviating errors in this branch of duty.

But it is not only with recruits that the medical officer has to deal in determining power of eyesight. Soldiers already in the service are frequently declared by musketry instructors to be incompetent for practice with the rifle on account of their inability to see the target at the necessary ranges. The medical officer has then to decide whether the defect complained of really exists or not; whether it is of a kind that admits of remedy; or, whether, being irremediable, the man should be invalided and discharged from further service. Important issues, involving pecuniary and other considerations, depend upon the decision he may arrive at. A soldier who is really the subject of serious disease, may by chance be regarded as a malingerer, because all the superficial ocular apparatus are free from disease, and all that can be seen by ordinary observation of the deeper structures of the eye are observed to act precisely as they do in eyes that are known to be healthy. We have, unfortunately, conclusive proofs that such errors as these formerly occurred very frequently; and that they led to soldiers being sent on foreign service, often to tropical climates, where their diseases became rapidly aggravated, so that they had shortly to be invalided home again, and also to the retention for considerable periods at home stations of others who were useless, and who had at last to be discharged from the service after much expense had been incurred by their prolonged maintenance. If a defect of vision really exist, the medical officer should be able to report to his professional superiors the exact cause of the disability, for on this also may hinge many points of importance to the public service, to the soldier, and to the state. If the defective vision be the result of some natural abnormality of the refractive media or special form of the globe, the service has suffered from the admission into its ranks of an ineligible recruit. If the defect be the result of disease, such as too often follows service under the glare of a tropical sun, then the soldier has suffered from his employment by the state, and is entitled to compensation according to the degree of his disability.

There is only one way in which a diagnosis in these cases can be truly arrived at, and that is by means of the Ophthalmoscope. The important discovery of this instrument by Helmholtz, in 1851, has opened up an entirely new field of observation and study, the value of which, as Mr. Bowman has observed, can only now be estimated by trying to suppose what would be thought of an instrument which would enable us to "see the membranes, the "cavities, the course of the fibres, the configuration of the "ganglionic masses of the brain, with the vessels pulsating, the "veins varying in emptiness or repletion, and every product and "physical condition of disease exposed to view,"* or of another, which would, in like manner, expose to our observation the contents of the chest.

A case containing the necessary means for ascertaining the condition of vision, whether normal or defective, and of diagnosing ophthalmoscopically the causes of defective vision when dependent upon disease, has been sanctioned for issue to medical officers, and an explanation of the contents of the case is one of the objects contemplated by the publication of this manual. The remarks in the following pages for observing the different conditions of vision alluded to have, for the most part, reference to the means placed at the command of medical officers by the contents of this case of instruments.

I have divided this *aide-mémoire*, for convenience of reference, into two parts. In the first part I have attempted to explain shortly the nature and distinguishing features of the several kinds of defective vision which the army surgeon is most liable to meet in the recruiting room. The second part is devoted to an explanation of the use of the ophthalmoscope, and its application in the diagnosis of disease. Knowing the difficulties under which many army medical officers on active employ, and in remote stations are placed for reference to scientific and certain professional works, I have thought it advisable to insert some of the laws of light affecting vision, and other collateral matters necessary to be remembered, in order that the practice of the visual examinations described may be conducted with more ease and precision. I have so frequently found explanations asked for on the subjects thus introduced by those who have been studying the practical use of the ophthalmoscope at the Army Medical School, that, although such memoranda may at first appear to some persons out of place,

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* Address by W. Bowman, F.R.S., read at the thirtieth annual meeting of the British Medical Association.

I cannot help believing that they will be found useful to those for whom the manual has been chiefly prepared.

In conclusion, I would beg to urge that this book is only intended to be what I have called it,—an aid to memory. To become expert in the use of the ophthalmoscope, or to speak with authority upon observations made by it, not only must the surgeon make himself practically acquainted with it by a long period of assiduous manipulation, but if he desire to be scientifically acquainted with the subject of his explorations, he must study the writings of those ophthalmologists who have gained European celebrity by their researches, among whom some of our own countrymen hold a conspicuous place.

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THE

# ARMY MEDICAL OFFICER'S OPHTHALMIC MANUAL.

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## PART THE FIRST.

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### OPTICAL EXAMINATION OF THE EYE.

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### CHAPTER I.

Preliminary Remarks.—Definition of Perfect Vision.—Radiation.—Transmission of Light.—Law of Visible Direction.—Inversion of Images on the Retina.—Visual Angle.—Field of Vision.—Angle of Vision of the Fixed Eye.—Normal Range of Motion of the Eye. Position, Apparent Size, and true Size of Objects in the Field of Vision.—Judging Distance.—Infinite and finite Rays.—Lenses.—Power of a Lens in relation to the Position of its principal Focus.—Army Optical and Ophthalmoscopic Case.—Equi-convex and Equi-concave Lenses for Spectacles.—Periscopic, Orthoscopic, Duplex Focal, Cylindrical, Prismatic, and Stenopœic Spectacles.—Prisms for Ophthalmic Purposes.—Symbols.—Abbreviations.

**Preliminary Remarks.**—In the practical instruction on the modes of proceeding for the optical examination of eyes it is usually found necessary to explain the few principles of optics which have to be borne in mind in order that there may be a right comprehension of the chief phenomena of normal and certain abnormal conditions of vision, and of the principles on which the means for correcting defects depending upon irregularities in the refractive and accommodatory powers of eyes are applied.

The chief of these optical memoranda are repeated in this introductory chapter in a concise form for convenience of reference.

The general arrangement of the subjects which form the special objects of consideration in this manual will be found noticed at the commencement of the succeeding chapter.

**Perfect Vision** exists when, firstly, the eye is so constructed that an exact picture of surrounding objects is formed upon the bacillary or proper sentient layer of the retina; and when, secondly, a correct appreciation of the forms, positions, colours, and most of the physical qualities of the objects so depicted is conveyed to the mind. To effect the first of these conditions, the curvatures and refractive qualities of the transparent media must be of such strength, and so combined, that the rays of light proceeding from the external objects are all brought by them to their proper foci upon the percipient retina. To effect the second of these conditions, the picture must be of sufficient size, sufficiently but not excessively illuminated, and must remain sufficiently long on the retina; the expanded retina and its associated layers, the optic nerve and its cerebral connexions, must be healthy; and the perceptive faculties must have been duly educated.

The properties of light, and formation of images, constitute a branch of physical science, the pursuit of which appertains to the student of Natural Philosophy. The study of the faculty of vision or the means by which the luminous impressions on the retina are converted into the act of seeing, belongs to the province of Physiology.

**Radiation.**—The expression *ray of light* indicates the straight line along which light is transmitted, and the term *radiation* signifies the transmission of rays in all directions from a luminous point. A collection of rays so disseminated from a luminous point as to assume a conical outline, is called a diverging *pencil of rays;* and the apex of the cone from which they proceed, is called the *focus* of the pencil. So also, when rays are artificially caused to converge to a common point, they are together spoken of as a converging pencil of rays; and the point at which they all meet is called the focus.

The illuminated surface of any object, in respect to the light it is receiving, is regarded as lighted by the bases of a number of pencils of rays, whose foci are at the source of illumination; and, in respect to the light it is imparting by reflection from its surface, by means of which it is rendered visible, it is regarded as composed of an infinite number of luminous points, which points are the foci of a corresponding number of pencils of rays. It is important, when speaking of the rays proceeding from an illuminated object, not to confound the rays emanating from two points remote from each other (as from the extreme points between which the visual angle is included, for example,) with the rays proceeding from each luminous point of the object independently.

**Transmission of Light.**—Rays of light proceed in straight lines so long as the medium through which they are travelling is of uniform density; but on passing from a rarer into a denser medium they are bent or *refracted towards* a line drawn perpendicularly to the surface of this medium; and conversely, on passing from a denser into a rarer medium, are *refracted from* a line drawn perpendicularly to its surface.

**Law of Visible Direction.**—Each point of an object is seen in a line perpendicular to the point of the retina which its image impinges. Whatever, therefore, may be the *real* place of an object, if the rays of light proceeding from it are brought indirectly by *reflection*, or by any other means, to the retina, it will not appear to the eye to be placed where it really is, but in a situation perpendicularly opposite to that part of the retina on which its reflected rays have fallen.

**Inversion of Images on the Retina.**—The mind does not judge of the positions of objects, whether primary or reflected, according to the part of the retina on which their images happen to fall; if it did, the positions of things would appear to change with changes in the position of the eyes looking at them. But the mind judges of the positions of objects by the direction in which the rays of light come from them to the eyes. Hence, though the images of objects looked at directly are inverted on the retina by the action of the refracting media of the eye, the mind, following the lines of light to their true sources in obedience to the law of visible direction, sees them in their real positions and relations to each other. This equally applies to the reflected images of real objects: the reflected images are inverted on the retina, but they are seen truly in the forms in which they proceed from the reflecting medium.

**Visual Angle.**—The visual angle is the angle included between two rays proceeding from the extreme limits of an object and meeting at a point within the eye. These rays, having met, cross each other and proceed to form the image on the retina.

The point at which they meet is known as "the point of intersection," or "nodal point." The size of the visual angle is similar on each side of the point of intersection—towards the object, and towards the image of it on the retina. The expression that an object occupies so many degrees in the circumference of a circle of which the eye is the centre, or that it subtends an angle of so many degrees, has the same significance as the expression "size of visual angle."

The size of the image of an object formed on the retina varies as the visual angle varies under which the object is seen. The larger the visual angle, the larger the retinal image. If the position of the point of intersection is made to alter, the size of the retinal image will be altered also, but this can hardly happen except artificially by placing a convex or concave lens before the eye. If a convex lens be placed before the eye, the point of intersection will be caused to advance, and the retinal image will become enlarged: if a concave lens be similarly placed, the point of intersection will be caused to recede, and the retinal image will be lessened in size.

**Field of Vision.**—The term "field of vision" signifies the whole of the open space which is visible in one position of the eye.

**Angle of Vision of the Fixed Eye.**—When the eye is directed fixedly in a given direction the horizontal limits of visual perception are comprised within an angle of about 123°.

**Normal Range of Motion of the Eye consistent with Vision.**—The eye can turn through an angle of about 140° horizontally, and of 138° vertically, and perception of objects be retained. On the eye being directed to a point straight before it, it can turn from it 50° towards the nose and 90° outwards in the horizontal plane, or through an angle of 48° from it upwards and 90° downwards.

**Objects on the Visual Field.**—The space and place of objects on the field of vision are measured by the visual angles under which they are seen. The *apparent size*, or lineal measure, of an object is estimated by the size of the visual angle alone. To estimate the *true size*, the distance of the object, as well as the size of the visual angle, must be known. Conversely, the *true size* of an object being known, the visual angle enables us to form a judgment of the distance at which it is placed from us. The ap-apparent size, or lineal measure, is to be distinguished from the apparent *superficial* size, or measure of surface of an object. The lineal measure varies inversely as the distance of the object; the measure of surface varies in proportion to the squares of the lineal measure at different distances.

**Judging Distance.**—An important part of the instruction of recruits at rifle drill practice consits of *judging distance*, for without this knowledge a soldier cannot use his rifle efficiently. The possession of the faculty of judging distance depends upon the capability of properly appreciating the differences in the *visual angles*, or, in other words, the differences in the sizes of the retinal images, formed by an object of known size, a man or horse for example, at different distances. The visual angle, and, therefore, the retinal image lessens as the distance increases. In proportion then as the distance of an object from the eye of an observer is increased, so will be the diminution of the apparent size of the object; and conversely, in proportion as the apparent size diminishes, so will be the increase in distance of the object from the eye of the observer.

The acquirement of the art of *judging distance* is facilitated by observing that certain parts of the object disappear from view at certain distances; this fact depends on the visual angles formed by these parts at such distances being too small to permit recognition. In like manner, and from the same cause, the whole object according to its size will disappear from view at some particular distance, even though no other impediments to a clear view of it exist. (See Ch. III. pages 43 to 45, for further remarks on this subject.)

It is not to be forgotten that the definition and character of the retinal image of an object, and the acuteness of the visual impression produced by it, will be modified by the degree of illumination of the object, the position of the sun in regard to it, the character of the back ground, and the state of the atmosphere between the object and the observer.

**Infinite Rays.**—This term, in reference to vision, is employed to express rays of light proceeding from an object and falling upon the eye in parallel lines, or rather in lines which are so nearly parallel with each other that their divergency is inappreciable; and the expression "infinite distance," or "*infinity*" is used to signify the distance from which such rays come to the eye. The rays proceeding from luminous points on any object distant from about six feet from the spectator up to that of the most distant star, for all practical purposes impinge on the eye parallel with each other, and are spoken of as *infinite rays*. The divergency of a pencil of rays from a luminous point at a distance of six feet from the eye (supposing the diameter of the pupil to be one-eighth of an inch) would only amount to six minutes of a degree. At a distance of 36 feet the angle of divergency would be only one minute of a degree. Rays from objects nearer than six feet are sometimes spoken of as *finite rays*. The divergency of finite rays increases in proportion to their proximity to the eye.

**Lenses.**—Lenses are solid transparent media, such as glass or rock crystal, bounded by a spherical surface on one or both sides, and having the properties of changing the direction of parallel rays of light, so as to cause them either to converge to a given point—the principal focus; or to diverge as if they proceeded from the principal focus.

The lenses which are chiefly used in correcting abnormal conditions of the refractive media of the eye, and which are employed for opthalmoscopic purposes are centric lenses, having two convex surfaces of equal degrees of sphericity, double convex lenses; and double concave lenses, having two concave surfaces also of equal curvature. They are sometimes designated centric bi-convex or equi-convex, and bi-concave or equi-concave lenses.

The *principal focus* of an equi-convex lens will be at the point to which parallel rays falling on one of its surfaces and passing through its substance are caused to converge beyond its other surface. The distance of this focus is measured from the *optical centre* of the lens. The measurement is usually made in inches and parts of inches. The optical centre of a lens is situated at the point where the axis of the lens is intersected by the diameter of the lens. In common speech, for sake of brevity, the principal focus of a convex lens is spoken of as *the focus* of the lens; and the distance of this focus is used to particularize the lens. Thus taking, *e.g.*, a lens whose principal focus is at ten inches from its centre, it is often designated as a convex lens whose focus is at ten inches, or a lens of 10-inch focus; or, still more briefly, as a 10-inch lens.

If the rays falling on a double convex lens are divergent instead of parallel rays, they will be brought to a focus farther off than its principal focus; if they diverge from a point at the distance of the principal focus, they will be refracted as parallel rays; if they are convergent, they will be brought to a focus nearer to the lens than its principal focus.

Parallel rays falling on a double concave lens are caused to diverge to the same extent as they would diverge if they were proceeding from a point at the same distance from its centre as its principal focus is. If the rays falling on the double concave lens are divergent instead of parallel rays, they will be rendered proportionably more divergent, just as if they came from a point nearer to the lens than its principal focus. If they are convergent, and they converge in a direction towards any point between the lens and its principal focus, the refracted rays will be convergent also; if they converge to a point at the distance of the principal focus, they will be refracted as parallel rays; if they converge towards some point beyond the distance of the principal focus, the refracted rays will be proportionably divergent, just as if they were proceeding from some point further off from the lens than the distance of its principal focus.

Regarding the eye as a combination of lenses having together a certain converging power, when a convex lens is placed closely before it, the converging action of the eye on rays proceeding from objects in front is necessarily added to; when a concave lens is similarly placed before the eye, its converging action on the rays will be lessened. The convex lens, therefore, is rightly designated in this respect a + lens; the concave lens a − lens. It is convenient too in calculating the focal distances or powers of lenses required to correct abnormal conditions of the refractive media of the eye, to apply the sign + to converging lenses, and − to diverging lenses. Thus, a convex lens of 10-inch focus is designated a + 10-inch lens, or simply a 10-inch lens, + being understood; while a concave lens of 10-inch focus is noted as a − 10-inch lens.

**Power of a Lens in relation to the Position of its Principal Focus.**—The power of a lens is in an inverse ratio to the distance of its principal focus. Inverting the focal distance gives, therefore, a ready means of expressing the power of a lens. Thus, taking a lens with power to cause parallel rays to converge to a focus at a distance of one inch from its centre as a standard of unity, another lens by which similar rays are brought to a focus at a distance of two inches from its centre, manifestly has only half the converging power of the former; another, whose focus is at three inches, has only one-third of the converging power of the first; at ten inches, one-tenth; and so on through the whole series. In the first instance the focus is one inch, and the power is expressed as 1; in the second, the focus is two inches (or $\frac{2}{1}$), and the power is $\frac{1}{2}$; in the third and fourth cases, the foci being 3 inches and 10 inches (or $\frac{3}{1}$ and $\frac{10}{1}$), the powers are $\frac{1}{3}$ and $\frac{1}{10}$ respectively; and so on through the series of lenses.

**Army Optical and Ophthalmoscopic Case.**—In the combined optical and ophthalmoscopic case used by officers of the Army Medical Department, in addition to the convex and concave lenses belonging to the ophthalmoscope, there is a pair of spectacles fitted with 10-inch convex lenses. Parallel rays falling on these lenses are therefore made to converge to foci at a distance of 10 inches from their respective centres; while divergent rays proceeding from points at 10 inches distance from their centres are refracted by them as parallel rays.

Formerly spectacles with concave — 6″ lenses were supplied in the army case; but the supply has been discontinued as it has been found that their employment can be dispensed with without inconvenience. (*See* page 19.)

**Equi-convex and Equi-concave Lenses for Spectacles.**—There is a certain amount of imperfection attached to the use of equi-convex and equi-concave centric lenses as spectacles when the eyes look obliquely through them, owing to the effects of spherical aberration. As the pencils of rays most free from aberration are those whose axes coincide with the axis of the lens, it follows that vision through a spectacle is best when the eye looks direct through its centre; and it is for the purpose of maintaining vision in this direction that persons wearing spectacles or using a glass, are in the habit of turning the head altogether towards an object in cases where persons without spectacles would merely turn their eyes.

**Periscopic Glasses.**—Lenses concave on one side, convex on the other; Meniscus lenses. They are positive or minus according as their convexity or concavity respectively is in excess. They have been designed to overcome the effects of the spherical aberration of equi-convex and equi-concave spectacles. They enable the wearer to see more obliquely and hence to have a wider field of vision; to look round with less inconvenience when the eye only is turned and hence their name.

**Orthoscopic Glasses.**—Spectacles consisting of a combination of lenses and prisms, so arranged that the deviation of the rays of light by the prism corresponds with the changes in the visual distance caused by the lens.

They have been designed to correct disproportions between accommodation and convergence of the optic axes, and some other defects in binocular vision, which may exist when ordinary convex and concave centric lenses are used.

**Duplex Focal Glasses or Franklin Glasses.**—Glasses with the upper half adapted for looking at distant objects; the lower half for near objects. The lower segment is sometimes united with the upper at an angle so that the visual axis, in the different positions required for seeing distant and near objects, may fall on the surface of each segment of the lens at a right angle.

Thus the upper segment may be made to correct H.; the lower H. combined with Pr.; or the upper to correct M., the lower to correct Pr., as in the glasses first used by the philosopher Franklin after whom they are named.

**Cylindrical Lenses.**—A cylindrical lens is the segment of a cylinder. Incident rays of light in the plane of the axis of the cylinder do not undergo refraction, while those which fall upon its surface in a plane at right angles to the axis of the cylinder are most refracted. They may have a positive or negative focal distance like spherical lenses according to the convexity or concavity of their curvatures.

*Simple Cylindrical Glasses.*—There are three principal kinds. They may be, like spherical lenses, bi-convex or bi-concave, plano-convex or plano-concave, concavo-convex or convex-concave. In these, if both surfaces are cylindrical, their axes must be parallel.

*Bi-cylindrical Glasses.*—These have both surfaces cylindrical, and the axes of these cylindrical surfaces are perpendicular to each other.

*Spherico-cylindrical Glasses.*—Compound lenses of which one surface has a spherical, the other a cylindrical curvature.

**Prismatic Glasses.**—Spectacles having the qualities of prisms, and used for various optical purposes; such as to correct slight declinations of the visual lines, whether upwards, outwards, or inwards, and thus to prevent visual confusion from double images; or to relieve asthenopia depending on affections of the M. recti interni (see Asthenopia).

**Stenopœic Glasses.**—Opaque glasses with very narrow openings, either in the form of a circle or of a slit, for the transmission of rays of light. They are used to improve vision, when only a particular portion of the dioptric media is clear, by preventing the disturbance due to light being diffused through partial obscurations of the cornea or of other of the dioptric media.

*Stenopœic Holder.*—An appliance provided with a slit, capable of being lessened or increased in width, and adapted for holding concave and convex lenses. It is employed in the diagnostic examination of astigmatism and other irregularities of the dioptric media.

**Prisms.**—Prisms of different powers are used in certain parts of ophthalmic practice, especially in the inquiries preliminary to operative interference for the cure of *strabismus* and *diplopia.* Such prisms essentially consist of a solid piece of crown glass contained between five plane surfaces, of which three are rectangular and the two ends triangular, these latter being at right angles with the base of the prism, and therefore parallel with each other. In order to adapt them for use in front of the eye, however, the angles are sometimes rounded off, and a shape thus given to them which is nearly circular. When a ray of light is made to fall upon one of the sides of this prism, and to pass through it, the ray is refracted towards its base, and the degree of deflection varies according to the size of the angle enclosed between the sides through which the refracted light passes, or, in other words, according to the angle of refraction of the prism. Taking advantage of these facts, the rays from a given object may be made to impinge upon any part of either retina, by the use of prisms of different degrees of strength; and by these means the presence or absence of binocular vision (both eyes seeing at the same time) may be determined in doubtful cases, diplopia may be counteracted, and single vision restored, or the relative strength of the several motor muscles of the eyes be tested. The prisms supplied in the cases of eye lenses and prisms in ordinary use have angles of refraction varying from 3° to 24°.

**Abbreviations.**—The following abbreviations are frequently used:—Em. for Emmetropia; M. for Myopia; Hm. for manifest Hypermetropia; Hl. for latent Hypermetropia; H. for absolute Hypermetropia; As. for Astigmatism; V. for acuteness of vision; Pr., Presbyopia; P., proximate or nearest point of distinct vision; R., remote, or most distant, point of distinct vision.

**Symbols.**—The following symbols are also found useful as abbreviations for expression of measurements:—1′, one foot; 1″, one inch; 1‴, one line; ∞, infinite distance, or infinity.

## CHAPTER II.

Vision according to Varieties of Focal Adjustment.—EMMETROPIA.—Definition.—Optical Causes.—Farthest Point of distinct Vision.—Diagnosis.—MYOPIA.—Definition.—Optical Causes.—Remote Causes.—Symptoms.—Diagnosis.—To determine the Degree of Myopia and its correcting Lens.—HYPERMETROPIA.—Definition.—Optical Causes.—Remote Causes.—Symptoms.—Diagnosis.—To determine the Degree of Hypermetropia and its correcting Lens.—ASTIGMATISM.—Definition.—Optical Causes.—Remote Causes.—Symptoms.—Diagnosis.—To determine the Kind, Degree, and Correction of Astigmatism.

ACCOMMODATORY FUNCTION OF THE EYE.—Act of Accommodation.—Mechanism, Power, and Region of Accommodation.—PRESBYOPIA.—Definition.—Optical Causes.—Remote Causes.—Symptoms.—Diagnosis.—To determine the Degree of Presbyopia and its correcting Lens.—Range of Accommodation in Presbyopia.—Presbyopia with Myopia.—Presbyopia with Hypermetropia.

**Arrangement of the Subjects in the Manual.**—The chief object of this first part of the manual is to furnish medical officers with such memoranda as will assist them in determining with accuracy the quality and power of vision of recruits and soldiers in cases submitted for their decision. It is necessary, therefore, first to describe the various qualities of vision which are liable to be met with. The chief characteristics of the different conditions of sight depending upon differences in the conformation of the eye, in its refractive power, and its accommodatory power, will be defined in the present chapter, while some states of vision occasionally consequent upon these conditions or associated with them will be remarked upon in the following one. A description of the means employed in the army for determining the existence of these several conditions in recruits and soldiers, and the methods of applying these means for the purpose of establishing the degrees in which they severally exist will be particularly noticed in the succeeding chapters. An explanation of the mode of examining the eye by the ophthalmoscope and a brief account of the principal diseased states which may be detected by this instrument will occupy the second part of the manual. It is not intended to refer to changes in strength or quality of vision dependent upon those diseases or injuries which are capable of being seen by the unaided eye of the surgeon. These are properly treated of in systematic works on ophthalmic surgery.

**Chief Varieties of Focal Adjustment.**—Measure of distance being the chief feature of those conditions of vision which depend upon focal adjustment of the eye in a passive state or state of repose, all varieties in this respect may be registered under three heads or natural divisions. They are expressed by the following terms:—1. EMMETROPIA, vision in measure, the refractive power of the eye being normal; 2. HYPO-METROPIA, vision under measure, the refractive power of the eye being in excess; 3. HYPER-METROPIA, vision beyond measure, the refractive power of the eye being deficient in degree. But the classical term—MYOPIA, derived from the habit of short-sighted persons partially closing their eyelids, is so familiarly known, and convenient for avoiding mistakes from similarity in sound between the Greek derivates signifying under and over, that it is held to be best to continue to use it instead of the term hypo-metropia.

AMETROPIA is a term which simply signifies that the condition of emmetropia does not exist; it therefore comprehends the condition of myopia as well as that of hyper-metropia.

ASTIGMATISM is a variety of disordered focal adjustment of a compound nature, the chief features of which, when considered separately, are subjective to one or other of the three leading divisions above named.

The focal adjustment of an eye in action may be changed by the exercise of a special function, named ACCOMMODATION. This is described at page 30.

## EMMETROPIA.

**Definition.**—Normal-sightedness, in respect of the refractive power of the eye in a state of repose, that is, when the eye is not exerting any of its accommodatory power.

**Optical cause.**—The refractive media of the eye are so adjusted, that, by means of their combined converging power, parallel rays of light emanating from distant objects and falling upon the eye are all brought accurately to a focus upon the anterior surface of the true sentient layer of the retina.

**Farthest point of distinct vision.**—Infinite distance. However great the distance of an object may be, so long as the other conditions necessary for vision, viz., sufficient size and illumination are preserved, a perfectly defined retinal image of it will be formed by the emmetropic eye.

**Diagnosis** is effected (1) by types, and (2) by spectacles.

1. *By Types.*—The emmetropic eye can read any of Snellen's types at the indicated distances.

2. *By Spectacles.*—Vision of distant objects is not improved either by convex or concave spectacles. The emmetropic eye can read printed letters of small type at a distance of 10 inches from a convex 10″ lens placed before the eye, for the rays of light coming from the print are caused to fall on the eye as parallel rays. The farthest point of distinct vision of the emmetropic eye with a convex 10″ lens before it is at 10 inches.

## MYOPIA.

**Definition.**—Syn: Hypo-metropia. Short-sightedness. Near-sightedness. Converging power of the eye in a state of repose, that is, when free from all exercise of accommodation, greater than normal: so that parallel rays are brought to a focus short of the retina. Only divergent rays are focussed upon the retina; so that vision is acute as regards near objects, while it is defective as regards distant objects.

**Optical causes.**—To produce a myopic condition of vision, either the optic axis must be prolonged beyond the normal measure, and this is the usual optical cause, or the refracting qualities of the transparent media must be increased beyond due proportion, or both causes may be combined.

**Remote causes.**—Congenital conformation of the eye, often hereditary, myopia being frequently seen to prevail in all the members of a family. Morbid changes of which distension, attenuation, and protrusion posteriorly of the sclerotic coat, together with an atrophic condition of the choroid coat, form the most conspicuous features. (Staphyloma posticum). Conditions in which the convexity of the cornea is unduly increased. Continued over-exertion at near objects, under which circumstances the capsule of the lens probably loses some of its subjectiveness to change of form, or, from being so constantly accommodated for a very near point, the accommodatory apparatus ceases to be able to relax itself sufficiently to allow parallel rays to be brought to a focus upon the retina. Here the parts concerned in accommodation are originally in fault, but myopia becomes one of the results. Certain neurotics, as the extract of the Calabar bean, by exciting contraction of the ciliary muscle and constrictor pupillæ, temporarily change an emmetropic into a myopic eye.

**Symptoms.**—In uncomplicated myopia very near objects are seen clearly, but more distant objects are misty, surrounded by a haze, and consequently only indistinctly visible. Hence the common name of the affection—near-sightedness. The reason that small objects when held near to the eye are seen distinctly by a myopic person without the use of a lens is that the pencils of rays proceeding from all the illuminated points of these objects impinge on the eye more divergently in proportion to the nearness; so that the increased divergency being rendered proportionate to the over-measure convergent quality of the eye, the rays are brought to a focus upon the perceptive layer of the retina, and proper images are formed there. The reason why an object more distant appears "blurred," or surrounded by a halo, is that after the rays proceeding from it have been brought to a focus short of the retina, they cross each other, proceed divergently, and become spread out upon the retina. An image of the object is then formed, but as the conical pencil of rays proceeding from each luminous point of the object, instead of being focussed to a corresponding point on the retina, is spread out in different circles of rays, and as these circles of rays become mixed up with one another, the image is necessarily confused and indistinct. Each circular set of rays corresponds with a section of the diverging cone of rays proceeding from the point of intersection. The circular outline is determined by the form of the pupil through which the rays originally passed into the eye. The diffusion is greater toward the circumference of the image because the rays of the conical pencil are more divergent in proportion as its peripheral limits are attained. These scattered rays, for sake of brevity, have been called "Circles of Diffusion." The farther an object is removed from the eye the greater will be the increase in the circles of diffusion, because each pencil of rays proceeding from the object becomes focussed at a greater distance away from the retina, farther off in front of it, and the cone of rays proceeding from the focus is therefore broader by the time it becomes intercepted by the retina than would happen if the focus were nearer to the retina. The habit which myopic persons have of partially closing their eyelids, and thus narrowing the interpalpebral fissure, when looking intently at any object, arises from an instinctive endeavour to prevent some of the peripheral rays of light reaching the eye, and so lessening the circles of diffusion upon the retina.*

Myopia, if severe, is not unfrequently found to be associated with Strabismus. The squint is occasionally, but comparatively rarely, convergent, in cases where the internal recti muscles have become disproportionately developed, or do not admit of being relaxed in proportion to the external muscles, from constant use, owing to the approximation of objects for distinct vision. It is much more frequently found to be divergent. This prevalence of divergent squint with high degrees of myopia is thus explained. As the myopic condition leads the patient to bring small objects near to the face to be seen clearly, so strong convergence is required, a strain is thrown upon the internal recti muscles, and as

* I have been informed by some myopic candidates for commissions in the army that they had been advised by trainers to apply calabar gelatines to the eyes shortly before appearing for physical examination. This would produce contraction of the pupils, and so lessen the diameters of the circles of diffusion, and consequently render the retinal images of objects less indistinct. For the time this influence lasted, vision would in this respect be improved.

these get fatigued, they cease to act in true concert, and confused, or double vision, is liable to result. In this case one eye, probably the stronger and more acute, will remain directed to the object in view, while the other eye will deviate a little outwards, so as to bring a less central and therefore less sensitive portion of the retina in line with it, and thus to cause the production of a mental impression of its image to be avoided with more ease. Or the eye not in use may deviate still further outwards, and receive only the rays coming from distant objects, when, from the myopic state of the organ, very diffuse and easily disregarded images only will result, and so again visual confusion be prevented. The strabismus may be only temporary in its nature, occurring when near objects are fixedly regarded, or it may be rendered permanent by continued repetition of the circumstances just explained, and continue equally when distant objects are looked at.

**Diagnosis** is established (1) by external signs, (2) by types, (3) by spectacles, (4) by the ophthalmoscope, and (5) by correction.

1. *External Signs.*—The myopic eye usually presents a peculiar appearance indicative of its condition. It is prominent, or even appears to protrude; the pupil is usually contracted, and the constant nipping together of the lids leaves a noticeable impression. The existence of divergent strabismus, whether observable only when the eyes are directed to very close objects, or constant, is, as already explained, a further diagnostic sign of myopia.

2. *By Types.*—The myopic eye, if the myopia be moderate, not above $\frac{1}{24}$, will be able to read No. 1 and also No. 2 of Snellen's types, but will not be able to read the larger types at the distances indicated by the figures placed above them. If the degree of myopia be higher than $\frac{1}{12}$, then No. 1 of S. will not be read at one foot, and the farthest distance at which the types can be distinctly read will indicate the probable degree of the myopia.

3. *By the Spectacles.*—Convex glasses make vision of distant objects worse; concave glasses improve vision of distant objects. When the 10″ convex spectacles are worn, one eye being obscured, and small type placed before the uncovered eye at a distance of 10 inches from the lens, it is found that the type cannot be read, but on bringing the type nearer to the lens it becomes legible. The farthest point of distinct vision of the myopic eye with the + 10″ lens before it is, therefore, short of 10 inches. In

examining the refractive conditions of eyes with spectacles, the patient should stand with his back to the light, which should so fall on the print as to illuminate it thoroughly. The print should be advanced gradually towards the lens, a rigid inch measure being held at the same time horizontally by the side, and the distance of the first point at which the print becomes clearly defined should be carefully noted. In obscuring the eye not under examination, the lids should not be closed by pressure by a finger, but should be simply shaded by the hand. If the eye be pressed upon some minutes must elapse before it recovers a suitable condition for optical examination.

4. *By the Ophthalmoscope.*—(See Part II., p. 106.)

5. *By Correction.*—When the true degree of myopia is ascertained, the proper concave lens for that degree will *completely* correct the abnormal condition.

**To determine M. or the Degree of Myopia,** or, in other words, the excess of refracting power as compared with Emmetropia. Having noted the distant point of distinct vision of the myopic eye with the + 10″ lens before it, invert it, deduct from it so inverted the power of the lens added to the eye, viz. $\frac{1}{10}$, and the difference will give the degree of myopia.

**Example.**—Suppose the distant point is found to be 6″, then $M = \frac{1}{6} - \frac{1}{10} = \frac{1}{15}$.

**Explanation.**—Let $x$ = the refracting power of the eye under examination; let $a$ = the refracting power of an emmetropic eye; $\frac{1}{10}$ = the power of the lens to which the eye has been subjected; and $\frac{1}{6}$ equal the power of the lens which would give the ascertained distant point of 6″ if the eye were emmetropic. The excess of refracting power in the example given is therefore equivalent to the difference between a $\frac{1}{6}$th and a $\frac{1}{10}$th lens. This excess can only be in the eye itself, and its refracting power must obviously be reduced to a corresponding degree to bring it to a par with an emmetropic eye.

Therefore $x - (\frac{1}{6}\text{th} - \frac{1}{10}\text{th}) = a$; or $x - \frac{1}{15}\text{th} = a$; or $x = a + \frac{1}{15}\text{th}$. M., the excess of refracting power over that of an emmetropic eye, is $= \frac{1}{15}$.*

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* *Reasons for adopting the Method described in the Text.*—The use of the constant + 10″ lens for examination of ocular states of refraction is adopted in preference to other methods, because it is equally applicable to the determination

**To find the correcting lens.**—The excess of converging power having been determined, it is corrected by a lens of corresponding diverging power. In the example given a $-\frac{1}{15}$, or a 15″ concave lens, will be the correcting lens, because this will neutralize the $+\frac{1}{15}$ in excess.

The distant point of distinct vision of the eye in this example when no lens is placed before it will be 15 inches off; or, in other words, the rays of nearest approach to parallel rays which the eye is able to focus with accuracy are the rays with that degree of divergency which they have when they start from a point placed at a distance of 15 inches from the eye. A $-\frac{1}{15}$″ lens held in front of the eye causes parallel rays from distant objects to have the same degree of divergency, and thus the eye is rendered competent to form distinct retinal images of those objects, just as it was able to do of the nearer objects at 15″ without the lens.

*Mem.*—In defining the degree of M. with precision, a slight correction has to be made for the distance at which the trial lens is placed from the eye; and when lenses are placed before both eyes together, another correction becomes necessary in practice for the gain in refraction due to the amount of accommodation in activity which is associated with the convergence of the optic axes when both eyes are employed in regarding an object. Rather

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of Emmetropia, Myopia, and Hypermetropia, and of the degrees in which the two latter conditions exist; because medical officers cannot usually avail themselves of regular series of lenses for conducting such investigations; because the mode of observation can be easily learned and the observations can be conducted within a moderate range of distance, such as can be obtained in any ordinary room; and further, since the trials are usually made on persons who have no knowledge of the effects of lenses, because efforts at deception, if attempted to be practised, are more readily defeated. Other methods of carrying out the investigation are only briefly referred to in the text as the main object is to render this manual for the use of beginners as concise and simple as possible.

Occasional cases will occur, when atropine has not been employed, in which the true degree of myopia may not be exactly found by the use of the + 10″ lens, because the person under trial has not been able altogether to relax his accommodation when fixing his sight on an object within 10 inches distance; but such instances are very rare when the trial is thoroughly conducted. This is proved by the fact that in almost all cases the degree of myopia thus found is shown to be the true one by the corresponding concave lens correcting the vision for distant objects.

weaker glasses are consequently required than those which the ascertained distance points indicate.

**Austrian test for high degrees of Myopia.**—Before concluding the remarks on myopia it may be well to refer to the plan of detecting high degrees of myopia by means of concave lenses. It has already been mentioned that formerly the Army Optical and Ophthalmoscopic case included spectacles fitted with −6″ lenses. They were originally introduced into this case for the ready detection of degrees of M. $=\frac{1}{12}$ and upwards. They had been used in the Austrian Army at the suggestion of Stellwag von Carion for determining, on high degrees of myopia being urged by conscripts as a plea for exemption from military service, whether such high degrees did really exist, or otherwise; the degree of M. being deduced from the *near* point at which small print could be read when the −6″ lenses were worn. The rule laid down was that if a man, when wearing −6″ spectacles could read small print (No. 2 Jäger) within 6″distance from the eye, he was obviously so myopic as to be unfit for military service, for he would be myopic $\frac{1}{12}$ or upwards.

A myopic eye of $\frac{1}{12}$ is converted into the condition of a hypermetropic eye of $\frac{1}{12}$ by −6″ lenses being placed before it. At the age of the recruit, 18 to 25, the power of accommodation is $=\frac{1}{4}$. On exerting this fully then a near point just within 6″ may be obtained under the condition above named. Eyes with higher degrees of M. than $\frac{1}{12}$ will be able to obtain still nearer points when the − 6″ lens is before them. Theoretically, therefore, the test of reading within 6″ with a dispersing lens of $-\frac{1}{6}''$ power will prove the existence of M. $=\frac{1}{12}$ or above, and will exclude M. less than $\frac{1}{12}$. But, practically, it has been found that myopes with M. $=\frac{1}{14}$, and even $\frac{1}{16}$, by practice can read within 6″ with the − 6″ lens, and their employment for deciding the presence of such high degrees of M. as $\frac{1}{12}$ or upwards is no longer considered reliable. Really they were seldom, if ever, used by English medical officers. It seems better to deal altogether with the distant point of distinct vision in determining ocular refractive conditions, and the convex lenses suffice for this purpose. Still if − 6″ lenses be at hand they may be used for determining the presence of M. = at least $\frac{1}{16}$ or higher in the manner already previously described.

**To find the correcting lens.**—The excess of converging power having been determined, it is corrected by a lens of corresponding diverging power. In the example given a $-\frac{1}{15}$, or a 15″ concave lens, will be the correcting lens, because this will neutralize the $+\frac{1}{15}$ in excess.

The distant point of distinct vision of the eye in this example when no lens is placed before it will be 15 inches off; or, in other words, the rays of nearest approach to parallel rays which the eye is able to focus with accuracy are the rays with that degree of divergency which they have when they start from a point placed at a distance of 15 inches from the eye. A $-\frac{1}{15}$″ lens held in front of the eye causes parallel rays from distant objects to have the same degree of divergency, and thus the eye is rendered competent to form distinct retinal images of those objects, just as it was able to do of the nearer objects at 15″ without the lens.

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weaker glasses are consequently required than those which the ascertained distance points indicate.

**Austrian test for high degrees of Myopia.**—Before concluding the remarks on myopia it may be well to refer to the plan of detecting high degrees of myopia by means of concave lenses. It has already been mentioned that formerly the Army Optical and Ophthalmoscopic case included spectacles fitted with $-6''$ lenses. They were originally introduced into this case for the ready detection of degrees of M. $=\frac{1}{12}$ and upwards. They had been used in the Austrian Army at the suggestion of Stellwag von Carion for determining, on high degrees of myopia being urged by conscripts as a plea for exemption from military service, whether such high degrees did really exist, or otherwise; the degree of M. being deduced from the *near* point at which small print could be read when the $-6''$ lenses were worn. The rule laid down was that if a man, when wearing $-6''$ spectacles could read small print (No. 2 Jäger) within $6''$ distance from the eye, he was obviously so myopic as to be unfit for military service, for he would be myopic $\frac{1}{12}$ or upwards.

A myopic eye of $\frac{1}{12}$ is converted into the condition of a hypermetropic eye of $\frac{1}{12}$ by $-6''$ lenses being placed before it. At the age of the recruit, 18 to 25, the power of accommodation is $=\frac{1}{4}$. On exerting this fully then a near point just within $6''$ may be obtained under the condition above named. Eyes with higher degrees of M. than $\frac{1}{12}$ will be able to obtain still nearer points when the $-6''$ lens is before them. Theoretically, therefore, the test of reading within $6''$ with a dispersing lens of $-\frac{1}{6}''$ power will prove the existence of M. $=\frac{1}{12}$ or above, and will exclude M. less than $\frac{1}{12}$. But, practically, it has been found that myopes with M. $=\frac{1}{14}$, and even $\frac{1}{16}$, by practice can read within $6''$ with the $-6''$ lens, and their employment for deciding the presence of such high degrees of M. as $\frac{1}{12}$ or upwards is no longer considered reliable. Really they were seldom, if ever, used by English medical officers. It seems better to deal altogether with the distant point of distinct vision in determining ocular refractive conditions, and the convex lenses suffice for this purpose. Still if $-6''$ lenses be at hand they may be used for determining the presence of M. = at least $\frac{1}{16}$ or higher in the manner already previously described.

## HYPERMETROPIA.

**Definition.**—Oversightedness.—The converging power of the eye in a state of repose as regards accommodation is less than normal. Parallel rays from distant objects are not brought to a focus by the time they reach the retina, but would unite in a focus, if they were not stopped in their course, at a point beyond the retina. Only convergent rays are focused on the bacillary layer of the retina.

**Optical Causes.**—In H. the antero-posterior diameter of the eye is disproportionably short, or the refracting qualities of the transparent media are too low, or both causes are combined.

**Remote Causes.**—H. is not unfrequently due to hereditary conformation of the eye, and, like myopia, is found to exist in several members of the same family. Any circumstances that lead to flattening of the globe of the eye, or of one or more of its component structures; absence of the crystalline lens, from displacement or removal by operation; induce the condition of H. It sometimes arises as age advances, beginning after the patient is 50 years old, without any distinguishable cause beyond senile changes, and is then associated with *presbyopia*. This form of H. has been designated *acquired* H., to distinguish it from *original* H., due to early ocular conformation.

**Symptoms.**—When a person affected with well pronounced H. looks intently for a short time at small objects, as in reading and writing, the letters become blurred and seem to run into each other. The vision of distant objects is more limited in range than normal, though the patient himself often fancies he can see well at a distance. The hypermetropic eye cannot readily adjust itself for distant objects, as in trying to hit the bull's-eye at rifle practice, still less for near objects as the "sights" of the rifle. When the eye is employed in looking at near objects, especially such as call for ocular exertion, fatigue and aching are quickly produced; the patient suffers from symptoms of *asthenopia* (see Asthenopia, p. 52). The symptoms above named are the more marked in proportion as the degree of H. is greater. H. is not unfrequently associated with convergent strabismus, and this circumstance arises in the following way. The hypermetropic eye being adjusted for convergent rays, and no such rays existing naturally, the accommodatory apparatus is subjected to a constant exertion, in order to give more convexity to the anterior surface of the lens, and thus to make up for the hypermetropic condition, and lessen the indistinctness of the retinal images of external objects. This exertion is increased in proportion as the rays are rendered more divergent by objects being brought close, as occurs in reading. The patient unconsciously tries to relieve the excess of this strain on the ciliary muscle by contracting the internal recti muscles to avail himself of the increased accommodation for near objects associated with convergence of the optic axes. As, however, the point for which such a patient is able to accommodate his vision, it situated beyond the intersection point of the visual axes, the inconvenience of double vision would result from this, if both eyes were directed equally towards the object. One eye is, therefore, caused to converge more than the other, and in this way one of the images, falling upon a less sensitive part of the retina in the less converged, or deviating eye, is ignored mentally, or, in other words, ceases to exist so far as the sensorial part of the act of seeing is concerned. This occurrence takes place more easily when one eye is naturally weaker than the other in respect to retinal power, or has a higher degree of H. than the other eye. The repeated disproportionate action of the internal recti muscles for these purposes becomes habitual, and at last leads to acquired strabismus. When the strabismus has been acquired, its tendency to become permanent is increased by the fact that the deviating eye gradually becomes retinally still weaker, loses sensibility, from disuse. It is for the purpose of neutralizing the ill effects of continued strain upon the accommodatory apparatus, that, in the treatment of H., convex glasses are recommended to be constantly worn; and it is by these glasses neutralizing the H. that strabismus depending upon it may be counteracted when it is first noticed in efforts to obtain accurate vision of near objects, and that the tendency to it may at last be prevented.

**Manifest and Latent Hypermetropia.**—As the Hypermetropic eye is not able to focus rays from distant objects by its refractive power, it calls in the aid of its accommodatory power in order to obtain clear retinal images of them. Still more powerfully does it exert accommodation to see near objects clearly. This habitual association of the act of accommodation with the act of vision at all distances leads to the loss of voluntary power of separating one from the other. The full amount of H. is therefore not shown unless the power of accommodation is artificially removed. This can be done by producing ciliary paralysis through the agency of atropia. The power of accommodation being thus removed, that portion of the deficiency of refractive power which was supplanted by its agency is rendered manifest. Hypermetropia, therefore, of ordinary degrees consists of a certain amount of deficiency of refractive power which is apparent while accommodation is exerted; and of another amount which, concealed by accommodation, becomes apparent when accommodation is prevented. The former deficiency is known as Hm., *manifest hypermetropia;* the latter, as Hl. *latent hypermetropia.* Obviously H., or the total amount of refractive deficiency, is composed of Hm. + Hl. If the degree of H. be moderate it may be only latent, that is, only apparent after paralysis of accommodation. H. may therefore sometimes exist without attracting attention. Usually, however, though slight in degree, and not noticeable at first, it becomes so increased by fatigue, by continued occupation at near objects, or by health becoming impaired, that the symptoms of H. become sufficiently apparent, and the diagnosis of it is rendered easy.

**Subdivisions of Hm.**—A further division of Hm. has been made by Professor Donders into, (1) *absolute* Hm., in which the rays from distant objects are not able to be focussed on the bacillar layer of the retina, but their focus still lies behind it, even with the aid of exercise of full power of accommodation, and the strongest convergence of the optic axes; (2) *relative* Hm., in which the rays from distant objects can be brought to a focus on the retina by the exercise of accommodation and convergence of the optic axes; (3) *facultative* Hm., in which the rays from distant objects can be brought to a focus on the retina with parallel optic axes, with and without convex glasses.

**Diagnosis** is effected by the following modes of observation; namely, (1) by external signs, (2) by test-types, (3) by spectacles, (4) by the ophthalmoscope, and (5) by correction.

1. *By External Signs.*—The eye is generally flatter and often smaller than normal as if it were stunted in growth, so that the space beneath and between the eyelids does not appear to be filled

out. Usually the iris is seen to approach the cornea owing to want of depth in the anterior chamber of the eye, and the pupil is inactive and relatively small. An abnormal hollow space exists between the eyeball and outer canthus.

2. *By Types.*—If the hypermetropia be severe, types cannot be read clearly at any distance without the aid of lenses; but if moderate, the larger and more distant type may be able to be read for a short time. The eye soon becomes fatigued and the letters indistinct. In trying to read, a tendency for the optic axes to converge will be noticed, and the patient will be observed to squeeze the eyelids together for the purpose of contracting the interpalpebral fissure. The reason why the larger and more distant types are perceived with less difficulty than the smaller and nearer type, is that the accommodatory strain is increased in proportion to proximity of objects as the rays are proportionably more divergent.

When very small type is used, the hypermetropic person will be generally observed to carry the type near to his eye in trying to read it. He will be able to distinguish it better when close to his eye than at a distance of a foot or so away from it. The patient does so because, with the great convergence of the optic axes when the object is close, he is better able to apply his accommodatory power to counteracting the difficulties of reading resulting from his hypermetropic condition of vision; and, in addition, because the retinal images of the letters are increased in size, and therefore more readily perceptible, while the circles of dispersion are not enlarged in anything like a corresponding proportion.

From this circumstance, in diagnosing by types, H., when excessive, may be mistaken for M. combined with amblyopia. Distant objects are seen indistinctly—type of moderate size has to be held close to the eye to be read—and very small type cannot be read at all, as happens in M. complicated with amblyopia. The diagnosis may be established, since in H. distant objects are seen more distinctly, and the moderately sized type can be read further off, with the aid of convex glasses. But even without + lenses the diagnosis may be established, for it may be observed that in H. the larger types of Snellen may be read quite as well, as regards *relative* distance, as the smaller types, which would not happen with M.

3. *By the Spectacles.*—Concave glasses make vision worse; convex improve vision. If the power of the convex glass accord with the degree of H., by its aid Snellen's 20′ types can be read at 20′ distance.

When the convex 10″ lens is worn, the hypermetropic eye is able to read small type at a distance beyond 10″ from the eye without the use of atropine. The distance at which the type can be read will be increased when the power of accommodation has been previously taken away by paralyzing the ciliary muscle with atropine.

4. *By the Ophthalmoscope.* (See Part II., p. 107.)

5. *By Correction.*—When the true degree of H. is ascertained, the proper convex lens for that degree will completely correct the abnormal condition.

**To determine H. or the Degree of Hypermetropia;** or, in other words, the deficiency of refracting power as compared with Emmetropia.

Having paralyzed the power of accommodation by the use of a strong solution of atropia, and noted the distant point of distinct vision of the hypermetropic eye, examined singly, with the + 10″ lens before it, deduct from the power of this lens the inverted value of the distant point, and the difference will give the degree of H.

**Example.**—Suppose the distance point is found to be 15″, then H. $= \frac{1}{10} - \frac{1}{15} = \frac{1}{30}$.

**Explanation.**—Let $x$ = the refracting power of the eye under examination; let $a$ = the refracting power of an emmetropic eye; $\frac{1}{10}$ = the power of the lens to which the eye has been subjected; and $\frac{1}{15}$ = the power of the lens which would give the ascertained distant point of 15″ if the eye were emmetropic. The deficiency of the refracting power in the example given is therefore equivalent to the difference between a $\frac{1}{10}$ and a $\frac{1}{15}$ lens. This deficiency can only be in the eye itself, and its refracting power must obviously be increased to a corresponding degree to bring it to a par with an emmetropic eye.

Therefore $x + (\frac{1}{10} - \frac{1}{15}) = a$; or $x + \frac{1}{30} = a$; or $x = a - \frac{1}{30}$. H., the total deficiency of refracting power, is $= \frac{1}{30}$.

If the distant point of distinct vision with the + 10″ lens be infinite, then H. $= \frac{1}{10} - \frac{1}{\infty}$, or $= \frac{1}{10}$.

If H. be suspected to be more excessive than this, a stronger lens than a + 10″ lens will be necessary to ascertain its degree by this method. The + 2″ lens employed with the ophthalmoscope is the only one available to army medical officers in general for the purpose. If H. = $\frac{1}{6}$ the distance point of distinct vision with the + 2″ lens will be at 3″, for H. = $\frac{1}{2} - \frac{1}{3} = \frac{1}{6}$. This will probably be at the highest degree of H. met with unless the lens be absent either from accident or operation. But it is absolutely necessary in such a case that only one eye be examined at a time, and that it should be atropinized, for the spasm of the ciliary muscle associated with the convergence required for so short a range would otherwise prevent a proper diagnosis being arrived at.

If it be only required to determine Hm., or the degree of manifest hypermetropia, in all moderate cases the same modus operandi as above described may be followed, and the previous use of atropia may be dispensed with. But each eye should still be examined singly.

**To find the correcting Lens.**—The deficiency of converging power having been determined, it is corrected by a lens supplying the amount of converging power which is deficient. In the first example given a + $\frac{1}{30}$ or a 30″ convex lens will be the correcting lens, because this will supply the converging power which has been proved to be absent.

The absence of this amount of converging power was shown in the experiment as already above explained. The action of the lens will be such that when the patient looks at distant objects, the parallel rays proceeding from them, in passing through the lens, will be caused to assume a converging direction before they fall in the eye; and the angle of convergence given to the rays by the action of the correcting lens will exactly correspond with that degree of convergence which is missing in the eye itself. The parallel rays from distant objects will thus become focussed on the bacillar layer of the retina, and clear vision obtained without exercise of accommodation as in an emmetropic eye.

This is the general principle on which correction of H. is effected; but in practice several points have to be specially considered in respect to the amount of Hm. and Hl., the condition of the function of accommodation, and other concomitant circumstances. As the object of this manual is not, however, to discuss questions of treatment, this subject will not be further pursued.

### Astigmatism.

**Definition.**—Inaccurate vision produced by distortion and blurring of the retinal images from unequal focussing of the rays proceeding from objects.

**Optical Causes.**—The refractive qualities of the dioptric media are not alike in all the meridians of the eye. The eye may be emmetropic in one meridian, while in another it is myopic or hypermetropic; it may be myopic or hypermetropic in both principal meridians, but the degrees of myopia or hypermetropia may differ in them severally; it may be myopic in one meridian, but hypermetropic in the other. Occasionally the refractive quality may vary in one and the same meridian of the eye.

**Remote Causes.**—Congenital asymmetry of the cornea: greater curvature of one meridian as compared with that of another, sometimes recognizable on observing the cornea. Inflammatory or other morbid changes in the cornea, inducing irregularities in its curvature. An abnormal position or unequal curvature or other structural peculiarity of the crystalline lens.

It has been shown that in nearly every eye a difference exists between the refractive power of the vertical and horizontal meridians, the vertical meridian having usually a shorter focal distance than the horizontal, though the difference between them is not sufficient ordinarily to disturb vision; an exaggeration of this difference, however, from any cause will give rise to the inaccurate vision and disturbing symptoms characteristic of astigmatism.

**Symptoms.**—Acuteness of vision is lessened both for distant and near objects. If of congenital origin, it will have been continuous and without much alteration in degree. The shapes of objects are altered in appearance, and some parts are seen more distinctly than others. Thus if the image of an object is defined in one direction, it may be rendered indistinct by the diffusion images of some other direction, or if the image be indistinct from diffusion images in one direction, it may be further confused by differently formed, or more widely diffused images in some other direction. In reading, the letters appear blurred from these causes. Objects presenting linear intersecting markings, such as patterns with crossed stripes, are comparatively strongly defined and darker in colour in one direction, while in the other they appear faintly marked; or the whole pattern may become confused from the diffused rays from one direction of lines spreading over and obscuring the defined images formed of the pattern in another direction. The astigmatic subject is apt to exercise his accommodation to obtain clearness of view, first in one meridian and then in the other, so that asthenopia is induced, and adds to the visual trouble. In certain conditions of astigmatism, the affected eye may be troubled with double vision of objects, or polyopia. The greater the difference in the refraction of different parts of the eye, in other words, the higher the degree of astigmatism, the more strongly marked will be the symptoms above mentioned. The more open the pupil of the eye, the more obvious to the patient are the effects produced by his astigmatism. The ametropic condition with which astigmatism is most frequently associated is hypermetropia.

**Diagnosis.**—*By Lenses.*—Though the eye may be hypermetropic, or myopic, neither + nor − *centric* lenses of any power, will correct the existing defective condition or materially remedy the absence of acute vision.

*By Lines.*—The 20′ vertical and horizontal lines of Snellen, and the rows of separate square dots, are not seen with equal definition at the distance indicated, nor at the farthest point of distinct vision, whatever that may be, short of that distance. When the vertical lines are seen accurately, the horizontal lines will have to be placed at some different distance, usually will have to be brought nearer to the eye, in order to be seen with equal clearness, and *vice versâ.* When the vertical lines are seen clearly, the horizontal lines will appear as if seen through a haze, an undefined shadow appearing above and below the top and bottom lines, and the white intervals between the lines appearing more or less darkened.

*By a circular point of light.*—When a small round opening is made in a dark screen and light admitted through it to the astigmatic eye, the cone of light appears elliptical in form, the direction of the ellipse varying as the eye approaches or recedes from the opening. Whatever may be the direction in which at one distance the hole in the screen appears to be elongated, at some other distance from the eye the hole will appear to be elongated in another and generally in a contrary direction.

*By a narrow slit.*—When the astigmatic eye looks through a very narrow fissure, and especially if the slit coincides in direction with that of its greatest or least curvature, the rays refracted in the corresponding meridian of the eye will be brought to a focus or nearly so on the retina, other things being favourable, and thus the interference with acuteness of vision dependent on the astigmatism will be in a great measure removed. Astigmatic vision will therefore be greatly improved by looking through such a narrow opening. If in a given case vision be not improved, and still more if it be not improved when ordinary trial + and − centric lenses are applied to the slit while the eye is looking through it, then the loss of acuteness and other symptoms are due to some other cause than astigmatism.

*By the Ophthalmoscope.*—See Part II., p. 109.

**To determine the kind and degree of Astigmatism.** —This is a delicate proceeding and can only be thoroughly arrived at when a trial case of cylindrical lenses is at hand, and other special appliances. The following proceeding will indicate the mode of ascertaining the degree when a case of ordinary spherical + and − lenses are available. Having ascertained the degree of visual acuteness, the patient's vision is tested by the aspect of a remote point of light, seen through an opening of from 2 to 4 millimetres in diameter, and the directions in which the opening is made to appear to extend when a positive centric lens is placed before the eye, and subsequently a modifying negative centric lens is placed before the former lens, are noted. This trial will determine the meridians in which the maximum and minimum of curvature are situated, and they will be usually found to be in opposite directions. We now hold in each of these directions the slit of a stenopœic apparatus and try the addition of + and − lenses as mentioned under diagnosis.

On the acuteness of vision being improved, the strengths of the + or − glasses by which the greatest improvement is effected is noted, and thus a knowledge of the state of refraction in each of the principal meridians is obtained, and the means of obtaining the degree of astigmatism is attained. If the eye be emmetropic in one meridian, but myopic in another (myopic astigmatism), the correcting glass for the myopic meridian is noted. If a certain degree of M. exists in both principal meridians (compound myopic astigmatism), the weakest negative glass with which vision is most improved is taken as the measure of the myopia. If H. be found in one meridian only, the other being emmetropic (hypermetropic astigmatism), the degree of H. is noted. If H. be found in both meridians (compound hypermetropic astigmatism), the weakest correcting glass gives the measure of the H. This gives the degree of ametropia common to both meridians, and the degree of astigmatism remains to be considered as a separate item in the account. Tension of accommodation must be removed by the use of atropia before the full amount of the ametropia can be ascertained in each of these instances; for the strength of the positive glass for total correction can only be found by these means. If H. be found in one meridian and M. in another (mixed astigmatism), whether H. or M. be predominant, the difference between them is noted. In each one of the cases mentioned the difference of refraction in the true principal meridians determines the degree of astigmatism.

**Examples.**—1. *Myopic Astigmatism.*—Am. Let the horizontal meridian be emmetropic, the vertical meridian, myopic, $\frac{1}{6}$; then Am. $= \frac{1}{6} - \frac{1}{\infty} = \frac{1}{6}$.

2. *Compound Myopic Astigmatism.*—M. + Am. Let the horizontal meridian be myopic $\frac{1}{20}$, the vertical, myopic $\frac{1}{10}$; then M. $= \frac{1}{20}$ and Am. $= \frac{1}{10} - \frac{1}{20} = \frac{1}{20}$. M. $= \frac{1}{20}$ + Am. $= \frac{1}{20}$.

3. *Hypermetropic Astigmatism.* — Ah. Let the vertical meridian be emmetropic, the horizontal hypermetropic $\frac{1}{8}$. Ah. $= \frac{1}{8} - \frac{1}{\infty} = \frac{1}{8}$.

4. *Compound Hypermetropic Astigmatism.* — H. + Ah. Let the horizontal meridian be hypermetropic $\frac{1}{6}$, the vertical hypermetropic $\frac{1}{18}$; then H. $= \frac{1}{18}$ and Ah. $= \frac{1}{6} - \frac{1}{18} = \frac{1}{9}$. H. $\frac{1}{18}$ + Ah. $\frac{1}{9}$.

5. *Mixed Astigmatism, with predominant Myopia.*—Amh. Let the horizontal meridian be hypermetropic $\frac{1}{24}$, the vertical myopic $\frac{1}{12}$; Amh. = M. $\frac{1}{12}$ + H. $\frac{1}{24} = \frac{1}{8}$.

6. *Mixed Astigmatism, with predominant Hypermetropia.*—Ahm.

Let the horizontal meridian be hypermetropic $\frac{1}{12}$, the vertical myopic $\frac{1}{24}$; Ahm. = M. $\frac{1}{24}$ + H. $\frac{1}{12} = \frac{1}{8}$.

**Correction.**—When the astigmatism is due to a difference in the refractive power of two principal meridians of the eye, it may be corrected by cylindrical lenses. If the case be one of myopic or hypermetropic astigmatism, a negative or positive simple cylindrical lens of power corresponding to the degree of astigmatism is employed to correct it. If it be a case of compound myopic or hypermetropic astigmatism, a negative or positive spherico-cylindrical lens of power corresponding to the degree of M. or H. plus the amount of myopic or hypermetropic astigmatism is employed for correction. If it be a case of mixed astigmatism, the correction is effected by bi-cylindrical glasses, the respective degrees of refraction varying according as the myopic or hypermetropic conditions predominate.

The astigmatism which depends upon unequal degrees of refraction in one and the same meridian does not admit of correction by cylindrical lenses.

## Accommodatory Function of the Eye.

The conditions previously described, viz., emmetropia, myopia, hypermetropia, and astigmatism, depend upon persistent qualities of eyes. It may be supposed that the quality of an eye, so far as either one of these several conditions is concerned, would remain the same whether the eye be a living eye, or whether it be removed and disconnected from the human body. The quality is determined by the form and refractive powers of the several dioptric media of the eye in concert, or of the whole regarded as a single lens.

The eye has the function, however, under certain circumstances of changing its refractive adjustment. This function is called the *accommodatory function*, or briefly, *accommodation*. The discharge of the function consists in the performance of the *act of accommodation.*

**Act of Accommodation.**—This act is performed on all occasions when vision is transferred from a more distant to a more near object. If two pages of print are placed a few inches apart before the eye, with an opening in the more near page, the eye while reading through this opening the print on the more remote page is unable to recognize any of the words on the near page. To read the words on the near page, although they are closer, the eye, in common language, must "look at them"; and on reading them the eye ceases to be able to recognize the words on the more remote page, although they are within reading distance, and may be directly opposite to the eye. The same effects may be noticed in looking at a landscape through a pane of glass, and then at some small object on the glass itself. The term "looking at the object" here signifies performing the *act of accommodation.* If carefully observed the act of accommodation will be noticed to be accompanied with a sense of muscular effort. If the parts concerned in the proceeding happen to be inflamed, as occurs in iritis and other diseases, the act of accommodation is accompanied with considerable pain.

**Demand for Accommodation.** — The need for the exercise of accommodation increases in proportion to the proximity of objects, or, in other words, to the divergency of the rays which have to be brought to a focus on the retina.

**Mechanism of Accommodation.**—The act of accomodation, which in ordinary optical instruments is effected by altering the mechanical adjustments subordinate to the lenses, in the eye is effected by changes in the form of the crystalline lens itself. The distance of the surface on which the images are received, the retina, from the front of the refractive media, the cornea, remaining the same, it can only be by increasing the refractive power of the eye, that the more divergent rays from nearer objects can still be focussed on the retina. Various experimental observations have proved that the agent in affording this increase of refractive power is the crystalline lens; and, indeed, that this lens does become more convex and so more refractive in exact proportion to the increased nearness of objects looked at by the eye has been demonstrated by various investigators and especially by Professor Helmholtz by means of his ophthalmometer. The anterior pole of the crystalline lens advances, while the diameter of its equatorial circumference is lessened, the whole anterior surface being thus rendered more convex and coming nearer to the cornea in proportion to the nearness of the objects to be observed. This convexity is lessened again when objects a little farther off are to be observed; and for objects beyond a distance of 20 feet or so, from which rays proceed in nearly parallel lines, the lens nearly resumes the form which belongs to its state of repose.

The production of the changes in the form of the lens is attributed principally to the action of the ciliary muscle. The iris has ceased to have any power of action or even has been totally absent; the external ophthalmic muscles have all been paralyzed; and yet the accommodatory faculty has remained apparently perfect. Therefore, this faculty could not have been dependent on the influence of any of these structures as was formerly supposed.

A further proof that the ciliary muscle is the agent, and the crystalline lens the anatomical structure acted upon by it, in the production of accommodation, is the fact that whatever paralyzes the ciliary muscle, by paralyzing the motive power, stops the faculty of accommodation; while the displacement or absence of the crystalline lens so that the ciliary muscle cannot exert its power over it, equally arrests the faculty of accommodation. The use of atropine, conditions of disease interfering with the nervous supply to the ciliary muscle by the third pair of nerves, arrest the faculty of accommodation; in like manner removal of the crystalline lens in the operation for cataract, or its dislocation from accidental injury, destroys the faculty of accommodation.

It is supposed by some that the circular fibres of the ciliary muscle, contracting in the manner of a sphincter, exert through the medium of the ciliary processes and the unyielding fluid in the canal of Petit a pressure on the equatorial circumference of the lens, and thus cause it to change its form for accommodation; while my colleague, Dr. Macdonald, has demonstrated an accessory annular muscle within the circular sinus, or canal of Schlemm, which may well be associated in this action. Although doubts still exist among many observers as to the precise mode of action of the ciliary muscle on the crystalline lens, —some, indeed, believing that the contraction of the ciliary muscle induces alterations in the tension of the Zonula Zinnii which permit the lens to expand by virtue of its elasticity, so that relaxation of the lens is present during the act of accommodation and not during its repose,—yet there are none who any longer doubt that the changes of accommodation depend on changes of form in the crystalline lens, and few that these changes are produced by the action of the ciliary muscle upon it.

**Power of Accommodation.**—The power of accommodation comprehends the extent to which the function of accommodation can be exerted, or, in other words, the extent to which the eye can increase its refractive quality. The range, or latitude, of accommodation depends on the amount of this power. The complete amount of power of accommodation is made manifest by the difference of accommodation employed when the near point of distinct vision is obtained, as compared with that which is exercised when the eye is adapted to its distant point of distinct vision. The position of the near point of distinct vision depends on the accommodatory power being exercised to its fullest amount.

It is frequently a matter of importance in ophthalmic examinations to determine and define the exact amount of this power, and Professor Donders first put forth a formula by which it can be readily found and expressed. It is the following:—

$$\frac{1}{A} = \frac{1}{P} - \frac{1}{R}$$

In this formula R is the measure of the remote point for which the eye is adjusted in a state of rest; P is the measure of the nearest or proximate point for which the eye becomes adjusted when its full power of accommodation is exerted; A is the focal distance of a supposed convex lens which would so lessen the divergency of the rays coming from the proximate point P, that they would follow the same path, after passing through the lens, as was followed by the rays coming from the remote point R, without the lens; and $\frac{1}{A}$ is the power of this lens. It is obvious that the eye in transferring vision from any remote point, R, to any near point, P, must so alter its focal adjustment as to act on the more divergent rays from P exactly in the manner attributed to the supposed lens A, and must exert a *power of accommodation* equivalent to $\frac{1}{A}$. $\frac{1}{A}$ may therefore be accepted as representing the power of accommodation, or as expressing the difference in the accommodation for R and for P. In like manner it expresses the range or latitude of accommodation which is of the same value as the power of A.

Thus, to apply the formula in an emmetropic eye adjusted for infinite distance in a state of rest, and capable of altering its focal adjustment by the exercise of accommodation, so as to see clearly small objects as near as 4 inches, $\frac{1}{A} = \frac{1}{4} - \frac{1}{\infty} = \frac{1}{4}$, or the power of accommodation will be equal to $\frac{1}{4}$. In other words, the eye, in altering its adjustment from clear vision at infinite distance to vision at a distance of 4 inches, has increased its refractive power to an extent equivalent to a lens of $\frac{1}{4}''$ power, or of a lens whose principal focal distance is 4 inches.

In a myopic eye, whose farthest point of distinct vision in a state of rest is 12″, and whose nearest point of distinct vision by the exercise of accommodation is 3″ $\frac{1}{A} = \frac{1}{3} - \frac{1}{12} = \frac{1}{4}$, or the power of accommodation is equal to $\frac{1}{4}$. In other words, this eye, in altering its adjustment for vision at a distance of 12 inches to vision at a distance of 3 inches, has increased its refractive power to an extent exactly equal to the eye in the previous example, viz., to an extent equivalent to that of a lens of $\frac{1}{4}''$ power, or of a lens whose focal distance is 4 inches. In each case the range or latitude of accommodation is $\frac{1}{4}$.

The power of accommodation is similar in all eyes that are healthy in condition, whatever may be their refractive qualities, at corresponding periods of life.

**Region of Accommodation.**—The region of accommodation signifies the particular tract over which an eye can see clearly, extending from the most distant to the most near point of distinct vision; or, in other words, comprehends the distance between the distant point of distinct vision and the near point of distinct vision. As shewn in the preceding paragraph, an equal power of accommodation may be exerted over regions of accommodation of very different positions and extents. In the first example a power of accommodation equal to a 4-inch lens is associated with a region of accommodation which extends from infinite distance to a near point at 4 inches distance from the eye. In the second example the same power of accommodation exists with a much more limited region of accommodation, viz., one whose limits are between a distant point of 12″ from the eye and a near point of distinct vision at 3″ from the eye,—that is, a region of 9 inches.

Although, as already stated, the power of accommodation is alike in all eyes of normal condition at corresponding ages, the region of accommodation differs at corresponding ages in different eyes, according as they are emmetropic, myopic, or hypermetropic.

**Association of the Internal Recti and Ciliary Muscles in Accommodation.**—When an object midway between the two eyes, and at a short distance in front of them, is looked at, the two internal recti muscles act concurrently with the ciliary muscles. There is no reason, however, for believing that the internal straight muscles have any specific influence on the production of accommodation, nor any influence excepting what results from their action in bringing the eyes into a favorable position for receiving the diverging rays proceeding from near objects.

The action of the internal recti muscles in accommodation is an associated, not a controlling one. As the convergence of the eyes increases in proportion as the object required to be seen is brought nearer to them, and the demand upon the accommodatory muscle must also increase at the same time, the actions of the internal recti and of the ciliary muscles are of necessity intimately and almost proportionally associated. It is essential to understand the fact of this intimate association, and of the difficulty of converging the eyes without the accommodatory force associated with the degree of convergence concerned being involuntarily called into action, for it explains many phenomena in visual diagnosis which without this knowledge would not be understood.

## Presbyopia.

**Definition.**—Vision of advanced age, characterised by being obscure for small objects at near distances. Diminished range of accommodation due to increase of age. The "near point" of distinct vision is removed further than 8″ from the eye, while rays from distant objects are still brought to a focus upon the retina, in the same way as they would be irrespective of the Pr.

**Optical Causes.**—There is no defect as to the refractive quality of the eye in its state of repose in simple presbyopia; it may be emmetropic, and neither concave nor convex lenses improve the sight for distant objects. But the necessary change of form of the crystalline lens cannot be obtained; or, in other words, the converging power of the eye cannot be increased by the exercise of accommodation to the extent necessary for bringing the more divergent rays from very near objects to a focus on the bacillar layer of the retina.

**Remote Causes.**—Natural changes from age. The near point recedes in all eyes in regular progression with increasing age; the change is a normal one, and advances with advancing years. The recession of the near point commences early in life. In the emmetropic eye, at 15 years of age, the near point of distinct vision is at 3″ from the eye; at 25 years it is not nearer than 4″; at 35 years it has receded to 7″; at 40 years to about 8″; at 50 years to about 12″; at 55 years to about 16″, and so on. This recession of the near point is solely attributable to diminution in accommodatory power. As already explained, exertion of this faculty is called for in proportion to proximity of objects or divergence of rays. The gradual lessening of this faculty is explained by the crystalline lens becoming more and more firm with increasing years, so that the ciliary muscle is incompetent to effect the same amount of alteration in its form. It is doubtful whether the changes which occur in structure and curvature of the cornea may not also assist in causing the difficulty of adapting the eye for near vision. Diseased conditions, such as interferences with the lens capsule by posterior synechiæ after iritis, changes in the structure of the capsule or lens itself, weakness or incomplete paralysis of the ciliary muscle, and the like, may increase the presbyopic condition or induce symptoms similar to those of presbyopia.

From the explanation just given of the nature and causes of presbyopia, it is evident that not only when an eye is emmetropic, or hypermetropic, but also if it be myopic, it may equally become subject to presbyopia with age. Whenever the near point of distinct vision becomes removed further than 8″ from the eye, presbyopia has arrived.

**Symptoms.**—Presbyopia is not usually complained of by persons with emmetropic vision till after 40 years of age, generally not till 45 years. The subject of it says that, though he can see as well as formerly at a distance, he finds it troublesome, or even painful to try and recognize small objects near him. In reading he has to remove the print farther and farther from his eye. Then, on account of the distance he has to hold the print, he cannot see the words accurately. The difficulty is greater in the evening with artificial light than during the daytime with sun-light. The nearest point of distinct vision can only be attained by extreme exertion of the ciliary apparatus, and, when this state of tension is produced, it quickly causes fatigue. To obviate this, objects are removed further off than the actual near point, but then, if the objects are very small, their retinal images become too minute for easy recognition. The objects are again brought nearer to the eye, the ciliary strain is again induced, and this course, on being persevered in, gives rise to ocular aching, super-ciliary pain, headache, and vertigo, until at last, a stop is put to the power of doing the fine work the patient is engaged in.

**Diagnosis.**—The age of the patient, with the usual evidences of the adjustment of the eye for parallel rays if the patient be emmetropic, as explained under emmetropia, and the distance of the near point, sufficiently distinguish presbyopia from any other affection. When either myopia or hypermetropia co-exist with presbyopia, there will be the evidences already described of these conditions in addition to the fact of the near point of distinct vision being distant deyond 8″ from the eye.

**To determine the Degree of Presbyopia.**—As presbyopia is held to exist when the near point has receded beyond 8″ from the eye, the degree of presbyopia is determined by finding the focal power of the convex lens which will bring back the near point to 8″.

The amount of Pr. is the amount of accommodatory power which has been lost, the accommodatory power which previously enabled the person to work continuously at fine work at 8″ distance from the eye without strain or fatigue. The convex lens which will so add to the refractive power of the eye as to bring back the near point to 8″ substitutes itself for the accommodatory power missing in the eye itself, and therefore serves as an expression for the missing power, or, in other words, for the degree of presbyopia.

The focal power of this lens is found by using the formula which has been already explained as serving for an expression of power or latitude of accommodation, viz., $\frac{1}{A}=\frac{1}{P}-\frac{1}{R}$. As in the present case $\frac{1}{A}$ signifies the missing latitude of accommodation, Pr. may be substituted for it: $\frac{1}{A}$, or Pr. $=\frac{1}{P}-\frac{1}{R}$. The proximate point, or P, is here 8″, because that is the near point for which a substitute for the missing accommodation is to be supplied, and to which the refractive power of the eye is to be adjusted.

The remote point, R., is the distance to which the near point has receded owing to presbyopia, or the distance up to which accommodation is missing.

**Examples.**—Suppose the near point has receeded to 12″ distance from the eye; then Pr. $=\frac{1}{8}-\frac{1}{12}=\frac{1}{24}$. If it has receeded to 24″ distance, then Pr.$=\frac{1}{8}-\frac{1}{24}=\frac{1}{12}$.

**To determine the correcting Lens.**—The same formula that determines the amount of accommodatory power which is missing, determines the focal power of the lens which must be added to the eye to act as a substitute for it. Thus in the example first given, in which the Pr. $=\frac{1}{24}$, a +24″ lens will neutralise the presbyopia; in the second example a +12″ lens. With the aid of the lenses named, the presbyopic $\frac{1}{24}$ and $\frac{1}{12}$ patients will be able to do fine work at 8″ distance from the eye as if the near point of distinct vision of the eye itself were at 8″ distance.

**Power and Range of Accommodation in Presbyopia.**—The power and range of accommodation of the presbyopic eye diminishes in proportion as the presbyopia increases, or, in other words, in proportion as accommodation for near objects is lost. Thus, in the emmetropic person whose remote point of distinct vision is at infinite distance, at 15 years of age the power and range of A. is $\frac{1}{3}-\frac{1}{\infty}=\frac{1}{3}$, at 25 years is $\frac{1}{4}-\frac{1}{\infty}=\frac{1}{4}$; at 35 years is $\frac{1}{7}-\frac{1}{\infty}=\frac{1}{7}$; at 40 years $\frac{1}{8}-\frac{1}{\infty}=\frac{1}{8}$; at 50 years $\frac{1}{12}-\frac{1}{\infty}=\frac{1}{12}$. The power of accommodation is thus shown to be considerably lessened as age advances.

**Presbyopia with Myopia.**—As the power of accommodation is alike in all eyes at corresponding ages, and as the distant point of distinct vision is nearer to the myopic eye than it is to the emmetropic eye, it follows that the near point of distinct vision will be nearer to the myopic eye than it is to the emmetropic eye at corresponding ages of life. The near point will not recede beyond 8″ so soon in the myopic person as in the emmetropic person, or, in other words, presbyopia will appear later in life in the myopic person than in the person with emmetropic vision. Moreover, the presbyopia can only occur in myopic persons whose myopia is moderate in degree. If the myopia amount to $\frac{1}{8}$th, presbyopia can never occur; for the distant point of distinct vision being at 8″ distance from the eye, so long as any power of accommodation remains, the near point cannot be removed to a distance of 8″ from the eye. Still more a person whose myopia is higher than $\frac{1}{8}$ cannot become presbyopic.

If myopia be moderate, then, as age advances, the near point may recede beyond 8″; and in such a case the myopia will require to be corrected by concave lenses to enable the person to see distant objects clearly, while the presbyopia will have to be corrected by convex lenses to make up for the deficiency of accommodation for seeing small objects at near distances.

**Presbyopia with Hypermetropia.**—As in the hypermetropic eye the distant point of distinct vision is negative, and, as it were, further from the eye than it is in the emmetropic eye, while the power of accommodation is the same at the same ages in both, it follows that the near point of distinct vision will be further removed from the hypermetropic eye than it is from the emmetropic eye at corresponding ages of life. The near point will be beyond 8″ sooner in the hypermetropic person than in the emmetropic person, and presbyopia will appear, therefore, earlier in life in the hypermetrope than in the emmetrope. When presbyopia is fully established the hypermetropia will require to be corrected by a suitable convex lens to secure clear vision of distant objects, while the presbyopia will have to be corrected by a lens of still greater converging power—one that will not only correct the general deficiency of refractive power of the eye, or the hypermetropia, but that will also make up for the loss of accommodatory power and so enable the eye to work without inconvenience with small objects at a near distance of 8″ from the eye.

## CHAPTER III.

Acuteness of Vision.—Normal and Relative Acuteness of Vision.—Measurement.—Optometric Test Objects.—Hair-wire Optometer.—Jäger's Test Types.—Snellen's Test Types.—Burchardt's Sight Tests.—Snellen's Test Types in Military Practice.—Amblyopia.—Definition, Causes, Symptoms, and Diagnosis of Amblyopia.—Hemeralopia.—Nyctalopia.—Hemiopia.—Scotoma.—Asthenopia.—Definition, Causes, Symptoms, and Diagnosis of Asthenopia.—Other Defective Qualities of Vision.—Strabismus.—Diplopia.—Achromotopsia.—Congenital Achromotopsia.—Importance of Achromotopsia in the Military Service.—Coloured Signals in the Royal Navy.—Causes and Diagnosis of Achromotopsia.—Amblyopic Achromotopsia.

### ACUTENESS OF VISION.

**Normal Acuteness of Vision.**—Perfect acuteness of vision exists when there is clear recognition of an object under the smallest visual angle which the human eye is organised for consistently with accurate perception. Perfect acuteness of V. can only exist when the organic textures and transparency of the media of the eye are perfect; when its refractive power is accurately adapted to the distance at which the object looked at is placed; and when the retinal sensitiveness and nerve conduction are also perfect. An eye may be emmetropic, yet its visual acuteness defective at all distances, owing to cloudiness of media, amblyopia, or other morbid conditions. An eye may be ametropic, and possess perfect acuteness of V. at some distances though not at others.

**Relative Acuteness of Vision.**—Relative acuteness of V. is determined by the relative sizes of the visual angles under which objects of known magnitude are perceived by different eyes at fixed distances. The power of separately discriminating visual impressions varies with the measures of the visual angles under which objects can be clearly seen, or, in other words, with the degree of acuteness of vision. If a standard of average normal acuteness of V. be fixed, it becomes easy to express the acuteness of V. in any given example by comparing it with the standard.

**Measurement of Acuteness of Vision.**—Instruments for measuring acuteness of vision, and the range of accommodatory power, are called "optometers." They consist of certain objects (optometric test objects) by which the visual power is tested under different circumstances, and of means, associated with them, of measuring the distances at which these objects form defined images on the bacillar layer of the retina.

They are usefully employed not only as means of ascertaining permanent states of visual acuteness, but also in observing changes in degrees of visual acuteness in patients under treatment. The measurements are usually taken in inches and parts of inches.

*Central Acuteness of Vision.*—Acuteness of vision is greatest in the normal state of the eye at the posterior pole of the axis of vision, at the region of the macula lutea, and gradually lessens in degree from this central point of the retina to its periphery; in using an optometric test object the eye is fixed upon it in the same way that it is in naturally observing any other object. It is, therefore, the *central acuteness of vision* which is ordinarily measured by optometers. In certain amblyopic states it becomes necessary to measure the acuteness of vision of ex-centric parts of the retina; the observations have then to be taken by other means.

**Optometric Test Objects.**—The test objects employed in the measurement of acuteness of vision are of various kinds. Those in ordinary use are fine hair wires, or objects of generally known forms as printed letters and numbers. They may be used for testing the distinctness of either near or distant vision. In testing the near point of distinct vision the objects employed for optometric purposes should, as a rule, be of very small dimensions. The retinal image of a small object, from its extreme minuteness, ceases to be recognizable if it is blurred by diffused rays, while a larger image, notwithstanding a certain absence of definition from circles of diffusion, might be recognised from its mere size. In testing the far point of distinct vision it matters not what the size of the object is, so long as the visual angle which it forms at given distances is understood.

*Hair-wire Optometer.*—This instrument consists of a series of very fine black wires, fixed in a frame which can be moved along a groove on a scale board between 30 and 40 inches long. There are two separate grooves on the board and two wire optometers for the two eyes. At one end of the board are two openings through which the eyes regard the wire frames, they consist of grooved wire receptacles into which lenses may be placed at pleasure. The measurement scales on the board are in inches and parts of inches, and in centimeters. The wires can be shifted in their position so that they can have either a vertical or horizontal or any intermediate direction. In testing for the near point of distinct vision the limit of nearness is found at which the wires can be seen with perfect definition and the distance read off on the scale board. A like proceeding is adopted for testing the far point of distinct vision. By changing the position of the wire optometer it may be ascertained whether the near or far points of distinct vision respectively are the same both when the wires have a vertical and when they have a horizontal direction. If not, there is astigmatism and the far and near points in the different positions should be noted and the degree of astigmatism may then be ascertained.

In practice it is found that the hair-wire optometer answers well for intelligent and observant persons, but frequently gives rise to difficulties when men in the military ranks are subjected to trial with it. It is by no means easy to get some persons to decide when perfect definition of the wires is obtained and when the definition first becomes imperfect. Letters that we know must form defined images when they are easily read, and of which we know the images are not defined when they cannot be read, or are imperfectly defined when they can only be read with difficulty, constitute more simple and reliable tests for such persons.

*Printed test-types.*—The test-types in common use are of two kinds, Jäger's test-types, and Snellen's test-types.

*Jäger's test-types.*—These consist of the differently sized types in ordinary use in printing in different countries. They are numbered according to their sizes, the smallest type deing distinguished as No. 1. The numbers increase as the sizes increase. They were first arranged with a view to overcome the difficulty experienced by ophthalmic surgeons of different countries in understanding the nature of the letters referred to by one another as objects which patients were able to read under special circumstances, whether under different refractive states, after operative proceedings, or other treatment, owing to letters being only then distinguishable by technical names arbitrarily adopted among printers and differing in different countries. To get rid of this difficulty Professor Jäger, of Vienna, arranged the types used in different languages according to their corresponding sizes, and distinguished them by numbers as above mentioned. Jäger's test-types in consequence received the names of *types of universal reference.*

The individual letters are not framed on any common principle. Although there is a general correspondence of size in the type according to the number assigned to it, particular letters differ in their dimensions from each other. Some letters differ in width, some strokes differ in thickness, whatever the number of the type. Various other differences exist among the letters. The application ot these types as test objects of acuteness of vision is in consequence necessarily imperfect and limited. They are however useful occasionally from their forms being familiar to readers, so that their recognition is not interfered with as far as any peculiarity of shape is concerned. But they would manifestly be more generally serviceable if each letter had been fashioned on such a fixed basis that every letter when placed at a given distance presented the same visual angle. Snellen's types have been designed for the purpose of meeting this requirement.

*Snellen's Test-types.*—As Snellen's test-types form the standard by which visual acuteness is tested by medical officers in the English army, and as they are also used in the Royal Navy for testing vision, their nature and peculiarities ought to be well understood.

Unlike Jäger's test-types, they consist of specially formed letters, all fashioned on one and the same fixed basis. The sets of types are of different sizes, and are accompanied by special numbers, but they bear a definite proportion to each other, just as the individual letters of each sized type do to each other.

In arranging these types Dr. Snellen determined the smallest visual angle under which letters can be read provided the vision of the reader be of normal acuteness, or, in other words, the least magnitude of the retinal image of a letter which enables that letter to be distinctly perceived,—for on the size of the visual angle must chiefly depend the size of the retinal image.

Dr. Snellen has taken as his standard that an emmetropic eye, of normal visual acuteness, can perceive a plain rectangular object when it occupies only the 60th of a degree, or one minute, in fair daylight. This space, in a circle of 12 inches diameter, of which the eye may be supposed to be the centre, is about the 600th of an inch of its circumference. At a distance of six inches therefore, on this basis, the eye can perceive the presence of a plain object the 600th of an inch in size.

But though an uniform object can be seen by the eye when occupying only a space of the 60th of a degree, a complex object, though visible, cannot be recognised under so small a visual angle. The smallest visual angle permitting clear recognition of such broken and irregularly formed objects as printed letters, according to Dr. Snellen's standard, is one twelfth of a degree, or five minutes. Thus at a distance of six inches, the eye can recognise a letter the 120th of an inch in size, or at 12 inches a letter of the 60th of an inch in size.

It is on these principles that Dr. Snellen has arranged his test-types. They are all quadratic in shape and are each formed of lines, or limbs as they are called, one-fifth part of the size of the letter in thickness. They bear numbers from 1 to CC according to their sizes; No. I being the smallest, No. CC the largest among them. These numbers also express the number of feet at which the types can be read by an eye possessing normal acuteness of vision. When the letters are read at the fixed distances in feet, which are numbered above them, the eye, in seeing a limb of the letter, is seeing an object which occupies an angle of one minute, while in seeing the whole letter it is seeing an object which occupies an angle of five minutes in the visual field. Arithmetical numbers of various sizes are included among the test-types for persons who cannot read letters but can decipher such figures; and for those who cannot distinguish either letters or numbers, simple objects such as circles, lines, crosses, squares, and others are added. They are drawn on the same principles as the letters, and may be used in the same way.

*Burchardt's International Sight-tests.* — These test objects designed for enabling military surgeons and others to determine the acuteness of vision, have been formed on principles which differ in some respects from those of the preceding optometric objects. They were published in 1870. They are also intended to enable surgeons to ascertain the near and distant points of distinct vision, together with the existence of astigmatism without the aid of lenses. The purpose of Dr. Burchardt was to get rid of the objections to the use of letters—that they are only applicable to men who know how to read, that some letters are easier to be recognised than others, that this recognition involves mental effort as well as the act of seeing, and that the taller letters can often only be recognized at different distances from the shorter letters owing to astigmatism. The test objects for acuteness of vision employed by Dr. Burchardt are black discs of different sizes on a white ground. I had already called attention to the use of discs for the same purpose in the Army Medical Reports for the year 1860.* My arrangement of the sets of discs was such that they corresponded in their diameters with the series of Jäger's test types;

* Notes on the Examination of the Visual Fitness for Recuits for Military Service, with special reference to instruction in the use of the rifle. Army Medical Reports, Vol. 2 for 1860. London, 1862, p. 462.

but they were very badly printed, and were needlessly scattered over the pages of the paper which they were printed to illustrate. Dr. Burchardt has improved upon these discs, and has extended their utility. He has also grouped them together on different principles, for instead of measuring visual acuteness by the visual angle under which the separate objects are recognised, Dr. Burchardt measures it by the visual angles of the intervals between the objects. Thus, for example, Dr. Burchardt shows that discs of 0·1 mm. diameter placed in a row at intervals of 0·1 mm. from each other, and viewed from a distance of 60 c. m. (24″) are perceived as a continuous line; at a distance of 20 c. m. (8″) appear as a rough line with occasional swellings; at 16 c. m., or a little more than 6″, are recognized separately and can be counted. Dr. Burchardt's discs are printed very accurately in a series of groups on small cards, and are accompanied with full instructions on the manner of using them in the detection of true as well as simulated differences of visual acuteness and refractive power. Special cards and tables for the diagnosis of astigmatism are added. On the whole, however, Snellen's system of test-types appears to be more practical and more readily applied in general use, so that there appears no reason for discarding them, especially as they have been already sanctioned for use by medical officers in the British army and are now familiar to them.

**Snellen's Standard of Visual Acuteness.**—In practice it will be found that particular eyes, especially young eyes, have a considerably higher degree of visual acuteness than the standard taken by Dr. Snellen. An object which subtends an angle of only half a minute, or even one-fifth part of a minute or 12 seconds, when directly illuminated by the sun, is visible to some eyes. Colour has an influence however: a white object with the light of the sun shining upon it may be seen under an angle of 12 seconds, but under the same circumstances, a similar object, but red in colour, would only be seen under an angle about double that size. Some persons can read test-types at distances considerably beyond that indicated by their accompanying numbers; when, therefore, the angle under which they are recognised is much less than an angle of five minutes. I have seen them read at double the indicated distances; when, therefore, the visual angle has been reduced to about $\frac{1}{24}$ of a degree, or $2\frac{1}{2}'$, and V. has been = 2, or twice Dr. Snellen's standard. Snellen's test-types, as numbered, are consequently to be regarded not as standards of perfect acuteness of vision, but of *average* normal acuteness of vision.

**Uses of Snellen's Test-types in Military Practice.**—As these letters are thus all formed on one and the same principle they are capable of being applied to various purposes of practical utility in the examination of visual acuteness. As they are all seen under the same visual angle at the distances indicated, they all at those distances have the same apparent magnitude; and as they are all formed in the same fashion, and occupy proportionate areas, so also at the distances indicated they not only have the same linear magnitude, but also the same apparent superficial magnitudes. Letters of any one size may, therefore, in practice be substituted for letters of any other size, of course provided illumination and other conditions be preserved alike.

Again, if two or more of the types be held at other than the named distances, whether more remote from or nearer to an observer, the visual angles under which they are severally seen will still be alike, so long as the distances at which the different types are placed are relatively in accordance.

Snellen's test-types afford a simple, and, practically, sufficiently accurate mode of expressing the degree of acuteness of vision. Snellen's formula is the following. If V. be used to express the acuteness of vision; D. the distance at which the type appears under an angle of five minutes, or the distance named with the type used; d. the utmost distance at which the type can be read by the person under observation; then $V. = \frac{d}{D}$. Examples: The 20 feet types are read at 20 feet, the 30 feet types at 30 feet; then $V. = \frac{20}{20}$ or $\frac{30}{30}$, and the acuteness of vision is normal. The 20 feet type can only be read at 10 feet, the 30 feet type at 15 feet; then $V. = \frac{10}{20}$, or $\frac{15}{30}$, or $\frac{1}{2}$, and the acuteness of vision is only one half of the normal standard. Practically, in determining relative degrees of acuteness of vision by these means, it is better to use one common test type, the 20′ type, for example, as the standard.

The use of Snellen's types saves time in the examination of quality of eyesight in any unknown case. If the person under examination reads with each eye the 20 feet type at 20 feet with ease, there is no ocular defect which requires further investigation. If it, and other types, can only be read short of the normal distances, some defect exists, and the necessity is at once indicated for further examination by trial lenses or the ophthalmoscope in order to ascertain the source of the deficiency of visual acuteness.

Ametropia or lessened accommodating power are indicated when some of the types are seen clearly at the normal distances, but other types are not seen clearly at their distances. In such cases the refractive power of the eye does not maintain correspondence with the relations which are preserved between distance and size in the types. If an eye can read the 1 foot type at the distance of 1 foot, the $1\frac{1}{2}$ type at a foot and a half, but cannot read the XX feet type at 20 feet, myopia is indicated; while if the XX feet type is read at 20 feet, but the 1 foot type cannot be read at 1 foot, either presbyopia or hypermetropia are indicated.

If deception is attempted, whether of a positive or negative kind, it may often be exposed by subjecting the person under examination to tests by different but adjacent types. If there be no attempt at deception, but an alleged deficiency in acuteness of vision be real, the relations between D and d will be preserved when such types of different sizes as the 20, 30, or 40 feet type, are presented to be read. If $V. = \frac{10}{20}$, it ought to be equally $\frac{15}{30}$ and $\frac{20}{40}$ if other like conditions be carefully preserved; if a different value be given to V., deception of some kind may be suspected. The smaller sized types, Nos. 1 to 3 or 4, should be excluded from the comparison.

The degree of V. naturally lessens after 45 years of age as years advance owing to decreased transparency of the dioptric media, decreased retinal sensitiveness, and other senile changes.

Snellen's test-types can be readily turned to account in the application of any rule that may be laid down as to a required standard of visual acuteness. Thus, for example, a military friend gives me, as the result of his experience, the rule that a soldier to be effective should be able to distinguish clearly a man from any other object at least at a distance of 500 yards under ordinary illumination, as in a moderately clear daylight, and with no more striking contrast of background than what is met with in ordinary fields or moorland. A sentry on an advanced post who could not distinguish an enemy at that distance in front of him would endanger the safety of a force. With such a background as the "sky-line" or any background forming a marked contrast with the object, a man ought to be recognized at 1,000 yards. The rule for recognition at 500 yards may be applied by means of Snellen's types thus:—Assuming the height of a man to be that at which the height for infantry is calculated in rifle practice, viz., 6 feet, the visual angle under which he would be seen at a distance of 500 yards is 13′ 44″, or nearly 2·7 times the visual angle under which Snellen's types are seen. Recognition of 20′ Snellen on toned paper in an ordinarily lighted room at a distance of 7′ 5″ may therefore be used as a test that one man is capable of distinguishing another man at a distance of 500 yards under the above-named conditions. A man 6 feet in height to be seen under the same visual angle as Snellen's types would have to stand at a distance of about 1,375 yards off.

## Weak Vision.

There are two descriptions of weak vision which it is necessary the observer should be able to distinguish in ocular examinations. The first of these is termed amblyopia, derived from ἀμβλὺς, blunt, obtuse; the second is asthenopia, from ἀσθενὴς, wanting in force. The first refers to imperfection in the sensitive recipient elements; the second refers either to weakness in the internal structures which are engaged actively in adapting the dioptric apparatus to the varied requirements for clear vision, or to a deranged balance of power in the external muscular motors of the organ. It will be convenient to consider separately these conditions, which are very distinct in their nature.

### I. Amblyopia.

**Definition.**—Feebleness of vision from diminished acuteness of retinal perception.

Impaired vision thus defined was formerly included with many other morbid conditions of different kinds under the general term "amaurosis."* Amaurosis is now only used to express total loss

* Amblyopia is sometimes used to express the indistinctness of vision which is directly dependent upon obstructions or diminished transparency in the dioptric media. It is practically more useful to limit its signification to diminished power of sight dependent on defective conditions of the optic nerve, and its retinal expansion, without, however, laying down any limitations as to their modes of origin, as explained in the text.

of vision from annihilation of the function of the optic nerve, generally due to intercranial disease, but due also to morbid changes of the optic nerve itself and the retina. Amblyopia, therefore, represents partial loss of visual sense, amaurosis complete loss of visual sense, due to morbid changes in the nervous apparatus of the eye.

**Causes.**—These may be either intrinsic, that is, due to diseased changes originating in the optic nerve itself, its cerebral origin, or retinal expansion; or extrinsic, when the diseased conditions are induced in sequence to disease of neighbouring but functionally independent structures, such as cerebral tumours and other cerebral diseases giving rise to pressure on the optic tracts, or involving them in the morbid processes, meningitis, sequels of insolation, intra-orbital tumours, diseases of the choroid, and other intra-ocular affections, reflex irritation from branches of the fifth nerve, and others. Amblyopia is also caused by a variety of constitutional disorders which lead to anæmia, impairment of nutrition, prolonged congestion, or to changes of the ocular nervous apparatus brought on probably by morbid materials circulating in the blood vessels. These include constitutional states of general debility due to repeated losses of blood from hæmorrhoidal or other sources, as also to excessive debilitating discharges whatever their nature; habitual and inordinate use of tobacco and alcohol, excessive cinchonism, lead poisoning, secondary syphilis, diabetes, albuminuria, and a variety of cachectic conditions. Other causes are mechanical injuries, such as blows about the orbit producing optic paralysis, hæmorrhagic effusion, and retinal detachment. Sudden severe shock, as from a close flash of lightning, may be a cause of amblyopia or even complete amaurosis.

Lastly, just as retinal perceptive acuteness may be increased on a healthy subject by proper and constant practice at natural objects, so it may be lessened by want of employment, *amblyopia ex anopsiâ*, as generally happens by mental suppression of the retinal image of one eye in strabismus, and sometimes, when a corneal opacity exists in one eye, by the patient excluding this eye from binocular vision in order to prevent visual confusion. On the other hand, *amblyopia* may be induced by injudicious continued overstraining of the retina, under artificial conditions, as in prolonged work at minute objects, especially if the person be subjected to circumstances tending to impair general health, and the retina be over-stimulated, as by artificial light, or the bright glare of a tropical sun.

From the variety of causes, above enumerated, which lead to amblyopia, it will be seen that amblyopia should rather be regarded as a symptom than as any distinct disease. It is as a rule the negative to the positive expression "acuteness of vision." In many instances the diseases which give rise to amblyopia are unavoidably obscure, as when they are intra-cranial, so that the effect, which is manifest, the amblyopia, can alone be distinguished and named. But in numerous other instances, the cause of the amblyopia can be traced and demonstrated, and the affection of which it is a result should then be properly designated.

**Symptoms and Diagnosis.**—In its mildest forms the patient simply cannot perceive small objects clearly. But it may vary in degree from inability to see the three or four smaller sizes of type up to inability to distinguish the types of largest size. The feebleness of vision may become aggravated until it is so weak that the patient is not able to see his way about, and the sensitiveness to light diminish until there is complete amaurosis. In moderate degress of amblyopia type of moderate size in reading is held closer to the eye than usual, in order to obtain larger images, and thus an inexperienced observer is liable to suppose the patient to be myopic. There is not usually the sense of effort or fatigue that accompanies asthenopia, nor the "blurred vision" of defective refractive power. Amblyopia will of course be accompanied by the characteristic symptoms of the particular diseased condition which gives rise to it, when it is of such a nature as to be definitely recognised. When the fact of the existence of amblyopia is established, a true diagnosis of its cause can only be hoped to be arrived at by a careful study of the history of the case, and by ophthalmoscopic investigation.

The following are also forms of amblyopia :—

(*a.*) **Hemeralopia,** night-blindness, or that condition of weak vision in which the patient can see well in the daytime, but cannot distinguish objects after sunset or in a dim light. It is frequently found among soldiers who have passed from a northern latitude to a tropical station. In these instances it is evidently due to exhaustion of nervous power from over-stimulation by the bright light of the tropical day and the reflected glare from the water of the ocean, unrelieved by the variety of shade and colour which are met with on land, and the consequent inability to perceive objects illuminated by the comparatively weak rays of moonlight. Snow-blindness appears to be of the same nature. The impairment of sensibility of the retina will be proportionably increased if circumstances have induced any scorbutic taint or marked debility in the constitutions of the individuals affected. This description refers to simple functional hemeralopia; care must be taken not to mistake it for the diminished visual power which co-exists with retinitis pigmentosa, atrophy, and other structural changes of a grave nature in the retina.

(*b.*) **Nyctalopia,** which is sometimes used as synonymous with night-blindness, really signifies the converse condition of hemeralopia, or that the patient can see better at night than he can during the daytime. In this state the weakness of the retina consists in its being unable to bear the stimulus of bright light from hyperæsthesia. The normal acuteness of vision may not be materially lowered in subdued light; but attempts to read print of moderate size, or to examine objects in bright daylight, produce all the symptoms of severe photophobia—ocular pain and dazzling, lachrymation, spasm of the eyelids, supraorbital pain, and general distress. After sundown, or when the eyes are shaded by tinted glasses, the patient moves about with comparative comfort, and sees objects clearly that he could not distinguish in ordinary daylight. The intolerance to the bright light thrown on the retina by the ophthalmoscopic speculum sufficiently indicates the presence of this abnormal irritability; often too in eyes where there have been no previous symptoms indicative of inflammatory action, and in which the fundus seems to be quite free from inflammatory effects. Such cases are occasionally met with among the soldiers who are invalided during the summer for impaired vision from India. In these instances the affection seems to be due to the effects of tropical glare upon an oversensitively organised retina, generally associated, however, with a lowered state of constitutional tone.

(*c.*) **Hemiopia. Half-vision.**—Impairment or loss of retinal perception, limited to the outer half of one eye and the inner half of the other eye. A recollection of the manner in which the fibres of the optic nerves decussate at the optic commissure explains how any cause, pressure or other, impairing the conductibility of either optic tract, before it reaches the commissure, may destroy visual power in the right or left halves of the two eyes, while the remaining portions of both retinæ retain their normal power of perception. The diagnosis can only be made out by noting carefully the field of vision of each eye. The limits of the field of vision sufficiently show the existence of the hemiopia. If the left half of the field of vision of each eye is wanting, loss of power of the right half of each retina will be indicated and *vice versâ*.

(*d.*) **Scotoma.**—Deficiency or loss of vision in an isolated portion or portions of the retina. It is occasionally central, and affects both eyes simultaneously. The defect may be a sequela of retinitis or optic neuritis, or be of cerebral origin. A dark spot, or spots, appear in ordinary vision, corresponding with the portions of the retina that have lost their sensibility to light. The spots move in concert with the movements of the eyes. Besides the amblyopia central scotoma is usually accompanied with localised disturbance of the power of distinguishing colours, the retina around retaining colour perception in integrity. In some cases a part of the retina may be infiltrated with choroidal pigment, or there may be localised exudative deposits, or a clot remaining from blood effusion. In many cases, however, no visible evidence of lesion can be detected. Careful examination of the field of vision is the best guide to diagnosis in these instances. There will be a certain constant space or spaces in the field where impairment or complete loss of vision is marked.

[Some other special conditions of defective vision, such as can particularly be distinguished by ophthalmoscopic observation, will be noticed in Part II.]

## II. Asthenopia.

**Definition.**—Feebleness of vision from deficient or irregular muscular action, altogether irrespective of amblyopia, which may or may not be present.

**Causes.**— Over-fatigue, atony, or paralysis of the ciliary muscle. Weakness of the internal recti muscles, which are chiefly employed for converging the eyes for near objects, as in reading.

The symptoms which result from these sources are in many respects similar, but the origins being so different in nature, the diagnosis between them should be clearly made out, for the principles on which treatment is to be conducted must be equally different. The two forms are, therefore, distinguished as (*a*) "motor asthenopia" and (*b*) "accommodatory asthenopia."

**Symptoms.**—The following are common to both forms of asthenopia. Reading and observation of near objects in general quickly induces fatigue. The effect of continued application of this kind causes a sense of fulness and tightness in the eyes, uneasiness about the brow, and perhaps headache. On trying to read, the letters at first appear clear and distinct, but afterwards become blurred, and, more or less, cross each other (incomplete diplopia). Epiphora, and perhaps conjunctival vascular injection, follow, if the exertion be continued. The symptoms are relieved by rest, and generally, according to the length of interval of rest, so is the degree of relief.

**Diagnosis, between Motor Asthenopia and Accommodatory Asthenopia.**—The power of mobility of the eyes must be examined, more especially the power of convergence of the optic axes. In *accommodatory asthenopia* mobility is unimpaired, and the convergence of the optic axes perfect; in *motor asthenopia* the opposite condition exists. The following is the usual way of examining the amount of convergent power possessed by the asthenopic eyes. An object, such as a ruler, is held up before the face in a line midway between the eyes, about the distance of a foot off. This is slowly moved toward the face, and when only about half a foot off, attention is paid to ascertain if one of the eyes becomes unsteady and turns outwards. Should this happen after repeated observations, it shows that the internal rectus is too weak to keep the eye in an inward direction. If the eyes be free from motor asthenopia they will converge together symmetrically to the last limit of convergence. Another plan is to shade one eye, and to direct the other at some object; if *motor asthenopia* be present, the covered eye will be moved by the stronger external rectus muscle, and turned more or less outwards. The relative strength of the converging and diverging muscles may be determined by testing their power of counteracting the deflection of rays from a given object by prismatic glasses of known varying degrees of strength.

(*a.*) *Motor Asthenopia* usually co-exists with *myopia.* From the closeness with which the myope regards objects, the internal recti m. are kept on a constant strain, and in certain cases this strain speedily induces exhaustion of muscular energy. If the patient, to counteract the effects of this exhaustion, increases his efforts to maintain the convergence of the eyes instead of giving them rest, the pain and other symptoms of motor asthenopia occur. If neglected, this state of things will probably lead to permanent strabismus. The patient, in order to prevent the annoyance of the partial *diplopia* produced by the two eyes, owing to their unsteadiness, not seeing near objects precisely in the same direction, will use one eye only; the other will move outwards, and, if habitually unemployed, not only will squint be permanently established, but the eye will be rendered amblyopic. This has been more fully explained under Myopia, at page 15. It is by prolonged and graduated exercise of the internal rectus muscle, by use of suitable prisms, or by division of the external rectus muscle, that attempts are made to remedy this condition.

(*b.*) *Accommodatory Asthenopia.*—The cause of this form of *asthenopia,* namely, want of sufficient tone in the muscle of accommodation, at once shows that whatever condition of the eye induces an excessive strain on this muscle must aggravate, even if it has not originated, the defect. Hence its constant co-existence with *hypermetropia,* and frequent occurrence with *presbyopia.* After reading or writing for a time, or working intently at any close work, the objects looked at become indistinct, and if only stronger exertion to get clear images is made, instead of resting the eyes, nearly the same symptoms as those of motor asthenopia are produced. But there is not the tendency to eversion of the eyeball that there is in motor asthenopia. Moreover, accommodatory asthenopia is relieved by convex glasses, in most cases is removed by them when they are of suitable strength, and these would only add to the difficulties of the motor asthenopia of myopes.

Loss of power in the ciliary muscle and subjectiveness to asthenopia may be brought about by other circumstances besides hypermetropia and presbyopia. Disease of the third nerve, or the production of partial paralysis by the action of atropine, loss of elasticity from continued contraction by constant occupation at near objects, spasm, general debility, all become inducing causes of accomodatory asthenopia when the ciliary apparatus is subjected to prolonged strain.

## OTHER DEFECTIVE QUALITIES OF VISION.

It will only be necessary to allude briefly to the remaining defective conditions which influence quality of vision independent of defects resulting frum obvious disease or injury. Some of them, if they exist to an extent to impair the power of sight required for the duties of a soldier, are at once seen in the ordinary examination of the recruit, while others are comparatively unimportant on account of their great rarity. The chief are (1) *Strabismus*, and (2) *Achromotopsia.*

## I. STRABISMUS.

**Definition.**—Malposition of the two eyes relatively to each other, so that their visual axes have not truly corresponding directions when a given object is looked at.

Formerly two forms of strabismus were recognised; one dependent directly upon muscular spasm or contraction, accompanying anomalous states of refraction or impaired vision of one or both eyes, under the name of "strabismus concomitans" from the squinting eye accompanying the healthy eye in all its movements; the other produced by paralysis of one or more muscles of the eyeball, or due to pressure from causes situated within the orbit. In the first of these two kinds of strabismus all the muscles act, but the balance of action is defective; in the second, the movements of one or more of the muscles are impeded or paralysed. The term "strabismus" is now only used to designate the former kind, or true concomitant strabismus; absence of correspondence of the visual axes from defective innervation &c., being considered under other headings.

Strabismus is commonly convergent towards the median line; or divergent, being turned outwards. The deviation may, however, be upwards or downwards, but is rarely so. In convergent and divergent strabismus, the retinal images are separated laterally, but remain on the same plane; in the other forms of deviation they vary in altitude and inclination according as the superior and inferior recti or oblique muscles are involved. It may be single, or monocular, when there is malposition of one eye only; or double, that is binocular, when both eyes are affected.

The existence of *strabismus* necessarily causes the formation of double retinal images, but does not necessarily cause diplopia, or double vision.

Diplopia does not exist in a large majority of cases of strabismus, and this results from the fact that the patient acquires the habit of mentally avoiding the act of vision in one eye, and attending only to the images pictured on the other. In many cases it cannot even be produced by prisms, binocular vision being quite absent. When strabismal diplopia does exist, it may be the result of so slight an absence of concordance in the position of the images of the two retinæ that merely an appearance of haziness may be given to the object; or, in its full extent, the two images being placed in totally independent positions on the respective retina, there may be the complete appearance of two objects when only one exists. In convergent strabismus the two images are formed on the corresponding retinæ; that which appears on the right side belongs to the picture formed upon the right retina; that on the left side belongs to the left retina. In divergent strabismus the images are crossed and formed on the opposite retinæ; that which appears on the right side belongs to the left retina, that on the left side to the right retina. The relative positions of the images in some instances are almost the only means by which the surgeon is enabled to decide which particular muscles are disordered. Their respective situation will be rendered obvious to the patient at once if the two images are seen by him under different colours, so that he can distinguish them from each other. This object is effected by causing the patient to look with one eye through stained glass. As *diplopia* may result from the existence of certain lesions in a single eye, it is always necessary to ascertain whether the defect is due to strabismal malposition of the two eyes or to an abnormal condition of one eye only, as well as to determine in this latter case which eye is affected. These points are at once settled by closing each eye in succession. If the *diplopia* be strabismal, it will disappear as soon as either eye is closed; if the disturbance be confined to one eye, the alternate closure will show which is the eye disordered.

Convergent strabismus is most commonly due to hypermetropia, divergent strabismus to myopia, but many other causes may give rise to these conditions; some remote, as convulsions, irritative disorders, spasmodic contractions of one or other of the ocular muscles, habit of imitation, &c.; some direct, as opacities of the cornea or lens and other ocular affections producing incongruity or disturbance of retinal images, excessive division of the antagonistic muscle in tenotomy, &c. The most common causes, however, are the anomalies of refraction above mentioned.

The existence of strabismus is, in most cases, conspicuous enough; but sometimes the natural balance of the associated or co-operative muscles is so slightly disturbed, or, in other words, the strabismus sometimes exists to so small an extent as to cause it to be by no means easy to decide at once whether there is or is not any want of harmony in the visual direction of the two eyeballs. But if any deviation be observed, however slight it may appear to be, it should attract the surgeon's notice and make him very carefully and thoroughly examine the visual power of each eye. If the strabismus has existed from childhood it will probably have resulted from morbid condition of some of the media or of part of the fundus of one or both eyes; or, if it has originated in other causes, such as abnormal conditions of form or refraction, it will probably have induced atrophic changes and advanced amblyopia in one of the eyes.

## II. Achromotopsia.

**Definition.**—Deprivation of visual perception of colour. Colour-blindness. It is of two kinds, viz., (*a.*) *congenital achromotopsia*, a defective state of vision, often hereditary, under which the subject, though possessing distinct perceptions of form, light, and shadow, is unable properly to recognise diversity of colour, or even to perceive certain colours; and (*b.*) *amblyopic achromotopsia*, deficiency, perversion, or loss of colour-sense associated with morbid states of the retina.

**Symptoms.**—(*a.*) *Congenital achromotopsia.*—Red, and what may be termed its qualities of tone, as well as the tints approaching this colour, are the most frequently inappreciable, or are only very imperfectly recognised in congenital achromotopsia. In persons so affected, the colour of a scarlet, red, or orange object cannot be distinguished from that of a green object placed by its side. The particular colours of the spectrum, however, and the number of them, which cannot be distinguished from each other, vary in different eyes labouring under this defect. In very rare cases no colour is recognised; black and white can only be distinguished; all objects appear to be of one uniform colour, as in a photograph, simply varying in degrees of light and shadow.

The defect has an infinite number of degrees. It may be said to begin with inability to distinguish accurately certain artificial complex colours, or different shades of the same colour, which very few persons, indeed, can do in perfection, and to end in complete and absolute colour blindness. It is only when the defect amounts to inability to distinguish one or more of the seven colours of the prismatic spectrum that it becomes generally of practical importance.

**Importance in the Military Services.**—This affection, so important as regards those who are guided by coloured signals, as signal officers and men at sea, railway officials, as regards the physician in the diagnosis of certain diseases characterised by colour, as *scarlatina*, and even as regards officers in general command who require to be able to recognise clearly and quickly the colours of uniforms,* has not been considered to be of importance in respect to either officers or soldiers in the ranks. It has not been included in the lists of disorders of the eyes incapacitating men for military service either in our own or in foreign armies. But the defect is of acknowledged importance as regards officers and sailors of the Royal Navy, part of whose duties it is to distinguish readily and accurately signals at sea, for this faculty depends more upon the right appreciation of the colours than of the forms or even the markings of the objects presented to view. A colour-blind officer or sailor could not recognise the distinguishing pennants of ships nor distinguish signals conveyed

* I was formerly aware of a musketry instructor who could not distinguish the red flag or "danger signal" at target practice by its colour, but only by its larger relative size; of a general officer who was necessitated from the same defect to ask a member of his staff whether a body of troops were dressed in red or blue; and I knew a surgeon in civil practice who for some time was affected with achromotopsia, during which period he could not distinguish red colours. A patient affected with scarlatina appeared to him to be of a yellowish tinge, as if he were suffering from jaundice.

by them, for they have all the same shapes and dimensions and only differ in their colours. This remark equally applies to most of the flags in use for signalling. The ill consequences of achromotopsia in such cases might not be confined to failure of recognition of the objects, but in many instances an erroneous interpretation induced by it would lead to grave and irremediable evils. It is not to be forgotten, moreover, that while the use of the telescope may make up for some visual defects, it cannot correct in any degree achromotopsia; candidates, therefore, for service in the Royal Navy, both officers and men, require to be carefully examined in respect to their faculty of distinguishing colours. The colours employed for pennants and flags in the Royal Navy of Great Britain are the three simple primary colours, red, blue, and yellow, with white and black, and it is for these that candidates require to be tested. At the same time it is not to be forgotten that in addition to the simple colours compound colours are used in the flags of foreign navies.

**Causes.**—The anatomical conditions connected with the defect are not understood. By some it is attributed to insensibility of special retinal fibres; the connexion between amblyopic achromatopsia and certain retinal diseases tends to indicate the retina as the seat of this affection. The prevalence of insensibility to the red colour in achromatopsia has been thought by some to depend on excess of yellow pigment in the region of the macula lutea, by others on special qualities of some of the transparent media through which certain constituents of the light proceeding from objects are intercepted and so prevented from reaching the retina. As the power of distinguishing colours appears to be originally more or less an acquired power, just as the power of distinguishing distance and form is, so achromatopsia may be due to some central defect by which the brain is rendered incapable of acquiring a correct appreciation of the differences, whatever their nature may be, which exist in rays of different colours.

**Diagnosis.**—Snellen's coloured 20-feet types afford means of testing achromotopsia. Four colours are supplied as distinguishing tests, viz., red, yellow, green, and blue. Types in grey colour are added. The orange, indigo, and violet colours of the spectrum are not included. Small flags are used for testing perception of colours in medical examinations for the Royal Navy.

No abnormal condition of the media or fundus of the eye can be detected by the ophthalmoscope, and this fact will distinguish congenital from most cases of amblyopic achromotopsia.

(*h*) **Amblyopic Achromotopsia.**—This is characterised in some cases by imperfect perception, or loss of perception, of certain colours, in others by the prevalence of a tint of some particular colour independent of whatever may be the colours of the objects presented to view; the later affection should be distinguished as "coloured vision" rather than as achromotopsia. Red, in amblyopic as in congenital achromotopsia, is the colour which is most frequently not discerned, while the power of distinguishing yellow or blue remains the most persistent. All degrees of amblyopia, moderate as well as severe, may be accompanied with this defect, the degree of achromotopsia not presenting as a rule any direct correspondence with the degree of amblyopia. Amblyopia with central scotoma seems to be particularly liable to be attended with impairment of perception of colour. Optic neuritis, neuro-retinitis, and any diseases inducing atrophic changes in the optic nerve have the same tendency, and interference with the right perception of colours sometimes appears very early in their course.

## CHAPTER IV.

Description of the Test-dots employed for proving the Power of Vision of Recruits.—Regulations regarding Visual Examination of Recruits.—Range of Vision necessary in Recruits.—Order of December 1863 on this subject. Principles on which the Circular Test-dots were formed.—Counting Test-dots.—Target Centres and Bull's-eyes.—Square Test-dots.—Regulation Distance for Counting the Test-dots.—Distance for Average Normal Acuteness of Vision.—Degree of Visual Acuteness with Round Dots at 10 Feet, and Square Dots at 15 Feet.—Reduction of Distance for Square Test-dots by order of August 1870.—Reduction limited to Myopia.—Rules for the use of the Test-dots.

**Regulations on Visual Examination of Recruits.**—The instructions, dated 1st July 1870, for the medical examination of recruits (clause D., paragragh 3) require that the recruit shall be free from defects of vision—that he sees well. It is further ordered, in paragraph 8 of the same clause D., that "the "special tests for power and range of vision are to be applied to "each eye, as directed on the card of test-dots furnished for that "purpose."

Under "defects of vision" are included all conditions, whether congenital or pathological, of the eyes and their appendages which interfere with clearness of view, and examination for these must be made accordingly. This is comprehended in the direction in paragraph 3, "The surgeon examines the eyes and eyelids."

**Range of Vision necessary in Recruits.**—But independent of clearness of view the recruit is required to possess a certain range and degree of acuteness of vision; and that he does possess this required range and power of vision is tested by means of the test-dots mentioned in the regulations already quoted. It is necessary to understand what range and power of vision are indicated by these test-dots, more especially as they have occasionally been supposed to be supplied for indicating full range and perfect acuteness or power of vision.

At first, when the introduction of long-range rifles with graduated aims in place of smoothbore muskets made it necessary to pay particular attention to the range and acuteness of vision possessed by recruits, efforts were made to obtain recruits with full range and perfect acuteness of vision. But it was found impossible to obtain recruits possessing such qualities of vision in sufficient numbers, and it therefore became necessary to relax the requirements in these respects. It was obviously necessary, however, to have some standard range and power of sight fixed, the possession of which would render men acceptable as recruits, and the want of possession of which would render men unacceptable as recruits, so far as these qualities of vision were concerned.

Ultimately the standard limits in this respect were published in the following order, which was issued to each army medical officer:—

Army Medical Department
3rd December 1863.

SIR,

HIS Royal Highness the Field Marshal Commanding in Chief having been pleased to notify

"That men should not be received into the service, who do not see well, to 600 yards at least, a black centre 3 feet in diameter on a white ground,"

I have the honor to request you will have the goodness to pay strict attention to this command in the examination of recruits.

(Signed) J. B. GIBSON,
Director General.

The black centre, 3 feet in diameter, on a white ground, mentioned in the foregoing circular, signified the bull's-eye of the target which was used by 1st Class soldiers in practice with the rifle at distances from 600 to 900 yards. The question then arose how medical officers were to carry out this instruction in examining recruits, there being many manifest difficulties in the way of ascertaining that men could see the actual bulls'-eyes at the required distance under the conditions in which the examination of recruits was ordinarily conducted.

**Test-dots.**—I had already suggested in an article in the Army Medical Reports for 1860 the use of black discs, formed on principles explained in the paper referred to, for the purpose above mentioned. I now prepared some of these discs so that when held at a given distance they formed retinal images of the same sizes as the bulls'-eyes 3 feet in diameter at 600 yards, and having submitted them for approval, they were adopted for effecting the desired object. The size of each of these discs or test-dots was one-fifth of an inch in diameter, and the distance at which it was to be held was 10 feet. A convenient distance, viz., 10 feet, being taken, the size of the small test-dot was found by a simple calculation of proportion, viz., as 600 yards : 3 feet :: 10 feet : $\frac{1}{5}$th of an inch. The visual angle of the dot $\frac{1}{5}$th of an inch in diameter at 10 feet then being the same as that of the large bull's-eye 3 feet in diameter at 600 yards, it followed, other conditions being alike, that if the recruit could distinguish clearly the small bull's-eyes at 10 feet distance, he could equally see the 3-feet bull's-eyes at 600 yards.

**Counting Test-dots.**—It was found by practical trials that recruits could not be relied on to count correctly more than seven of the small centres at a time, even though they were visible to him, and the small bulls'-eyes or test-dots were therefore at first limited to this number. But it was found that the limit in number was made known to the recruits by the "bringers," so that the recruits, probably judging by the amount of test-dot card exposed, occasionally guessed the number submitted to them, though the dots were not clearly seen.

To counteract this trick, a larger number of dots was printed on the test-dot card, and they were so disposed that by means of a covering card of a certain shape, which could be shifted into six positions in front of the test-dot card, 25 variations in the number and relative positions of the dots could be obtained without exposing more than seven or eight at a time. The test-dot card was ultimately adopted in this shape, directions for using it being printed on the back.

**Change from Circular to Rectangular Bulls'-eyes.**—Subsequently the circular bulls'-eyes on the targets were changed to rectangular bulls'-eyes. In January 1868 a corresponding change was directed to be made in the test-dots. It was ordered that the 2-foot square bull's-eye should be seen by recruits at a distance of 600 yards, the same distance as by the circular of the 3rd December 1863 the round 3-feet centre* had been ordered to be seen at. In arranging the new test-dots to comply with this order, it was found convenient to retain the dots one-fifth of an inch square in size. To apply them as tests for carrying out the order for examination of range of vision, these test-dots had to be held at a distance of 15 feet from the recruit. As before, the distance at which the test-dots were to be held was determined by a simple calculation of proportion, viz., 2 feet : 600 yards :: $\frac{1}{5}$th of an inch : 15 feet. In other respects the square test-dot cards were similar to the former round test-dot cards.

**Printing of Test-dots.**—The round test-dots had been lithographed, and in many instances were printed so coarsely as to present broken and irregular outlines. They formed proportionably imperfect tests for accuracy of vision at the distance named for their being seen by the recruit. To obviate this imperfection, and to ensure the outlines being sharply defined, it was recommended

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* In rifle drill instruction a distinction is made between the bull's-eye and centre. The bull's-eye consists of a black rectangular figure on a white ground, varying in size according to the distance at which the target is placed and according to the class of marksmen firing at it. Outside the bull's-eye is a white space bounded by rectangular black lines. The space within these lines and between them and the bull's-eye is called the centre. Outside these lines is the remainder of the target. The size of the bull's-eye aimed at by recruits and soldiers of the 1st Class is 2′ × 3′, used for distances varying from 450 to 800 yards; of the 2nd Class, 2′ × 2′, for distances from 250 to 600 yards; of the 3rd Class, 2′ × 1′, for distances from 50 to 300 yards. The size of the bull's-eye ordered to be adopted as the test for vision was therefore that of the bull's-eye used by marksmen of the 2nd Class.

that the square test-dots should be engraved on copper, and this was accordingly done.

**Test-dots introduced among Snellen's Test-types.**—About the time that the round test-dots were introduced Snellen's test-types were printed for distribution among the medical officers of the British army. Dr. Snellen at my request introduced the test-dots in his volume of test-types, and it may be observed that he placed above them the number 54, to indicate the number of Paris feet at which the test-dots ought to be held for testing normal acuteness of vision. At this distance the test-dots would form a visual angle of the 60th part of a degree, which, as already explained, according to Dr. Snellen constitutes the average smallest visual angle under which an object can be seen.

But as all Dr. Snellen's types and figures were rectangular objects, while the test-dots introduced among them were circular, it followed that a difference of calculation was required for the test-dots. The difference between the area of a circle and the area of a square had to be taken into account. The area of a square to that of a circle is as 1 : ·7854, and taking 54 feet as the distance at which a rectangular object one-fifth of an inch square should be seen by normally acute vision, a circular object one-fifth of an inch in diameter would be only visible by normally acute vision at a distance of about 43 feet.

**Degree of Visual Acuteness shown by Counting Circular Test-dots at 10 feet.**—As before mentioned the circular test-dots one-fifth of an inch in diameter were ordered to be held at 10 feet distance from the recruit, this distance, so far as concerned the production of the image on the retina, being equivalent to that of the bull's-eye 3 feet diameter, when seen, as ordered, at 600 yards. But it has been shown that for perfect acuteness of vision they ought to be held at 43 feet. Therefore, since 10 : 43 :: 1 : 4·3 it follows that recruits accepted by the visual test just named, were accepted with $\frac{1}{4\frac{3}{10}}$ths, or roughly one-fourth, of normal acuteness of vision. In other words, if Snellen's test-types had been used instead of the test-dots as the standard of visual sufficiency, a recruit would be accepted who could only read the 20-feet type at 5 feet distance instead of the full distance of 20 feet.

The rectangular test-dots one-fifth of an inch square had not been introduced when Snellen's test-types were published. Had they been, the number 54 would have been rightly attached to them as the distance where they ought to be placed from an eye to test normal acuteness of vision. The order required the 2 feet square bull's eye to be seen at 600 yards, which is the same as requiring the $\frac{1}{5}''$ square test-dot to be seen at 15 yards, for 2′ : 600 yards : : ·2 inch : 15 feet. But as for normal acuteness of vision they should be seen at 54 feet;* it follows that recruits were accepted, when the dots were held at 15 feet, with only $\frac{1}{3\frac{3}{5}}$ths of the normal standard (15 : 54 : : 1 : 3·6).

**Reduction of Distance for the Square Test-dots by Order of August 1870.**—In August 1870 the following circular modifying the standard of vision to be determined by the test-dots was issued :—

Recruiting. Horse Guards, 3rd August 1870.

*Circular Memorandum.*

With reference to the instructions for the medical examination of recruits, dated 1st July 1870, it is notified that the medical officer will adhere strictly to the necessity that the vision of the recruit be sufficiently good to enable him to see clearly—that paragraph 3 of clause D be carefully attended to, but that paragraph 8 of the same clause, as regards short sight, is so far modified that each test-dot on the card now required to be seen distinctly at 15 feet may, till further notice, be tested for a distance of 10 feet only.

CLEM. A. EDWARDS,
I. G. of Recruiting.

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* *Calculation of Distance with respect to Visual Angle.*—The distance at which an object the measure of whose extreme limits is known ought to be placed in order to subtend so small an angle as that of one minute may be roughly ascertained without difficulty, for the radius of the circle of which that measure forms part under the angle named will give very closely the distance required.

Thus, taking the square test-dot under notice :—If an object ·2 of an inch is supposed to occupy 1 minute of a circle, 1 degree of the circle will be equal to 12 inches, and the circumference will be 360 feet. The diameter being equal to the circumference divided by 3·1416, the radius will be 57 English feet omitting fractions. Therefore, at 57 feet distance the visual angle of the ·2 of an inch test-dot will be one minute. All the distances in Snellen's test-types are stated in French feet, and as the ratio of English to French feet is 46 : 49, so omitting fractions the 57 English feet will be equal to 54 French feet, the number stated above the test-dots in Snellen's tables.

No change has taken place since the issue of this circular, and by it the measure of distance is at present regulated throughout the service.

By this order a further reduction in visual acuteness took place for recruits were to be taken who could recognize the test-dots at 10 feet only. The standard of visual acuteness was lowered from $\frac{1}{3\cdot6}$ to $\frac{1}{5\cdot4}$ of the standard of average normal acuteness of vision.

**Reduction of required Visual Acuteness limited to that caused by Myopia.**—It should be noticed, however, that the circular limits this depression of the standard to cases of myopia, and it throws on the medical officer the responsibility of distinguishing between limitation of vision due to short sight, and limitation of vision resulting from other ocular defects or diseases. The medical officer is directed to adhere strictly to the necessity that the vision of the recruit *be sufficiently good to enable him to see clearly*; only the range of vision within which he is required to see clearly is curtailed.

**Rules for the Use of the Test-dots.**—In using the test-dots for trying the power and range of vision of recruits it is essential that the rules laid down for the manner of using them should be duly attended to. The following were the directions originally issued with them.

*Directions for using the Card of Test-dots.*

1.—Measure off 15 feet with precision.

2.—Hold the Test-dot Card perfectly upright in front of the recruit, and let it face the light so as to be fully illumined.

3.—Examine each eye of the recruit alternately; the eye which is not under trial being completely shaded by the hand of an assistant, who should take care not to press upon the eyeball.

4.—Expose some of the dots, not more than 7 or 8 at a time, and desire the recruit to name their number and relative positions.

5.—Vary the groups frequently to provide against deception. The covering card can be shifted into six positions, and thus numerous variations may be obtained, without exceeding the number of dots above mentioned.

The Test-dots should be kept perfectly clean.

## CHAPTER V.

Mode of conducting the Visual Examination of Recruits and Soldiers.—The Appliances used in the Examination.—The Examination Room.—Each Eye to be separately tested.—Disease or impaired Vision of either Eye a Cause of Rejection of a Recruit.—Pressure upon the Eye during the Examination to be avoided.—Use of the Test-dots.—Steps to be taken if a Recruit practices Imposition.—Visual Examination of Soldiers.—Use of Snellen's Test-types.—Proceedings for ascertaining the Sources of Defective Vision.—Preliminary Examination of the Anterior Parts of the Eye.—Lateral Illumination.—Myopia.—Hypermetropia.—Astigmatism.—Amblyopia, how to distinguish from Myopia.—Amblyopia complicated with Myopia.—Disqualifying Degree of Myopia in Recruits.—Visual Acuteness needed in different Parts of an Army.—Degree of Myopia which unfits Soldiers for Military Duties.—Myopic Vision of $\frac{1}{24}$.—Test-dots at 15′ admit M.=$\frac{1}{30}$.—Ametropia in continental armies.—Use of Spectacles by Soldiers in the ranks.—Visual acuteness desirable for Commissioned Officers.—Quality of Vision required in Candidates for Commissions.—For the Line.—In the Medical Department.—In the Royal Artillery and Royal Engineers.—For the Royal Navy.—Regulations for Naval Cadets in Germany.—Pathological Changes in the posterior Parts of the eye.—Impaired Vision, or Blindness, of one eye in a Soldier not a Cause for Discharge.—Aiming with the Left Eye.—Detection of simulated Impairment of Vision.—Assumed Blindness of one Eye.—Modes of Detection.—Case.—Assumed extreme defective Vision of both Eyes.—Modes of Detection—Case.—Defective Vision not often simulated by Soldiers.

1. *Visual Examination of Recruits.*—The determination of the *quality of vision* of a recruit, if it be not at once proved to be normal, will perhaps occupy 10 or 15 minutes. It is therefore best to make this examination after the rest of the inspection is completed, so as to allow the recruit to dress himself before it is commenced.

2. *Appliances for Visual Examination.*—The regimental optical and ophthalmoscopic case is sufficient, in conjunction with the types and dots, for proving the quality of vision possessed by a soldier or recruit in all ordinary instances. For special cases, which now and then occur, complete series of lenses, both convex and concave, are necessary. It is also advantageous to have a case of cylindrical lenses for occasional reference. Such full sets of lenses have the advantage of offering additional facilities for solving complicated and doubtful cases, detecting attempts at imposition, and are therefore especially useful in general and invaliding hospitals, to which such cases are commonly sent for decision. They also afford means of proving the existence of diagnosed abnormalities

of refraction, or amounts of loss of accommodatory power, by positive correction of the defects.

3. *Examination Room.*—All rooms in which the examination of recruits is conducted should be well lighted. This is especially important in testing vision. The light falling on the test-objects to be looked at should as nearly resemble the degree of external daylight as possible. It is a matter of convenience and also a means of saving time to have some lines, showing distances in feet, permanently marked in ink upon the floor of the room in which Snellen's types or the minature bull's eyes are used. The distance should extend at least to 20 feet. The addition of some simple means for suspending Snellen's 20′ types at the end of the 20′ range is also useful. They should be suspended on a level with the eyes of the person to be examined.

In conducting the examination the soldier or recruit is placed with his back towards the light, so that the fullest illumination is upon the types or dots by which his sight is tested.

4. *Separate Examination of each Eye.*—It is always necessary to test each eye separately. It will not often be found even in healthy eyes that the absolute refractive qualities of the two eyes of the same person, independent of accommodatory exertion, are precisely alike; but in defective conditions of vision of the two eyes the difference between them is usually more marked. It has even not seldom occurred that a man has been totally blind in one eye without knowing it, until attention has been directed to each eye separately by optical examination.

5. *Defect of either Eye in a Recruit.*—Musketry instructors naturally direct attention principally to the right eye, because it is with this eye that the enlisted recruit is taught to aim at objects; but the existence of defect or disease in either eye is a sufficient cause of medical rejection of a recruit seeking enlistment. Though the right eye may be sound, if the vision of the left eye be defective in any marked degree, especially if the defect be the result of diseased action, not simply of conformation, we must remember that there is always a certain amount of risk of the right eye eventually becoming defective also. Moreover, as regards a recruit, the chances of the normal eye becoming independently affected by disease originating in the exposure and causes incidental to military service, and of the man thus becoming com-

pletely disabled for duty, have their influence in determining the rule that not only the right eye, but the left also, of a recruit should be ascertained to be normal before he is passed fit for acceptance as a soldier.

6. *Pressure on the Eye.*—In examining the eyes separately, it is best for an assistant to cover with his hand the eye not occupied in regarding the object, and not the man himself. If the man be allowed to close it, he will probably, from carelessness or nervousness, exert undue pressure on the globe, and so disturb its condition for vision, and cause delay until this disturbance is recovered from. The assistant who covers the eye should be taught that if any pressure be made it should be limited to the margin of the orbit. The object is simply to exclude light by closing the lids or shading the eye with the hand; the eye itself should not be pressed upon. If undue pressure have been made, it will be necessary to wait a minute or two until all mistiness of vision has disappeared before applying the test for visual power.

7. *Application of Test-dots.*—If the man under examination be a recruit, as soon as he is dressed and placed in position, the test-dots are held upright before him at the prescribed distance, and he is asked to state the number of dots exposed to his view, in the manner already explained at page 66. He should be required to count two or three series of dots with each eye, and if he replies readily and satisfactorily, so far as power of vision is concerned, he is medically fit for service.

8. *Rejection of a Recruit.*—If the recruit should make repeated mistakes in counting the number of dots presented to him at the prescribed distance, and there is no reason for suspecting that he is doing otherwise than his best to try and see them clearly, especially if he should succeed in counting them correctly when they are held at some point nearer to him than the prescribed distance, he is then rejected as unfit for service on account of defective vision. The regulations do not require that the nature or degree of the defect should be particularly stated as regards recruits.

9. *Procedure when Imposition is suspected.*—In the British service as recruits are for the most part men voluntarily seeking enlistment as soldiers, not like the majority of conscripts in continental armies trying to escape enlistment, if they make any efforts to

deceive, they are usually directed to the concealment of any defects of vision they may labour under.

If, however, there is any cause for suspecting that the man who has volunteered for enlistment has changed his wishes on the subject, and that he is trying to escape from the bargain he has so far entered into by assuming a defect of visual power which does not exist, he must be subjected to further tests before he is pronounced unfit for service on this account.

10. *Visual Examination of Soldiers.*—When it is necessary to determine the acuteness of vision of a soldier already in the service, the general manner of conducting the examination is the same, only the test-types are used instead of the test-dots. The trial by test-dots at a prescribed distance, as before explained, has been specially ordered for men seeking admission into the army. In the cases of soldiers already in the army, a closer and more complete examination is required, for it is necessary to determine the quality of vision with precision. The question usually submitted to the medical officer is whether marked awkwardness or apparent inability to perform certain parts of musketry instruction drill, or rifle practice, which the soldier has exhibited is due to defective vision or not. The nature of the defect, and the extent to which it disqualifies the man for duty, have therefore to be stated with accuracy.

11. *Use of Snellen's Test-types.*—In such cases the acuteness of vision must first be determined, and this is done by Snellen's test-types or test-figures. The mode of ascertaining and expressing the acuteness of vision by these objects has been explained at page 46.

12. *Vision not defective.*—If these tests are so answered as to show the man under examination possesses average normal acuteness of vision, or a near approach to the average, the subjects of complaint are not due to visual defect.

13. *Procedure if Vision be defective.*—If the acuteness of vision is considerably under the average, the cause of the deficiency must be ascertained. The mode of proceeding is the same in such a case as it is in the ocular examination of a recruit who has shown want of ability to count the test-dots at the prescribed distance, and whose apparent visual defect is suspected for some reason or other to be assumed.

In the first instance, particular and special attention must be paid to the examination of the anterior ocular structures. The cornea, anterior chamber, iris, and crystalline lens of the affected eye should be subjected to minute observation. Defects may exist in these structures sufficient to obscure vision without their having been perceived in the observation of the organ made at the general inspection of the recruit. They may equally exist in the case of the soldier without being visible by ordinary observation. This preliminary inspection is important, and should invariably be made. Considerable time is often wasted afterwards when it has been neglected.

14. *Lateral Illumination.*—The superficial examination is very rapidly made by *lateral illumination,* and indeed can only be thoroughly accomplished by its means. Lateral illumination signifies lighting up the parts required to be observed by concentrating upon them a pencil of rays cast in an oblique direction. The recruit is brought near the window of the room, one of the bi-convex object lenses in the optical case is placed vertically near the outer angle of the eye in such a way that the light passing through it is made to converge upon the cornea, or through the cornea on the iris or lens, and the condition of any of these structures is then examined by the spectator standing in front. This lateral illumination is of course more brilliantly seen when the flame in the ophthalmoscopic room is used as the source of light, but is sufficiently marked by solar light on any ordinarily clear day. By these means the slightest roughness of the surface of the cornea, interstitial haziness, minute ulcers or the remains of them, fine exudations at the margin of the pupil, posterior synechiæ, commencing cataract, are made most obvious to sight, while the pencil of rays at or near its focus is made to play upon each structure at pleasure. Nothing can be more beautiful than the perfect precision with which opacities of the cornea and lens, adhesions of lymph to the capsule, and other morbid changes, scarcely perceptible by ordinary observation, are defined by light thrown laterally upon them in the manner just described. If minuter observation be required, the objects while thus illuminated may be magnified by a second lens held within its focal distance in front of the eye, without impairing their brilliancy or distinctness of outline.

A sufficient explanation of the impairment of sight will sometimes be found in this preliminary examination of the eye; but if nothing abnormal can be detected, the examiner must proceed further, with a view to discovering the source of the defective vision under which the recruit or soldier appears to labour. It may be due to ametropia, astigmatism, amblyopia, or disease of some of the structures constituting the fundus of the eye.

15. *Detection of Simple Myopia.*—The recruit who has not been able to count the test-dots at the normal distance has been found able to count them at some distance short of it. The soldier also who has not been able to read the larger types at the proper distances, has been found able to read the Nos. 1 or 2 types at or near the distance of 1 or 2 feet respectively from the eye. The external signs described in the general remarks on myopia will probably at once cause the surgeon to judge that no simulation is being practised, and indicate the nature of the affection he has to deal with. The shortest way is at once to use the convex spectacles, and establish the diagnosis as explained in the section on Myopia; or else to test the refractive condition of the eye by the ophthalmoscope in the manner described in the second part of this work.

16. *Detection of Simple Hypermetropia.*—The difficulty which the hypermetropic recruit or soldier exhibits in recognising the types and dots at any distance, and the form of the eye, will probably lead the surgeon to suspect the affection under which the man is labouring. The diagnosis should be established by the convex spectacles, as already explained in the section on Hypermetropia or by the ophthalmoscope, as will be hereafter explained.

17. *Detection of Astigmatism.*—If the man under examination has exhibited particular difficulty in recognising the letters or counting the dots at any distance, and the tests for simple hypermetropia and myopia are not readily responded to, the existence of astigmatism may be suspected. The man should be then tried by Snellen's 20-feet vertical and horizontal lines or dots, or he should be subjected to ophthalmoscopic examination in order that the diagnosis may be established by the method explained in the second part of this work. The method of proceeding for determining the kind and degree of astigmatism has been explained in the special section on Astigmatism.

18. *To distinguish Amblyopia from Myopia.*—If it is found that the smallest sized types and dots cannot be distinctly seen at any distance, and that larger sized type is held nearer than normal to the eye, the recruit is probably labouring under *amblyopia;* he cannot be affected with simple *myopia.* To ascertain if this is the defect he is troubled with, weak concave lenses, if these are at hand, are placed before his eyes. If he now sees distant objects of apparent small size worse than before, his defect is almost deyond doubt amblyopia; for the concave glasses which would improve vision if he were myopic, renders vision worse in *amblyopia* by diminishing the retinal images. When the convex 10″ spectacles are placed before his eyes, if the man under examination be emmetropic but at the same time amblyopic he will be able to see the 3′ or 4′ type, or type of larger size, at a distance of 10″ from the lenses, although he is unable to see the smallest sized types at that distance.

The following is another mode of settling the question. If a man be myopic and look through a pinhole in a card at distant objects he will perceive them far more clearly, while if he be amblyopic, there will be no improvement. A person affected with a high degree of myopia, as an $\frac{1}{8}$th or $\frac{1}{10}$th, will be able to recognize Snellen's moderately sixed types No. 7, or No. 8, at double the distance when regarding them through a pinhole that he will be able to do with his naked eye, while a person affected with amblyopia will not be able to see them any farther off by this proceeding.

19. *Amblyopia with Myopia.*—Myopia may be complicated with Amblyopia, and it is important to distinguish simple short-sightedness from short-sightedness with this complication. In the latter case, when the 10″ convex spectacles are worn, the subject will see types up to some distance within ten inches, say, for example, five inches. The patient's true far point is then $(\frac{1}{5}-\frac{1}{10})=\frac{1}{10}$, and if the *myopia* be uncomplicated with *amblyopia,* he will be able to read the one-foot type at the distance of ten inches without the aid of lenses. If it be complicated with *amblyopia* he will require the one-foot type to be held nearer to the eye than ten inches; he will only be able to read some of the larger types at that distance. Again, simple *myopia* is completely corrected by suitable lenses, and hence a ready mode of establishing an exact diagnosis between simple *myopia,* and *myopia* with *amblyopia,* is afforded.

Having proved the existence of *myopia* according to the methods already explained, the degree of *myopia* is next determined. The proper concave lenses to correct this *myopia* are then applied, and with them the simply myopic person will be able to see plainly the smallest sized types at their proper distances; but if he be also amblyopic, he will only be able to see clearly types of larger sizes according to the degree of *amblyopia*. By refeṛrring to the description of the causes of *amblyopia* it will at once be seen that the concurrence of *amblyopia*, if extensive, with *myopia* is a grave complication: for it indicates the existence of disease, and not merely peculiar conformation of the eye. The nature of this disease must be solved by ophthalmoscopic examination.

20. *Disqualifying Degree of myopia in Recruits by existing Orders.*—As myopia is by no means an uncommon affection, though far from being as common as it is in some foreign countries, it becomes very important to be aware of the degree which, according to existing regulations, unfits a recruit for military service in the combatant ranks. Myopia in a soldier is a grave matter not only on account of its incapacitating him for the accurate use of his rifle, but also because it may lead to the safety of an important post, which he has been placed on sentry to guard, becoming endangered owing to his limited range of distinct view. No limit has as yet been defined with respect to the degree of M. which incapacitates for service in the English army; but it may approximately be arrived at by experimental observation of the degree of uncomplicated M. which admits of the test-dots being counted at the distance, 10 feet, which, according to order, determines recruits to be eligible for service so far as vision is concerned.

Experimental trials show that persons of equal ages, and still more persons of varying ages, differ considerably in their power of distinguishing the presence of objects notwithstanding that the objects are obscured by an equal amount of blurring from diffused rays. But taking the average of a number of trials, at about the ordinary ages of recruits, I find that persons affected with uncomplicated M. $= \frac{1}{24}$ can manage, with each eye singly, to count the test-dots at 10 feet under suitable exposure in good daylight. The test-dots are seen mistily, sometimes they appear altered in form, but they can be separately distinguished so as to be counted. The present test-dot standard for vision of recruits, therefore, admits degrees of M. up to $\frac{1}{24}$. It will usually exclude degrees of M. higher than $\frac{1}{24}$.

21. *The Qualities of Vision needed varies in different Parts of an Army.*—The myopia which would make a man unsuitable for the duties of one arm of the service may not make him unsuitable for another. The myopia which would unfit a soldier for aiming at long ranges, whether with a rifle or a gun, or for the duties of a cavalry vidette, would not unfit him for the working duties of a sapper, a pioneer, for the army service corps train, for a commissariat soldier, or a hospital attendant. Just as there are different standards of height, girth of chest, &c. for different parts of the army, so equally necessary appear to be different standards of visual acuteness to fit them for their special duties. Certainly riflemen, artillerists, and cavalry soldiers, "the eyes of the army," should especially be as free as possible from shortsightedness and other defects of vision.

What particular degrees of myopia, however, should exclude from special parts of the army in which very acute vision, and a long visual range, are essentially important, can only be determined after a definition by military authority of the special requirements in these several parts. It is the province of the military authorities to settle the degree of visual acuteness which is necessary for the military duties and responsibilities demanded from each branch of the military service. At present in the enlistment of recruits for the British army the same orders in respect to the examination of vision hold good for all recruits alike, whatever branch of the army they may be destined for.

22. *Degree of Myopia which unfits for Military Duties in the Ranks.*—The circumstances of military service are so different in the British army from what they are in continental armies, the cost as regards the individual soldier is so much greater, that in the selection and acceptance of men for service, remembering too that only one general rule exists for all parts of the army alike, a far higher standard in respect to visual power may well be looked for in the British as compared with continental armies. In a country in which *conscription* is in force, and very large armies are maintained, it is an object not to allow any men to escape conscription who can be turned to useful account in military service—if not fit for one branch then to utilize them for some

other—so that only an extreme degree of M. is allowed to exclude altogether from conscription. In a country in which *voluntary enlistment* and highly paid wages are the rule, it is the object not to accept any who are not fully qualified for the performance of the duties which will devolve on them in the army. And when only one rule exists for all alike, evidently the standard for those parts of the army in which a high dergee of visual acuteness is a necessity should be chiefly taken into account in framing rules on the subject, in order that the necessary degree of military efficiency may be attained. To admit recruits with myopia approaching $\frac{1}{6}$th or $\frac{1}{4}$th as conscripts are admitted in Italy and France, or even with $\frac{1}{12}$th as in other countries, and then to draft them for service as riflemen, would be a wasteful pecuniary outlay in the English army. Experience proves that high degrees of myopia rarely exist without the existence of posterior staphyloma and a tendency for the myopia to increase. Considering moreover the amount of military service which is passed by a large proportion of the men of the British army in India, and the ill effects resulting from the overstimulation of the retinæ of myopes by tropical light, the expediency of admitting men into the ranks of the army with such a degree of myopia as is compatible with the present test of counting the test-dots at a distance of 10 feet, appears to be very doubtful. It seems to be very questionable whether any man with myopia $= \frac{1}{24}$ ought to be accepted as a recruit; such a man certainly cannot be a desirable recruit for the ranks in which the Martini-Henry rifle constitutes the firearm in ordinary use, or in any part of the service where precision of vision for distant objects is demanded unassisted by correcting spectacles. For parts of the army in which accurate sight is not such a necessity, it would be difficult to lay down any rule as to the limits of myopia, or other ametropic conditions, admissible; for just as the regulations regarding the height, girth of chest, and other physical conditions required in recruits are varied according as they are wanted or not, or according as the supply of them is scarce or plentiful, so also it may be expected that the regulations regarding ametropia will be varied. In case there are more recruits to be had than are wanted, better qualities of vision may be insisted upon; in case the need is greater than the supply, inferior qualities of vision will have to be accepted. But obviously, when the standard for vision has to be reduced, the reduction should be confined as far as practicable to those parts of the army in which it will least interfere with the performance of the duties appertaining to them.

23. *Character of Vision possessed by a Myope of $\frac{1}{24}$.*—A person affected with M. = $\frac{1}{24}$ sees all objects beyond two or three feet with more or less indistinctness. At the distance of 20 feet books on shelves, or other objects of like sizes, appear mixed up together owing to want of definition and reduplication of outlines, while, though at this distance, the figure of a man may be seen well enough, his features are not separately distinguishable. An acquaintance even is not recognised at this distance if the recognition depend upon peculiarities of feature, unless the light is very strong and happens to fall directly upon the face, though striking contrasts in uniform such as stripes on the sleeve, medals, differences in colour, or peculiarities of carriage and of movements of the body, are sufficiently obvious, even under moderate light. At a distance of 50 yards and upwards, groups of five or six persons standing together before a moderately dark background cannot be readily separated from one another so as to admit of being counted with accuracy. Dark objects on a white ground, such as large black letters on a white notice board, appear lighter, and the white ground appears darker, than they really are, while the letters are so spread out that they are altogether indistinguishable at a distance at which an eye with normal vision can recognise the painted words without difficulty. More distant objects, such as the general features of a landscape, houses and persons among trees, are huddled together and converted into little else than general shadows with indeterminate outlines. The nature of particular objects even of large size can only be made out when the accidental advantage of some sharply-marked contrast is afforded, such as is presented by a ship floating on water, by a building or a tree having the skyline as a background, or when a well-known object such as a horse is in movement on a road. Even this last object ceases to be distinguishable at a distance of seven or eight hundred yards if it be passing by a dark background such as a belt of trees. The want of clearness of view increases, and the power of recognition diminishes, in proportion as the intensity of light diminishes, so that on a day when the sun is

obscured by cloud, and the light therefore comparatively dull, but not so dull as to interfere with perception by normal vision, the power of distinguishing objects by the myope of $\frac{1}{24}$ and higher degrees is materially curtailed. The opening of the pupil to admit more rays of light obscures the view through greater diffusion of the peripheral rays. Still more difficult does it become for such myopes to distinguish particular objects after sundown, even when there is sufficient light for men with emmetropic vision to be able readily to perceive and recognise them.

It is true that such myopic persons have the compensating advantage of seeing minute objects near to their eyes clearly, and that they retain this power at periods of life when convex spectacles have become a matter of necessity to persons with emmetropic vision; but obviously this special power is of no advantage so far as military service is concerned.

24. *Degrees of Myopia admissible when the Test-dots are held at 15 feet.*—A myope with M. = $\frac{1}{30}$ still sees objects mistily, but the difference between the degree of haziness and that of a myope with M. = $\frac{1}{24}$ is considerable. As the test-dots were originally ordered to be used, viz., at 15 feet, myopes with M. = $\frac{1}{30}$ were just capable of admission, and of course all lower degrees of M. could pass the test; but myopes with M. = $\frac{1}{24}$ and upwards were excluded.

A myopic eye of $\frac{1}{30}$ can read No. 2 Snellen at a distance of 2′, but not No. 3 Snellen at the full distance of 3′, can recognise No. 20 Snellen in good light at about 10′, showing V. = $\frac{1}{2}$; and has a distant point of distinct vision for No. 2 Snellen at $7\frac{1}{2}''$ with the 10″ convex lens before it.

25. *Degrees of M. which exclude from Service in Continental Armies.*—In continental armies the degree of myopia which renders men unfit for military service is always much higher than $\frac{1}{24}$. But it must be remembered that these armies are raised by conscription, and the degree of ametropia which has been fixed for excluding from military service is that which is understood to cause total unfitness for military avocations, not merely a degree which unfits men from becoming reliable and good soldiers. The important point is not to be forgotten too that in armies raised by conscription, if a conscript is affected with a less degree of ametropia than the absolute disqualifying

degree, but still one that unfits him for becoming a good rifleman, cavalry scout, or artillerist, he is simply drafted to other parts of the army in which his amount of ametropia will not interfere with the right performance of the duties belonging to them. The system of the British army, as already mentioned, does not permit distribution of men on these principles.*

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* *Degrees of Myopia and other Ametropic Conditions which exclude from Military Service in Foreign Armies.*—The degree of ametropia which excludes altogether from service, or which excludes from service in particular parts of foreign armies, varies in different countries, as do also the regulations by which the existence of the disqualifying degrees of ametropia are ordered to be ascertained.

In Holland, Dr. Snellen informs me, the following rules are laid down (*Act of 26th March* 1871):—Conscripts are unfitted for military service by M. (after mydriasis by atropine) = $\frac{1}{12}$, or higher; by H. (total hypermetropia) = $\frac{1}{6\frac{1}{4}}$, or higher; by astigmatism of such an amount that acuteness of V. may be considered to be reduced to less than $\frac{1}{10}$ for the right, or to less than $\frac{1}{20}$ for the left eye.

In France, M. = $\frac{1}{4}$ and above exempts from conscription for military service. Young men affected with a less degree of M. than $\frac{1}{4}$, although it may be high enough to cause spectacles to be required for serviceable vision, are liable to be placed in the auxiliary military service. In order to determine the existence of the disqualifying degree of M. above named, the regulations require (*Instructions for medical officers on the infirmities which render unfit for military service, of 3rd April* 1873) that the myope shall read the 20-feet types at a distance of 5 metres when wearing − 4″ spectacles, or small print at 35 Cm. (14″) with − 6″ or − 7″ spectacles.

In Germany, the regulations order that such a degree of M. as prevents the myope from distinguishing one man from another at a distance of 10 paces (about 20 feet) entails complete and permanent unfitness for military service. It is scarcely possible to fix a particular degree of M. according to this regulation, for recognition at the distance named will be modified by peculiarities of figure, modes of movement, colour and characters of uniform, positive and relative illumination of the persons to be recognised, independent of the degree of M. Conscripts for the artillery, for riflemen and sharpshooters (Jäger und Schützen) are required to possess normal vision; they must be free from M. They must prove their power to distinguish with the naked eye the movements of the limbs of a single man at the distance of 250 paces. Volunteers who pay for their uniform, rations &c., are exempt from this rule, and are allowed to wear spectacles to correct their M. when necessary. Myopic conscripts who are not fit for the arms of the service just named, but who are able to distinguish one man from another at 10 paces, are eligible for all other parts of the military service, for the train, military workmen, as tailors, bakers, saddlers, for sick attendants, &c. These rules guide in time of peace; in time of war all must serve in whatever way they are capable of serving.

In Italy, the myopic conscript who can read ordinary print at a distance of

26. *Use of Spectacles by Soldiers in the Ranks not sanctioned.*—The use of spectacles by soldiers for the correction of ametropic defects of vision is not sanctioned by any published regulation in the British Army. Special difficulties would be experienced if glasses were allowed to be worn in the English army as they appear to be in some parts of the troops of continental armies. These difficulties particularly relate to the want of means of replacing them when injured or broken in many of the distant stations in which English troops are habitually employed. The education in respect to the use of such appliances and the habits of the men composing the ranks of the English army must also be taken into account. If the glasses were damaged or broken while troops were on active service, there would be almost insuperable difficulties in replacing them, and this would just be the time when they would be most urgently required. Moreover, though the spectacles may be perfect, when dust, rain, condensed moisture, or other circumstances interfere with the transparency, and therefore with their utility, accoutred infantry soldiers carrying rifles, or mounted troopers, are too fettered to be in a position to remove these impediments as they occur, and the spectacles would cease to be of any advantage. These are probably the reasons which have prevented the use of spectacles from being sanctioned among men in the ranks of the army.

27. *Range and Power of Vision necessary for Commissioned Officers in the Army.*—The requirements for distinct vision appear to be even more imperative in officers than in private soldiers. They must look down whole lines of men, and see them with distinctness. They are required to observe distant objects and

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30 Cm. (about 12″) when wearing − 3″ or − 4″ spectacles, and can distinguish distant objects with concave spectacles up to $-\frac{1}{5\frac{1}{4}}''$ lenses is excluded from military service. Here the minimum of exclusion is M. = about $\frac{1}{12}$.

In Austria and Switzerland, a myope who is capable of reading letters of the size of No. 2 Snellen, with − 6″ spectacles at or within a distance of 6″ from the eye is incapacitated for military service. Making allowance for the range of accommodation at the ordinary ages of recruits, 18 to 25 years, which is = $\frac{1}{4}$, this rule causes M. = about $\frac{1}{12}$ to incapacitate for military service.

Several of the foregoing rules are thought by some military surgeons in the countries respectively concerned to require amendment, both as regards the degrees of ametropia laid down as incapacitating for service, and also the means employed for determining their existence.

not unfrequently to give important directions according to the judgments they form of them. It is also of personal importance to combatant officers on taking the field that they should possess a normal range and power of vision, or at least, a range not far short of normal range. I have myself known in the midst of active service an officer declare himself unable to take picket duty because he could not distinguish an enemy from a friend at a short distance from him, and to be declared by a committee of medical officers unfit for service in the field in consequence of shortsightedness; and during the Crimean war it certainly once happened, if not more often, that an officer was taken prisoner by walking into the midst of a party of the enemy whom he failed to distinguish from his own troops owing to the same cause. An unfortunate English army surgeon in the Crimea who was affected with myopia failed to recognise a French sentry at a distance at which the sentry saw him but too plainly, and he lost his life in consequence.

28. *Visual Acuteness required in Candidates for Commissions in the Line.*—The existing rule for the visual examination of candidates for commissions in the line is as follows: Simple myopia or hypermetropia is not held to be a disqualifying condition. So long as these defects can be corrected by suitable glasses they do not exclude from admission. The practice is that if the candidates for commissions can count the test-dots at the ordinary distances, with or without the aid of glasses, they are accepted for service so far as vision is concerned.

29. *Visual Acuteness required in Candidates for Army Medical Commissions.*—The rule just mentioned applies to medical officers of the army equally with combatant officers.

30. *Visual Acuteness required in Candidates for Commissions in the Royal Artillery and Royal Engineers.*—Candidates for admission into the Royal Military Academy at Woolwich fall under a special regulation. Since March 1871, by order of H.R.H. the Field Marshal Commanding in Chief, these gentlemen have been required to possess a range of vision which will enable them to see clearly the 2′ square bull's eye at 900 yards. In order to decide that a candidate for admission into the Artillery or Engineers possesses this required qualification the examining medical officer will have to ascertain that he can count the re-

gulation test-dots at a distance of 22½ feet instead of the distance of 15 feet named in the instructions on the back of the card. The permission to wear spectacles is not included in the order.

31. *Visual Acuteness required in Candidates for Commissions in the Royal Navy.*—Candidates for commissions in the Royal Navy are not considered eligible who are subjects of any degrees of myopia or hypermetropia. They are required to see Snellen's test-types at the full distances. Exceptions are, however, made in some special cases under particular circumstances. This rule applies to candidates for the medical service of the Royal Navy equally with those for the combatant service.*

32. *Disease of some of the posterior Parts of the Eye.*—When the ocular examination of the recruit or soldier leads to a suspicion that he labours under impaired vision owing to deeply seated disease of the eye, there is only one way of determining the correctness or incorrectness of the suspicion, and that is by ophthalmoscopic examination. It is the object of the second part of this work to indicate the method of employing the ophthalmoscope for establishing a correct diagnosis of the state of the posterior parts of the eye.

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* It may be useful to quote the regulations regarding the acuteness of vision required in naval cadets in Germany, for they are remarkably precise and clear. The Imperial Admiralty Orders (26th June 1872) are to the following effect:—

1. The acuteness of vision is to be tested by Snellen's test-types. When the types can be read at the denominated distances it is to be considered normal, or = 1. The certificate must state clearly the result of this examination.
2. If the acuteness of vision be not normal, the surgeon must determine by ophthalmoscopic examination whether there is any organic disease of the inner parts of the eye. If there be, the candidate is to be considered unfit.
3. In the absence of organic disease of the eye, the following limits are to be adhered to:—
   (*a*.) Candidates who recognise Snellen's types at $\frac{3}{4}$ of the denominated distance, *i.e.*, whose visual acuteness is = $\frac{3}{4}$, are to be considered fit for the naval service.
   (*b*.) Candidates who recognise the types at distances between $\frac{3}{4}$ and $\frac{1}{2}$ of the normal distance, can be admitted, provided it is proved, by the application of spectacles, that their diminished visual power is perfectly corrected by their help.
   (*c*.) Candidates whose visual power is only $\frac{1}{2}$ or less, are to be considered unfit for the naval service.

33. *Impaired Vision, or Blindness, of one Eye in a Soldier.*— It has been mentioned with regard to a recruit that grave visual defect in either eye renders the man unfit to engage for service as a soldier. The rule is different with regard to men who are already serving in the ranks. Impaired visual power, or total loss of vision of one eye, if the other eye be efficient, is not held to be a cause of unfitness for further military service. This rule is laid down in War Office Circular, No. 874, of the 17th August 1864, in the following terms: "No soldier shall be discharged for the loss of "one eye only, whether it be the right or the left; but if a soldier "shall have lost one eye by a wound in action, or by the effects "of service, and shall receive other wounds or injuries in action, "or be otherwise so disabled, as to render his discharge necessary, "the loss of an eye shall be taken into consideration in fixing "the pension at such a rate as his combined wounds or disabilities "may entitle him to receive."

34. *Aiming with the left Eye.*—If a soldier after enlistment is found to have a defect of vision of the right eye, which has not been previously detected, and it is found to incapacitate him for using his rifle from his right shoulder, or if the right eye of a soldier becomes disabled by disease or injury, he is permitted by the musketry regulations under certain rules to fire from the left shoulder — thus using his left eye for sighting the objects aimed at.

This permission is never granted excepting under certificate from a medical officer that the soldier is labouring under defective vision of the right eye. The permission does not extend to what used to be called the platoon exercises. Now that skirmishing and independent firing are so much more employed than firing in close order, it is of less consequence that a man's mode of firing differs in the respect named from that of the other men of his company.

35. *Assumed Blindness of one Eye.*—Blindness of the right eye is not unfrequently simulated in foreign armies to escape conscription, but English soldiers very rarely make pretence of blindness of one eye, because it is well known among them that loss of sight of one eye does not incapacitate for further military service. Should, however, blindness of one eye be alleged to exist, and no objective signs to warrant the assertion be obvious,

so that a suspicion of simulation be excited, there are various tests which may be resorted to for determining whether the suspicion is well grounded or not.

In the first place, in complete blindness of one eye, the pupil is partially dilated owing to the absence of reflex stimulus from the insensible retina. If then, on trial, the iris is found not to contract when the retina of the alleged blind eye is subjected to the sudden admission of strong light, but is found to contract when the retina of the other eye is similarly exposed, it is evident that the alleged existence of blindness is real; on the other hand, if the iris of the alleged blind eye does contract when its retina is exposed to sudden light, at the same time that the other eye is kept closed, there cannot be complete amaurosis. If the iris of the alleged blind eye does not answer to the stimulus of light, either when its own retina or that of the other eye is excited, then the alleged blindness may or may not exist, but there must be paralysis of the iris either from natural causes or artificially induced.

But the most effective means for unmasking an attempt at deception of this sort is Gräefe's prism test. If a prism of 12° or so be held with its base upwards or downwards before the eye in which visual power is acknowledged to be retained, and the person who is subjected to the test on being asked what effect it has on his sight, states that it causes double vision, the simulation is proved, for diplopia could only result by both eyes seeing. Again, if the base of the prism be turned horizontally inwards, and the eyes then squint, it is proved that an effort is being made to prevent double vision, and that, therefore, the assertion of blindness of one eye is untrue. By getting the person to describe first one of the two images and then the other, and by varying the sizes of the objects presented, the surgeon may even arrive at a conclusion as to whether any amblyopia exists or not in the alleged blind eye, and, if it does exist, even its degree.

*Case.*—The following case selected from the records at Netley will serve to illustrate the application of this test. Private T. F. 84th regiment, was invalided in 1866 from Malta, and admitted at Netley, under Amaurosis. His condition at Netley he stated to be: right eye quite blind, no perception of light; left eye, reads No. 4 Snellen at 3″, counts fingers at 3′. No ocular abnormality was visible by ordinary or under ophthalmoscopic examination. The left eye was kept bandaged for a couple of days, on the plea of resting the eye, but really to observe whether he could guide his movements by the right (alleged totally blind) eye. While thus bandaged he was reported to have been seen reading, or apparently reading a book. I then tried the prism test, and the man described two images of a single object held at a distance of about 4′ from him together with the movement of one round the other as the prism was made to revolve before his left (acknowledged seeing) eye. The imposture being thus proved, the man was discharged to duty at his depôt.

The stereoscope has been suggested by Mr. Lawrence for detecting simulated blindness of one eye, and is still more puzzling to one who is not acquainted with its effects. One case has been related to me in which imposture by a foreign officer who simulated blindness of one eye was fully detected by its means, where the use of a prism, owing to the intelligence of the person examined and his knowledge of the effects of prisms, had failed. Indeed it is hardly possible for a person who is not blind on one side to answer the steroscopic tests as if one eye were blind, provided the experiment is fairly performed. But the surgeon must be on his guard that the person under examination does not close the eye which is alleged to be blind while the objects placed in the stereoscope are exposed to his view. The stereoscopic objects have to be specially prepared. Series of lines, differing in colour, red and blue for example, so arranged that in the combined image they cross each other, have been suggested by Helmholtz for the purpose. When both eyes are sensible to light, the red and blue lines are seen constantly changing places with each other, and it is not possible to say by which eye either coloured lines are seen. A person blind of one eye will see the lines of one colour only. Two printed paragraphs, equal in size and similar in character, but differing in parts of the text, may be placed on the stereoscopic slide. A person regarding the slide with both eyes through the stereoscope will not be able to read the portions where the texts differ, for the print of one side will be mixed up with the print of the other in constant interchange so as to make reading impracticable. A person who does not see with one of his eyes will read easily the print presented to the seeing eye. Figures in endless varieties of shapes and colours may be employed in a similar manner; so that no simulator who is capable of seeing the objects presented to him on the stereoscopic slides with both his eyes when describing what he sees, can help including those parts which could only be visible to him through the agency of his pretended blind eye.

36. *Assumed extreme defective Vison of both Eyes.*—Supposing a

soldier maintains that he cannot see clearly the bull's-eye at any range, or only within a very limited range; that no description of lens improves his vision; while no cause for the alleged disability can be discovered, but, on the contrary, both eyes appear to be of normal visual power, can it be proved that he really does see clearly enough for duty? To a certain extent the surgeon must be guided in such a case by circumstantial evidence and observation. A cross-examination, instituted with ordinary judgment, will usually expose the attempt at fraud. But in such cases the lenses can generally be turned to important use; with the convex spectacles before his eyes, a trickster will almost certainly become confused, and will either see types or dots at distances which show that his vision is normal for distant objects, or he will overstate his case by giving only negative replies, saying that he cannot see at all or scarcely at all at any distance. When this last-named position is maintained by a simulator, the surgeon can only hope to expose the deception by contriving to obtain positive evidence showing that the man's statements are untrue. This plan was adopted in the following case:

*Case.*—Private G. Mc. A. æt. 19, was sent after enlistment to the depôt at Parkhurst. Subsequently to his arrival there he declared his sight to be extremely defective, and he was reported to be unable to learn his drill on this account. He was then examined by a medical board at Portsmouth. The board not finding anything to explain the alleged condition sent him back to Parkhurst. The surgeon in charge again after some time reported his inability to serve as a soldier on account of defective sight, and he was ordered to Netley for observations. At Netley according to statement 100 Snellen could not be seen beyond 2½′; fingers could not be counted farther off than 1′ and hardly at that distance. Nothing abnormal could be detected in either eye by ophthalmoscopic or ordinary examination. When tried with lenses all replies were negative; he persisted in saying that he could see nothing through them at any distance. The extreme degree of amblyopia complained of was inconsistent with many of the man's observed actions, but it was difficult to get a positive proof sufficient to convince others of the deception and a trap was therefore laid for him. While walking he was suddenly told by a sergeant in the presence of a witness to pick up a pin which had been purposely placed a little way off on the floor before him. The man being taken unawares at once stooped and picked it up. He was sent back to the depôt and made no further complaint of weak sight.

If the man admits that he sees at any particular distance, the surgeon can notice whether, after varied changes, he always returns to the same distance as affording clear vision. Should he be sharp enough to do so, the surgeon notes the distance at which the objects are seen with the spectacles, and ascertains whether proportionate distance is preserved when lenses of different powers are used, or when objects of the necessary size are exposed to his view without the spectacles.

If the man admits that he is able to read, the distance at which a given type is read may be noted, and observation made whether he reads the larger types at proportionate distances. If he should state he is not able to do so, and he still maintains that neither concave nor convex glasses make distant objects clearer, and there is no evidence of the presence of astigmatism, he must be trying to deceive. Where there is a command of lenses of many varieties of focal range, the demonstration that he is trying to deceive is comparatively easy.

I would not, however, wish it to be inferred from the above remarks, that I believe attempts at fraud, in respect to defective vision, are frequently to be met with among soldiers in the ranks. On the contrary, my experience leads me to believe that in the greater number of instances which have been suspected to be instances of deception, real disabilities have existed, though their true natures have not been ascertained. Suspicion has been excited in these cases, because the determination of the existence of the particular defective conditions of sight under which the soldiers were labouring was not included in the surgeon's range of diagnosis.

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# SECOND PART.

## OPHTHALMOSCOPIC EXAMINATION OF THE EYE.

### CHAPTER I.

Description of the Ophthalmoscope in the Army Case.—Care required for keeping it in serviceable Order.—Objects effected by the Ophthalmoscope.—Why Points in the Fundus of the Eye cannot be seen without its Aid.—Arrangements of the Ophthalmoscopic Room.—Exclusion of Sunlight.—Artificial Light.—Position of the Patient.—Position of the Surgeon.—Mode of acquiring the Use of the Instrument.—Examination by the Direct Method.—Examination by the Indirect Method.—Appreciation of these Methods.—Mode of bringing the several Objects of the Fundus into View.—Obstructions from Spectra in the Object Lens or Cornea.—Artificial Mydriasis.—Different effects of Atropine according to Strength.—The System to be pursued in Ophthalmoscopic Examinations.

IN the first chapter of the first part I gave a brief description of the convex lenses supplied for the *optical* examination of the eye, in the combined optical and *ophthalmoscopic* case supplied to Army Medical Officers. I have now to describe the instruments contained in this case for the *ophthalmoscopic* examination of the eye. I will not attempt to describe the several varieties of ophthalmoscopes which have been devised since the discovery of Helmholtz first made it possible to bring into view the several structures which appear upon the fundus of the eye, although some of them have special advantages, but will simply point out the objects of the several parts of the instrument supplied for general use in the military case, and the manner of employing them.

This instrument is known as Liebreich's ophthalmoscope from the name of its designer, and consists of the following parts:—a speculum, fitted with a moveable clip for holding ocular lenses; 5 ocular lenses; and 2 object lenses.

The speculum is a small concave mirror of about eight inches' focal distance. It is made of bronze metal, the surface of the mirror being coated with polished silver. In the centre of the mirror is a small opening about $\frac{1}{10}''$ in diameter, which expands into a funnel-shaped depression at the back of the speculum. By this means the margin of the opening is reduced to the narrowest dimension. This opening is the sight-hole. Attached to one side of the speculum by a double hinge is the ocular clip, so arranged that when one of the ocular lenses is placed in it, the lens can be laid directly upon the back of the sight-hole, their centres being in concert, or it can be removed on one side out of the line of vision at will. The whole is supported on a handle three inches in length.

The lightness and handiness of this form of speculum makes it very convenient for the operator's use. Some mirrors are made of silvered glass, but they are too fragile for military service, and if pierced by a central opening, the opening is usually left too large, and the thickness requisite to give the glass strength necessitates it being so deep that the examiner's view is disturbed by the light reflected from its sides. If there be no opening, but merely a circular space left unsilvered, then the clearness of the view is lessened by looking through the glass medium. It is very important that the sight-hole should be thin at its margin, and as small as is consistent with vision through it; for the thinner the edge the less interference there will be with the rays coming from the object under observation, and the smaller the diameter, the less break there will be in the central illumination thrown upon the object. The only precaution to be taken with the speculum is, not to polish it with materials calculated to scratch its silvered surface, and to take care, after using it, to replace it in its case, so that it may be kept dry and oxidization be prevented. Only ordinary care is necessary for keeping it always in a serviceable state.

There are four concave and one convex ocular lenses in the case; their focal distances are marked upon them. They can each readily be fixed in the clip, and are chiefly intended to correct defects in the visual power of the observer. The two object lenses are double-convex lenses of $1\frac{3}{4}''$ and $2''$ focal distance; they are employed to modify the direction of the rays coming from the objects under examination in the observed eye.

The following five objects are effected by the use of the ophthalmoscope:

1. A large amount of light is concentrated upon the fundus of the observed eye.

2. The observer's eye is shaded from the direct light of the flame or source of illumination.

3. The observer's head is so placed as not to intercept the light in its passage to the eye under examination.

4. The observer's eye is in the line of reflected light issuing from the eye under examination.

5. The rays which escape from the observed eye are modified in their direction, so as to be brought to a focus upon the observer's retina, by suitable lenses.

It is because these several objects cannot be attained without the aid of such an instrument, that the back part of a healthy eye is always in shade, and the pupil always appears black to an ordinary observer: just as the entrance to a cave, which may be light enough to those inside, appears black to one looking at it from a distance standing in the broad glare of sunlight. To understand this, one has only to consider the smallness of the pupil compared with the size of the inner chamber of the eye and the moderate amount of light which can, therefore, pass into it naturally, together with the provision made against reflection of this light by the darkened choroid; secondly, the impossibility of looking into a person's eye closely without the head of the observer shutting off the greater part of even the amount of light just referred to; and thirdly, the difficulty which arises from the refracting properties of the eye and the consequent extreme nicety of focal adjustment which would be necessary for one eye to adjust upon its retina rays passing from the retina of another eye without artificial aid. Even when the interior of the eye is lighted by a flame immediately in front of it, as the rays received through the pupil, or those of them which are reflected from the fundus, follow the same path on returning through the media and on issuing from the eye as they pursued in entering and passing through it to the fundus, they will necessarily become concentrated at the point from which they started, so that only to an eye in the same position as the flame could the fundus of the eye appear to be illuminated; to all others it still appears dark. Practically, by using a mirror as a means of reflecting the rays from the flame, instead of sending them into the observed eye direct, the observer's eye at the sight-hole of the mirror is in the same position as the source of the light transmitted to the eye, and so the illuminated fundus is exposed to his view. From all these reasons, although a general luminous appearance under certain circumstances of the fundus of the eye had been previously noticed, no one had been able to see particular objects behind the pupil until the invention of the ophthalmoscope.

In commencing the use of the ophthalmoscope the surgeon must direct his attention to the room where it is to be employed, the source of illumination, and the mode of manipulating with the instrument, as well as to numerous other details to be noticed subsequently.

(1.) *The Room.*—Any ordinary room from which daylight can be excluded by shutters or thick curtains serves for ophthalmoscopic observation. The room should be darkened as completely as possible. It should not contain any bright reflecting objects. There should be only one flame or source of light. The purpose is that all reflected light may be prevented excepting that which is intentionally thrown into the fundus of the eye by means of the mirror. The room used at the Army Medical School has its ceiling and walls of a dull deep-black colour, all daylight is excluded, and hence, when the patient sits with his back to the flame, there are scarcely any reflected rays to fall upon him, the contrast between the darkened face and illuminated fundus is greater, and a less amount of illumination serves to bring distinctly into view the objects to which the observer is directing his attention.

A room so completely darkened, however, is not absolutely necessary. The fundus can be even lit up in ordinary daylight by concentrating the light of a lamp upon it, but the objects in it will be less clearly seen. They will make fainter images upon the retina of the observer in proportion as the daylight is brighter, on the same principle that, although the stars transmit the same amount of light to the eye by day as by night, they are not visible at the former time through the greater brightness of the diffused sunlight.

The only necessary furniture of the room is a small table on which the light is placed, with seats for the patient and surgeon.

(2.) *The Flame.*—Any moderately bright light that is not flickering will answer the purpose. The more colourless the flame the better. If a gas burner be not available an ordinary argand lamp will well supply its place. If a lamp be not at hand a wax candle will serve the purpose for one who is used to the ophthalmoscope, especially if the room be well darkened. When gas, or an oil lamp, is used, a glass chimney of a blue tint causes the light to be more neutral in colour. The light should have such a support as will serve to place it on a level with the patient's eye.

(3.) *The Ophthalmoscope.* In describing the manner of manipulating with the instrument it is requisite to note the position of the patient relatively to the ophthalmoscopist, and to explain several modes of examination to which the instrument may be applied. In the following remarks it is presumed that the examiner uses his right eye for observation of the examined eye.

(4.) *Position of the Patient.*—The patient should be in a sitting position, the light being behind and to the left side of his chair. His head should be erect, and, if possible, supported at its back to obviate fatigue, and secure steadiness when the eye is under observation. The chair should be so placed relatively to the light, that the light is on a level with the patient's eye, and a little to the left of it. The rays from the flame will then pass to the eye of the surgeon over the patient's left shoulder.

(5.) *Position of the Surgeon.*—He should sit on a stool opposite to the patient, his eye being on the same plane with the eye to be observed. The surgeon, while sitting, will be able to make longer and closer examination unfatigued than if he were standing. He will rise naturally and assume other positions in case he finds a difficulty in getting the patient to bring the different parts of the fundus into view according to oral directions.

(6.) *Illumination of each Eye.*—By the relative positions just named of the flame, the patient, and the surgeon, when the patient's left eye is examined, the surgeon can look through the sight hole without any slanting of the speculum, at the same time that he reflects the light fully upon its fundus. When the patient's right eye is to be examined, all the change that is necessary is to cause the patient to incline his face slightly towards the surgeon's right, so as to gain the necessary angle of reflection for concentrating the light upon its fundus.

(7.) *To acquire the use of the Ophthalmoscope.*—In commencing the use of the instrument, the best way is to practice at first with the speculum alone, until the power of concentrating luminous rays on any particular spot is acquired, and the eye is able at the same time to observe the illuminated spot in a direct line through the sight-hole with perfect ease. This can be acquired by employing any ordinary object, as a button or a coin, placed in front of the observer for the practice. The handle of the ophthalmoscope being held in the right hand, the back of the mirror should be applied close to the surgeon's eye, the edge resting against the concave inner and upper margin of the orbit so as to keep the instrument steady. The beginner will not fail to notice how slight a turn of the mirror is sufficient to cause a considerable movement of the reflection of the flame, and after a few trials will ascertain the particular inclination which must be given to it in order to secure an illumination of the object he is practising upon. A full and unwavering illumination of the object should be attained. It is necessary next to exercise oneself in working the speculum and object lens together, the observer's head being moved with the speculum backwards and forwards in the line of the optic axis until a clear image is obtained. The object lens should be held between the thumb and forefinger of the left hand, in front of the object, and at the length of its focal distance from it. In applying the object lens before a patient's eye, the tip of the middle finger may rest lightly on the eye-brow: this *point d'appui* gives steadiness, and enables the requisite but limited movements for the adjustment of the object lens to be made with more freedom and precision.

Some ophthalmoscopes are arranged to be fixed to the side of the table, with the object lens and speculum connected in such a way that the distance between them can be varied according to circumstances, at the same time that the necessary relations in respect to direction are mutually preserved. Although, however, there is at first a certain amount of difficulty in manipulating with the speculum and object lens detached, as they are from each other in Lubreich's small ophthalmoscope, necessitating as it does separate but concerted adjustment of the several parts, yet when the difficulty is overcome, the advantages of the freedom of operating, and the complete power of controlling the movements of the instrument afforded by this method, more than compensate for the labour expended in its acquisition.

*Modes of Examination.*—There are two modes of examining the eye by the ophthalmoscope. They are named the *direct* method, and the *indirect*.

**The Direct Method,** or mode for observing the erect image. In this method the speculum is used alone, and an illuminated object in the fundus of the observed eye is imaged directly upon the retina of the observer. The accommodatory power of the patient's eye should be paralysed by atropine, and the surgeon's eye brought very close, from one to two inches, to the patient's eye, so that it may receive the rays as they emerge nearly parallel from the illuminated fundus. If the eye under observation be myopic, the reflected rays will emerge convergently, and will have to be made divergent or parallel by means of one of the concave ocular lenses fixed in the clip. The same rule applies if the examiner cannot help adjusting his accommodation for divergent rays, as habitually happens when near objects are looked at, or happens to be himself myopic. By this direct method the image is inverted on the retina of the examiner, but is seen as an enlarged image of the object in its erect and real direction, projecting apparently beyond the patient's eye. This method is ordinarily applied to the examination of particular points in the fundus of the eye, only a small portion of which can be seen at one and the same time. The direct method of ophthalmoscopic examination is a more difficult proceeding than the indirect method next described, although only the speculum has to be employed in it, and it requires greater practice in order to carry it out efficiently.

**Indirect Method.**—Here the illuminated eye is looked at with one of the biconvex object lenses interposed between it and the speculum. The object lens should be held at such a distance from the patient's eye that the rays reflected from the mirror upon it after transmission should find their focus at the pupil of the eye. The distance will be nearly that of the principal focus of the lens. The effect of this method of examination is to increase the convergence of the rays going to illuminate the fundus of the eye, and also to cause the reflected rays returning from the fundus to converge to a focus between the lens and the mirror, and there to form an image which is seen by the examiner looking through the sight-hole. The image depicted on the observer's retina is in its real direction, but is mentally seen as an inverted image before the eye. It appears also enlarged, but not so much so as in the direct method, so that the whole of the fundus of the eye can be very distinctly observed. The image is strongly illuminated in consequence of all the luminous rays reflected from the fundus of the eye being concentrated upon it by the action of the convergent lens.

*Comparison of the two Methods.*—Of these two modes, the indirect method of examination is that which is ordinarily employed. It naturally occurs as the first proceeding in the examination of an eye. The general view which is gained at one and the same time of a large part of the fundus, so that the parts can be studied in their several relations to each other, and the rapidity with which observations can be made, owing to the clearness and brightness of the images formed by its means, are exceedingly useful in practice. Occasionally it is necessary to examine some limited point of the fundus more closely, and then the direct method for obtaining the direct image is resorted to with advantage owing to the comparatively large size under which it is presented to the observer.

*Ophthalmoscopic Examination of the Dioptric Media by transmitted light.*—When the interior of the eye of a patient is lit up by the light of the flame reflected from the speculum held at a distance of 18 inches, if any portion of the rays so reflected are interrupted in their passage owing to opacities on or in any of the transparent media, these opacities are made particularly obvious in the highly illumined state of the media, and appear as dark objects to the observer. Very slight sources of opacity in any of the transparent media from the cornea to the vitreous humour can be detected in this way. The effect of this direct transmission of the rays differs from the effect of oblique transmission or lateral illumination. By lateral illumination the sources of opacity are seen by reflexion, and the colours as well as their forms are rendered apparent to the depth of the anterior half of the globe of the eye; by the transmitted light the colours of the objects are not shown, but their outlines are strongly marked and they are visible to the full depth of the transparent media. The manipulation of the ophthalmoscope resembles the *direct method* of using the instrument in so far as the mirror is employed without the object lens; but differs from it in regard to the distance at which the mirror is held for the purpose of the examination. The ophthalmoscope is used in the same way as it is for the ophthalmoscopic diagnosis between myopia and hypermetropia.

*To bring different Parts of the Fundus into view.*—When a clear view of the *optic entrance*, and vessels of the fundus (not merely of the generally illumined fundus), has once been attained, it will be necessary to acquire the faculty of bringing each particular object of the fundus under observation at will. The optic nerve enters the eye through the sclerotic and choroid about $\frac{1}{10}$th of an inch to the inner, or nasal side of the axis of the eye. A ready means of bringing the *optic entrance* into view, if it be that in the right eye, is to desire the patient to fix his sight upon the top of the observer's right ear: if it be that in the patient's left eye, to look at the same part of the surgeon's left ear. If the patient carries out this direction, the optic papilla will be brought opposite to the observer's eye. But, from various causes, patients not unfrequently cannot obey these directions, and the optic nerve can then frequently be arrived at by tracing up the retinal vessels to their origin, and by directing the patient as to the way he is to move his eye in order to assist the observer in attaining his object. To bring the *macula lutea* into view, the patient is desired to look straight at the sight-hole of the mirror; or, if the patient has not the required power of sight, its situation can be found by the peculiar arching of the retinal vessels above and below it. It must not be forgotten when seeking to bring into view any particular portion of the periphery of the fundus, that all the parts of the fundus are seen inverted in position by the indirect method of examination, and the movements of the eye must be directed accordingly.

In practising with the ophthalmoscope, the positions described should be constantly preserved, and the operator should accustom himself to using the same glasses. By these means differences in size and in the shading of objects will be better appreciated.

*Ocular Reflexions of the Speculum.*—Small images of the speculum are in certain relative positions formed upon the object lens, and frequently give rise to annoyance when they appear near the axis of vision. In like manner the cornea sometimes becomes the seat of images produced from pencils of luminous rays proceeding from the surface of the object lens. The nature of these spectra is readily perceived, and the interruption they cause can be got rid of by a little adroit inclination of the object lens to the right or left, or by turning it slightly on its horizontal axis, without disturbing the picture of the fundus. It is well to make a special practice of throwing aside these specular reflexions in order to acquire the requisite dexterity for removing them readily and quickly from the line of vision.

*Artificial Mydriasis, or Dilatation of the Pupil.*—If the iris is not paralyzed by disease, it is well, especially for surgeons not habituated to the use of the ophthalmoscope, to dilate it artifically when it is desired to make a complete examination of the eye. The pupil will otherwise contract to its utmost under the stimulus of the concentrated light, and a small pupil interferes with observation in two ways; 1st, by limiting the amount of light that can enter the eye; and 2nd, by limiting the field of view of the observer. Mydriasis is effected readily and speedily by a solution of atropine. Surgeons, however, who are in the habit of using the ophthalmoscope will only require to produce artificial mydriasis in particular cases; in a majority of the cases submitted to examination the ophthalmoscopist, by taking advantage of the expansion of the pupil when the light is thrown on the optic disc, and by acquired adroitness, will be able to diagnose sufficiently the condition of the fundus without subjecting the patient to the inconvenient interference with his power of accommodation which results from the use of this neurotic.

*Employment of Atropine.*—Atropine is employed with two objects in view in examinations of the eye. One is simply to dilate the pupil, for the reasons explained above; the other is to paralyze completely all accommodatory power in cases where it is desired to ascertain the exact refractive power of the eye, independent of the variable adjusting qualities from ciliary exertion. For the first purpose two or three drops of a very weak solution of atropine are sufficient (one or two grains to the ounce of distilled water); but, for the second purpose, at least four grains to the ounce are necessary, and then its influence must be allowed to exert itself for some time in order that the paralysis may be complete.

I have for some time past used the following ointment for producing artificial mydriasis as a preparatory measure to ophthalmo scopic examination and have found it more convenient than atropia in solution: atropia 2 grs., glycerine 30 min., atropia ointment 190 grs.; mixed thoroughly together. A small quantity is well rubbed into the skin of the eyebrow, particularly over the site of the supraorbital nerve. If this be done at bedtime, the pupil will be sufficiently dilated in the morning for the examination.

This plan is not attended with any difficulty or uneasiness to the patient. Considerable smarting of eyes constantly occurs when the atropine solution is dropped into them, and owing to epiphora, and rapid removal of the solution, there is often a good deal of delay before the desired effect is obtained. Similar irritation not unfrequently attends the use of atropinized paper or gelatine discs when they are placed under the eyelid for the same purpose. Moreover, occasionally rather serious results follow the use of the solution, when it is strong and repeated several times, especially if the atropinized tears flowing over the face get into the mouth of the patient. A very minute quantity of atropine reaching the mouth suffices to induce symptoms of atropine poisoning in some patients. The ointment does not give rise to any of these ill effects as far as I have seen, and is equally effective with the atropine in solution.

**Systematic Examination of the Eye in all Cases.**—Much loss of time may be avoided, and a more satisfactory result arrived at, by adopting a regular system, in ocular examinations. Supposing a case of disordered vision, presumed to be connected with deep-seated disease, to be brought for investigation, the following should be the successive steps taken for its elucidation:—

1st. As clear and connected a history of the defect or disease should be obtained as possible.

2nd. The optical examination should be made to ascertain the acuteness and quality of vision.

3rd. The field of vision should be observed and determined.

4th. The ophthalmoscopic examination should be made step by step; and for that purpose, the state of the cornea, pupil, and crystalline lens should be first examined with lateral illumination by the + 2″ lens.

5th. The same structures, together with the vitreous humour, should next be examined by the direct transmission of light reflected from the speculum.

6th. The fundus should be examined by the indirect method. In examining the fundus, the optic entrance should always be first sought for; and, starting from it, the *macula lutea* and all other parts of the fundus should be successively explored. If both eyes have been prepared for examination, it saves time to make the examination by lateral illumination, and by the direct method, of each eye successively, before proceeding to examine and compare the background.

7th. Lastly, if special parts of the fundus require to be particularly observed, the examination should be made by the direct method.

**Mode of examining and determining the Field of Vision.**—Observation of the field of vision is frequently necessary for arriving at a correct diagnosis of the extent of visual derangement, as well as for marking the progress or recedence of diseased action. The extent and shape of the field of vision are obtained by causing the patient to look at a given point, and, while the eye is fixed upon it, drawing an outline of the boundary of distinct vision in all directions around it. The most convenient plan is to place the patient with one eye closed at a distance of about two feet in front of a black board, on which, at a level with the eye under examination, a small cross in white chalk has been drawn. The patient is desired to fix his eye on this cross. At the same time the surgeon, who must watch that the patient does not take his eye off the cross, holds the piece of chalk between the fingers of his right hand, and carries it from point to point over the board by slight quick movements of the hand, jotting down the points in various directions where it ceases to be seen. These points are now joined together by lines, and thus an outline of the shape of the field of vision is formed. If the map thus made be copied on paper, it can be retained for comparison with other diagrams to be made in a similar way on future occasions.

If it be important to ascertain the field of vision with great precision, separate outlines can be obtained by a similar plan showing where vision sufficiently distinct to count fingers ceases, and more externally where imperfect vision ceases and complete absence of sight begins. Remarkable irregularities of form, and limitations in extent, of the field of vision will occasionally be made manifest by this mode of examination in cases of *amblyopia* depending on certain diseases of the optic nerve and retina.

When it is not required to make a picture of the field of vision but only to ascertain quickly the extent of the field, or whether there is any break in it in any given direction, the following method will answer the purpose readily and quickly. The surgeon, standing face to face with the patient, desires him to close one eye, the right, for example, and at the same time closes his own left eye opposite to it. He now desires the patient to look steadily into his right eye, and while the two eyes, the one of the surgeon and the other of the patient, are thus directed to each other, the surgeon moves his forefinger around the field of vision. He is thus able to note the extent of the patient's range of vision, by comparing it with his own range. This ready method has the advantage of being capable of being put into execution anywhere without need of any appliances or previous preparation.

*Records in the Ophthalmoscopic Room.*—A slate for the purpose of pencilling down sketches, and noting brief memoranda of the observations made while using the ophthalmoscope (which should always be recorded at the time of examination), is an useful appendage to every ophthalmoscopic room.

## CHAPTER II.

Ophthalmoscopic Appearances of the Eye in its Normal State.—General Effect of Illuminating the Retinal Interior of the Eye.—The Colour of the Fundus.—Various Appearances of the Optic Disc.—The Colliculus.—The Retinal Vessels.—Lamina Cribrosa.—The Retina.—Position and Appearance of the Macula Lutea.—Various Conditions of the Choroid Tunic, and their Effects upon the Appearances presented by the Fundus.—The Refractive Media.

The following are the appearances presented by the interior of the globe of the eye in its normal state when examined by the ophthalmoscope.

The view which is first obtained when the interior of the globe of the eye is illuminated by the speculum is simply the appearance of a bright pink light through the pupil instead of the usual black colour. On looking attentively, the examiner sees that he is looking into a cavity, but nothing more than this coloured brightness is observable. The only reason why no distinct objects are seen, is that none of them have yet been brought to the proper focus so as to form images on the retina of the observer.

But when the proper focus has been found, by the means described in the previous chapter, the pink haze resolves itself into a definite back ground, on which red lines are observed branching,—the blood-vessels,—and a conspicuous circular spot, at first appearing almost wholly white by contrast with the surrounding redness, is noticed,—the *optic papilla.* On closer observation, the several parts assume more definite characters, but some of these are found to vary in different individuals. It is, therefore, useful to study the appearances presented by each structure separately, so that their abnormal conditions may afterwards be more easily appreciated.

In the following description, the ophthalmoscopist is supposed to be making his observations by the indirect method.

**The Fundus,** by which term is implied the whole of the interior of the retinal sphere which can be brought into view through the pupil, is generally of a pink or orange tint, the colour chiefly depending on the reflected rays from the blood-vessels of the choroid which are seen through the transparent retina. The depth of colour of the fundus varies in men of different shades of complexion. In the negro the illumination of the fundus is scarcely visible, so comparatively few rays are reflected back to the observer; in the albino it is dazzling bright and very pink, for nearly all the incident light is thrown back into the observer's eye. This depends upon the amount and disposition of the epithelial pigment.

**Optic Disc, or Papilla.**—The termination of the optic nerve, or the spot at which it expands into the retina, is usually of a light pink tint, but sometimes appears as if a light grey were mixed with the rose colour; and this light tint, and its defined outline, distinguish it at once from the rest of the fundus whatever the degree of colour may be. The lightness of the tint of the optic disc is the more marked in proportion as the depth of hue of the rest of the fundus is greater: this is due to simple contrast of colour. It is nearly circular in form: occasionally elliptical, and is then generally longer in the vertical than in the horizontal diameter: more rarely the horizontal axis appears to be the longer. The centre of the optic disc which appears bright and white is slightly depressed, the so-called physiological pit. This depression is now and then excentric, but never reaches the margin of the disc. The pit is bounded by what appears as a somewhat elevated rounded zone. This zone is called the *colliculus.* It has the appearance of a shaded ring, and is often more shaded on one side than on the opposite side. The deeper shading may depend on the thickness of the retinal fibres, or on some effect of the light thrown upon its rounded surface. Immediately outside the *colliculus* is the light pink or pinkish grey limit of the optic disc, This is bounded by a fine whitish ring indicating the *scleral aperture* or inner sheath of the optic nerve joining the sclerotic tunic. Outside this again there is sometimes a complete linear circle, sometimes a narrow crescent on side, of a dark colour, pointing out the choroidal limit. When a complete ring is visible, the appearance is due to encroachment of the choroid upon the sclerotic aperture; when crescentic, it is owing to the peculiar direction in which the optic nerve enters, passing more obliquely than usual, so as to leave a slight edge of the choroidal opening exposed to view. The apparent size of the optic disc varies according to the refractive qualities of the eye under observation, as well as on the differences of the lenses through which it is observed. The central artery of the retina is seen to issue from within the disc and to divide into branches which appear to pass over its surface; the darker branches of the retinal veins are likewise seen to cross over its border and passing on become lost in its substance. The observer must be prepared to meet with many varieties in shade of colour, outline, and appearance of the optic disc even in normal eyes.

**Central Artery of the Retina.**—This vessel may be usually observed to issue from the depression in the centre of the optic disc. It is not always, however, central in reference to the optic disc, but occasionally may be seen emerging at various distances between its centre and circumference. When the physiological pit of the optic papilla is excentric, the artery usually issues excentrically also. It often remains single for some little distance, and then divides into an upward and downward branch or branches. The division sometimes occurs more deeply, and then the branches appear on the disc independently of each other. These branches as they proceed may be noticed invariably to divide dichotomously, ramifying in all directions, and tapering in size as they approach towards the periphery of the retina. They arch around and never cross the situation of the macula lutea.

**Venous Circulation of the Retina.**—The two principal venous branches usually join to form the central vein of the retina deeper in the optic nerve than the division of the artery. They are therefore usually seen still separate as they disappear from view at the disc. The venous ramifications correspond in their directions with those of the arteries; they are, however, readily distinguished from each other. The arteries may be known from the veins by their smaller calibre, lighter colour, sharper outline, usually straighter direction, and more marked evidence of their tubular formation. The thinner coats of the veins cause their contents to be more readily seen, and hence their darker and more red appearance. They are not seen with the same distinctness in all directions even when allowance is made for difference of size; because, in some parts they are lying immediately beneath the *membrana limitans*, while in others they are covered in addition by the expansion of the optic nerve and are lying in the layer of the retina beneath. This becomes more noticeable when the transparency of the retina is lessened by any cause.

**Lamina Cribrosa.**—The white central physiological depression already described in the optic papilla is sometimes seen under a sufficient magnifying power to be studded with minute grey spots. These are the openings of the *lamina cribrosa*. The obliquity with which the nerve fibres enter the fundus to expand into the retina, assists in causing the lamina cribrosa to become more or less visible.

**Retina.**—The retina is usually so transparent as not to be itself visible: it is recognized by means of the vessels which ramify in its texture. When the choroidal pigment is very abundant, and the fundus, therefore, deeply tinged, the retina may be sometimes noticed by its reflecting the light in such a manner as to give the resemblance of a faint bluish haze over parts of its surface. The retina is more transparent towards its periphery, because the fibrous lamina is less thick as it retires further from the optic disc.

**Macula Lutea.**—This part of the fundus is not easily discernible until after some practice with the ophthalmoscope. But its position may be readily found from being in the direct axis of the eye. It appears as a nearly round spot of a darker shade of colour than the rest of the fundus. The appearance of a yellow halo, *limbus luteus*, such as is described in cadaveric examinations of the eye, does not present itself under ophthalmoscopic illumination. Branches of the retinal artery of second size arch above and below, but do not cross it, and its immediate neighbourhood usually appears free from even the smallest vessels. In the centre of the *macula lutea* is a minute white spot, sometimes appearing like a very small white ring with a dark point in its centre. This is the *fovea centralis*, formerly wrongly designated the *foramen centrale*. The shade of the *macula lutea* is darkest immediately around the *fovea centralis*.

**Choroid Tunic.**—The choroid is recognized chiefly by its vessels and pigmentation. The choroidal vessels, though larger than the retinal vessels, are not ordinarily seen. They are more or less visible according to the varying amount of pigment in the epithelial stratum, intervening between them and the retina. Sometimes the interspaces of the choroidal vessels, from the stroma of the vascular layers containing abundant pigment, show themselves through the retina like dark patches and stripes, the vessels appearing among them like a bright red net-work. The fundus has then a general appearance of being streaked like the skin of a tiger. In light-complexioned persons, in whom a comparatively small amount of pigmentation exists both in the pigmentary epithelial layer, and in the cells of the stroma of the vascular layers, the finest ramifications of the choroidal vessels are sometimes traceable by the ophthalmoscope. The less pigment there is in the choroid, the more reflection there is from the sclerotic coat, and the lighter is the pink or orange colour which the fundus assumes. Thus the colour and appearance of the fundus, as before mentioned, is constantly diversified by differences in the amount of pigment in the epithelial layer, and in the stroma of the vascular layers of the choroid.

**Humours of the Eye.**—These, in the normal eye, are not seen, or, in other words, are perfectly transparent when the eye is examined ophthalmoscopically.

## CHAPTER III.

Ophthalmoscopic Appearances, and Diagnostic Signs of Morbid Conditions of the Structures within the Ocular Cavity.*—Importance of Accuracy of Diagnosis in the Military Service.—Ophthalmoscopic Diagnosis of the Myopic and Hypermetropic Anomalies of Refractive Power, and of Astigmatism.—Lesions of the Optic Nerve and Retina.—Anæmia.—Atrophy. — Depression or Cupping. — Hyperæmia.—Optic Neuritis.—Retinitis. — Retinal Hæmorrhage. — Detachment of Retina. — Retinitis Syphilitica.—Retinitis Albuminuriensis.—Retinitis Pigmentosa.—Lesions of the Choroid. — Hyperæmia. — Choroiditis Disseminata. — Retino-Choroiditis. — Choroido-Retinitis Pigmentosa.—Posterior Staphyloma.—Morbid Changes in the Dioptric Media. — Cysticerci in the Ocular Cavity.—Impaired Vision from Wounds near the Orbit without direct Injury to the Eye.

It will be convenient, in recording succinctly the diagnostic marks of the several diseases which are capable of being recognized by the ophthalmoscope, to follow the order which was adopted in the preceding chapter for describing the normal appearances of the several structures visible in the interior of the globe of the eye.

The term "amaurosis," which never, indeed, conveyed much definite information, is scarcely any longer admissible in scientific records. Under any circumstances it should only be applied to those diseased conditions in which vision has been lost owing to morbid changes in the nervous apparatus of the eye, as explained under "amblyopia."

The study of ophthalmoscopic *diagnosis* is especially of importance to military medical officers. It is not often that the medical officer is called upon to subject to prolonged treatment patients labouring under impaired vision depending upon deep-seated lesions, when the disease has become so advanced as to render the diagnostic marks plainly manifest. If the disease be discovered in a recruit, the man is simply rejected as unfit for military service. If the diagnosis be established unmistakeably in a soldier already

* It is, of course, essential that the surgeon should be well acquainted with the textural anatomy of the parts concerned in vision, in order properly to appreciate the appearances which accompany many of the lesions rendered visible by the ophthalmoscope, and the phenomena which accompany them. A minute and lucid description of the histology of the tunics and refractive media of the eye will be found in the edition of Quain's Anatomy, by Sharpey. Thomson and Cleland, Lond. 1867, vol. 2., pp. 705 to 739.

in the service, he is invalided and discharged from the army. And, remembering how rarely a cure can be hoped for from any treatment in such advanced cases, it would evidently be unjust to the public service to retain in the ranks of the army a soldier who is so little likely to become efficient, when once the nature of his disease has been clearly defined. The military surgeon has therefore to turn his attention more to acquiring accuracy of diagnosis than to experimenting upon the effects of remedies in deeply ingrained lesions of the tunics within the cavity of the eye. But a further advantage of the study of ophthalmoscopic diagnosis is that it may lead to these diseases being distinguished in earlier stages than they are usually recognized at present, when treatment may be of essential use in arresting their progress.

Before proceeding to describe the indications of structural lesions, it will be useful first to notice the applicability of ophthalmoscopic examination to the detection of deranged refractive power in the eye, whether the defect be *myopia* or *hypermetropia.* It may occasionally happen that the surgeon is unable to arrive at a certain conclusion in reference to the existence of these sources of impairment of vision, from the stupidity of the patient or from determination on his part to try and thwart the surgeon's object. In such cases the ophthalmoscope can be resorted to with great advantage, and, if the impairment of vision be at all severe, its presence and its nature can be readily detected. The test-types or test-dots will show the degree of alleged disability, and as, if any, a high degree of the malady is likely to be assumed, the following mode of observation will determine the question, without the subject having any power to interfere with the conclusion.

**Ophthalmoscopic Diagnosis of Myopia.**—When the eye of a person is examined ophthalmoscopically through the speculum alone at a distance somewhere about 18″ off, if the observer's eye be adapted for focussing the diverging rays proceeding from an object at the same distance, and the observed eye be emmetropic and devoid of exercise of accommodation, no object on its fundus will be separately perceived. Only a general glare of light reflected from the fundus will be visible. The explanation of this is that the observed emmetropic eye being adapted for focussing rays which enter parallel, the rays reflected from the fundus after issuing from the eye will have a parallel direction, with one another. The observer's eye is however adapted for focussing diverging rays, not for parallel no more than for converging rays. The rays issuing from the emmetropic eye cannot then be brought to a focus on the observer's retina, no distinct image is formed, and no object is seen by him.

But if, instead of being emmetropic, the examined eye be myopic, and the myopia be at least $\frac{1}{16}$, distinct images of objects on the fundus can be formed on the observer's retina at the distance before named, and these objects will then be plainly visible to him. If the myopia be less than $\frac{1}{16}$ in degree, the observer will find that he will have to remove his eye further off than 18″. The objects seen will appear inverted. The fact that it is the inverted image which he is seeing will be at once recognized by the observer noticing that if his eye be fixed on some small object in the fundus, as one of the retinal vessels, and he then moves his head to one side, the vessel will appear to move towards the opposite side. The explanation of this effect is easily understood, if it be remembered that the only *entering* rays which the myopic eye can focus are divergent rays, and that these rays on being reflected from the fundus and *passing out* of the myopic eye must follow the same path as that by which they entered, and so become convergent rays. The convergency causes the rays to meet at a point of intersection a few inches in front of the eye, and, after crossing, to become divergent; so that the examiner, by placing himself at a proper distance, is able to bring the rays which diverge on leaving the point of intersection to a focus upon his retina, and there to obtain an image, necessarily inverted, of the object from which the rays proceeded. Now if the subject under examination describes himself to be very short-sighted, the presence of the inverted picture of the fundus on examination by this direct method will prove the correctness of his assertion, and for the same reason its absence will show the man's description to be unfounded, or that his defect of vision has originated in some other cause than myopia.

**Ophthalmoscopic Diagnosis of Hypermetropia.**— This anomaly of refraction is detected with the ophthalmoscope by the same method of examination. But in this case the image of the fundus is seen erect instead of inverted. The hypermetropic eye, it will be remembered, is adapted to *receive* convergent rays, and therefore the *reflected* rays pass out of the eye divergently. The observer, therefore, finds the exact distance at which his eye will bring these divergent rays to a focus, and, on this being found, he immediately perceives a distinct upright image of the background of the eye under observation. The test, described in the diagnosis of Myopia as affording the means of recognizing the inverted image, when applied to the object seen in the fundus of the hypermetropic eye, exhibits a contrary result, and serves to prove that the image in the latter case is erect. For if the observer, after fixing his eye upon a retinal vessel, now moves his head to one side, the vessel will appear to move, not in the opposite but in the same direction. This is a necessary consequence of the reflected rays coming direct from the object under observation, and not crossing each other after their exit, as they do from the myopic eye.

*Summary of the Diagnosis of Emmetropia, Myopia, and Hypermetropia, by the Ophthalmoscope.*—It follows, therefore, that in examining an eye under the circumstances named, if it be emmetropic, no particular object on its fundus will be visible. If any be seen, it serves to show that the eye under examination is either myopic or hypermetropic. If the observer move his head, and the object on the fundus which he has singled out appear to move in the opposite direction, it is a proof that the observed eye is myopic; if the object appear to move in the same direction with the observer's head, it proves that the eye under observation is hypermetropic.

**Diagnosis of the Degree of M. or H. by Ophthalmoscopic Examination.**—If the observer, while observing the eye under examination, can cease to regard it as a near object, but being emmetropic and avoiding all accommodatory effort, can maintain his eye adapted for focussing parallel rays, then he may determine the degree of M. or H. of the eye before him. For by regarding the myopic eye before the converging rays issuing from it have met, and by finding and placing before his own emmetropic eye a concave lens which will cause these rays to assume a parallel direction and to be focussed on his retina, on ascertaining the power of this lens, he ascertains very nearly the degree of myopia of the eye under observation. Certain slight allowances will have to be made to ascertain the exact degree. In a similar way, if the observer, his eye still being adapted for focussing parallel rays, places before his eye a convex lens which shall give to the diverging rays issuing from a hypermetropic eye a parallel direction, such that they will be brought to a focus on his retina, he equally knows by the power of this lens with a corresponding allowance to that in the former case what the exact degree of H. of the observed eye is. The degree of M. and that of H. are shown by the power of the — or + lens by which the converging and diverging rays issuing from the two eyes respectively have been severally neutralized.

If the observer's eye be myopic or hypermetropic, by knowing his degree of ametropia and keeping his eye adapted for his distant point of distinct vision, he can, by calculation, arrive at a similar conclusion as to the degree of M. or H. in an observed eye.

**Ophthalmoscopic Diagnosis of Astigmatism.**—The ophthalmoscopic examination of the eye for astigmatism is made in the same manner as for the diagnosis of M. and H. If no astigmatism be present in the observed eye the retinal vessels radiating over the fundus are seen in all directions with equal distinctness. If astigmatism be present, the vessels appearing in one direction will be less distinctly visible than the vessels which appear in the opposite direction, so long as the observer's eye remains adapted for the same distance. There must be an exercise of accommodation in order to see clearly those vessels which appear indistinctly visible, and when these are seen well defined, then those which were before distinct become less so.

The appearance of the optic disc furnishes another test for the existence of astigmatism. If the observed eye be astigmatic, and the ophthalmoscopic observation be made by the method described for testing M. and H., it may be noticed that the optic disc appears enlarged and elongated in one direction as compared with its dimensions in the opposite direction. It is most enlarged in the direction of the meridian of greatest curvature, it is least enlarged in the direction of the meridian of least curvature. The eye is then to be examined by the indirect method, so that the inverted image of the fundus may be observed. Now the appearance of the optic disc will be found to be changed. The direction in which the optic disc appeared most enlarged under the former mode of examination will now appear least enlarged; that which appeared least enlarged, will now appear most enlarged. It is the varying appearances in respect to the shape of the optic disc which are presented on looking at its upright and then at its inverted image, that establishes a proof of the existence of astigmatism.

*Structural lesions.*—In the following three sections the principal morbid conditions to be recognized by the ophthalmoscope are shortly described:—

## SECTION I.—LESIONS OF THE OPTIC NERVE AND RETINA.

There is no part of ophthalmoscopic diagnosis which more deserves attention than that which concerns the optic nerve and retina. Besides the importance of the lesions visible in these structures in relation to the function of sight, they are so often indicative of serious local disease in the brain and spinal cord as well as of general constitutional disease, that a correct appreciation of them must constantly involve very grave issues. Ophthalmoscopic observation of the vascular condition of the optic disc and retina is often useful too in medical diagnosis, for the state of the cerebral circulation is in a great measure rendered visible by the state of the optic and retinal circulation, owing to the intimate connexion of the blood supply between the brain and optic nerve.

Lesions of the optic nerve are of course intimately associated with corresponding lesions of the retina, and in some instances they can be equally well observed in each. In other diseased conditions, however, the characteristic signs are so much more marked in the optic papilla that they there particularly attract the surgeon's attention from their special appearances. Such are anæmia of the optic nerve, atrophy in its several stages, hyperæmia, and the effects of intraocular pressure indicated by the excavated or depressed condition, which is generally known by the name "Cupping." There are doubtless corresponding changes in its retinal expansion accompanying all these altered appearances of the optic nerve, although from the disposition of the nerve fibres and connective tissues in the optic nerve, and from the transparency of the retina and its proximity to the choroid some of these changes are obvious in the former, but not observable in the latter. That these changes do exist, though not visible, may be often sufficiently known by their effects on vision. Amblyopia is the general accompaniment of all these lesions and achromotopsia in some of its forms very frequently so.

### 1. Anæmia of the Optic Nerve.

*Ophthalmoscopic Appearances.*—The normal rose, or greyish pink, colour of the optic papilla is absent, and, instead, a more uniform white appearance is presented. The absence of coloration on the inner or nasal parts of the disc, where the pinkness is usually more marked, is noticeable. If the amæmia is symptomatic of advancing atrophy, the arterial vessels appear shrunken, and contracted by contrast with the veins, which are often turgid and tortuous, the diameter of the papilla is lessened, and the circular aperture of the sclerotic, or scleral ring consequently becomes more obviously apparent.

*Diagnostic Signs.*—The general character of the paleness of the papilla is the principal diagnostic mark. In estimating the degree of anæmia, the general colour of the fundus should be noticed, for the contrast will be increased in proportion to the darkness of the fundus, and the paleness be more striking. The observer must be on his guard not to attribute paleness, which may be the ordinary condition of the optic disc under observation, to a morbid state of anæmia. The appearances of early ophthalmoscopic observations, if they have been taken, will assist in establishing the diagnosis. If the anæmia be due to a drain of blood from the system, or to morbid changes, the paleness of the disc will be associated with loss of visual power and probably with limitation of the field of vision.

### 2. Atrophy of the Optic Nerve.

*Ophthalmoscopic Appearances.*—The optic papilla is of a bright, remarkably chalk-white aspect, free from all translucency and its limit usually sharply defined. The perfectly colourless condition of the sharply outlined disc forms a striking contrast with the rest of the fundus, so that it is very easily recognized. The retinal vessels appear less in number than usual. They are wasted and thin, and often cannot be traced far from the optic entrance. The white papilla appears to be quite flat but occasionally becomes depressed and excavated, and is then usually attended with the peculiar bluish grey spotting indicative of the lamina cribrosa nearly, or quite, up to the edge of the disc.

*Diagnostic Signs.*—The peculiar whiteness of the papilla in complete atrophy prevents it from being mistaken for any other condition. It is frequently associated with intercranial causes, which can only be elucidated by a careful investigation of the history of the case, and study of the symptoms concomitant with the progress of impairment in power of vision. Amblyopia and limitation of the field of vision occur in proportion to the extent to which the atrophic changes have taken place, and anomalies in perception of colours have been noticed more frequently in this than in any other morbid condition of the nerve apparatus of the eye.

In complete atrophy vision is wholly lost. There is no sensitiveness when the strong light reflected from the mirror is thrown upon the fundus. The parts of the fundus brought to view under ophthalmoscopic inspection have a peculiar fixed aspect, for no variation in their images can take place as the eye has lost all accommodatory power. The dilated pupil is equally fixed.

### 3. Depression or Cupping of the Optic Disc.

*Ophthalmoscopic Appearances.*—These vary according as the excavation is deep and abrupt, or shelving. In the former case, the attention is attracted to the defined scleral boundary of the papilla and the peculiar disposition of the retinal vessels as they pass from and to its centre. A narrow border of a more or less light yellow colour is seen to surround the optic disc; this is the scleral ring rendered visible from the superimposed choroid having been stretched and wasted. The excavation of the disc sometimes produces on the eye of the observer at first the effect of a conical protrusion when the eye is examined by the indirect method. This optical illusion is explained by the fact that light falling with a little obliquity upon a concave surface is reflected from the side opposite to that from which it is reflected when thrown upon a convex surface, and from the circumstance that the relative positions of the light and shade are changed in the inverted image. The vessels at the edge of the disc are seen to bend abruptly, and on being observed attentively, indicate the differences in level between the retina and papilla. The surface of the papilla is whiter in the centre than in the surrounding part of its disc, where there is not only a darker shading of greyish pink colour, but where also a number of grey spots marking the lamina cribrosa may frequently be seen. This appearance of the lamina cribrosa is the more marked as the excavation is deeper. When the disease is advanced and the excavation extends circumferentially, the margin of the sclero-choroidal opening becomes undermined, so that the branches of the retinal vessels on reaching it have to curve round and pass under it. They are thus for a short space lost to view, and when they are again seen on the disc, they appear as if they were separated from the retinal vessels to which they belong. The veins as they lie upon the optic disc appear to the eye to be shrunken and more pale than they do at the scleral boundary of the disc. The retinal arteries appear small and thin, while the retinal veins are distended and often tortuous, as occurs in the earlier periods of atrophy. The *vena centralis* on being carefully observed may often be seen to pulsate, an effect due to the state of intra-ocular tension. The same effect may be produced artificially on pressing the upper part of the globe of a normal eye by means of the finger placed upon the eyelid. But under the circumstance of intra-ocular pressure, the vein may be seen spontaneously alternately losing its colour and becoming apparently narrower, and then dilating again and assuming a dark colour from fresh injection of its contents. If the pressure be increased by the finger the same effect will be rendered visible in the artery. It is well, when making this experiment, to fix the eye upon a branch at the spot where it passes over the border of the scleral opening to the surface of the optic disc.

In the other form of cupping the excavation is more shelving, so that the appearance of interruption in the continuity of the vessels is not presented. The vessels, or some of them, according to the extent affected, are attenuated and are seen to form a curve as they reach the scleral margin, but can be followed to the trunk from which they ramify. This form of excavation usually accompanies atrophy of the optic nerve, of which the diagnostic signs have been already noticed.

*Diagnostic Signs.*—The peculiar aspect of the vessels sufficiently establishes the condition of the optic entrance. In the first form, in which the depression abruptly commences at the periphery, the larger veins afford the most marked evidence of the cupping; in the second the smaller vessels, as they can only be seen when close to the surface of the papilla, are the safest guides. The first form is diagnostic of diffused intra-ocular pressure, such as occurs in glaucoma, a condition which is further indicated by the pulsation of the central vessels, and the tense state of the globe perceptible on external pressure; the second, as before mentioned, points to wasting of the nerve tissue, or atrophy of the optic nerve. The amount of change of direction which the vessels lying on the optic papillary surface assume in turning over the scleral margin to ramify on the retina indicate, to a certain extent, the depth of the excavation.

In some eyes there appears a slight cup-like depression of the white central portion of the disc, unconnected with any morbid state. It is a depression due simply to congenital form. Its situation, and the general healthy condition of the optic nerve and retina, sufficiently distinguish it from the other kinds of excavation of the optic nerve.

### 4. Simple Hyperæmia of the Optic Nerve.

*Ophthalmoscopic Appearances.*—Hyperæmia, which may be due to local or cerebral congestion, or to inflammation concurrent with retinitis, shows itself by an exaggerated colouring of the disc. The depth of colour varies according to the amount of hyperæmia, from a rose blush to greyish red; and as the colour increases, the papilla becomes less conspicuous from loss of contrast with the general colour of the fundus. Hyperæmia from local congestion is seen very frequently in persons who are subjecting their eyes to excessive strain at near objects, especially when an abnormal condition of refractive power is not corrected by suitable lenses. In such cases the pinkiness may be limited in appearance to the *colliculus*, or to a part only of the *papilla*, or the whole disc may appear injected.

*Diagnostic Signs.*—The appearances described, together with the absence of the indications of serious lesions in the other structures, sufficiently distinguish this condition. The appearances will in many cases be confined to the nerve of one eye when the hyperæmia is due to local disease; when both eyes are equally affected, it usually indicates a cerebral origin.

## 5. Optic Neuritis.

*Ophthalmoscopic Appearances.*—In optic neuritis, the indications of hyperæmia just described are followed by a train of appearances which vary according as inflammatory products are effused, or more remote consequences developed. Inflammation of the optic nerve may exist as a local affection, originating in congestion, the result of vascular obstruction, or to inflammation extending down the nerve, or as an accompaniment of general retinitis. In all these varieties of optic neuritis the ophthalmoscopic appearances are very similar. Not only is the papilla less conspicuous, owing to its state of injection, but its circumferential limit is less defined. This obscurity appears owing to a haze covering the papilla, like, as it were, a veil extending over it, which is blended with the neighbouring portion of the fundus. The optic entrance appears magnified, yet uncertain. Elevation, or intra-ocular projection of the papilla, occurs as an accompaniment of inflammation. The whole disc will in some instances not exhibit the hazy and tumid appearance just described, but only a portion of it. The adjoining portion of the retina presents a similarly veiled and hazy aspect. The arteries are shown lessened in calibre, while the veins appear increased in size and frequently tortuous. Small hæmorrhagic spots are sometimes visible on and about the optic disc. The vessels cannot be followed to their regular termination in the central arterial and venous trunks, but are partially lost to view in the hazy film and often seem to finish abruptly at several points upon the surface of the papilla, at varying distances between its circumference and centre. These appearances appear to be chiefly due to serous infiltration or exudation of lymph or other products arising from the inflammatory action, together with obstruction of circulation and vascular engorgement. Variations in the appearances presented continue according to the course the inflammatory action pursues. It may proceed to resolution, and partial recovery, to atrophy, to extension of the inflammatory action to other structures, or, in its chronic form, induce a variety of consequences, some of which will be noticed hereafter.

*Diagnostic Signs.*—The ophthalmoscopic appearances serve sufficiently to diagnose the disorder. It is usually accompanied with subjective appearances of light, with impairment of visual acuteness, and limitation of the field of vision, but the extent to which these symptoms exist does not necessarily accord with the extent of the neuritis. Cases of optic neuritis are recorded in which the visual acuteness has remained perfect.

### 6. Retinal Hæmorrhage.

*Ophthalmoscopic Appearances.*—Retinal extravasations of blood, which may result from any cause inducing excessive vascular congestion, present appearances which can scarcely be mistaken under ophthalmoscopic examination. The spots present the usual colour and characters of ecchymoses in other parts, but will slightly differ in character according to their situation. If the effused blood get to the outer layers of the retina or to the choroid, it usually has a defined outline and portions of retinal vessels may be seen above it. If the hæmorrhage is in the inner layer of the retina, its outline will be more irregular, and the retinal vessels will be concealed from view by it. If it breaks through the membrana limitans into the vitreous, the presence of the dark blood in this body will be sufficiently manifest. The extravasation may be limited to one spot, probably in the immediate neighbourhood of a blood-vessel, or may be scattered in irregular patches over the fundus. The arteries may retain a normal appearance, or may appear shrunken, as if partly emptied of their contents, while the veins are dilated and tortuous. Under repeated ophthalmoscopic observations, the ecchymoses may be seen very slowly to diminish in size and darkness of colour, if the structures be originally healthy and favourable absorption of the effused blood takes place, vision being gradually restored as these changes occur, or they may remain for long periods unchanged; they may be succeeded by the usual indications of choroidal atrophy, detachment of the retina, and other results.

*Diagnostic Signs.*—The ophthalmoscopic appearances sufficiently establish the nature of the disorder. The ocular symptoms, perhaps sudden complete loss of sight, or obscuration of part of the normal field of vision, according to the part of the retina where the hæmorrhage has occurred, will aid the diagnosis. If the hæmorrhage has concurred with some structural degeneration, as happens in albuminuria or in syphilitic changes, or with heart disease or other morbid state of the circulatory system, the previous history will also strengthen the diagnosis and explain the predisposing condition.

### Detachment to the Retina.

*Ophthalmoscopic Appearances.*—As just noticed, after retinal hæmorrhage, or if retinitis be followed by serous exudation, or if from any cause, such as accidental blows about the orbit, or vascular distension, an effusion of blood takes place from the choroid, and lodges between it and the retina, the occurrence is often followed by separation of the retina to a greater or less extent. Detachment of the retina is also not unfrequently produced by vascular congestion and serous or hæmorrhagic effusion in cases of high degrees of myopia accompanying posterior staphyloma. Retinal detachment is recognised by the following appearances. The ophthalmoscopic observations may be made by the direct or indirect method. If the direct method be employed, and the fundus be observed after the patient has turned the eye two or three times quickly upwards and downwards, a fold of an opaque white or bluish gray colour, presenting a marked contrast with the rest of the red fundus, may be noticed having a slightly undulating movement. If it be then observed with the aid of the object lens, not only the wavy fold will be seen, but small vessels may be noticed upon it, and these will alter in size, direction, and focal distance, in correspondence with the movements of the retinal fold. If the detachment be of long standing, the waving movement and the retinal fold itself will be more conspicuous, probably from the retina being looser as well as from its being more opaque, and therefore reflecting more light to the eye. When it is recent, the colour of the effused fluid beneath is more obvious; if this be transparent, the red fundus will be seen through it, excepting in lines where the retina happens to be folded upon itself. Such detachments are usually partial and therefore the appearances may only be noticeable in certain positions of the observed eye; if it happen to be detached from the whole circuit of the optic disc, the disc will generally be hidden by its movements. The movements of the detached retina can sometimes be observed with the aid of favourable position and a good light without the ophthalmoscope.

*Diagnostic Signs.*—The movements of the small vessels agreeing with the movements of the fold, serve to diagnose this lesion. The general indications will vary with the extent and site of the detachment. If the retina around the macula lutea be undisturbed, partial vision will be retained. The patient complains that his vision is impaired by the presence of a dark cloud floating before the eye: a certain portion of his field of vision is lost: perhaps he labours under complete hemiopia, the upper half of the field of vision being that which is usually lost. If the detachment be very limited, the effusion fluid may become absorbed, and vision restored, but only few such instances have been recorded.

### 8. Retinitis Syphilitica.

*Ophthalmoscopic Appearances.*—The impairment of vision which is occasionally found to accompany certain constitutional pathological conditions, such as syphilis, morbus brightii, &c., without any appreciable changes in the external structures of the eye, has been shown by ophthalmoscopic observation to be accompanied by characteristic changes in the aspect of the retina. The syphilitic retinitis is characterised by cloudiness of the optic disc, haziness of the retina, which is extensively diffused, and occasionally by scattered spots of retinal ecchymosis. The bluish white retinal haziness is most marked around the optic entrance, along the course of the principal vessels, and around the *macula lutea,* but it has nowhere any defined limits. A number of small opaque white spots are occasionally irregularly disposed around the *macula lutea.* The syphilitic retinitis is also not unfrequently accompanied by disseminate spots of choroidal atrophy.

*Diagnostic Signs.*—The ophthalmoscopic appearances, together with the syphilitic history, serve to establish the diagnosis. The small opacities when they occur around the *macula lutea,* and the retinal patches elsewhere, are less intensely white than they are in retinitis albuminuriensis. Under judicious treatment, such as would remove the syphilitic taint expressed in other parts of the frame, syphilitic retinitis may disappear, ecchymoses be absorbed, and the impaired vision greatly restored. A certain amount of amblyopia as a rule always remains.

## 9. Retinitis Albuminuriensis.

*Ophthalmoscopic Appearances.*—The optic disc is indistinctly seen as if through a haze, and presents many of the characters, especially in the early stage of the disease, which it has been described to assume in the remarks on optic neuritis. It appears blended with the surrounding retina, which is opaque for some distance around, but not of an uniform colour. Around the papilla it is ordinarily of a yellow colour inclining to brown, and this passes into a diffused dead white border, of irregular outline, at the outer margin of which are scattered a large number of separate white spots. The outline of the white opacity, with its border of white spots and streaks, is rather sharply defined, so that the whole diseased appearance is isolated as it were from the rest of the fundus so far as colour is concerned. A group of similar white spots is frequently disposed in a circle around the *macula lutea.* These appearances are partly due to serous infiltration and increase of the connective tissue, and partly to fatty degeneration. The arteries are finer, while the veins are more distended and tortuous, and appear darker than normal. Portions of the vessels are occasionally lost to view in the white retinal deposits. Hæmorrhagic spots, both retinal and sub-retinal, are scattered over the fundus, as well in the degenerated parts of the retina as in other parts where no visible changes have occurred. While the disease is advancing in its earlier stage the white spots coalesce, and thus extend the limits of the white margin, but subsequently the infiltration may in great measure disappear, and the disorder terminate in complete atrophy.

*Diagnostic Signs.*—The locality in which the appearances above described show themselves, the manner in which the infiltration or fatty patches are disposed around the clouded entrance-disc, the spots round the *macula lutea,* combined with the hæmorrhagic appearances, are considered sufficient to characterize them as connected with Bright's disease. The amblyopia resulting from the retinal changes is generally very considerable, but is occasionally not noticed until the disorder is in an advanced stage.

## 10. Retinitis Pigmentosa.

*Ophthalmoscopic Appearances.*—The appearances presented ophthalmoscopically in this disease are very striking. The retina is seen to be studded with patches of black pigment, and this pigment seems to have a close affinity with the retinal vessels. The retinal vessels seem to be small in calibre, and are in parts hidden by the pigment when their course happens to lie through some of the pigment spots, or the pigment appears to follow the course of direction of the finer ramifications of the vessels so that they appear as black lines. In many cases the pigment spots are seen to group themselves within the spaces formed by the angles of bifurcation of the vessels. The black spots then assume the appearance of minute arrow-heads, one line of the arrow-head lying close to one side of the bifurcation, the other line to the opposite side, and both meeting at the point of the angle. Sometimes the dark patches assume characters which have been likened to those of the bone corpuscles. The immediate vicinity of the optic entrance and *macula lutea* is usually free from the pigmentation which appears to be scattered more around the periphery of the fundus, and generally to be more extensive on the inner than on its outer side. In occasional cases when seen early the pigmentation can only be observed by bringing the periphery of the fundus well into view, and in these instances, by repeated observations, the pigmentation may be seen to advance gradually from the periphery towards the axis of vision, the field of view of the patient gradually contracting in proportion. Corresponding appearances may be usually observed in both eyes of the same patient. Observations leave it still uncertain whether the appearances above described are due to changes causing the formation of pigment in the retina independent of the choroid, or whether the pigmentation of the retina is necessarily connected with associated disturbance of the epithelial layer of the choroid.

*Diagnostic Signs.*—The opthalmoscopic appearances are so peculiar that the diagnosis is usually easy enough. The usual occurrence of the disease in both eyes together; the co-existence of hemeralopia, a diffused bright light being necessary for distinct vision; and contraction of the field of vision, although the patient's sight may be good when directed to objects straight before him, are general signs which serve to corroborate the ophthalmoscopic diagnosis.

## SECTION II.—LESIONS OF THE CHOROID.

The choroid tunic is the seat of a variety of lesions some of which are exceedingly conspicuous under ophthalmoscopic observation, from the contrasts in colour which are presented when exudation, or atrophy of its structure, has taken place, and the epithelial layer of pigment cells has been disturbed. From its great vascularity it is frequently the subject of simple congestion, or inflammation, leading to some of the changes above noted. It is also the frequent cause of associated or consecutive disease in the retina. These morbid conditions of the choroid, or choroid and retina, are chiefly recognized under the forms of "choroiditis disseminata," "retino-choroiditis," and "choroido-retinitis pigmentosa."

### 1. CONGESTION OF THE CHOROID.

*Ophthalmoscopic Appearances.*—The differences in the colour of the choroid in its normal condition, and the varied appearances due to the different distribution in different eyes of the epithelial and stromal pigment, render considerable practice necessary for forming a correct judgment of the altered appearances which may be due to congestion or hyperæmia. Congestion will cause an increased depth of red colour in the fundus, but in order to recognize the amount of increase, the complexion of the individual must be considered, and the manner and extent to which the increased redness is distributed. If the congestion be limited to one eye, there will be a contrast of colour between it and its fellow. If the complexion be light, and the epithelial layer be not rich in pigment, the choroidal vessels may be perceived to be fuller than normal, and perhaps more close together in one part of the fundus than another, but the ophthalmoscopic appearances will rarely enable one to come to a conclusion that choroidal congestion is present with certainty.

*Diagnostic Signs.*—In addition to the increased redness of the fundus, the general symptons of choroidal congestion must be looked for to aid in establishing the diagnosis. These are—a sense of tension in the globe, and speedy fatigue on application of the eye to near objects as in reading, *scotomata, muscæ volitantes,* and *mistiness* of vision, varying in degree from time to time; slight *photophobia* and *epiphora*; and probably frontal headache.

### 2. Choroiditis Disseminata.

*Ophthalmoscopic Appearances.*—In this form of choroiditis numerous spots of exuded lymph are seen scattered over the fundus in different directions, usually presenting a yellow or dull white colour. The exudations may be placed between the choroid and retina, or may be poured out in the choroidal tissue itself. They vary in form and size, but generally appear as small spots, quite separate from each other, more or less circular in outline, and disseminated in groups. Sometimes a layer of exudation appears as if spread out by pressure, and its outline is then very irregular. In a late stage of the disease the disseminate spots are of a bright white colour. These spots are generally surrounded at their margins by small deposits of very dark black pigment; or the deposits of pigment are grouped at points in their neighbourhood. The pigment at the margin has the appearance of having been removed from the part where the exudation has taken place, and of being heaped together in patches where the deep black colour appears. Occasionally little spots of pigment will appear separate from the white exudations. The fundus will sometimes appear hazy in the earlier stage of the disease, but is clearer as it becomes chronic. The vessels of the retina may be observed to follow their course irrespective of the changes just described. They are seen to cross both the white spots and thin dark margins, or to ramify over the distinct white patches if they happen to be at a part of the fundus where the larger branches of the vessel circulate. The direction of the retinal vessels will sometimes indicate whether the retina has been raised or not by the choroidal exudations beneath. The exudations, if slight, may sometimes be observed to gradually wear away, leaving the choroid complete in texture, though perhaps functionally weakened; but usually as they disappear, they leave behind an atrophic condition of its tissues, so that the atrophied patches are seen as glistening white spots, as above described, owing to the sclerotic being visible through them.

*Diagnostic Signs.*—The ophthalmoscopic appearances described sufficiently distinguish the disease. The normal state of the retinal vessels, and their undeviating course over the patches of exudation or of atrophied choroid, indicate that the morbid changes are subretinal.

### 3. Retino-Choroiditis.

*Ophthalmoscopic Appearances.*—If inflammation of the retina be added to that of the choroid, there will be after a time, in addition to the disseminate indications just explained, the misty indistinct optic entrance, retinal exudations, either serous or plastic, and the general appearances described under retinitis. As the active symptoms subside, the appearances and general signs may point to advancing atrophy, or the vision may improve to some extent, but remain permanently weak. In the latter case the ophthalmoscope will probably reveal from time to time improvement in the condition of the retina, but the disturbance of the choroidal structure, especially of its epithelial layer will be found to be permanent. The extent to which vision is affected will frequently be found to depend upon the side where the morbid changes have been chiefly developed.

*Diagnostic Signs.*—Very marked amblyopia will accompany retino-choroiditis, when severe or advanced in its character, but in the early stages in which the retina has not yet become much implicated in the inflammation, the ophthalmoscopic diagnosis is uncertain on account of the difficulty in appreciating simple inflammatory congestion of the choroidal vessels. When the choroiditis has led to disturbed distribution of the pigment cells, and the other signs noticed under "Choroiditis disseminata," and these are accompanied by opacity of the retina, diffused haze about the optic entrance, or indications of commencing atrophy, the diagnostic signs are clear enough.

### 4. Choroido-Retinitis Pigmentosa.

*Ophthalmoscopic Appearances.*—The most striking ophthalmoscopic appearances are those from which retinitis pigmentosa derived its name, the peculiar manner in which pigment is seen to be scattered over the retina, associated with certain altered appearances in the choroid tunic. These latter changes are probably consecutive to those in the retina, for they are usually met with in the later periods of retinitis pigmentosa. The appearances show thinned or atrophied patches of the choroid, with disturbance of its pigmentation, the pigment often accumulated at the margins of the atrophied patches, and not unfrequently the white sclerotic seen shining through them. The patches vary in brightness and tint according as the atrophic changes are more or less advanced in the choroid. Sometimes the vessels of the choroid are plainly visible in isolated parts of the fundus, proving that the pigment cells of the epithelial layer are in these parts lessened in number. With all these changed appearances of the choroid are mixed up the peculiar characteristic signs of the retinitis pigmentosa. In very advanced cases the optic entrance as well as the retinal vessels show the usual marks of atrophy.

*Diagnostic Signs.*—The situation and characters of the retinal pigmentation, together with the condition of the choroid, serve to distinguish this disease from choroiditis disseminata. The amblyopia and the contraction of the field of vision as the disease advances, serve as corroborative diagnostic indications.

### 5. Posterior Staphyloma.

*Ophthalmoscopic Appearances.*—This constant accompaniment of high degrees of myopia takes its name from the projection at the back part of the globe of the eye which characterizes it. It used to be described as "Sclerotico-choroiditis Posterior," but as the appearances presented are now considered to be the result of changes which are chiefly induced by pressure or stretching, and not inflammatory action, the term is no longer generally used. "Ectasia bulbi," or aneurism-like extension of the globe, and "Sclerectasia posterior" are other names applied to this disease. It presents a very marked appearance to the observer when examined ophthalmoscopically. Its chief feature is the striking contrast which is presented between the projecting part of the fundus near the optic entrance, and the normal colours of the neighbouring tissues.

In its early stage the disease appears as a narrow white crescent adjoining the optic nerve, being usually placed on its outer side, with the convexity turned in direction towards the *macula lutea.* Its bright whiteness, which is due to the tendinous sclerotic being visible through the unpigmented wasted choroid, prevents it from being confounded with the optic nerve itself, the limit of which is usually plainly marked by contrast of colour. The boundary also between the convex margin of the crescent and the red fundus is strongly defined. A line of dark pigment, or some irregularly shaped patches of pigment, frequently appear around the outer border of the crescent. As the disease advances the crescent extends, as well by embracing the optic nerve more completely within its horns as by spreading from its convex border towards the *macula lutea.* It frequently thus obtains a fan shape, the broad part of the fan expanding towards the outer part of the eye (the apparent inner aspect when seen in the inverted image). Occasionally the aspect presented is a large white circle surrounding the optic entrance, spreading out irregularly in several directions. The whiteness is excessively brilliant, and, as the retinal vessels cross over it, their outline and colour are very strikingly conspicuous. Not unfrequently small isolated patches of choroidal atrophy may be observed in parts of the fundus around, accompanied by irregular groupings of dark pigmentary epithelium. The optic entrance sometimes appears as if it were oval, with its long axis placed vertically, and the vessels appear to proceed from it on one side instead of from the centre; this effect is produced by the peculiar direction in which it is regarded by the observer when the posterior projection is deep. This disease is frequently accompanied by changes of the *macula lutea,* either atrophic, or visible as small spots of disseminate choroiditis surrounding it. Opacities in the vitreous humour and retinal detachment are not unfrequent concomitants also in the advanced stage of the disease.

*Diagnostic Signs.*—The ophthalmoscopic appearances are characteristic; at the same time, the myopia, which is necessarily induced, corresponding with the extent to which the axis of the eye is elongated by the staphyloma, the intolerance of dazzling light, sense of ocular tension on prolonged use of the eye, and amblyopia, are additional aids to the diagnosis.

## Section III.—Other Morbid States.

### 1. Glaucoma.

*Ophthalmoscopic Appearances.*—The ophthalmoscopic appearances in this disease, which consist essentially of changes dependent upon intraocular pressure and consequent excessive tension of the outer tunics of the globe, vary according to the stage of its development. Its prominent features under ophthalmoscopic examination are the peculiar signs of excavation, or *cupping*, of the whole optic disc, with pulsation of the *arteria centralis* at the disc, together with congestion of the retina and choroid. The cupping derives its name not only from the excavation, but from the abruptness of the margin of the disc. A light ring surrounds the edge of the disc. The retinal vessels in approaching the centre of the disc do not pass evenly forward, but become curved at its margin. If the excavation be deep, and the scleral margin undermined, the vessels in following the surface of the excavation are partially lost to view before they appear on the disc itself. The arterial pulsation, if not visible at once, may be rendered so by slight pressure of the finger upon the globe. The retinal veins are generally dilated and tortuous. The increase in the vitreous humour, from which the intraocular pressure appears to be mainly derived, is not at first accompanied with changes obvious to ophthalmoscopic observation; but, as the disease advances, loss of transparency of the vitreous humour becomes marked. Sometimes this change is shown by a degree of haziness or greyish cloudiness in the humour, proportionably obscuring the view of the fundus. At other times it will offer a yellow tinge, and this colour usually indicates light reflected from extravasation of blood in the retina. The green tinge which is sometimes observed appears to depend on a change in the crystalline lens, and this advances in certain instances to complete cataractous opacity. The usual signs of retinal and choroidal congestion are presented.

*Diagnostic Signs.*—The ophthalmoscopic diagnosis of glaucoma is much assisted by attention to the subjective symptoms. The abnormal hardness of the globe on pressure by the finger, flattening and dullness of the cornea, dilated and sluggish pupil, the pain around the orbit, concur with the ophthalmoscopic indications of depression of the optic disc, and of the obstruction to the venous circulation in the retina and choroid, in pointing to the existence of intraocular pressure. It is for the relief of this distension that the operation of iridectomy is practised. The optical signs are, at first symptoms resembling those of presbyopia, these being induced by the flattening of the cornea, subsequently gradual narrowing of the limits of the field of vision and increasing amblyopia, and finally, if the disease advance, complete blindness.

## 2. Morbid Changes in the Dioptric Media.

*Ophthalmoscopic Appearances.*—Loss of transparency in the dioptric media, opacities in or upon the cornea, lens, and vitreous humour, are at once noticed when the eye is illumined and examined by the ophthalmoscope. Lateral illumination is preferable for observing the anterior media of the eye as far as the crystalline lens and its capsule, and direct ophthalmoscopic examination for observation of the vitreous humour. The evidence afforded by lateral illumination posterior to the crystalline lens is so uncertain as to be seldom useful in diagnosis. General loss of transparency in either of the media leads to the same effect when the ophthalmoscope is used, viz., an absence of brightness in the fundus, and indistinctness of the objects upon it, in proportion to the degree in which the normal transparency of the media has been lost. But special opacities are conspicuous as dark objects in the field of view, and it is frequently desirable to determine in which of the media these dark objects are contained. There is no difficulty in establishing the diagnosis when they are upon the cornea, whether superficial or interstitial, for if the naked eye cannot perceive them, their position and limits can be easily ascertained by lateral illumination. Lateral illumination will also exhibit plainly, after dilatation of the pupil, opacities of the crystalline lens, whether situated upon the anterior or posterior aspects of the capsule, or in the structure of the true lens. One advantage of checking the ophthalmoscopic appearances by lateral illumination is that the colours of the opaque objects are seen by it, whereas by the ophthalmoscopic illumination they always appear in shade. Thus the white bands of lymph after iritis, or spots of the uveal pigment, upon the front of the lens are seen in their natural colours by the one mode; by the other they both appear equally black colourless objects. In making these observations, a bright light is better for the oblique lateral illumination, a weak light for ophthalmoscopic examination. If a strong light be used in the latter method, and the corneal or capsular opacities happen to be very thin, or the lenticular cataract be in a very early stage, these causes of cloudiness in the vision of the patient may be overlooked by the examiner from the reflected rays passing through them, and no shadow existing to render them visible. With a weak light under ophthalmoscopic observation, the most delicate of the lines or radiating striæ which occasionally occur in the substance of the lens in the earlier stages of certain forms of cataract will be rendered plainly visible as fine dark streaks, more plainly than they will be by lateral illumination.

Opacities in the vitreous humour when small and not very numerous, are generally not so readily conspicuous, but require a little management, in order to bring them distinctly under notice. They also should be observed by the direct mode, and with a moderate degree of light. The patient should be told to move his eye quickly in opposite directions two or three times, then to look straight at the sight-hole of the mirror. In this way small opacities may be observed to float past the fundus in various directions, and to settle down slowly toward the lower part of the field exposed to view. Their manner of movement, and varying forms, readily distinguish them from opacities whether of the cornea or crystalline lens, which possess definite outlines, and retain fixed positions. An effusion of blood in the vitreous body will be usually found at its lower part. It will appear as a dark irregularly shaped object, with surrounding haziness, projected against the illumined fundus. If, in addition to floating opacities in the vitreous humour, there exists softening of its structure (synchysis), the opacities are usually seen more readily, because they are more easily put into movement; but the chief means of forming the diagnosis, so far as the synchysis is concerned, will be the peculiar undulating movement of the iris, to which the name of "tremulous iris" is given, as well as the other symptoms usually indicative of pathological changes in the globe of the eye.

### 3. Cysticerci in the Ocular Cavity.

Many instances in which the presence of a cysticercus in some of the parts of the eye has been detected by the ophthalmoscope have now been recorded. One such instance occured in the case of a gunner who was sent as an invalid to Netley. The cysticercus was seen at the back part of the eye, apparently projecting from the retina into the vitreous humour. Professor Soelberg Wells kindly examined the patient at my request, and confirmed the diagnosis. Great care will be necessary to establish a diagnosis in these cases. When beneath the retina, the animal has appeared as a bluish semi-transparent vesicle, and some of the retinal vessels have been seen to ramify over its projecting surface. The head and neck have been indistinctly traced through the vesicle, and movements have been observed. It would seem that when these entozoa have been noticed in the vitreous humour they have previously existed beneath the retina, and have made their way from that situation into the latter by a gradual advancing movement. In the vitreous humour the form of the head and neck, its attachment to its vesicle, and the movements of the animal, have been very plainly distinguished by ophthalmoscopic observation. It has even been extracted by Von Graefe and Dr. Liebreich. The presence of the cysticercus leads to opacities in the surrounding vitreous humour, which have been attributed to the effects of suction, that being the manner in which the nutrition of the animal is carried on. They may also be due to inflammation excited by the presence of the parasite. The ocular cysticerci have in some cases been associated with the presence of tapeworm, in others with indications of cystic entozoa in other parts of the body: the history of any suspected case of this disease should be inquired into in this respect, with a view to additional elucidation of the indications necessary for forming an accurate diagnosis.

### 4. Loss or Impairment of Vision from Blows upon the Bones of the Orbit, or in their Neighbourhood.

It frequently happens that gun-shot wounds of the face or forehead are followed by irregularity, impairment in power, or total loss of vision, without direct impingement of the eye itself, or any evidence of injury, so far as its anterior structures, which are exposed to view, are concerned. Blows accompanied with less violence, such as a stroke from a stone, from the jerk of a horse's head against the edge of one of the orbits of its rider, and other injuries, sometimes apparently trivial in their nature, will occasionally produce the same effect. Before the use of the ophthalmoscope, these accidents were generally attributed to concussion of the optic nerve, but they are now known to be owing to lesions which are usually rendered obvious enough by ophthalmoscopic examination. Either the retina wholly or in part is found to be detached: or there is effusion of blood beneath it, or in the vitreous body: or the retina is found to be rent across: or isolated fissures occur in the choroid: or inflammatory action is set up in the retina and choroid, which eventually leads to retinal thickening, atrophy, or complete disorganization. The ophthalmoscopic appearances of these several conditions, which have been already noticed, will of course vary according to the length of time which has elapsed between the injury and the date of observation. Intra-orbital hæmorrhage, and pressure upon the globe, may lead to diplopia and other lesions, more or less temporary in character. In old cases complete atrophy of the optic nerve will be sometimes found; sometimes the scar, where the retina, or choroid, has been torn, will be apparent as an opaque white or yellowish line in some part of the fundus: sometimes the usual evidences of retino-choroiditis will present themselves: and in other cases the vitreous humour will be found to have undergone changes consequent upon irritation set up by the presence of the previously existing clot. In such instances ophthalmoscopic examination is often the only means of proving positively that a soldier is not simulating the defect of sight of which he complains.

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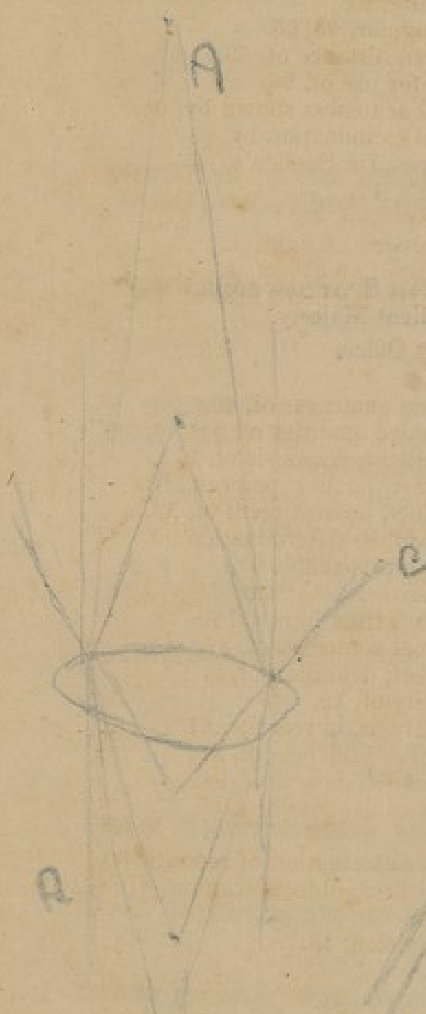
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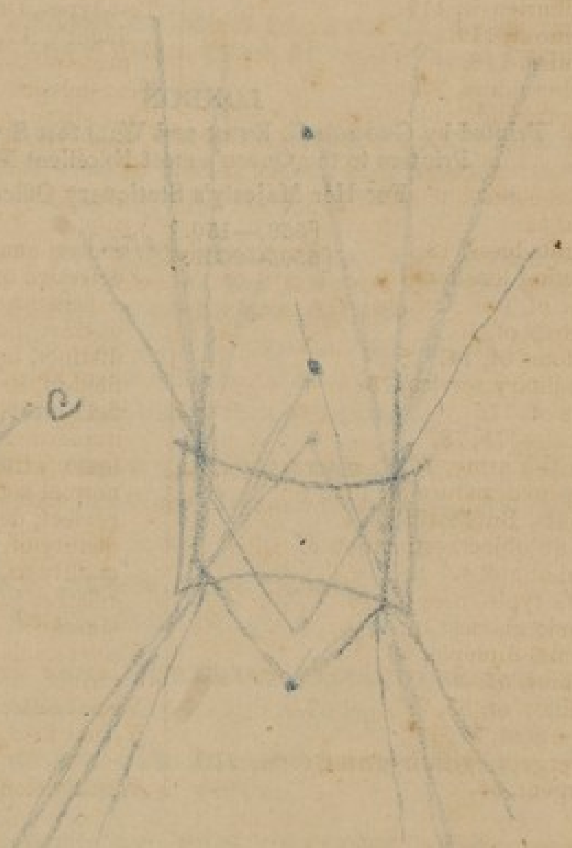

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