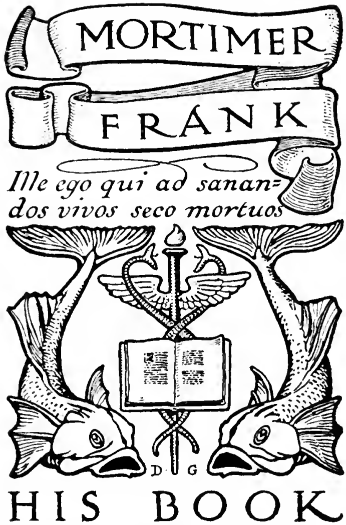
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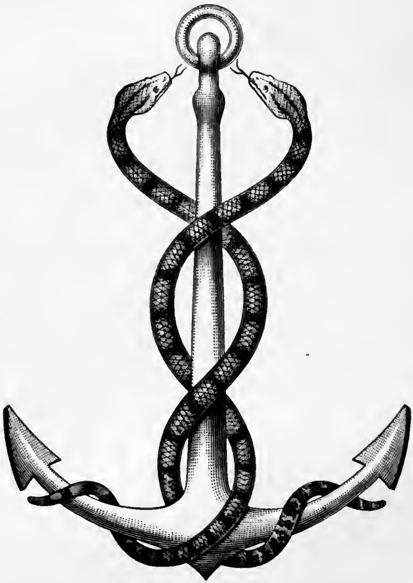

NUNQUAM ALIUD NATURA, ALIUD SAPIENTIA DICIT.

A PRACTICAL GUIDE TO

THE EXAMINATION OF THE EYE

FOR STUDENTS AND JUNIOR PRACTITIONERS

BY

SIMEON SNELL, F.R.C.S.Ed.

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WITH EIGHTY-EIGHT ILLUSTRATIONS

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PREFACE.

My experience with students has taught me that much of the initial difficulty they encounter in the study of ophthalmology, depends on the fact that many of the methods employed for examining eye-patients differ so markedly from those they have become familiar with in the practical work of medicine and surgery. For years, therefore, it has been my habit to deliver a few lectures dealing with the modes of examination to be adopted in the investigation of eye cases. Information on this subject is given in many excellent text-books on diseases of the eye, but is usually arranged in a way that is not easy of reference. In the pages of this volume it has been the writer's object to describe the various methods of examination in such a manner and at such length as to be readily understood by the student. Illustrations have been freely introduced, as being frequently more explicit than mere verbal description.

Some of the photographs from which the illustrations have been prepared were taken by myself, but, for the greater number, I am under obligation, as I have been on other occasions, to Mr. J. H. Bellamy, one of the students of the Sheffield School of Medicine. I am also indebted for permission to use other illustrations to Mr. Berry and Mr. Priestley Smith, as well as to Messrs. John Wright & Co. To Dr. Andrew Walker I am indebted for making drawings for some of the illustrations.

Mr. Sinclair, of Ipswich, has very kindly rendered me great assistance in looking over my manuscript and reading the proof-sheets. From my colleague, Dr. Cocking, and my house surgeon, Mr. Connell, I have also received assistance.

The character of the volume has not permitted such a copious reference as I should have wished to the work of those upon whom I often have drawn in its preparation. I append, therefore, a list of works which have been consulted:—

Fuchs' "Text-Book of Ophthalmology," English Translation by Duane; Swanzy's "Handbook of Diseases of the Eye"; Noyes' "Diseases of the Eye"; Berry's "Diseases of the Eye"; De Schweinitz's "Diseases of the Eye"; Maddox's "Clinical Use of Prisms"; Edgar Browne's "How to use the Ophthalmoscope"; Lang's "Methodical Examination of the Eye"; Oliver's "Ophthalmic Methods employed for the recognition of Nerve Diseases"; Foster's "Physiology."

SIMEON SNELL.

SHEFFIELD,
January, 1898.

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THE EXAMINATION OF THE EYE.

THE EXAMINATION OF THE EYE.

CHAPTER I.

INTRODUCTORY.

To the trained observer a glance at a patient, or a remark from him or a friend, will suffice to indicate the direction in which his inquiry should be turned. It is well for a beginner, however, to recognise at the outset that the examination of eye cases requires care and patience, and, above all, that it should be carried out according to a definite, regular system.

It is essential, moreover, that an examination of the eye should be associated with a consideration of the physical condition of the patient, and, of course, for this purpose a knowledge of the general principles of medicine and surgery is requisite. The eye must not be regarded merely as an isolated organ apart from the body generally, but as one intimately connected with it, and liable to be affected by systemic diseases. Not only have disorders elsewhere an important bearing on the diagnosis and treatment of eye disease, but it is very often the case that an affection of the eyes is the means of revealing disease, the existence of which had previously been unsuspected. For example, an ophthalmoscopic examination in a patient seeking advice for failing sight may detect changes in the fundus, suggesting an analysis of the urine, and thus lead to the recognition of renal disease.

The *diathesis* of the patient will first claim attention. Is he gouty or tuberculous? What part does rheumatism play in the case under examination? Syphilis, in all the stages of the acquired form, has much to do with eye affections. Inherited syphilis, also, has important bearings on the examination of eye patients. A variety of corneal disease is frequently associated with this form of syphilis. It is not difficult to recognise the peculiar *facies* of this type, with sunken nose, ill-developed jaws, and the fine lines of cicatrices on the lips and at the angles of the mouth. The condition of the teeth, also, often confirms the diagnosis of this diathesis. In hereditary syphilis, and frequently when keratitis is present, the permanent upper central incisors will be found to be notched, bevelled at the edges, and imperfectly developed. The teeth in the lower jaw may be similarly affected, but are less often so than those in the upper. The engraving (Fig. 1) is from a young girl suffering from keratitis, and illustrates the kind of teeth to which attention is directed. Neglected dental caries is not an infrequent cause of ocular pains, and in the examination of eye patients it will be well to bear this fact in mind.

Exploration will be facilitated by the use of a dentist's mouth-glass.

The condition of the *nervous system*, spinal and cerebral, has frequently an important relation to eye cases. The examination of the superficial and deep reflexes, together with inquiry into the condition of cerebral function; the absence or presence of headache, its situation and association, or not, with sickness, may roughly be instanced as lines upon which observation will have to be directed. Nor must the gait of the patient, nor the presence of tremors, fail to be noted.

A knowledge of the state of the *heart and vascular system* is likewise of importance in many ocular affections.

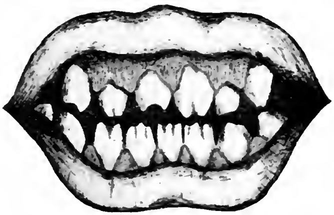


FIG. 1.—Teeth (Hutchinson's) in hereditary syphilis.

The *occupation* of the patient has also to be considered, for in various ways it may act injuriously. Workers in lead, bisulphide of carbon, dinitrobenzol, and other substances, frequently present ocular symptoms as part of a general poisoning of the system. Colliers are subject to nystagmus, owing to the fatigue induced in the ocular elevator muscles by the constrained attitude necessitated by their work. The bright light connected with certain occupations is hurtful, as, for instance, that in electric welding. Workmen are also especially exposed to injury by foreign bodies.

The *habits* of a patient demand inquiry, and his occupation will often afford a clue in this direction. If he be a publican, for instance, an inquiry as to his indulgence in alcohol will be suggested. And, in considering the patient's habits, our chief concern will be with the quantity and kind of alcohol drunk, and the amount and variety of tobacco smoked.

A complete and systematic examination may be pursued in the order sketched in the following table. It has been somewhat altered from de Schweinitz, and has the advantage of bringing in succession before the examiner the various points to which attention should be directed. In many cases some will be unnecessary, and may be passed over. Such a table will enable records of cases to be taken systematically for preservation :—

NAME AND ADDRESS.

AGE.

MARRIED OR SINGLE.

FAMILY HISTORY :—
Health of parents, brothers, sisters, etc.
Ocular histories of the same.
Hereditary tendencies.

PERSONAL HISTORY :—
Children, their number and health ;
Miscarriages ;
Former illnesses ;
Syphilis, gonorrhœa ;
Gout ;
Rheumatism ;
Diphtheria ;
Injuries.

OCCUPATION :—

Its relation to present ailment.

HABITS :—

Mental ;
Tobacco ;
Alcohol ;
Narcotics ;
Sexual.

PRESENT COMPLAINT :—

Date and mode of onset and supposed cause ;
Outline of symptoms and their course.

EYES :—

Right ? Left ? or both affected ;
Inspection of skull and orbits (symmetry and asymmetry) ;
Lids, ciliary borders, and eyelashes ;
Upper and lower cul-de-sacs ;
Puncta lachrymalia, and tear passages ;
Caruncle ;
Conjunctiva ;
Cornea (oblique illumination) ;
Anterior chamber (depth and character of contents) ;
Iris (mobility and colour) ;
Pupil (shape, size, reflexes) ;
Lens ;
Vision ;
Accommodation ;
Balance and parallelism of external eye muscles ;
Mobility of globe ;
Tension ;
Light sense ;
Colour sense ;
Fields of vision ;
Ophthalmoscope.

GENERAL CONDITION :—

Organs of digestion—
Teeth ;
Tongue ;
Stomach ;
Bowels.

Organs of respiration—
- Nose ;
- Throat ;
- Lungs.

Organs of circulation—
- Heart ;
- Arteries and pulse ;
- Veins ;
- Blood.

Abdominal organs—
- Kidneys, examination of urine ;
- Liver ;
- Spleen.

Organs of generation—
- Menses ;
- Leucorrhœa ;
- Uterine disease.

Nervous system—
- Intelligence, memory ;
- Evidence of hysteria ;
- Hallucinations ;
- Sleep ;
- Vertigo ;
- Gait ;
- Superficial and deep reflexes ;
- Paralysis ;
- Tremor ;
- Convulsions ;
- Headache and its position.

CHAPTER II.

EXTERNAL EXAMINATION OF THE EYE.

Before proceeding to the examination of the eye itself, it is well to notice the general appearance of the forehead, eyebrows, and face. The two sides admit of ready comparison; and at this stage, as well as throughout the whole examination of the eye, any difference of development detected should be noted.

Eyelids.

Position and motility.—The position and motility of the eyelids will need observation. It should be noted whether they can be closed normally, or, on the other hand, whether the upper eyelid droops, and if there is any inability to raise it properly. The long axis of the palpebral fissure should be almost horizontal. Any alteration in the length and height of the fissure should be noted, and it will sometimes be desirable to take the measurements and compare them with those of the opposite side. Any adhesions between the eyelids and the eyeball should also be noted.

Swelling.—The eyelids may exhibit redness and swelling, which may be either general or localised.

If the eyelids show a general swelling, they should be gently palpated with the forefingers. This will enable the observer to distinguish between swelling due to œdema and that resulting from emphysema of the eyelid, in which latter condition a peculiar and characteristic crepitation is felt by the finger. Localised swelling occurs either as a painful abscess (stye) at the edge of the lid affecting the follicle of an eyelash, or as a rounded tumour in connection with a plugged Meibomian gland causing a hard swelling in the lid. Eczema may affect the skin of the eyelids, and yellowish patches (xanthelasma) may occasionally be observed. The possibility of an ulceration of the eyelid being a syphilitic chancre must be borne in mind, and whether or not the pre-auricular gland is indurated, is important in this connection, and should be ascertained. A malignant form of ulcer (rodent ulcer) is prone to be situated in the neighbourhood of the inner canthus. The margin of the eyelid is often the seat of small pustules or ulcerations at the roots of the eyelashes (tinea tarsi).

Edges of the eyelids.—The position of the edges of the eyelids should be noted. An eyelid may be inverted (entropion), and occasion, in like manner to displaced cilia, irritation and inflammation of the ocular surface. Or an eyelid may be everted (ectropion), and the eyeball, as a consequence, be more or less exposed. The inner surface of the eyelid will then be visible in proportion to the extent of the ectropion, and the exposed conjunctiva will be correspondingly inflamed and thickened. Such a condition is represented in the illustration (Fig. 2). In this case, eversion of the eyelid resulted from cicatricial contraction after suppuration in the eyebrow and forehead.

Eyelashes.—A faulty position of the cilia may be the cause of much trouble. Examine the edge of each eyelid carefully. Note if any eyelashes are turned inwards and rub against the surface of the globe. The position of the cilia, if not readily evident, will be made more so by drawing the eyelid away from the eyeball. Short transparent hairs easily escape observation. Their detection is rendered more certain by using a magnifying glass. A cone of light focused on the ciliary edge, by the method of focal illumination to be presently described (p. 16), will be an additional help. It should be further ascertained whether the ingrowing eyelashes are merely wrongly directed (trichiasis), or whether they form a new and misplaced row of cilia (distichiasis).

FIG. 2.—Ectropion of upper eyelid.

Inner surface of the eyelids.—The inside of the eyelids next demands attention. Inspection of the conjunctival surface of the lower eyelid is readily attained by telling the patient to look upwards, while, at the same time, the observer draws down the eyelid by means of the thumb placed over the malar bone. In this way the inner surface of the lower eyelid is exposed to view (Fig. 3), and examination is permitted of the conjunctiva lining the lid, the retrotarsal fold, and the lower ocular surface.

FIG. 3.—Examining inner surface of lower eyelid.

A view of the inner surface of the upper eyelid may be required in order to search for a foreign body (this being a favourite position for particles of all kinds); to ascertain the existence of trachoma and other diseased conditions; or to apply remedies. It is not so easy, however, to evert the upper eyelid satisfactorily, as has been shown to be the case with the lower lid. More skill and practice are required. Two methods of effecting it may be described.

FIG. 4.—Everting upper eyelid, to examine the inner surface.

1. The patient should be directed to look downwards, and, with a probe held in his right hand, the examiner makes slight pressure on the outer surface of the lid, above the upper edge of the cartilage, and, using the probe as a fulcrum, the eyelashes, towards the centre of the lid, are seized with the thumb and index finger of his left hand (Fig. 4), and the

eyelid is slightly drawn down and then turned up over the probe.

2. The probe is replaced by one or two fingers of the examiner's hand, whilst the thumb is slipped under the projecting eyelid, which is then turned over the fingers, which act as a fulcrum. This method is more difficult to accomplish than the first mentioned, and is most readily performed upon people with lax eyelids.

Fig. 5.—The inner surface of upper eyelid after eversion, fixed for examination.

After everting the upper lid by either of these plans, the inner surface may be kept exposed as long as desired by supporting it with the thumb, as shown in Fig. 5.

Eversion of the upper eyelid not only displays for inspection its inner surface, but, by causing the patient to look strongly downwards, the retrotarsal fold may to some extent be rendered visible, especially if the edge formed by the everted eyelid be lifted forwards with a probe or retractor. If cocaine be instilled, the fold can be gently drawn downwards with forceps. These points are mentioned because this fold of conjunctiva is especially liable to be the seat of granulations, and is prone to harbour minute, but often very troublesome, foreign bodies. The search for, and removal of, these latter may be sometimes facilitated by passing the bend of a clean hairpin well up into the cul-de-sac, either with or without everting the eyelid, and sweeping it along the retrotarsal fold. Another plan is to wash out the cul-de-sac with a gentle current of water from a syringe introduced underneath the upper eyelid.

It should be mentioned that, if the lachrymal gland be enlarged, it may be felt beneath the outer part of the upper eyelid. It is possible, also, in some cases, to render the lower lobe of the gland visible by drawing the lid upwards and outwards by means of the thumb placed above the outer canthus. The patient should, at the same time, look downwards.

Tear Passages.

Swelling over the lachrymal sac indicates obstruction in some part of the tear passages, and pressure exerted on the sac will frequently cause regurgitation of mucus or pus through the puncta. Should there be any doubt as to the patency of the lachrymal apparatus, assistance may be derived by ascertaining whether water, passed into the punctum by a fine syringe, finds its way into the nose. Or a drop of a 2 per cent. solution of fluorescin may be placed in the conjunctival sac. It will very soon find its way into the nose if the tear passages are open, and the stain will be evident on blowing the nose with a handkerchief.

It is necessary, also, to observe the position of the puncta, and to ascertain whether they lie against the surface of the globe or are everted, and whether they are patent or closed. An eyelash has occasionally been found to have been carried into a punctum, and its projecting end has, until removed, been a mysterious source of irritation.

The puncta in both upper and lower eyelids should be examined. If the patency of a punctum is not readily made out, the aid of a magnifying glass may be sought, and a small probe, passed into the punctum, will show whether, in a case of epiphora, the stricture be in the canaliculus or beyond it. The examination of a case of lachrymal obstruction would not be complete without an inspection of the nares.

CONJUNCTIVA.

The ocular conjunctiva should be transparent, with only a few small vessels distinguishable in it, so that it allows the white underlying sclerotic to be seen. The surface of the eyeball is often congested ("blood-shot"), and the varieties of congestion may be thus classified :—

Varieties of ocular congestion.—1. A network of superficial vessels least dense just around the cornea, giving a bright brick-red colour, moving freely over the subjacent sclerotic, and readily emptied by slight pressure exerted through the lower eyelid. This variety is met with in affections which are purely conjunctival.

2. A zone of pink congestion, which is most intense just around the cornea, which does not move with the conjunctiva, and is unaffected by pressure.

This form indicates inflammation of the cornea, iris, or ciliary body.

3. A peculiar, dusky congestion, formed of tortuous, deep-lying veins, is met with in glaucoma, and in cases where there has been a long-standing increase in the intraocular tension.

4. Congestion which takes the form of isolated narrow bands of a bright red colour, points usually to disease of the phlyctenular type.

Sclerotic.

The colour of the sclerotic should be uniformly white; in children it has frequently a bluish tint, and in old age it becomes yellowish white. Its curve should be noted, as well as the presence of patches of discoloration or localised bulgings (staphyloma).

In doubtful cases of ciliary protrusion, the presence or absence of an opaque body, such as a tumour, may be determined by directing a small cone of light from a powerful convex lens (*vide* focal illumination, p. 16) upon the suspicious part, the remainder of the globe being in the shadow. Should a tumour be present, the interior of the eye cannot be illuminated; but if the protrusion be staphylomatous, the membranes are thinned, and the rays of light pass freely into the interior of the globe (Mules).

Cornea.

The cornea should be bright and transparent. Its appearance may be altered by the presence of superficial opacities (nebulæ), or of denser opacities involving its substance (leucomata); by the covering of its surface with vessels (pannus); by ulceration; by interstitial inflammation, giving it the appearance of ground glass; by a deposit of pus between the corneal layers (onyx); or by foreign bodies. Vascularisation at the upper part of the cornea should at

FIG. 6.—Examining the cornea by focal illumination.

once suggest everting the upper lid and inspecting its inner surface for granulations.

METHODS OF EXAMINING THE CORNEA.

Examination of the cornea may be made in the following ways:—

1. Place the patient in front of a window with good light, and, as the eye follows the movements

of the finger, opacities will be noticed. The outline of the window, which is seen reflected in miniature upon the cornea, should also be watched. If any abrasion or irregularity of the corneal surface be present, the outline will become distorted.

2. A better method is that of focal or oblique illumination (Fig. 6). This is effected by focusing the

FIG. 7.—Examining the cornea by focal illumination, with addition of magnifying glass.

light from a flame on the cornea by means of a lens of 2 or 3 in. focus. The lens should be held between the thumb and index finger in such a position that the apex of the cone of light can be directed to any part of the cornea which it is desired to examine. The anterior chamber, the iris, lens, and anterior portion of the vitreous can also be explored by focal illumination. To examine the cornea, the cone of light should be thrown at an acute angle, but for the deeper parts, it should be cast more perpendicularly.

The examination may be made more complete by using a magnifying glass to inspect the cornea at the same time that a cone of light is concentrated upon it (Fig. 7). A thorough inspection is facilitated by conducting the examination in a darkened room. Diffused daylight may be employed, but not direct sunlight.

3. Priestley Smith's candle lamp (Fig. 8) may be employed by using the stronger lens to focus a beam of light on the cornea.

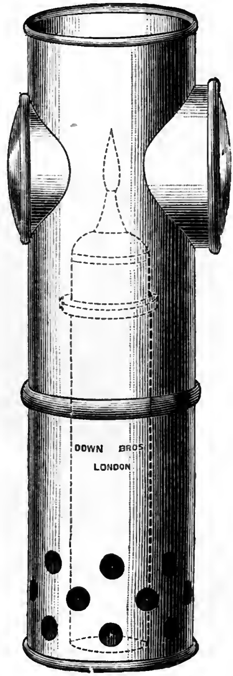


Fig. 8.—Candle lamp (Priestley Smith's).

4. A concave mirror of short focus is a convenient means of concentrating light upon the cornea. Artificial or diffused daylight (Priestley Smith) may be utilised.

5. The transparency of the cornea can also be inspected by throwing upon it the light from a mirror; an ophthalmoscope mirror answers the purpose, but a plane mirror perhaps is preferable.

6. If Placido's disc (p. 108) be used, nebulæ will occasion distortion of the rings on that part of the cornea where they are situated.

The use of fluorescin.—Ulceration or abrasion of the corneal surface, if small, may be difficult to detect. It will be rendered more evident by instilling a drop of fluorescin into the conjunctival sac. A 2 per cent. solution of the potassium or sodium salt is employed, and any excess should be washed away with distilled water. If the corneal epithelium be wanting in any part, the area so denuded, however minute, is stained a bright green by the fluorescin solution, while the intact surface is unaffected. Abraded areas on the conjunctiva are stained a yellowish tint.

FIG. 9.—Reflection of Placido's disc on normal cornea (enlarged).

Examination of conical cornea.—The curve of the cornea should be noted. Conical cornea, if well marked, shows itself in daylight by the brilliancy of the reflex from the cornea. View the case in profile, and the centre of the cone looks dark, as if a drop of water were resting on the cornea. The retinoscopy mirror (p. 98) will give shadows, which "come and go, and may assume a vortex-like shape as the condition varies in extent" (Noyes). Placido's disc (p. 108) gives characteristic indications (Figs. 9, 10, and 11). At the centre of the cone the rings appear smaller and crowded together, whilst at the sides of the cone they are distorted, the figure being somewhat oyster-shaped, the narrow end being towards the apex. The disc of radiated lines (p. 19), suggested by the author, shows, also, characteristic distortions. The figures (Figs. 12, 13) represent the normal appearance of the image on the cornea, and the distortions displayed in a case of conical cornea.

FIGS. 10, 11.—Distorted reflections of Placido's disc in a case of conical cornea (enlarged).

Measurement of the cornea.—The cornea may be measured by Priestley Smith's keratometer (Fig. 14).

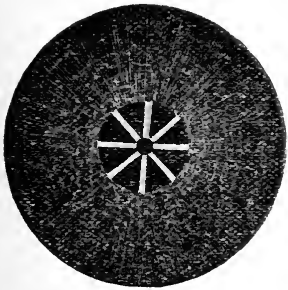


FIG. 12.—Reflection from author's disc of radiating lines on normal cornea (enlarged).

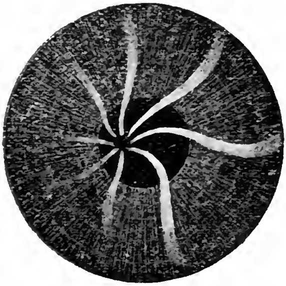


FIG. 13.—Distorted reflections in a case of conical cornea (enlarged).

It consists of a millimetre scale placed between two plano-convex lenses, in the form of an eyeglass having a focal length of 10 in. It should be held

10 in. from the observer, and about 1 in. from the patient's eye, or nearer if convenient. The margin of the cornea not being a perfectly sharp line, its position cannot be determined to a small fraction of a millimetre. It is sufficient to note the nearest half millimetre—thus, 11, 11.5, 12, etc. The horizontal diameter is measured. A string may be attached to the keratometer to indicate readily the distance at which the observer is to hold it. The average diameter is about 11.5 mm. The keratometer also serves usefully as a means of measuring the size of the pupil (p. 27).

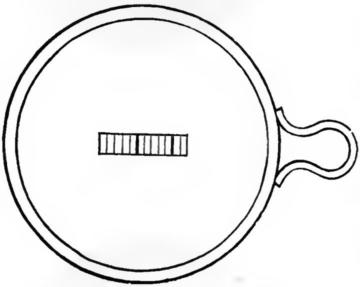


FIG. 14.—Priestley Smith's keratometer.

A rough method of measuring the cornea is to hold a rule or steel tape measure as near to the eye as possible, and read off the width on the scale.

Corneal sensitiveness.—The sensitiveness of the cornea is lessened in glaucoma. It is abolished in some affections of the fifth nerve, and by the application of cocaine, etc. Corneal anæsthesia can be ascertained by touching the cornea with a piece of thread or soft blotting-paper. A small roll of cotton wool may be used. Care must be taken to touch the cornea only, and to avoid the eyelashes or eyelids. Anything hard or pointed should not be employed.

Blepharospasm.—The examination of the eye, which has up to now been described, presupposes that the patient under inspection is willing and able to open his eyes, and thus facilitate the observer's work. Frequently, especially in children, an inability to open the eyes is present, and this spasmodic closure of the eyelids renders an inspection of the surface of the globe more difficult. Cocaine may be instilled, and in some cases it will enable the patient

FIG. 15.—Mode of examining the ocular surface in a child who is unable or unwilling to open its eyes.

to open the eyes sufficiently to permit of an examination. In other cases, the additional measures to be now mentioned will have to be adopted. The examiner should sit in a chair (Fig. 15), cover his lap with a towel, and fix the head of the child gently but firmly between his knees, whilst the parent or nurse, sitting opposite, secures the legs and arms. An adult may be examined sitting, or even standing, but in many cases a more careful examination can be made if he be lying on a couch, the surgeon standing behind him.

1. The eye may be exposed by raising the upper lid with one or two fingers, taking care to keep to the curve of the eyeball, and thus prevent eversion of the eyelid. At the same time, the lower lid is drawn downwards with the other hand.

2. By inserting a retractor under the upper eyelid and drawing it upwards. The retractor depicted (Fig. 16) is a suitable one. It is convenient for carrying, and has the advantage of having two ends of different sizes.

FIG. 16.—Eyelid retractor.

3. The means already mentioned will be usually sufficient to allow of the eyeball being properly examined. It may, however, be found necessary to put the patient under the influence of a general anæsthetic in order to make a complete inspection. Advantage should be taken of the narcosis to apply any remedy thought desirable. It has been considered by some that the induction of narcosis alone exerts beneficial effects on the morbid condition. The introduction of cocaine into ophthalmic practice has, however, greatly reduced the necessity for an anæsthetic in these, as in other cases.

ANTERIOR CHAMBER.

Examination of the anterior chamber is best made by means of focal illumination (p. 16), if inspection in good daylight has not afforded the required information. The depth of the chamber should be noted; it is shallow, for instance, in glaucoma, and often deep when the crystalline lens is absent. The aqueous fluid may be turbid, owing to the presence of lymph, pus, or blood, which have a tendency to gravitate, forming a layer, flat along the top, at the lower

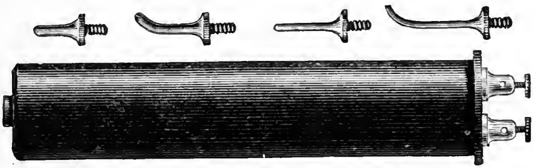


FIG. 17.—Electro-magnet (Snell's—half-size).

part of the chamber. This feature constitutes a distinguishing mark between pus in the anterior chamber (hypopyon), and pus between the layers of the cornea (onyx), in which the upper margin of the deposit, instead of being horizontal, is crescentic or irregular in outline.

Foreign bodies in the anterior chamber.—Foreign bodies may be situated in the chamber, or on the surface of the iris. The history and the appearance of the foreign body will often give a clue as to its nature. Uncertainty as to its being a fragment of steel or iron may often be set at rest by bringing an electro-magnet (Fig. 17) in contact with, or in close proximity to, the corneal surface. In many cases, should the foreign body be of the nature suspected, it will spring forward towards the back of the cornea, and follow the movements of the magnet. The use of the magnet in such a case will not only decide whether or not the fragment be steel or iron, but will often enable the surgeon to so move the foreign body about, that, on withdrawing the magnet, it can be left in the situation most favourable for its extraction.

Another means for ascertaining the nature of a foreign body is the magnetic needle. Ordinary sewing needles, if magnetised, will answer the purpose, and when held suspended by a fine silk fibre in front of the cornea, deflection of the needle would indicate that the foreign body was either steel or iron. I have used, instead of sewing needles, a finely made magnet, like the needle of a compass, with a tiny hook in the middle for the attachment of a thread. This method is not always reliable in its results, and is apt to be interfered with by extraneous influences. I have, however, met in some instances with encouraging results, especially when the fragment was steel, and could itself be rendered magnetic by passing a galvanic current through the eye.

It may be mentioned here, that in the case of an iron or steel chip embedded in the substance of the iris, an electro-magnet, held near the cornea, will either draw the foreign body into the anterior chamber, or cause a localised forward bulging of the iris, and so reveal the exact position of the fragment.

Iris.

Should the cornea be transparent, and the aqueous be clear, a view of the iris and the pupil is obtainable. The colour of the iris, and the size and motility of the pupil should be noted. Slight differences of tint in the two eyes are not uncommon, but more rarely the colour of the two eyes is totally different. In noting the colour of the iris, or the size of the pupil, the comparison of the two sides is important. The iris may be discoloured by iritis, in which a normally blue eye becomes greenish. Iritis, again, renders the stroma and fibrillation of the iris indistinct, and may block the pupil with lymph. A gumma on the iris may be noticed as a rounded yellowish-brown elevation. All these points will be examined better, and be made more distinct, by using focal illumination in the manner already described (p. 16).

Tremulous iris.—Mention should be made of the condition known as "tremulous iris," in which the iris oscillates and trembles with every movement of the globe. It indicates a want of support, such as would be occasioned, for instance, by displacement or absence of the lens.

The Pupil.

The pupil is rendered inactive or sluggish by iritis, and the pupillary outline may be irregular, as the result of adhesions, by which the iris is fixed at places to the anterior lens capsule. These are called posterior synechiæ. To render these adhesions evident, or to cause them to break down, it is necessary to expand the pupil by the instillation of a solution of sulphate of atropine. The strength of the solution required is that of the Pharmacopœia, namely, 4 grs. to the oz. The dilatation caused by the atropine will be irregular if iritis is, or has been, present (Fig. 18), because the pupil responds to the mydriatic at some points, whilst it remains fixed by adhesions at others. In cases where the iritis is recent, it may be observed that adhesions have been broken down by

FIG. 18.—Adhesions of the pupil.

FIG. 19.—Pigment deposit on lens capsule.

the atropine, and that little dots of uveal pigment have been left on the surface of the lens capsule (Fig. 19). The pupil may, on the other hand, be so bound down by adhesions that no dilatation results from the instillation of atropine. This condition is called "exclusion of the pupil," and is distinguished from that in which the pupil is filled with opaque inflammatory matter, and to which the name "occlusion of the pupil" is given.

In contradistinction to the posterior synechiæ just mentioned, we meet with anterior synechiæ, which are adhesions of the iris to the cornea. These result either from wounds of the cornea or from ulcers which have perforated and drawn the iris into the aperture thus occasioned.

Measurement of pupil.—The size of the pupil may be estimated by a pupilometer, of which there are many varieties.

A convenient form, which at the same time serves as a strabometer, is here depicted (Fig. 20). It is made of aluminium, and is similarly marked on each surface. It is a modification of Mr. Edgar Browne's rule and pupilometer.

Hold the pupilometer by the side of the eye, and

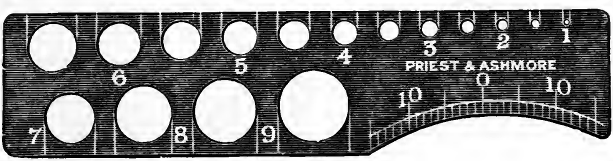


FIG. 20.—Pupilometer.

read off the size of the pupil on the gauge. The patient should face a window or other source of diffused daylight; he should be tested with both eyes open, and also with one shaded; and when looking at a distance, as well as when gazing at a point about 30 cms. from his eye.

The pupil will be found to be larger in children than in old people—larger in myopia than in hypermetropia. It is dilated by certain drugs (mydriatics), and contracted by others (myotics). Myosis may be associated with spinal and cerebral affections, and so may mydriasis. The action of mydriatics is diminished in spinal myosis, and that of myotics in spinal mydriasis. The pupil is often large in amblyopia and amaurosis.

Hippus.—Hippus, or "nystagmus of the pupil," is characterised by successive contractions and dilatations of the pupil without alteration of illumination—the rapidity and extent of the oscillations vary considerably. It is a rare condition. "It is observed in recovering paralysis of the motor oculi, and is then associated with nystagmus. It is much rarer as an independent condition, and is then found almost always in diseases, such as tabes, multiple sclerosis, etc., in which there are frequent lesions in the region of the nuclei of the ocular muscles" (Knies).

The light reflex.—The light reflex may be tested in the following ways:—

1. Place the patient in front of a window,—shading both eyes,—uncover one and watch for contractions, or, on uncovering both, observe the pupil of one eye.

2. If the action is uncertain, take the patient into the dark room, and watch the pupillary reaction, when the light is concentrated on the pupil, by means of a strong convex lens, or by the ophthalmoscopic mirror.

The accommodation reflex, or more correctly, reaction with convergence, is ascertained by covering one eye, and directing the patient with the other to look into the distance, and then at a finger or other object held close to the eye, when contraction of the pupil will be observed.

In the "Argyll Robertson pupil," a valuable sign in certain cases of spinal disease, the reflex to light is feeble or absent, while the reaction on convergence (or accommodation) is retained.

Convergence reflex.—This is an associated reflex, for, when both eyes are directed to a near point, such as a pencil or finger held in the median line, both pupils will be observed to contract.

Skin reflex.—Cutaneous irritation will cause the pupil to dilate, being a sympathetic reflex. Pinching the skin at the back of the neck will cause it.

Hemianopic iris inaction (Wernicke).—This test is of significance, as indicating the position of a lesion causing hemianopsia (p. 124). If a beam of light cast on the blind half of the retina does not occasion contraction of the pupil, the lesion is anterior to the corpora quadrigemina, *i.e.* at the chiasma, or in the optic tract; but if reaction of the pupil ensues, it is posterior to the corpora quadrigemina.

The test, to be successful, requires care. Many plans have been suggested. A practical method is the following:—The patient should be placed in the ordinary ophthalmoscopic position, except that the lamp must be so placed that the rays will come over his head. The eyes should be tried separately — the eye not under examination should be excluded from all rays of light entering it. "The observer, standing in front of the patient, is to faintly illuminate the iris that he wishes to study by means of a piece of plane looking-glass, such as is employed in the fundus-reflex test. This can be done by some permanent arrangement of mirror, or by holding a glass in the hand. An ordinary concave ophthalmoscopic mirror is to be held in the other hand, and a narrow beam of concentrated light is to be thrown upon the pupil from the periphery of the blind area of the field of vision. This beam is then slowly moved in towards the position of the line of fixation. If the sign be present, there will not be any iris movement until the edge of the retained field area has been reached. At this point an immediate pupillary contraction will take place. This contraction will persist as long as the light stimulus is kept within the persistent field area" (Oliver).

The same hemianopic pupil inaction (Knies' pupil symptom) is found, in some instances, where there is no hemianopic field defect, and then indicates localised disturbance in the pupillary reflex-path, between the third nerve nucleus of one side and its related tract (Oliver).

Pupillary contraction associated with action of the orbicularis is observed (Gifford) when forcible effort is made to close the lids. If the eyelids are held apart by the observer, and the patient is desired to shut the eyes tightly, the pupils, if the eyes are not rolled up too sharply, will be seen to contract sometimes very markedly. This is best observed in the dark room with just sufficient light coming from one side to allow of the pupillary changes being seen. The reaction is said to be of use in determining whether the pupil sphincter is paralysed where the ordinary tests fail.

LENS.

Opacities of the lens may be detected by means of focal illumination, or by the ophthalmoscopic mirror (p. 47). To reflected light striæ in the lens look greyish (Fig. 21), but to transmitted light they appear black (Fig. 22). It is often necessary, in order to examine the lens carefully, to dilate the pupil with atropine. A weak solution only should be used, or some other mydriatic, such as hom-

FIG. 21.—Striæ in lens, as appearing with reflected light.

FIG. 22.—Striæ in lens, as appearing with transmitted light.

FIG. 23.—Zonular cataract.

To illustrate opacities of the lens.

atropine, or mydrine, the action of which is more transient, may be substituted. Cocaine will often suffice. It is, however, frequently possible to avoid the use of a mydriatic, by directing the patient to look strongly upwards, downwards, etc., while the examiner uses the ophthalmoscopic mirror. By this means, a little practice and care will enable one to inspect the whole of the lens even to its periphery.

Foreign bodies are occasionally located in the lens. For their examination and detection focal illumination is required. Their presence may be concealed by the opacity of the lens substance, which their entrance has occasioned. It is necessary not to mistake the glistening appearance sometimes presented by opaque lens sectors for a foreign body. Focal examination will often detect the fine mark left in the lens capsule by the passage of a foreign body.

VITREOUS.

For the anterior part of the vitreous valuable help is gained by using focal illumination, but, practically speaking, the inspection of the interior of the eyeball behind the lens calls for the use of the ophthalmoscope (p. 49).

For the detection of foreign bodies in the vitreous, photography by means of Röntgen's X-rays has been used in a few cases. The difficulties in the case of the eye, surrounded as it is by bony walls, are very great, and have not hitherto been altogether overcome.

ORBIT.

An examination of the exterior of the eye would be incomplete without a consideration of the orbit.

Position of the eyeball.—First, as to the position of the globe. The eyeball may be either too prominent, or too sunken. The latter condition (enophthalmos), except when it occurs in old people from absorption of orbital fat, is very rare. It results from injury, and is most frequently unilateral. It gives the patient very much the appearance of using an artificial eye. The amount of the depression can be measured in this way: place a sheet of paper or a ruler edgeways between the angle of the mouth and the eyebrow; then measure the distance between the edge of the paper and the cornea, and compare it with the measurement on the other side. Protrusion of the eyeball (proptosis; exophthalmos) may be bilateral or unilateral. High degrees of exophthalmos at once attract attention, but when the protrusion is small, it can often only be detected with certainty when it is unilateral. The examiner will derive assistance from a profile view and a comparison of the two sides, and he may observe the relative positions of the cornea to each other, and to the line of the brows. The proptosis of Graves' disease, which is generally bilateral, is associated with other symptoms claiming attention here. Among these are widening of the palpebral fissure, and a lagging of the upper eyelid, which allows a rim of sclerotic to be seen above the cornea when the patient is directed to look downwards. This can often be best observed when the patient is lying down. Exophthalmos may be associated with other conditions, such as inflammation, tumour, aneurism, or foreign body in the orbit, and then it will frequently be unilateral. The presence of a tumour or other swelling in the orbit will reveal itself to the touch, if it be of any size and not confined to the cone of the orbit. Careful palpation with the finger, introduced beneath the upper orbital ridge, will then detect a tumour growing from the roof, or from the outer or inner wall of the orbit. The lower margin may be similarly explored. In the case of orbital aneurisms pulsation may be felt, and auscultation by means of the stethoscope, or through a towel, will frequently make audible a peculiar bruit, not only at the orbital aperture, but over a more or less extensive area of the skull. Note also any limitations to the movements of the globe. The conditions which cause proptosis also often interfere with the motility of the eyeball. Moreover, as tumours may originate outside, as well as inside, the orbit, and may involve that cavity by extension of the disease, the neighbouring structures should receive careful examination. The frontal sinus, the antrum of Highmore, and the nares should be explored.

In this connection it may be observed that transillumination has recently been suggested, and it is asserted that, if properly carried out, a configuration of the bony cavities can be made out, and the eyeballs rendered partially translucent. An electric lamp of five or ten candle power is carried far back and up into the nasal fossa, and then rendered incandescent.

Tension of the eyeball.—The manner in which the coats of the eyeball yield to pressure affords most valuable information in diagnosis. Increased tension is synonymous with glaucoma, whilst lessened degrees of tension are frequently associated with degenerative processes. Instruments, called tonometers, have been devised for registering the tension of the globe. None of these have, however, as yet proved of clinical value, and the estimation of the tension of the eyeball is effected by the surgeon's finger. Practice, and a cultivation of the *tactus eruditus* are required to attain proficiency in appreciating variations in tension.

Direct the patient to look downwards and to close the eyelids gently without effort, and then place the middle and ring fingers of each hand on the patient's forehead. This will steady the hands whilst the fore-fingers are feeling the tension, which is done by fixing the eyeball through the closed upper lid with one

FIG. 24.—Examining the tension of the eyeball.

finger, whilst the other ascertains whether or not the globe dimples to pressure made upon it (Fig. 24).

Bowman's divisions of the degrees of tension are still adopted. In addition to normal tension (Tn) there are four degrees of *plus*, and four degrees of *minus* tension. They are commonly expressed in the following manner:—

Tn = normal tension;
T + ? = uncertain increase;
T + 1 = a perceptible increase in hardness;
T + 2 = markedly hard and dimples but little;
T + 3 = stony hardness.

The degrees of lessened tension are represented thus:—

T–?; T–1; T–2; T–3.

The eyes of different persons vary somewhat in tension without any pathological import. But it may be recollected that frequently only one eye is affected and the other remains for comparison, or, if both be diseased, it may be in different degrees.

Increased tension is associated with glaucoma. A difference in tension may also be the distinguishing feature between a simple detached retina and an intraocular neoplasm; the tension in the former is, as a rule, *minus*, and in the latter often *plus*.

CHAPTER III.

MYDRIATICS AND MYOTICS.

MYDRIATICS.

CERTAIN drugs, when brought into contact with the surface of the eyeball, are absorbed, and occasion dilatation of the pupil. Most of them, also, cause paralysis of the ciliary muscle. These drugs are called mydriatics. They are largely employed in ophthalmic cases, but it is here only necessary to direct attention to their use in the examination of eye patients. They may be required for two reasons. First, for their dilating action on the pupil alone; and, secondly, in refraction cases, for their effect on the ciliary muscle.

The best known mydriatics are atropine, homatropine, cocaine, duboisine, hyoscine, daturine, and scopolamine. Mydrine is a new mydriatic, to which attention will again be directed; up to the present it has been little used. Scopolamine has of late been employed a good deal. Daturine is obsolete; and the same may be said of duboisine, which was so apt to cause toxic symptoms, sometimes of a very alarming nature, that it has ceased to find much employment in ophthalmic surgery. Hyoscine, also a very active and powerful drug, has, for similar reasons, been abandoned in practice. Cocaine differs from other mydriatics, in that its action on the accommodation is very slight. Moreover, the mydriasis it produces is unlike that occasioned by atropine and the others, for, under the influence of a general anæsthetic, it is observed to disappear, while, as recovery from the anæsthetic takes place, the pupil again becomes dilated. This fact was pointed out by me just after the introduction of cocaine as a local anæsthetic in ophthalmic surgery. Added, however, to other mydriatics, cocaine increases their effect both on the pupil and on the ciliary muscle.

All these drugs may be employed either as solutions in distilled water; or in the form of gelatine discs containing definite quantities of the alkaloid; or dissolved in olive oil, castor oil, or vaseline. It has been claimed that the use of these oily media yields better and more constant results, because they retain the drug longer in contact with the eyeball. Oily solutions are, however, uncleanly in practice, and, when used preparatory to testing refraction by the shadow test, the greasy smearing of the cornea which they produce becomes a disagreeable drawback.

The employment of mydriatics.—We may now discuss the purposes for which mydriatics at present claim our attention.

1. *In iritis.*—In cases of suspected iritis the use of a mydriatic is often desirable to render evident the presence of adhesions of the iris to the lens capsule (p. 25). Atropine, in the form of the sulphate, is most generally employed for this purpose, and the

strength required is 4 grs. to the ounce, though a solution half as strong, if used several times in succession, will often suffice for diagnostic purposes. Cocaine, added to the atropine, increases the effect of the latter, and a 1 per cent. solution is strong enough. Scopolamine is at present vaunted a good deal for its efficacy in freeing iritic adhesions.

2. *For ophthalmoscopic examination.*—It is often necessary, for the complete examination of the interior of the eye, to have the pupil dilated, and thus mydriasis is frequently required for ophthalmoscopic examination, and for ascertaining the condition of the crystalline lens and the vitreous humour. For these purposes it is desirable to employ a mydriatic which acts as little as possible on the ciliary muscle, and the effects of which pass off quickly. Atropine has the disadvantage, even in a weak solution, of affecting the accommodation, and, besides this, its effects last for a long time. If, therefore, it is employed for the purposes just indicated, the solution should be weak, 1 gr. to the ounce, for instance. A solution even as weak as 1 gr. to 8 oz. of water, though much slower in acting, occasions sufficient dilatation of the pupil for ophthalmoscopic examination, and the effects pass off more quickly. Cocaine, of a strength of 2 per cent., is useful, but the mydriasis produced by it persists for twenty-four hours or more. Either atropine or cocaine will dilate the pupil sufficiently in from twenty minutes to half an hour.

My own practice has been to employ either homatropine, or a weak solution of atropine, and, less frequently, cocaine alone. A new mydriatic, called ephedrine, is asserted to occasion mydriasis, which remains at its maximum for half an hour and then subsides, disappearing in two hours after the first use of the drug. Combined with 1 per cent. of homatropine the effect is increased, but the return to the normal state is a little delayed. The following formula gives the proportion in which they are used:—Ephedrine hydrochlor., 1.00; homatropine hydrochlor., 0.01; aq. dist., 10.00.[1] This combination is manufactured by Merck under the name of mydrin. The ephedrin-homatropine solution does not influence the accommodation in the least, and, though the mydriatic action is quite rapid and powerful, still the pupil never entirely fails to react to light. After a single application of this combined solution to the eye, the pupil begins to dilate, on an average, within about eight minutes and a half (varying from six to thirteen minutes), and attains its maximum dilatation within about half an hour, the average being thirty-four minutes (varying from twenty-three to forty minutes). Within an hour after the application the pupil slowly begins to contract, and, after the lapse of from four to six hours, has again attained its normal size. The greatest dilatation continues for about half an hour, varying from fifteen to forty-five minutes, the average being twenty-nine minutes. At the maximum dilatation the pupillary diameter measures from 5 mm. to 6 mm. (average, 4.5 to 7 mm.), which is sufficiently large for diagnostic

[1] George F. Suker, M.D., *New York Medical Journal*, 8th June 1895.

purposes. My experience with mydrin is, up to the present, a favourable one.

3. *In testing refraction.*—In testing refraction it is necessary that the drug employed should exercise a temporarily paralysing effect upon the ciliary muscle, in order to reveal the actual refraction apart from any influence of the accommodation. Atropine answers this purpose well. If a 4 gr. solution of the sulphate be dropped into the eye, the pupil will become dilated in from twenty minutes to half an hour, but it will take about two hours for the ciliary muscle to be completely paralysed. The minimum time, therefore, to allow for the action of atropine in a refraction case is two hours; but it is seldom that such a period is sufficient, and particularly is this true in the case of children. It may be deemed as essential that the application of atropine should, as a rule, be repeated several times. My custom with children is to prescribe the use of the drug twice daily for two days, the last instillation on the second day being more than two hours before the time fixed for the examination. In cases, also, where spasm of the ciliary muscle is present, it is often necessary to continue the use of the atropine for days, or even weeks. The great disadvantage of atropine, however, is the slowness with which its effects pass off. Its action on the ciliary muscle begins to diminish in about three days after the drug has been discontinued, but it takes a week, or more often ten days, for the eye to recover its normal condition. These drawbacks are so great, that they have acted as a hindrance with many to the

systematic use of a mydriatic for refraction cases. To the artisan the incapacity occasioned, even when the eyes are treated singly, is a matter of considerable inconvenience; and to the well-to-do the lengthened period of inability for close work is disagreeable and much objected to. The regular use of a mydriatic in testing refraction in young people is, however, of the utmost importance, and is frequently called for even in adults. A mydriatic is therefore desirable the effects of which will pass off quickly, and for this reason homatropine, in my practice, has for long replaced atropine, save in exceptional cases.

The action of homatropine differs from that of atropine, in being more rapid and more evanescent. Under its influence the pupil becomes dilated in about twenty minutes, and the accommodation is paralysed in an hour or little more. The hydrobromate is the salt generally used, and the strength of the solution 1 to 4 per cent. It should be instilled three times, at intervals of quarter of an hour, and before testing an hour and a quarter to an hour and a half must elapse after the first instillation of the drug. The addition of cocaine increases the efficacy of homatropine. The combination is most satisfactory, and for the majority of refraction cases its action on the ciliary muscle is sufficiently great. A better mode of using homatropine and cocaine is, however, in the form of gelatine discs. The gelatine slowly dissolves and allows the mydriatic to remain for a longer time in contact with the surface of the eyeball, and thus the action produced is more certain as well as more powerful than that obtained by using a watery solution. After considerable experience with this method I can speak confidently of its value. The gelatine discs to which I have referred are made by Wyeth Bros. according to the suggestion, in the first instance, of Dr. Casey Wood, of Chicago. Each disc contains $\frac{1}{50}$ gr. of homatropine and the same amount of cocaine. The patient is directed to look upward, and then, on drawing down the lower eyelid, a disc is allowed to slip on to the ocular surface; the lid is next permitted to slide gently back, the disc remaining between it and the globe, and the patient is desired to keep the eye closed for a short time. A second disc is inserted in a quarter of an hour. The action of the ciliary muscle will be set on one side, and the eye ready for testing in from seventy to ninety minutes. The usual time allowed by me is an hour and a quarter. In cases of suspected spasm of the ciliary muscle, the two discs may be followed by another containing $\frac{1}{25}$ gr. of homatropine only. The effects of homatropine, used in the manner just described, last from twenty-four to thirty-six hours, and this period can be further abridged, if it be thought desirable, by inserting a drop of eserine solution after the examination. The rest ensured to the ciliary muscle is, however, of therapeutic value, and, generally speaking, should not be curtailed. Instances will be met with, but infrequently, in which the combined action of homatropine and cocaine is not sufficiently powerful, and a resort to atropine will then be necessitated. The combination, however, suffices in the great majority of cases, and the prompt action and quick disappearance of its effects are features greatly inducing to the regular and systematic use of a mydriatic in refraction cases.

A caution as to the employment of mydriatics.—An important caution is necessary as to the use of mydriatics. All of them have a tendency to increase the tension of the eyeball, and hence, in incipient glaucoma, their employment may precipitate an attack of this serious disease. It is well, therefore, to use them with care in the case of patients over 40 (or younger); to ascertain previously the tension of the globe; to inquire as to the presence of any prodromata of glaucoma, such as "rainbow rings," etc.; to employ weak solutions when practicable; and to instil afterwards either eserine or pilocarpine (myotics). Atropine, and those mydriatics the action of which is prolonged, are perhaps more likely to be injurious than others, such as homatropine and cocaine, the effects of which are more transient. In practised hands these drugs may be used with advantage, but great caution in their employment is desirable, as, by no means infrequently, cases of glaucoma are met with in which the affection has either been induced, or aggravated, by the injudicious use of atropine or one of its allies.

MYOTICS.

The action of these is the reverse of that of mydriatics. Myotics cause contraction of the pupil and spasm of the ciliary muscle. They are but rarely employed in the examination of eye patients. It is sometimes desirable, however, to distinguish between mydriasis due to irritation and that caused by paralysis. In the former there is an absolute immobility of the pupil to stimuli, except strong myotics, which may bring it back to the normal size. In paralytic mydriasis a myotic will only restore the pupil to medium size (Swanzy). In irritation mydriasis, moreover, the pupil is dilated ad maximum, while in paralytic mydriasis, it is moderately dilated, and becomes more so on using a mydriatic.

The two myotics in use are eserine and pilocarpine. The former is employed in solutions varying in strength from $\frac{1}{20}$ gr. to 1 gr. per cent. The salts used generally are either the sulphate or the salicylate. The nitrate of pilocarpine is employed in the strength of from 1 to 2 per cent.

CHAPTER IV.

THE OPHTHALMOSCOPE.

In describing the ophthalmoscope and the methods of using it, it is not intended to enter upon the question of optics. For such matters the reader is referred to the larger text-books. The ophthalmoscope is dealt with here only as a means of examining eye patients, and the subject will be treated in a practical rather than a theoretical manner.

The principle of the ophthalmoscope is perfectly simple, and will be understood by remembering that all the light which passes into the interior of the eye is not absorbed by the choroidal pigment, as was once supposed; but that part of it, at all events, issues again. The light in returning, of course, passes out under the same conditions of refraction as it did on entering. The interior of the eye illuminated would be visible if the observer's eye could occupy the position of the original source of light, or be placed just behind it. This is effected by means of the ophthalmoscopic mirror. For, as the light from the lamp is reflected from the mirror, the mirror becomes a fresh starting-point for the light. The rays from the mirror pass into the eye to be examined, and the returning rays, passing through the perforation in the centre of the mirror, enter the observer's eye immediately behind it, and so enable him to see the interior of the eye under examination.

Many excellent ophthalmoscopes are in the market. The best are furnished with both a flat and a concave mirror (the latter of which should be capable of being tilted), and with a series of lenses for refraction work, moving on a rack at the back of the instrument, and so arranged that, whilst the observer is using the ophthalmoscope, he can, by moving a wheel with his finger, bring the lenses required behind the sight hole (Fig. 26).

A simple and convenient ophthalmoscope is depicted in Fig. 25. An ordinary case is dispensed with, as the handle slips up and serves as a cover to the instrument. This makes it very compact for the pocket. The mirror can be tilted, and a sufficient number of + and — lenses for general use are arranged at the back of the instrument.

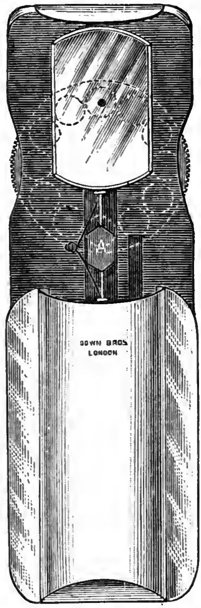


FIG. 25.—Snell's ophthalmoscope.

METHODS OF USING THE OPHTHALMOSCOPE.

THE MIRROR ALONE.—A mode of employing the ophthalmoscope, in which the mirror only is needed, must first be mentioned. The observer sits or stands in front of the patient, at about the same distance, or something less, as for the indirect method (Fig. 27). He directs the light into the patient's eye, and, if the media are clear, the red reflex is at once noticed. Should there be opacities in the media, they will appear black against

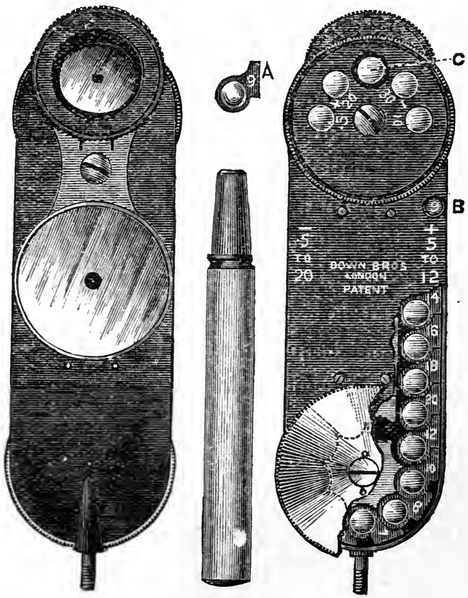


FIG. 26.—Morton's ophthalmoscope.

the background; if extensive, they may altogether interfere with a reflex. An idea as to the depth of any opacity may be gained by observing whether it moves with or against the mirror. The placing of a + 3D or + 4D lens behind the sight hole will aid in the examination of corneal opacities, or of the lens, or of the anterior segment of the eye generally.

On approaching nearer the patient a more powerful glass may be employed. Opacities of the lens show themselves as either a dull central opacity (nuclear cataract), or as striæ running in from the edge and appearing, with the mirror, as black lines (Fig. 22, p. 31). The mobility of opacities in the vitreous will be displayed by directing the patient to rapidly

FIG. 27.—Examination of the media, etc., with ophthalmoscopic mirror only.

turn the eye upwards and downwards several times in succession, and then, whilst the mirror is illuminating the eye, requesting the patient to suddenly stop the movements and look directly forwards. Floating bodies, especially large ones, will, by this sudden arrest of movement, be observed to rebound, and to make a rapid course through the vitreous. Finer opacities of the vitreous will be better seen if a flat mirror is employed and the illumination diminished.

If, when the ophthalmoscope mirror is used in the way just now described, the retinal vessels can be seen by the observer, the eye is ametropic, and, by watching the movement of these vessels in relation to the motions of the mirror, the nature of the refractive error present may be ascertained. Should the vessels follow the mirror, hypermetropia is the condition; should they go against the mirror, the eye is myopic.

There are two methods of using the ophthalmoscope—the *indirect* and the *direct*.

FIG. 28.—Examination with the ophthalmoscope; indirect method.

THE INDIRECT METHOD.—By this method a real object is not seen, but an inverted aërial image of the fundus is observed. The requisites are a mirror with a focus of 8 to 10 in., and a convex lens 14D, or one more powerful. The examination in a dark room may be proceeded with in the following manner (Fig. 28):—

(1) Place the lamp above and behind the patient's head.

(2) The patient should be seated on a chair, preferably one with a high back.

(3) The observer should be seated at about 50 centimetres from the patient; he should place the mirror before the right eye,—he may use which he prefers,—and then direct the light into the eye to be examined; if he succeeds in doing this, and the media be clear, a red reflex will be visible; but if the optic disc be in the line of light, the reflex will be whiter. The next step is to interpose the convex lens. The observer holds this between the thumb and index finger perpendicularly before the eye to be examined, and looks through the lens into the patient's eye. He should steady his hand by resting the little finger against the upper margin of the patient's orbit, and then bring the lens into focus by advancing or withdrawing it until the proper position is ascertained. If this has been successfully accomplished, and the eye be properly directed, the observer will notice the details of the fundus, which, though they will appear to him to be seen through the lens, are in reality formed as an aërial inverted image between the observer's eye and the lens, at a distance from the latter corresponding to its focus.

(4) To obtain a view of the optic disc, the patient should turn the eye somewhat inwards, and, for this purpose, he may be desired to look at the observer's ear, on the side opposite to the eye which is being examined. For the examination of the macular region, the patient should look straight at the mirror. To examine the periphery, the patient should be directed to turn the eye upwards, downwards, inwards, and outwards, as described when speaking of

the direct method, and each part of the fundus should thus be brought under observation.

(5) Remember that objects move in a direction *opposite* to the movements of the observer.

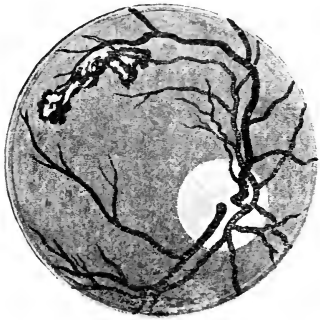
The beginner will find it essential, for the indirect, as well as the direct method, to have the pupil dilated with atropine, or some other mydriatic (p. 39).

The difficulty of maintaining a steady illumination of the eye can only be overcome by practice. The obstacles met with in learning the use of the ophthalmoscope are very much those pertaining to the correct employment of a mirror. The beginner will do well, therefore, to practise throwing the light from a mirror on to a dark surface, and to learn in this manner the direction, and the extent of movement, given to the beam of light by each turn of the mirror. Annoyance will be caused by reflections from the corneal surface, and from the edges of the sight hole in the mirror. He will learn to disregard, or get rid of them, by tilting the mirror, changing the position of the lens, or altering the place of the lamp. Facility in focusing the object lens can be acquired only by practice.

The image observed by the indirect method is inverted and reversed. A patch of choroidal atrophy, for instance, situated above the optic disc in the upper and outer part of the fundus, will be observed below the disc and in the inner and lower part of the image. The diagrams (Figs. 29, 30) will help to make the effect of this inversion of the image clear to the reader.

A plane mirror will give a larger but less brightly

Upper.

Right.  *Left.*

Lower.

A.

Lower.

Left.  *Right.*

Upper.

B.

FIGS. 29, 30.—Illustrate the "inversion" effected by the indirect method of using the ophthalmoscope. A.—Erect image of the fundus; B.—The same "inverted."

illuminated image than a concave one. A weaker convex glass (for instance, one of 3½ in. focus) will also magnify the details of the fundus more than a stronger (2 in.) one, but the latter will display a larger extent of field.

THE DIRECT METHOD.—By this method the details of the fundus are seen in their natural position, and magnified by the patient's own refractive media. An

FIG. 31.—Examination with the ophthalmoscope; direct method.

ophthalmoscope with a mirror of from 8 to 10 in. focus, and one which can be tilted, should be selected. The following directions may be followed (Fig. 31):—

(1) The lamp should be one giving a clear, steady flame, and capable of being varied in height. An Argand gas burner, fitted on a bracket with parallel movements, answers the purpose, or an incandescent electric lamp may be used. The lamp should be

placed on the same side and on the same level as the eye to be examined, and a few inches from the patient's ear. The room should, of course, be dark.

(2) The patient should be seated upright on a chair with a back reaching high up, to give steady support.

(3) The observer should seat himself on a stool at the side of, and facing, the patient; a music-stool, the height of which admits of easy adjustment, answers the purpose well. The right eye is employed to examine the right, and the left to examine the left eye. The observer places himself in front of the patient in such a manner that the opposing eyes will be on the same level, and look directly into each other.

(4) The observer places the ophthalmoscope before his eye, and rests it against the upper margin of his orbit, and then directs the light collected from the lamp into the eye to be examined. He advances close to the patient (as near as an inch, or even less, will give the best view), and then looks through the sight hole into the eye, just in the same way as one would spy "through a key-hole into a room."

(5) If the observer looks properly through the sight hole, and the media are clear, the pupil will present a uniform red appearance—the red "fundus reflex,"—and the details of the background should be visible. In order to obtain a view of the optic disc, the patient should be directed to look a little

inwards; if he looks straight forwards, the observer must approach from the outer side. A useful method of obtaining steady fixation in the desired direction, on the part of the patient, is to have one or more circular pieces of white paper or cardboard, about 3 in. in diameter, fixed to the opposite wall of the dark room. A few trials will indicate the best position for the white discs in relation to the patient. By then directing him to look steadily at the white object, a satisfactory view of the optic disc is easily obtained. This plan is especially helpful in the case of children. If the patient looks directly into the mirror, his pupil, unless a mydriatic has been employed (p. 39), will contract strongly, and a view of the fundus be rendered difficult, or even impossible.

(6) The observer should either close the eye which he is not using, or learn to disregard what it sees.

(7) Remember that objects in the fundus move in the same direction as the observer.

(8) The successful use of the direct method depends on certain conditions. Any refractive error in the observer, or in the patient, must be corrected. For this purpose many ophthalmoscopes are furnished with a series of lenses working on a rack behind the sight hole. Should the observer be ametropic, he selects his own correcting lens, and then proceeds to allow for the ametropia in the patient, and he must bring behind the sight hole the lens which corrects the combined refractive errors of both,

before the details in the fundus can be sharply made out.

It is further desirable that the observer should possess the power of relaxing his accommodation. This can be generally accomplished by practice, but many find it difficult to acquire. If one places a printed page at the ordinary reading distance, and stares vacantly at it, the type will become indistinct, in consequence of the accommodation becoming relaxed. This is the method of looking into the eye which has to be cultivated. The accommodation may be neutralised by placing a concave glass behind the sight hole.

A beginner, in using the direct method, generally finds it difficult to keep the fundus constantly illuminated by the mirror, as he changes his position in the examination. This will be surmounted by practice, but he will derive assistance by moving the lamp with his disengaged hand.

The *direct* is the best method for the minute examination of the details in the fundus, as it displays objects magnified about fifteen times. The area brought under view is, however, small, being not much more than 2 mm. in diameter, and therefore practically confined to the optic disc and a narrow zone round it. The other parts of the fundus may be quickly examined in succession.

The *indirect* method affords a much larger field, and is therefore the best for obtaining a general view of the fundus, and for forming a correct idea as to the exact situation of any lesion. The image is, however, much smaller[1] than that obtained by the direct method, the size being regulated by the diameter of the objective lens, and by its focal length. A lens of 2¼ in. focus will show the fundus details enlarged to four times, whereas one of 3 in. focus will give an image five times the actual size. The weaker the lens the more is the image magnified, and the smaller is the area visible at one time.

The diameter of the optic disc may be taken as a standard for measuring lesions in the fundus. Their position may also be described as situated so many diameters (or "discs") from the papilla.

The red tint of the fundus varies considerably with the degree of pigmentation of the choroid. It differs, therefore, in fair and dark individuals. In the blonde, it is bright pink, or rose-coloured, and the choroidal vessels may be clearly visible. In the brunette, the tint is much deeper and duller.

Optic disc.—The fundus having been made out by

[1] Landolt gives the enlargement of the ophthalmoscopic images in the direct and indirect methods of examination respectively as follow :—

	Inverted Image with + 15 Dioptres.	Upright Image.	Proportion.
Emmetropia	4.4	20	1–4.54
Axile hypermetropia (punctum remotum situated at 80 mm.) .	5.58	18.4	1–3.3
Hypermetropia of curvature (punctum remotum situated at 80 mm.)	4.78	15.8	1–3.3
Axile myopia (punctum remotum situated at 80 mm.) . .	3.35	30	1–9
Myopia of curvature (punctum remotum situated at 80 mm.) .	4.2	38.2	1–9

the direct method, the first object to be sought for is the optic papilla. This can be found by tracing up a main vessel, as it gradually increases in size, to the optic nerve entrance, which will be recognised by its more or less round shape, its pinkish white colour, and by its being pierced by numerous vessels—arteries and veins. Examine its colour, and note if there is pallor or increased redness; observe also the distinctness of its surface, and whether the edges of the disc are clean cut, or if its contour is irregular and ill-defined. Observe the shape of the disc, and if it be markedly oval, note the direction of its long axis. The vessels, both on the expanse of the papilla, and in their further course, will demand attention. Note their comparative size, whether the arteries are attenuated, and if there is engorgement of the veins, or if they are tortuous. The arteries will be recognised by their bright red colour, and a " light streak " running in their centres; the veins are darker, larger, and more tortuous, and have the " light streak " much less marked.

The yellow spot region.—The macular region with the fovea centralis will next require examination. To bring this into view, direct the patient to look directly at the sight hole of the mirror. The examination of the macula is difficult, unless the pupil has been artificially dilated, as the bright light at once causes the pupil to contract. The macula is deeper tinted than the surrounding fundus, and devoid of visible retinal vessels. Note any splashes of exudation, hæmorrhages, or disturbances of pigment.

Periphery of the fundus.—Having made out the condition of the optic disc, and of the yellow spot region, the rest of the fundus must be examined in all its parts. By directing the patient to look strongly upwards, inwards, etc., even the extreme periphery

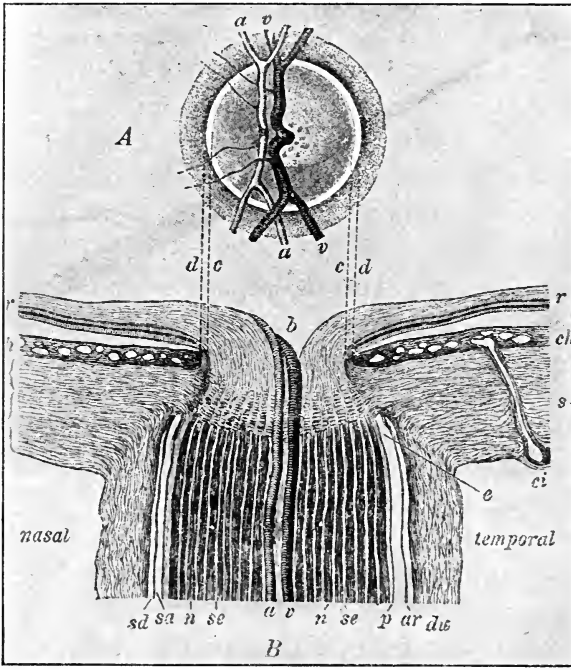


FIG. 32.—Head of the optic nerve (figure and description from Fuchs).

A. Ophthalmoscopic view.—Somewhat to the inner side of the centre of the papilla the central artery rises from below, and to the temporal side of it rises the central vein. To the temporal side of the latter lies the small physiological excavation with the grey stippling of the lamina cribrosa. The papilla is encircled by the light scleral ring (between *c* and *d*), and the dark choroidal ring at *d*.

B. Longitudinal section through the head of the optic nerve. — Magnified 14×1. The trunk of the nerve up to the lamina cribrosa has a dark colour, because it consists of medullated nerve fibres, *n*, which have been stained black by Weigert's method. The clear interspaces, *se* separating them, correspond to the septa composed of connective tissue. The nerve trunk is enveloped by the sheath of pia mater, *p*, the arachnoid sheath, *ar*, and the sheath of dura mater, *du*. There is a free interspace remaining between the sheaths, consisting of the subdural space, *sd*, and the subarachnoid space, *sa*. Both spaces have a blind ending in the sclera at *e*. The sheath of dura mater passes into the external layers, *sa*, of the sclera; the sheath of pia mater into the internal layers, *s*, which latter extend, as the lamina cribrosa, transversely across the course of the optic nerve. The nerve is represented in front of the lamina as of light colour, because here it consists of non-medullated, and hence transparent, nerve fibres. The optic nerve spreads out upon the retina, *r*, in such a way that in its centre there is produced a funnel-shaped depression, the vascular funnel, *b*, on whose inner wall the central artery, *a*, and the central vein, *v*, ascend. The choroid, *ch*, shows a transverse section of its numerous blood vessels, and toward the retina a dark line, the pigment epithelium; next the margin of the foramen for the optic nerve, and, corresponding to the situation of the choroidal ring, the choroid is more darkly pigmented. *Ci* is a posterior, short, ciliary artery, which reaches the choroid through the sclera. Between the edge of the choroid, *d*, and the margin of the head of the optic nerve, *c*, there is a narrow interspace in which the sclera lies exposed, and which corresponds to the scleral ring visible by the ophthalmoscope.

may be inspected. It is well, here, as elsewhere, to be methodical. Commencing above, direct the gaze of the patient "up," then "up and in," "in," "down and in," "down," and so through the entire circle. In this way only can every part of the fundus be with certainty brought into view.

Note generally any alterations in the choroid or retina, such as hæmorrhages, exudations, deposits of pigment, or absorption of the same. A broad distinguishing feature between affections of these two coats is, that retinal disturbances tend to interfere with the vessels in their course, whilst the deeper choroidal affections allow the retinal vessels to pass over them unaffected.

The illustration (Fig. 32) shows the anatomy of the optic nerve, exhibited at the optic disc or nerve head, as observed with the ophthalmoscope.

The arrangement of the retinal vessels on the disc

FIG. 33.—Normal fundus.—BERRY.

varies a great deal. Usually the artery bifurcates into a superior and inferior division (Fig. 33), which again divides into a temporal and a nasal branch. The veins run more or less parallel to the arteries, and are also crossed by the latter. Pulsation may be sometimes noticed in the veins, or slight pressure on the globe will induce it. Pulsation in the arteries is always pathological.

The colour of the disc is not uniform, the inner half being darker tinted than the outer.

The centre where the vessels issue is white and somewhat depressed. The depression is occasioned

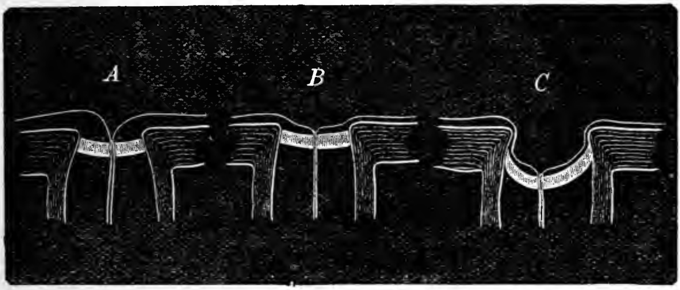


FIG. 34.—The three kinds of excavation of the optic nerve. Schematic.—FUCHS.

A. Physiological excavation.—Funnel-shaped, partial, with normal lamina cribrosa.
B. Atrophic excavation.—Bowl-shaped, total, with normal lamina cribrosa.
C. Glaucomatous excavation.—Ampulliform, total, with the lamina cribrosa bulged out posteriorly.

by the separation of the optic nerve fibres as they enter the eye (Fig. 32); the light colour is due to the white fibres of the lamina cribrosa visible at the bottom of the depression. Not infrequently this depression (physiological cup or excavation) is much exaggerated, involving the outer half of the papilla, and, it may be, extending to its external border. A physiological excavation or cup never involves the whole of the optic disc, and this distinguishes it from the excavation of glaucoma, which affects the entire disc, and from the cup of optic atrophy, in which the excavation is shallow, and the whole papilla white.

Differences in level in the fundus can be recognised by both methods of employing the ophthalmoscope.

With the indirect method a difference of level will give rise to parallax. It will be seen in certain cases that, when the objective lens is moved to and fro, different parts of the image move at unequal rates. The vessels, for example, at the edge of a glaucomatous cup, being on a nearer level, will move in front of, and more quickly than those at the bottom of the excavation. In optic neuritis again, the papilla projects forwards, and the summit and base present the same unequal parallax.

For the accurate estimation of differences in level, the direct method should be used, and the measurement effected by placing lenses behind the sight hole of the mirror. Each dioptre of refraction will indicate a difference of 0.3 mm. of level.

Routine examination with the ophthalmoscope.—First employ the mirror only—stand at about 16 or 18 in. from the patient, and illuminate the eye. In this way the degree of transparency of the refractive media is ascertained, and opacities in the cornea, or lens, or "floaters" in the vitreous are revealed. If, also, there be marked ametropia, the retinal blood vessels will be visible, and the nature of the abnormal refraction may be diagnosed by observing whether they go "with," or "against," the observer as he moves his head from side to side.

Next interpose the biconvex lens, and examine by the inverted, or indirect method. A general view of the fundus will be thus obtained, and the relative positions of any pathological changes may be noted.

Finally, remove the lens, advance close to the patient, and examine the fundus in detail by the upright, or direct method, bringing behind the sight hole of the ophthalmoscope any lenses which may be required to neutralise refractive errors.

Haab's *Atlas* of coloured representations of the fundus will be found useful for preserving, in a ready manner, a record of appearances which may have been observed in an ophthalmoscopic examination. The plates are made up of superimposed layers of colour. The surface colour is that of the normal fundus; by gentle rubbing, a buff-coloured patch can be illustrated, and a further rub will produce the appearance of white atrophic patches, while deposits of pigment can be indicated by marking with a dark pencil.

The writer has for many years employed an india-rubber stamp, giving an outline representation of the fundus, for entering in his case-books a rough record of the situation of any lesion. The stamp is quickly pressed on to the page of the case-book, and the place and apparent size of any patch of hæmorrhage or exudation is indicated by a pen-mark, a word by the side expressing the nature, colour, etc. of the lesion. Outlines of the fundus, ready gummed for pasting in a case-book, can also be obtained.

CHAPTER V.

TESTING OF SIGHT.

THE sense of sight consists of three parts: the form sense, the light sense, and the colour sense. Each of these will have to be considered separately.

Form sense.—The form sense, or, in other words, the acuity of vision, means the power possessed by the eye of distinguishing form after any error of refraction, if such be present, has been corrected.

The methods of testing the sight used in bygone days were very crude. Von Jaeger was the first to arrange types systematically for testing sight, and he did so by selecting the different sizes of type used by printers, and arranging them in series from the large *Roman* down to the small *Brilliant*. These types are now obsolete, and have been replaced by others chosen on more scientific principles.

The test types now universally used are those of Snellen, which are constructed on the following principle:—Each letter is inscribed within a square; each side of which is further subdivided into five equal parts. The dimensions are such that, at the distance at which the normal eye should see them, the larger squares subtend a visual angle of five minutes. It follows that the small squares contained within the larger figure, and within which the details of the letters are inscribed, subtend a visual angle of one minute, which has been calculated to be the minimum visual angle for the normal eye. (The visual angle referred to is the angle formed by the two lines from the extremities of an object at the nodal point of the eye (Fig. 35).)

It will be apparent (as shown in Fig. 35) that, in order to subtend the same visual angle, the size of the letters must increase with their distance from the

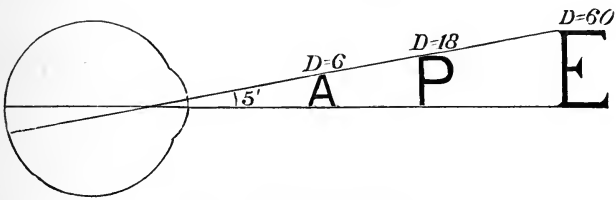


FIG. 35.—The visual angle.

eye. The letter A, clearly seen at 6 metres, must, in order to be equally visible at 18 metres, be three times as large, and so on.

The types in general use are intended to be placed at a distance of 6 metres, but others are obtainable which are suitable for a shorter space. The letters employed are illustrated here in miniature (Fig. 36). The top one should be read in a good light at 60 metres; the next at 36 metres; and the succeeding ones at 24, 18, 12, 9, and 6 metres. The acuteness of vision is ascertained by finding the smallest type which can be read at the distance of 6 metres. If the smallest letters are read, then the visual acuity is expressed thus: V (vision) $= \frac{6}{6} = 1$. If nothing smaller than the fifth line down can be seen, then $V = \frac{6}{12} = \frac{1}{2}$. Vision is frequently found to exceed the accepted standard $\frac{6}{6}$, and it may be $\frac{6}{5}$, or even $\frac{6}{4}$.

With regard to practical details. The test types should be well illuminated. If artificial light be employed, it must be shaded from the patient. He should sit with his back to the light, 6 metres from the types, the smallest of which should be on a level with his eyes.[1]

FIG. 36.—Snellen's types (about ¼ size).

Test each eye separately; shield the eye not under examination either with your hand, avoiding all pressure on it, or by holding a card in front of it, or by using a spectacle frame with an

[1] In my consulting room at the Sheffield Royal Infirmary, the distances 6, 5, 4, and 3 metres from the types are marked by metal plates fixed in the floor.

opaque disc before it. The patient is taken from the top through the series of letters until he stops, unable to read any more; vision is represented in the manner mentioned above, as $V = \frac{6}{12}$, or whatever may be the result arrived at.

Cohn has arranged transparent test types, which are framed between two panes of glass and fastened to a window. The letters can be read in their true or reversed aspect. Opposite, at 3 metres distant, is placed a mirror, in which the patient will see the reversed letters in their true position. For a short room these types are a convenience, as the letters which should be read at 6 metres only require 3 metres. Moreover, the observer can point to the line of letters, which he may wish the patient to read, on the frame which is hanging on the window behind. There are three rows of letters for each size, with Latin and Gothic characters, Arabic figures, and crooks, and there is therefore no want of choice in each trial. A further advantage is that the types cannot get dirty, as the glass on either side can easily be cleaned.

Snellen's types are very generally accepted as the standard, but letters constructed to subtend an angle of 5′ do not always show accurately the best acuity of vision obtainable, and types have sometimes been substituted in which the letters subtend an angle of 4′.

The tests are usually made in daylight, which is, of course, subject to considerable variation. A lessened light will mean reduced visual acuity. To avoid inaccuracy in results, it has been suggested that the tests should always be made with artificial light. A simple plan, however, on occasions when the weather is dull, is for the observer, should his sight be normal, to compare the patient's vision with his own.

When, on using the test types, vision has been found to be subnormal, it must be ascertained whether the visual acuity can be improved by the help of glasses. The method of procedure for this purpose will be described in the chapter dealing with errors of refraction (p. 92).

Should the patient be unable to read any of the letters at the stated distance, 6 metres, he is to be advanced nearer to the types until they become visible, and in this case the distance is accordingly altered when expressing the state of vision. Thus, if the top letter is not visible at 6 metres, but can be read only at 2 metres, V is expressed as $\frac{2}{60}$.

If the types are not recognised at any distance, resort is had to finding at what distance fingers can be counted. For example, V = fingers at 2 ft.

If, again, the patient is unable to count fingers, it is necessary to ascertain if there is perception of light (P L). This can conveniently be done by taking the patient into the dark room, and, by means of the ophthalmoscopic mirror, the eye not under examination being excluded, throwing light from the lamp on to the eye, and inquiring whether or not the light is perceived. An idea of the perceptive power is ascertained by gradually reducing the intensity of light. By throwing the light from different parts, absence of the light perception in the whole, or only in portions, of the retina can be detected.

Another method of testing light perception is the following:—Darken the room, and, holding a candle in front of the patient, alternately cover and uncover it with the hand, and ascertain if the difference between light and dark is noticed. The degree of distinctness may be found out by making the test at first near, and then removing the light farther away. The different portions of the visual field may be examined by approaching the candle from different directions, while the patient fixes his gaze directly forwards.

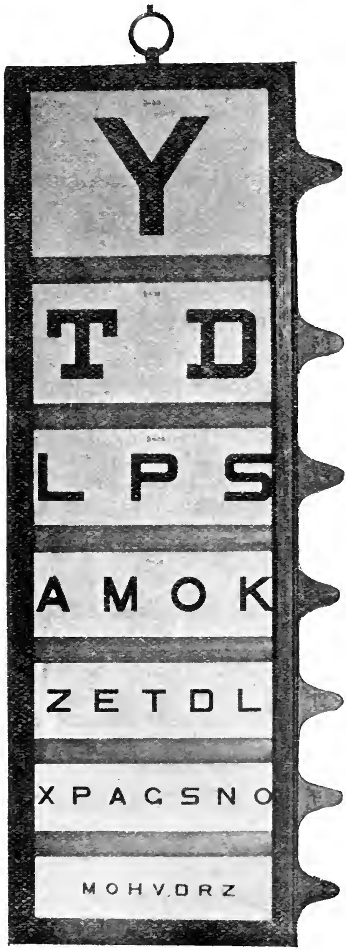


FIG. 37.—Author's frame of test types, with readily movable rows of letters.

Perception of light is sometimes spoken of as being "qualitative" or "quantitative"; in the former, the difference between a blank paper and that with printing on it can be recognised, while, in the latter, the difference between a dark room and a lighted room, or the reduction in the size of the gas jet, as already mentioned, can be perceived.

A patient whose vision cannot be brought up to the normal standard, should next be submitted to an ophthalmoscopic examination (p. 47).

The results obtained in testing vision with types are liable to be vitiated by the patient becoming familiar with the types. For this reason the ready substitution of one set for another is desirable. With this object, I have employed a device of the following description (Fig. 37):—A frame, about the size of the ordinary test board, is so arranged that each line of the types can be removed and another slipped into its place. As many of these removable lines of test letters can, of course, be provided as may be desired, but the number required can be reduced by having different letters painted on each side of the slip. With my frame three slips, equal to six changes of letters, are supplied. This plan admits of any individual line being changed, or of the whole series of types being altered; and it will be readily understood that a considerable number of variations in the types, as presented to the patient, is obtained with the three slips for each line as used in my set.

It must, however, be remembered that the test types already described are of little use to the illiterate, and therefore other devices are adopted to ascertain the condition of vision in such individuals. Types are arranged in Snellen's series with the letter E so turned that the divisions of the letter will point in different directions in succeeding figures. Thus the letter may be open upwards, downwards, or to the right or left, and the patient is asked to name the direction in which the figure is open, and towards which the

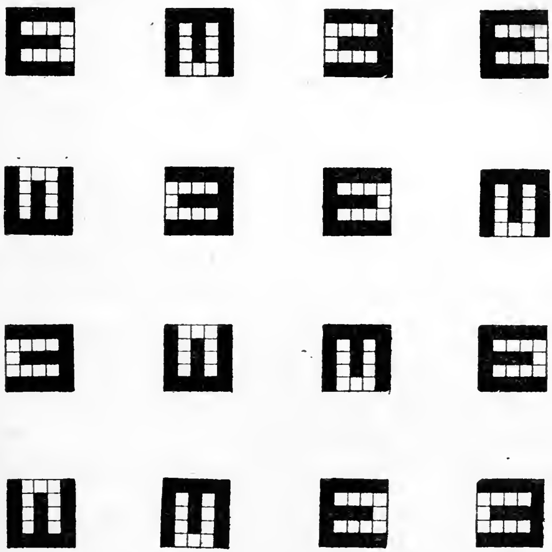


FIG. 38.—Cohn's test types reduced to a square of four letters instead of six.

branches point. Cohn has utilised this principle for testing the vision of school children, and the type devised by him for this purpose consists of thirty-six E's in six rows of six each, of the size of Snellen's type which should be visible at 6 metres (Fig. 38). To each side of the card is attached a hook for suspending the type, so that the figures presented to each child admit of easy alteration. This prevents one child communicating to the others the test to which they will be submitted.

Another method of testing illiterates is by means of the dots used in the army examination. Placed at the proper distance, the patient has a certain number presented to him, whilst the others are covered, and is requested to count those shown. The test may then be repeated with a different number exposed.

NEAR VISION.

Having ascertained the acuteness of sight, the condition of near vision, or, in other words, that of accommodation, has to be investigated.

Types for this purpose, constructed according to Snellen's principle, are printed in several languages, and arranged in order of size down to one which should be read at 0.5 metres.

The types of von Jaeger are also still used for testing near vision. Von Jaeger's No. 1 is taken as corresponding to Snellen's 0.5.

Dr. C. A. Oliver, of Philadelphia, has arranged an admirable series of test words for the determination and estimation of the power of accommodation. "Each word is composed of three or four letters constructed in strict conformity with the Snellen basis of letter formation; each column of words has a purposive succession of test letters, so arranged as to be of value in the recognition of astigmatism; each grouping of letters is composed of series of words which bear no relation

D.-0.50

F E L T	L E F T	F E E L	T E L L
C O O L	L O D E	C O D E	D O L E
D E F T	F L O E	L E E T	F E E T
C L O D	C O L T	D O L L	C O O T

D.-0.75

L E E	E L L	E L F	F O E
C O D	T O D	C O T	T O O
F E E	L E T	E E L	E L L
O D D	C O D	L O O	D O E

D.-1.00

F E L L	T O L L	D E L L
D O T E	F O O L	T O L D
F L E D	L O L L	C E L T
C O L D	F O O D	D O F F

D.-1.50

F E E D	L O F T
L O O T	T O O L
F O L D	D O L T

D.-2.00

T O E	O F T
D O D	O D E
L O T	F E D

to one another; and each test letter is surrounded by a space which is equal to, or greater than, the area that is occupied by the letter itself." The letters have the great advantage of being very clearly cut, and are imprints from a steel plate.

In estimating the condition of the accommodative power, certain terms are employed which it is necessary to define.

1. *The far point* (*punctum remotum* = *R*).—This is the most distant point of distinct vision.

2. *The near point* (*punctum proximum* = *P*).—This is the nearest point to the eye at which small print is still legible.

3. *The amplitude of accommodation* = *A* is the amount of accommodative effort of which the eye is capable.

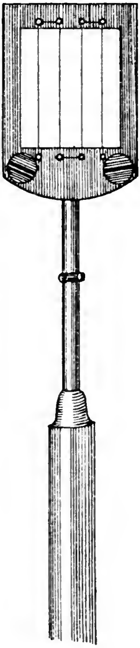


FIG. 39.—Hair optometer.

In the emmetropic eye the amplitude of accommodation is expressed by the convex glass, the focal length of which equals the distance of the near point from the eye. If the near point be, for instance, 20 cms., the amplitude of accommodation = 5 D.

The general formula for ascertaining the amplitude of accommodation is: $A = P - R$, in which P and R are expressed in dioptres.

The near point (P) can be ascertained by measuring the nearest distance at which small print can be read, or by means of the hair optometer (Fig. 39).

The near point can be estimated in the following manner (Fig. 40):—A trial frame is adjusted, having in front of the eye to be tested the correcting glass for ametropia, if such be present, and before the other eye a shutter. A hair optometer is now held in front of the eye under examination, and attached to it is a

FIG. 40.—Mode of measuring near point.

dioptre steel tape. The optometer is advanced as close to the eye as possible, until the nearest point is ascertained at which the hairs remain clear and distinct—the tape gives the distance between the outer canthus and the optometer, and registers, in dioptres, the amount of accommodation. The other eye may be similarly tested.

If the accommodation be paralysed, it will be found that small print is not visible at the ordinary reading distance, but that only large type is legible. By placing in front of the eye a plus glass, which will equal the loss of accommodation (+ 5 D, for instance), small type can again be read at the usual distance. At the same time, distant vision is unaffected unless ametropia be present. Should this be the case, the power of the lens required to restore near vision will need to be increased or reduced, according as the refraction is hypermetropic or myopic.

As life advances the near point recedes. Presbyopia, as the condition is called, is evidenced by the fact that, in order to obtain clear vision, the patient holds his book or newspaper farther off than the usual distance. A convex glass is required to correct this condition, and to bring back the near point to 22 cms. The following is the rule as to the glasses required by emmetropes:—At 40 none is needed, but convex glasses are required in the ratio of a +1 D for each five years, thus—

At 45 +1 D is requisite.
„ 50 +2 D „
„ 55 +3 D „
„ 60 +4 D „

In practice (Landolt) this series is found to be too strong, bringing the near point closer than is comfortable, and the following series may be substituted, which allows a patient to read at 30 cms.:—

At 45 +1 D.
„ 50 +1.5 D.
„ 55 +2 D.
„ 60 +2.5 D.
„ 65 +2.75 D.

Should the refraction be hypermetropic, the strongest plus lens which improves distant vision must be added to that required to correct the presbyopia. A convex glass ordered for presbyopia should render the type clear and distinct, but should not magnify.

The relation of accommodation and convergence.—There is an intimate association between accommodation and convergent movements of the eyes. We have seen that accommodation is measured by dioptres; convergence is estimated in terms of "the metre-angle."

When an eye is directed to a point in the median line, 1 metre distant from it, the angle of convergence formed by the visual line of the eye with the median line is called "the metre-angle." It will be readily seen that, for a point $\frac{1}{2}$ a metre distant, convergence = 2 metre-angles; for a point $\frac{1}{4}$ metre distant, convergence = 4 metre-angles, etc. etc.

The average emmetropic eye requires, for binocular vision, as many metre-angles of convergence as it does dioptres of accommodation, thus, for a distance of $\frac{1}{3}$ metre, an emmetropic eye requires 3 D of accommodation and 3 metre-angles of convergence.

In ametropia this relation is altered—for the hypermetrope, according to the amount of his defect, must call upon his accommodation before convergence is necessary, and the reverse is the case with the myope, who will exercise his convergence before an effort of accommodation is needed.

To ascertain the convergence (positive) let the patient (Fig. 41) hold a hair optometer 25 cms. in front of his nose, and look with both eyes at the bead.

A dioptre steel measure is attached to the optometer, and the other end is held by the surgeon by the side of one of the patient's eyes. The latter is then directed to advance the optometer towards his eyes until the bead appears double. This point is ascertained as accurately as possible by advancing and withdrawing the optometer, and, when the nearest point is found at which single vision can be maintained, the distance between the optometer and the

FIG. 41.—Mode of measuring convergence.

external canthus, as given by the steel measure, will indicate the number of metre-angles of convergence.

THE LIGHT SENSE.

Until recently this sense has not been regarded as of much practical interest; but increased attention is now being bestowed upon it. For testing the light sense some form of photometer is necessary. Förster's has been most generally used, but Izard's and Chibret's is convenient (Swanzy).

"On looking through this instrument towards the sky, two equally bright discs are seen. By a simple mechanism one of the discs can be made darker. If the eye does not perceive the difference in illumination between the two discs within 5°, its light sense is abnormal; or we may say its L D (light difference) is too high. Again, if one disc be made quite dark, and be then gradually lighted, the patient is required to indicate the smallest degree of light, or L M (light minimum), by which he can observe the disc issuing from the darkness. This should not be more than 1° or 2°."

In this country daylight is anything but an unvarying quantity, and Henry has recently described an instrument[1] in which the light used is a constant one, namely, that of the standard candle. The variation in the intensity of the light is produced by the removal of a series of opal discs of standard density, arranged in the manner to be now described (Fig. 42):—

"The instrument consists of an oblong box, A, open at the anterior end, through which the person examined looks; to the margin of this opening a hood, F, is affixed, which is drawn over the patient's head to exclude any external light from the candle. At the posterior end is an aperture, opposite which are nine discs of '15 oz.' standard opal, B, so arranged that one by one they can be swung back. Behind that, on a bar, C, distant a third of a metre

[1] *Ophth. Rev.*, London, 1896, p. 33.

from the box, is a standard candle, D, in a spring holder, keeping the flame at a constant level; behind this is a shade, E, to prevent any flickering. The instrument rests on a weighted stand, G.

"The method of use is as follows:—The person whose light perceptive power is to be tested is kept in the dark for about five minutes, till the retina has become adapted to the darkness. He then sits as above described, and the eye not under examination is covered with a shade, care being taken not to

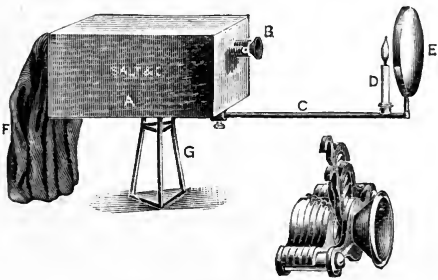


FIG. 42.—Henry's photometer.

exercise any pressure. The head having been covered with the hood, the opal discs are one by one removed, and the patient is told to say when he detects any light; should he detect it through seven opals, his light perceptive power is registered as 7; if through six, five, four, etc., 6, 5, 4 is entered; a note is also made of sex, age, and condition of fundus."

The light perceptive power diminishes after 30, and most markedly after 60. It is most diminished in those diseases in which the retina is chiefly affected either by pressure, or by a poisoned condition of the blood; so that a healthy nutrition of the retinal elements is the first essential to good light perception (Henry).

For testing this sense, Bjerrum uses letters on the same principle as Snellen's, printed on a grey ground.

Phosphenes.

When the eyeball is pressed upon, a subjective sensation of light, or phosphene, is induced. Pressure on the globe with a probe or bodkin will occasion the sensation. Its presence, or absence, in any given part of the retina can be ascertained by pressure over the corresponding portion of the eyeball. In detachment of the retina in the lower part, for instance, pressure on the eyeball over it will not occasion a phosphene in the upper part of the field; but if the retina is sound above, pressure exerted on the globe in that region will cause the phosphene to be observed below. The phosphene, or light sensation, will be induced in the dark, but in the light a dark impression will be seen.

The Colour Sense.

The examination of the colour sense is of much importance in connection with the detection of colour blindness.

Holmgren's test with skeins of wools is the one most generally used. It is based upon the Young-

Helmholtz theory of colour perception, according to which the retina has different percipient elements for the three primary colours: red, green, and violet, all other colours being compounds of these. No question is asked in testing as to the *name* of a colour, but the patient is requested to match the different skeins of wool with the sample given him. For this purpose the bundle of coloured wools, consisting of about a hundred, is laid out on a table covered with a white cloth. A test skein is handed to the patient, and he is desired to select from the bundle skeins of similar colour, though they may differ in shade.

The first test given is a skein of light but pure *green*. This test will show the presence of colour abnormality, if any exists, but will not determine whether the defect is more for green or red. Should the matching be done correctly, the colour sense may be regarded as normal, and there will be no need to proceed further with the examination. Should, however, what are called confusion colours be selected, consisting of greys, light browns, or yellows, abnormal colour sense will be indicated, and it will be necessary to continue the examination to determine the kind and degree of the defect.

The second test, a *rose* skein, a mixture of blue and red, is handed to the patient. If the matching is now done properly, he is incompletely colour blind. Should he, however, select as matches blues and violets, he is red blind; while if he picks out greens or greys, he is green blind.

The third test corroborates what has already been found out. A bright *red* skein is taken. Should green and brown darker than the red test be chosen, red blindness is indicated; if the same colours are selected, but lighter than the test skein, the defect is green blindness.

Red and green blindness often go together.

Violet blindness is very rare. In such a case, in the second test, purple, red, and orange would be confused.

A record of any case can be preserved by cutting off a small piece of the test skein, and from each of the wools matched with it. They can be readily gummed by the ends in a note-book, or simply placed in slits on a sheet of paper.

Another method of using the wools is to have them arranged on a stick (Thomson). Each skein is numbered, and it is thus easy to keep a record of the cases tested. Cartwright's modification in providing a sheet behind the wools, and furnishing the stick with a hinge for folding it up, is an improvement.

Jeaffreson's colour circle.—This has been recommended as a test for colour blindness by the Committee of the Royal Society. It consists (Fig. 43) of a test board, upon which are six coloured wools, namely, green, purple, red, blue, yellow, and violet. The circle bears the colours, forty in number, to be matched with these, and by means of a central handle each can be turned round and be brought in succession before the test colour. Both the test colours and the matches are hidden from view. The selected test is brought in front of a slot, and the matching colours are moved round, and those which are recognised as matches, each being numbered, are noted.

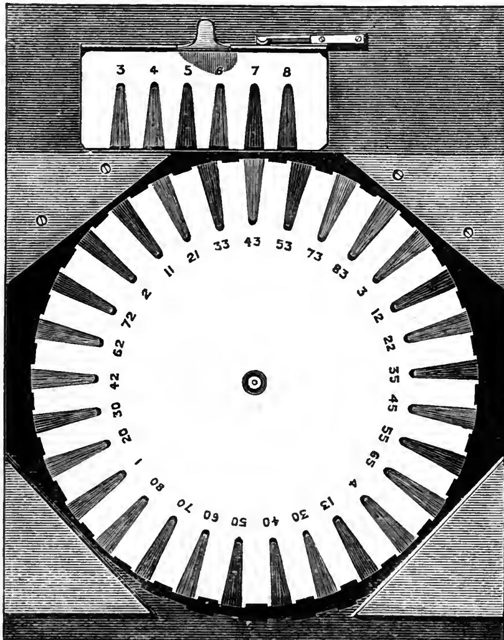


FIG. 43.—Jeaffreson's colour circle.

Abney's pellets.—These brick-clay pellets, about $\frac{3}{16}$ in. in diameter, are painted with colours mixed with soluble glass solution, of the same tints as the wools. They are placed in a tray and presented to a patient with a central scotoma (see p. 128) for colours, and he is desired to pick out all the pellets which match red or green. He will see neither one nor the other.

A red pellet he will match with a red, green, or grey, or a brown one and a green one with the same. If, however, the patient be instructed to turn his look a few degrees away from the tray, and not to look directly at the pellets, he will at once see all the colours and try to pick them up, but in the attempt he will direct his eyes again to the collection, and once more the colours will vanish.

CHAPTER VI.

ABNORMALITIES OF REFRACTION.

EMMETROPIA.

THE emmetropic or normal eye is so adapted that parallel rays are brought to a focus on the retina (Fig. 44); its range of vision is from infinity to its near point. No glass improves distant vision. Spectacles are not needed for reading until the age of 40 is passed.

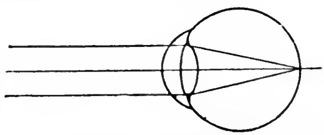


FIG. 44.—Emmetropia.

AMETROPIA.

All departures from emmetropia are grouped under the term ametropia. The varieties of ametropia are the following:—Hypermetropia, myopia, and astigmatism (for presbyopia, see p. 77).

1. *Hypermetropia.*—Hypermetropia is that condition in which the refractive power is too low; the hypermetropic eye is too short from before backwards, and rays coming from a distant object are not brought to a focus on the retina, but behind it

(Fig. 45). A convex glass is required for its correction.

2. *Myopia.*—Myopia is the exact opposite of hypermetropia. The refractive power is too high; the myopic eye is too long from before backwards, and parallel rays are not brought to a focus on the retina but in front of it (Fig. 46). A concave glass is necessary for its correction.

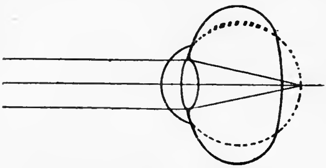


FIG. 45.—Hypermetropia.

3. *Astigmatism.*—Astigmatism is that condition in which the curvature of one principal meridian of the eye is different from another. The long and short radii of curvature of the bowl of a spoon illustrate broadly what is meant by astigmatism. As a consequence of the unequal curvature, the refraction of the different meridians is unequal. Cylindrical glasses are required to correct this anomaly.

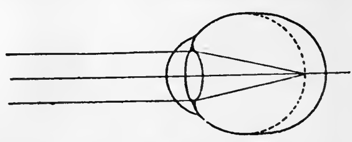


FIG. 46.—Myopia.

Astigmatism is either "regular" or "irregular." *Regular astigmatism* is occasioned by congenital inequality in the curvature of the cornea. The directions of the greatest and least curvatures are always at right angles to one another. The following varieties are met with:—

(1) *Simple astigmatism.*—(*a*) Hypermetropic—One principal meridian is hypermetropic, the other emmetropic. (*b*) Myopic—One principal meridian is myopic, the other emmetropic.

(2) *Compound astigmatism.*—(*a*) Hypermetropic—The refraction is hypermetropic, but that of one principal meridian is in excess of the other. (*b*) Myopic—The refraction is myopic, but that of one principal meridian is in excess of the other.

(3) *Mixed astigmatism.*—The refraction of one principal meridian is hypermetropic, while that of the other is myopic.

The *rule* in regular congenital astigmatism is, that *the vertical meridian has a greater curvature than the horizontal.* This is spoken of as "astigmatism with the rule." The opposite condition, however, also occurs, and it is then called "astigmatism against the rule."

Acquired regular astigmatism may result from the alteration in the corneal curvature caused by operations on the cornea—for instance, the sections required for cataract extraction or iridectomy—or by disease of the cornea.

Irregular astigmatism.—This results most frequently from ulceration, or other pathological conditions affecting the cornea; commencing opacity of the lens may also give rise to it. Objects appear irregularly distorted, or multiplied, and it is impossible to correct by glasses the diminished acuity of vision.

Trial Lenses.

The lenses in trial cases, or in spectacles, are numbered according to the metric system. A lens with a focal length of *one metre* is taken as the unit, and is spoken of as "one dioptre" or 1 D. The numbers attached to lenses indicate their strength in dioptres. Thus 2 D is twice as powerful as 1 D; 0.5 D is half as strong as 1 D, and so on. Convex lenses are distinguished by the sign +; concave ones by the sign −.

A case of trial glasses usually contains thirty pairs of convex spherical lenses and thirty pairs of concave spherical lenses, each of these running from 0.25D to 20D; also twenty pairs of plus and minus cylindrical lenses running from 0.25D to 8D. A trial case con-

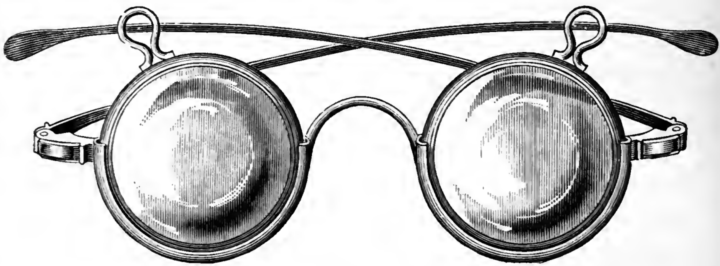


Fig. 47.—Trial frame for single lenses.

tains, besides these, a varying number of prisms; but for proper testing of muscle anomalies, the series should be in pairs, and be more complete than that usually supplied (p. 149). A red and a green glass, and other tinted glasses, with stenopaic slits and opaque discs for shielding the eye not under examination, make up, with trial frames, the usual contents of a box of lenses.

The trial frames required are of different kinds. The simplest (Fig. 47) hold only single lenses, but for astigmatic cases it is necessary to have a frame with at least two cells, so that two lenses can be placed before the eye at the same time, and the anterior part should be marked in degrees for reading off the axes of the cylinders. A useful one is Landolt's adjustable trial frame, depicted in the engraving (Fig. 48). Besides the two cells in which the lenses are fixed by a

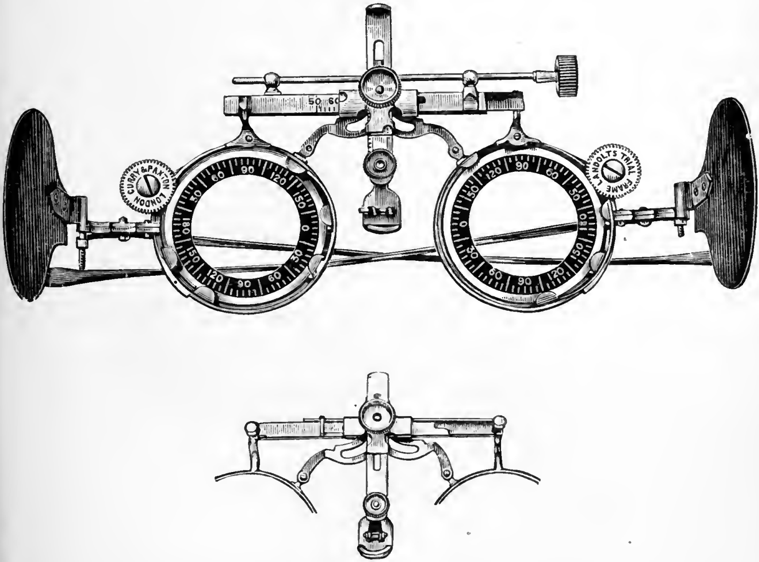


FIG. 48.—Landolt's trial frame for spherical and cylindrical lenses.

spring, which prevents their dropping out, the groove containing the cylindrical lens is made to rotate in front of the graduated scale, so that the axis is indicated and its position readily varied. It has a screw motion for varying the centres, and indicates the exact inter-pupillary distance. It has flat shutters, which allow either eye to be shielded when not under examination.

Methods of Testing Errors of Refraction.

By best types.—Snellen's types (p. 67) are hung on a wall in a good light, and the patient is placed facing them at 6 metres distance. Each eye must be tested separately. A spectacle frame is fitted on the face, and an obturator is placed in front of the eye not under examination. The patient is directed to read the type, and a note is then made of his vision, unaided. Should vision be subnormal, it is desirable to ascertain whether the acuity can be improved by glasses. The next step, therefore, is to place in front of the eye weak plus or minus lenses, say 0.5 D.

If a weak plus glass improves vision, the eye is hypermetropic; if a weak minus glass improves, the eye *may* be myopic; but the possible presence of spasm of the ciliary muscle, giving rise to an apparent myopia, must be remembered, and the existence of true myopia should be corroborated by further tests.

(*a*) *Hypermetropia.*—If vision is improved by a weak plus glass, a succession of plus glasses is placed in the trial frame. The *strongest* lens which yields the best result gives the amount of manifest hypermetropia. Thus, if + 2 D is the best glass, the "manifest hypermetropia" is represented as Hm = 2 D. Frequently, however, a further amount of hypermetropia is latent (Hl). This is especially so in children and young people, and occasionally in adults. To reveal the "latent hypermetropia" the use of a mydriatic is necessary. The rules for the use of mydriatics, and directions as to the one to select, have already been given (p. 41). Tested again, when the ciliary muscle has been brought under the influence of a mydriatic, the strongest convex glass which gives the best vision will represent the total hypermetropia (H). Thus, if + 6 D be the lens required, H = 6 D, and the latent hypermetropia is the difference between the manifest and the total hypermetropia. In our example the Hm = 2 D and the H = 6 D, therefore the latent hypermetropia (Hl) revealed by the mydriatic = 4 D.

(*b*) *Myopia.*—Concave glasses are placed, one after the other, in front of the eye under examination. The *weakest* minus lens which gives the best visual result indicates the amount of myopia present. Thus, if — 5 D be the glass, the myopia is expressed as M = 5 D. In certain cases the amount of myopia is increased by the accommodation, and the use of a mydriatic is often desirable.

(*c*) *Astigmatism.*—The presence of astigmatism will frequently be suggested by the fact that the best + or — glass leaves vision still subnormal. The different varieties of astigmatism can be tested in the following manner:—

Simple astigmatism.—Snellen's test (Fig. 49), consisting of radiating lines, is hung on the wall, and the patient placed 6 metres from it. The patient is requested to state whether any one line appears to him much blacker and sharper than the others. Should this be so, and if no + or — glass makes this line still more distinct, he is emmetropic in the meridian at right angles to that line. The next step is to make the line at right angles to the distinct one, which is at present dull, equally clear and sharp. This can be accomplished with spherical glasses or with cylinders in the following manner:—

Place *spherical lenses* in the frame until the picture is exactly reversed, *i.e.* until the dull line has become as sharp and distinct as that originally seen

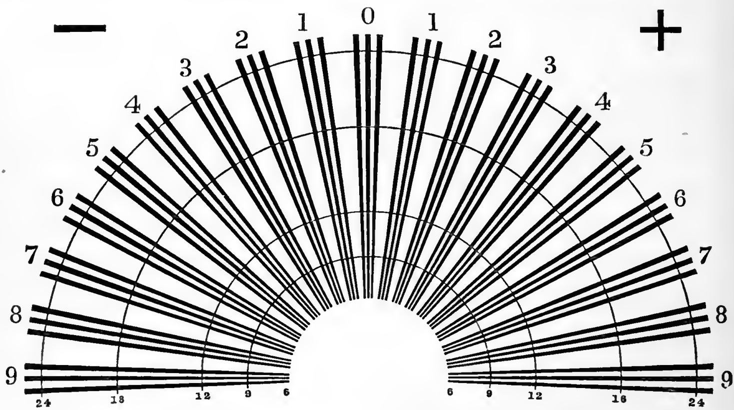


FIG. 49.—Snellen's test for astigmatism (reduced nine diameters).—BERRY.

clearly, and *vice versâ*. The strongest plus, or the weakest minus, glass which gives this result will represent the amount of simple astigmatism, hypermetropic or myopic, as the case may be. A cylinder of strength corresponding to the spherical will be required for correction.

By cylinders.—Should the horizontal line be seen most distinctly, + cylinders must be placed before the eye, with their axes vertical. The highest convex cylindrical glass which gives the patient the best vision represents the amount of simple hypermetropic astigmatism (AsH) present. Should the lens yielding this result be a + 2 D Cyl, it would be noted as AsH = 2 D. Should the vertical line be most distinct, "according to rule" the eye will be myopic in its vertical direction, and will require a minus cylinder, placed with its axis horizontally, for correction. The weakest cylinder which gives the best result represents the amount of simple myopic astigmatism present. If the lens be – 3 D Cyl, it will be represented as AsM = 3 D.

These results with the "fan" should be supplemented by ascertaining the best vision with the lenses and test types. The principal meridians having been once discovered, either by the fan, retinoscopy, or one of the other methods to be presently mentioned, the subsequent correction can be done by the test types.

Compound astigmatism.—If this condition be present, vision will be improved up to a certain point with spherical lenses. The best results obtained with + or – glasses with the test types is ascertained. The glass thus selected is placed in the trial frame, the most distinct line on the fan found; cylinders are placed at right angles to it, and the correcting cylinder is ascertained in a manner similar to that described under *simple astigmatism.* The result so obtained is then verified by finding the visual acuity by means of the test types with both the spherical and cylindrical lens in the trial frame. The latter may want some alteration to give the best vision. Supposing that + 3 D gave the best vision obtainable by sphericals (V + 3 D = $\frac{6}{18}$) and cylindrical + 1 D completed the correction (V + 3 D + 1 D Cyl = $\frac{6}{6}$), the astigmatism is represented as H 3 D + AsH 1 D horizontal. If the compound astigmatism be myopic instead of hypermetropic, the result would, of course, be represented by — instead of + lenses.

The use of the fan is not, however, imperative, and the examination may be conducted throughout with Snellen's test types. Taking, as an example, compound hypermetropic astigmatism, the strongest plus spherical which gives the best visual result is left in the trial frame. If the axes of the principal meridians have already been ascertained by retinoscopy or the ophthalmoscope, the placing of cylinders in front of the spherical can be at once proceeded with. It should further be borne in mind that three-quarters of the cases of astigmatism met with are "according to rule," that is to say, the meridian of least curvature is the horizontal one, and therefore, in our example, the cylindrical lens will require to be placed with its axis vertical or approximately so. The exact direction will be readily ascertained by moving the glass in the frame until the position giving the best vision is observed.

Mixed astigmatism.—Both — and + sphericals will improve vision, but the best correction will leave it subnormal. If the fan be employed a + spherical may bring out the vertical lines most clearly, while a — spherical may make the horizontal lines distinct. By testing each meridian separately, as above described, the degree of H and M in the two meridians may be ascertained.

Another plan is to ascertain, with Snellen's types, the + spherical which gives the best visual result, and to place in front of this concave cylinders until the greatest improvement of vision is attained. As an example, supposing + 3 D gives the best vision (V + 3 D = $\frac{6}{24}$), and a — 6 Cyl placed over this gives the best obtainable further result (V + 3 D — 6 D Cyl = $\frac{6}{6}$), the mixed astigmatism is represented by AsH 3 D horizontal, AsM 3 D vertical. The correcting glass may be ordered, either as two cylinders, or with a + spherical and a minus cylinder, or by prescribing a — 3 D spherical and + 6 D Cyl with its axis vertical.

It is often desirable, in testing cases of astigmatism, to employ a mydriatic; and especially is this the case when dealing with compound or simple hypermetropic astigmatism.

THE OPHTHALMOSCOPE may be used to estimate the refraction. For this purpose the "direct method" (p. 54) is employed, and the strongest convex, or, weakest concave glass behind the sight hole of the mirror which renders a small vessel, preferably in the region of the macula, distinct, represents the amount of hypermetropia or myopia present. When this correction has been made, should a neighbouring vessel running somewhat at right angles to the former one be still indistinct, it will indicate that the axis represented by that vessel differs in refraction from that already corrected. Astigmatism is thus diagnosed, and this second vessel must be rendered distinct by the appropriate lens.

Astigmatism may be diagnosed by the "indirect method" (p. 50). When astigmatism is *absent*, the round or oval shape of the optic disc is not altered, whether the lens is held close to, or farther from, the eye. If astigmatism be *present*, the optic disc is usually oval horizontally if the lens be placed near the eye, but it changes to oval vertically if the lens be moved farther away.

The varieties of astigmatism may be distinguished in this way:—

If, on withdrawing the lens, the horizontal diameter lessens, it is hypermetropic; if the vertical diameter increases, it is myopic; if both diameters are lessened, but one of them more so than the other, it is compound hypermetropic; if both diameters are increased, but one of them more so than the other, it is compound myopic; if the horizontal diameter lessens and the vertical increases, it is mixed astigmatism.

RETINOSCOPY.—If a light be thrown by a mirror on the pupil, and the mirror be then tilted in different directions, a *shadow* will be observed to flit across the illuminated field. This constitutes the "shadow test," or, as it is otherwise called, retinoscopy, keratoscopy, or skiascopy. The indications learnt from the shadows differ accordingly as a concave or a flat mirror is used. The former is more generally employed, and will therefore be described first, as well as more fully.

The patient (Fig. 50) should be seated upright in a dark room with a bright light (from an Argand gas burner, electric or other lamp) placed above and behind him, and so arranged that the light does not fall on the eye to be examined. If the light be placed by the side, a screen must be interposed. Some surgeons have employed a metal funnel to the lamp, fitted with a rotating disc with perforations to regulate the size of light exposed. Next adjust a trial frame, and, especially if there be strabismus, the placing of an obturator

FIG. 50.—Retinoscopy with concave mirror.

in front of the eye not under examination will be an advantage. A box of trial lenses should be at hand.

The examination is better made if the pupils are dilated by homatropine or other mydriatic (p. 39); in a case in which the pupils are small, and in children, the use of a mydriatic is imperative.

The patient should be directed to look straight at the mirror in order that the refraction at the macula may be estimated. The examination is made more easily with the optic disc in view, but the refraction at the disc frequently differs by one or more dioptres from that at the macula.

The examiner should seat himself at 1.25 metres distance from the patient, and then, with a concave mirror (the ordinary ophthalmoscopic mirror answers the purpose), he should throw the light into the patient's eye. As the mirror is tilted in different directions, a shadow will be observed to flit across the field, "with" the mirror if the refraction be myopic, or "against" the mirror if it be emmetropic, hypermetropic, or myopic, to 1 D or less.

The direction of the shadows, in both horizontal and vertical meridians, should be observed. The mirror may further be tilted and the course of the shadows noted in oblique directions.

The next step is to insert lenses, from the trial case, in the frame on the patient's face, until one is found which reverses the direction of the shadow.

It may be mentioned that a bright illumination and a distinct shadow, which moves rapidly, indicate a low degree of ametropia, whilst a dull illumination and an indistinct shadow, moving more slowly, indicate a high degree of ametropia. The varieties of refraction may be ascertained thus:—

Hypermetropia.—Convex glasses are put in the frame in succession. First place 1 D. If the motion still remains against the mirror, put in stronger lenses until the shadow is reversed. The correcting glass is not the one that reverses the shadow, but somewhat weaker. It is usual to subtract .75 D or 1 D from the glass which reverses. Thus, if the shadow is converted from being against the mirror to being with the mirror by + 3 D, the correcting glass would be + 2 D.

Myopia.—Concave glasses are inserted in the frame. Commencing with — 1 D the glasses are changed for higher numbers, until the shadow is reversed and goes against the mirror. The correcting glass is not the one causing the reversal, but somewhat stronger. Thus, if — 2 D causes the shadow from being with the mirror to go against the mirror, the correcting glass would be — 3 D.

Astigmatism.—In estimating astigmatism by the shadow test, each principal meridian is taken separately. The correction may be done entirely with spherical lenses or with cylinders as well.

In *simple astigmatism*, the axis having been recognised, the spherical glass which reverses the shadow in the ametropic meridian will indicate the cylindrical lens which is required for correction. If it be preferred, a cylinder with the axis corresponding to that indicated by the shadow may be employed, and changed until the rectifying one is found.

Compound astigmatism.—Insert a spherical glass in the frame and ascertain the correcting lens for the meridian of least ametropia; then place in front of this another higher number and find the correcting glass for the opposite meridian. The first glass will represent the hypermetropia or myopia present, and the second, the degree of astigmatism. The latter is, for subjective testing, replaced by a cylinder of corresponding strength. If cylinders are employed, the procedure is

FIG. 51.—Hand frame with lenses for correction with retinoscopy.

the same to ascertain the degree of H or M, but a cylinder in front of the spherical is used to correct the opposite meridian.

Mixed astigmatism may be corrected in one of the following ways:—

Correct the hypermetropic meridian with a + spherical, and over this place a — spherical sufficiently powerful to correct the shadow in the opposite meridian. The latter will represent the concave cylinder, which may be prescribed in combination with the + spherical.

Correct the hypermetropic meridian with a + spherical lens; note the glass; then remove it, and proceed to neutralise the myopic meridian. This latter, with the addition to it of the strength of the + spherical, will give the number of the cylinder which may be prescribed with the + spherical.

Each meridian may in turn be corrected with cylinders, and bi-cylinders may be ordered.

Many suggestions have been made to obviate the necessity for the frequent changes of the glasses in the frame when using the shadow test. Rotary discs have been devised, armed with + and — lenses, to pass in succession before the patient's eyes. All have been too cumbersome, and probably too costly, to come much in vogue.

For some time I have employed the simple device

FIG. 52.—Method of using hand frame of lenses with retinoscopy.

depicted in the illustration (Fig. 51). It is modified from Wurdeman's. It consists of a series of lenses set in a vulcanite plate, furnished with a handle. Two of these frames are required; one with convex, and the other with concave glasses. The numbers of the glasses are marked on both sides of the frame; the + in red and the — in white. If + glasses are required with the shadow test, the patient is given the frame with those lenses. The patient (Fig. 52) is directed to look through the glass it is desired to commence testing with, and then he can, at request, readily raise or lower the frame, so as to bring other lenses before his eye until the correction is completed. If it be found that, whilst one number under-corrects, the next dioptre over-neutralises, recourse may be had to the .5 D between these two numbers. The other frame containing — lenses is employed similarly in cases in which concave glasses are needed.

The saving of time in using such a simple apparatus as this is considerable, and, as all cases of astigmatism can be tested, as well as H and M, with sphericals only, its employment will be found a convenience. Wurdeman has further suggested having at hand two reversible spectacle frames, one containing + 1 D and + 2 D, and the other + 3 D and + 4 D. These may be placed in front of the eye, in instances of high degrees of H, before using the frame of glasses.

One eye having been tested, it is desirable to proceed to examine the other in a similar manner.

When the correction in both eyes is completed, note the lenses and the axes of the cylinders. The patient may then be tested with Snellen's distant types, and any alteration in the strength of the sphericals, or in the direction of the axis of the cylinders, can be effected. One skilled in retinoscopy will find that little alteration will usually be necessary.

For preserving in the case-book a record of the axes of the cylindrical lenses, or for use when prescribing, the writer has for several years employed an indiarubber stamp (Fig. 53), which gives a ready impression, on which may be marked off the precise direction of the axis.

Retinoscopy with a flat mirror.—When a plane mirror is employed, the movements of the shadows are exactly opposite to those obtained with a concave mirror. That is to say, the shadows are "with" the mirror in H and E, and "against" it in M. In using the flat mirror in cases of M, it is necessary to bear in mind that, if the observer goes closer to the eye than its far point, he will not obtain the myopic shadow against the mirror. He should be as far as possible from the eye under examination. If the M

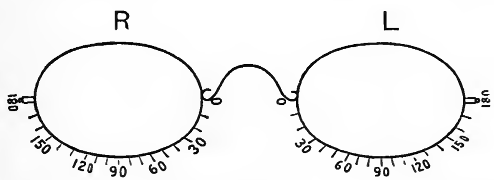


FIG. 53.—Indiarubber stamp for entering axes of cylindrical lenses in case-book.

be of high degree, the examination may be commenced close to the patient, but it will not be complete until the shadow ceases to go "against" the mirror at 4 metres. If the shadow is found to be "with" the mirror in any case, the refraction will either be E or H. If a + .25 be placed in the frame, and the shadow be found to be reversed at 4 metres, the case may be regarded as E. Should, however, the shadow still go "with" the mirror, + glasses are in succession placed in the frame until the correction is completed.

OPHTHALMOMETER.—*Javal's ophthalmometer* estimates the differences in curvature of the cornea, and in this way the astigmatism can be calculated, but it leaves uncorrected any hypermetropia or myopia which may be present. The description of the instrument and the

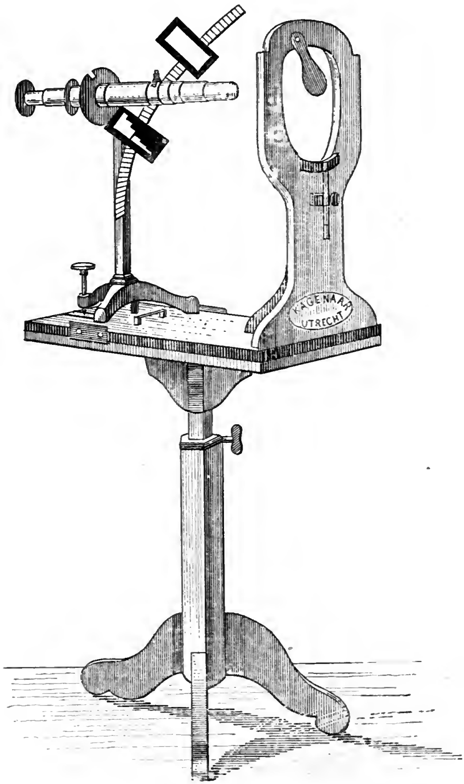


FIG. 54.—Javal's ophthalmometer.

illustrations are taken from Berry's *Diseases of the Eye*, p. 550. "The instrument (Fig. 54) consists of a telescope placed horizontally and so arranged as readily to be directed on the cornea of the eye to be examined.

Firmly fixed to the telescope is a graduated arc of 35 cms. radius, the centre of which is in a line with the axis of the telescope, and therefore also with the visual axis of the patient when it coincides with that of the telescope. On either side of the midpoint of the arc are two movable white figures. These are the objects whose images on reflection from the cornea are seen magnified by the telescope. By means of two prisms joined at their apices, suitably placed in the tube of the telescope, the two corneal images are doubled. When the objects are placed at a certain

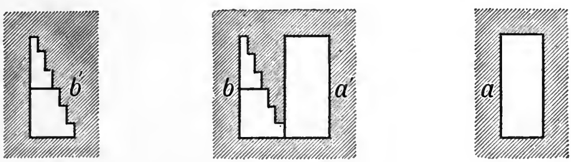


FIG. 55.

distance apart, one of the images of the one object can then be made to appear to be close up to one of the images of the other object. This is seen in Fig. 55. The distance separating the two objects which produces this effect will depend upon the curvature of the cornea. Now, if in one position of the arc, say the horizontal, the white objects have been so placed that the one of their corneal images exactly touch, but do not overlap each other, and it is found that an overlapping takes place when the arc is rotated, so as to take up a position at right angles to its former position, evidence is thus afforded of a difference in the radius of curvature of the cornea in different meridians, *i.e.* of corneal astigmatism. In Javal's instrument, while the one object is rectangular, the other is so shaped, in steps, that for every step overlapping in the meridian of greatest curvature there corresponds one dioptre of astigmatism. This is shown in Fig. 56, which represents four dioptres of corneal astigmatism."

This instrument has the merit of being an objective test. The indications which it gives are definite and rapidly obtained, but opinions are considerably at

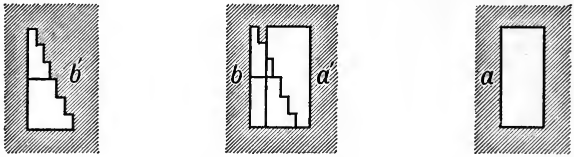


FIG. 56.

variance as to its real value for accurate work. It has, moreover, the disadvantage of being expensive.

PLACIDO'S DISC is another method of ascertaining the presence of astigmatism. It only, however, indicates the axes of greatest and least curvature, but this is seen at once. It consists of a metal plate about 10 in. in diameter, on which are painted a number of concentric circular white and black bands, arranged alternately and about half an inch in breadth. A hole is placed in the centre, this contains a plus glass of about 4 D, and from it extends a short tube. The manner of using it is as follows:—Place the patient with his back to the window, or, in a dark room, with an Argand burner behind him. If the observer now looks down the short tube and holds the disc a little distance from the eye to be examined, he will notice an image of the concentric rings on the cornea. If there be no astigmatism, the rings will be circular. On the other hand, should there be astigmatism, the figure will be elliptical in shape, the long axis corresponding with the meridian of least curvature, and the

FIG. 57.—The method of using Placido's disc.

short axis of the ellipse with the meridian of greatest curvature of the cornea. In irregular astigmatism the image of the rings on the cornea will be irregular and distorted.

The author has employed a disc perforated in the centre and marked with rays across the circle, like a double Snellen's astigmatic fan, with, however, fewer radii (p. 19). If this is advanced towards the patient, the reflection of the lines will be observed on the patient's cornea, and should astigmatism be present, one of the radii will become distinct and sharp before the others, and the direction of one axis is at once rendered evident. A slit is provided behind the perforation, in the centre of the disc, for placing a convex glass (+ 3 D) before the observer's eye; and the disc is so made that the front plate with the radiating lines can be rotated. A single line running across a circle may be used, and by watching the reflection on the cornea, as the disc is rotated, the direction can be noted in which the line is most sharply seen. White lines on a black ground are to be preferred.

Having described the methods for investigating cases of refraction, it will be well now to mention the routine plan to be adopted in any individual case.

1. *Ophthalmoscope.*—The nature of the error will be discovered by standing with the mirror at a short distance from the patient, as described on p. 47, or the degree of ametropia may be measured by the direct method. The accuracy with which this measurement can be done will very much depend upon the skill of the observer. Latent hypermetropia will frequently be overlooked. Until, therefore, the observer has gained considerable experience, he will do well, after having ascertained that the media are clear, and that the ophthalmoscope reveals no change in the fundus, to note the kind of ametropia present, and to proceed at once to the examination by the shadow test.

2. *Retinoscopy.*—This is the most easily acquired, as well as one of the most reliable methods of investi-

gation. For children it is indispensable. The observer is therefore advised to rely upon it for his objective examination. The axes of the meridians in astigmatism are easily detected by this method, and a beginner will find it of service at a time when he is compelled to rely more upon subjective investigation with test types than, with greater experience, will be necessary.

3. The results obtained by the shadow test must be verified by *trial glasses* and *Snellen's types.* No examination is complete without the use of the test types and trial glasses, but the whole investigation will be considerably shortened by the previous use of the shadow test.

A Committee of the American Medical Association, appointed to report on the value of the objective tests for the determination of ametropia, reported as follows :—

Ophthalmoscopy.—The ophthalmoscope enabled one to immediately assign an approximately just share to the influence of ametropia in causing imperfect vision, and that the presence and degree of hypermetropia, myopia, and astigmatism were ascertained very quickly. As to the ability of the ophthalmoscopic examination to reveal latent hypermetropia there was some doubt, as it failed in a certain portion of cases. Accuracy with this method cannot be obtained by all observers, or by any observer, at all times and in all cases.

Ophthalmometry.—Ophthalmometry determined the existence and amount of corneal astigmatism to within .25 D, or less, if the patient be steady and the other conditions favourable. The ophthalmometer gave no information as to the degree of hypermetropia or myopia present, and the committee thought that the chances of conformity between the corneal and total astigmatism are not sufficient to justify reliance upon the method as determining the cylindrical correction required.

Retinoscopy was, upon the whole, the most accurate and reliable objective method of estimating ametropia. Applied in the direction of the macula, it measures in the visual zone exactly the refraction that is determined by the subjective method.

The Committee urged that while each of these methods should be used, they should be followed by the subjective determination.

CHAPTER VII.

THE FIELD OF VISION.

WHEN we direct our eyes towards any object, we see not only the object thus directly looked at, but also the other objects around it. For instance, when we look across a room at a picture on the wall, we see the other pictures, articles of furniture, etc.; and, again, when looking at a distant church steeple, we perceive, though less distinctly, the fields, trees, and clouds which make up the landscape. An object looked at directly is said to be seen by "direct vision"; the surrounding objects are seen by "indirect vision"; and the general view obtained is spoken of as "the field of vision."

The boundary of the visual field of each eye, under ordinary conditions, may be stated to subtend an angle of about 145° in the horizontal, and an angle of about 100° in the vertical meridian. Any object situated beyond these limits is outside the field of vision for that position, and can only be brought into it by moving either the object or the eye. The fields extend farther on the temporal than on the nasal side. The limits of the field in the different directions may be thus given:—Outward, 90°; outward and upward, 70°; upward, 50°; upward and inward, 55°; inward, 60°; inward and downward, 55°; downward, 72°; downward and outward, 85°.

The field of the two eyes taken together (Fig. 58) differs much from a monocular field. In the binocular field the central area, corresponding roughly to a circle of about 90°, is common to both eyes, but the parts on the left and right of the combined field belong

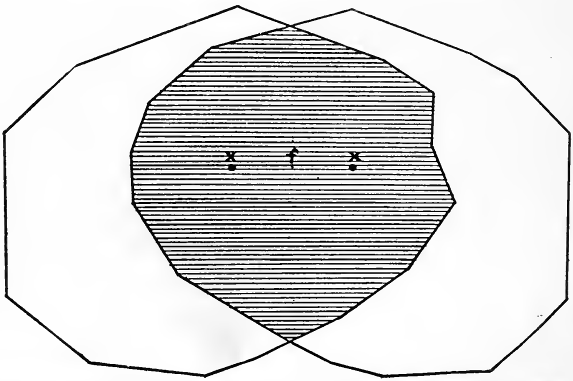


FIG. 58.—The visual fields of the two eyes when the eyes converge to the same fixed point. The shaded part is that common to the two eyes; *f*, the fixation point, corresponding to the fovea of each eye; *x*, the blind spots of the two eyes.—AUBERT.

entirely to the left or right eye, as the case may be. The combined field subtends an angle of about 180° in the horizontal meridian, instead of about 145° as in the monocular field.

METHODS OF MEASURING THE FIELD OF VISION.

The measurement of the field of vision is of importance, as an alteration of the visual field is a feature of many ocular diseases. There are several methods of measuring the field.

A simple way is the following:—The patient, with his back to the light, faces the observer. He covers one eye with his hand (avoiding any pressure on it), and, with the other eye, looks into the opposite eye of the examiner. Let him look into the eye which is opposite to his uncovered one; the patient's right eye fixing the examiner's left, and *vice versâ*. Whilst his eye is steadily fixed, the observer moves his hand towards the limits of his own field on either side horizontally, upwards, and downwards. In this way the examiner can ascertain somewhat roughly whether the patient's field of vision corresponds with his own or not.

Another plan is to employ a black rod, to the end of which a white disc is attached, and to use this instead of the hand in the method just described. A red or green disc may be substituted for the white one, and used as a rough test of the colour field. A long hat-pin, with a white bead at one end, and a knob of red sealing-wax at the other (Priestley Smith), is a simple contrivance for this purpose.

When the hand cannot be seen by the patient, as, for instance, in a case of cataract, it may be replaced by a candle, which is then moved about in different directions, so as to reveal the dimensions of the field.

A black board may be used. The patient, standing at 30 cms. distance, is directed to look at a chalk mark in the centre of the board, while the examiner watches closely that, during the test, the eye is kept fixed upon, and does not wander away from, this central point. Then, by advancing from the edge of the board towards the centre, a black rod which carries a disc of white 10 mm. square, and marking with the chalk the spot on the black board at which the disc becomes visible; and by repeating this process in different directions, and afterwards uniting by lines the various chalk dots, the extent of the visual field is displayed. It is convenient to have the black board marked with concentric circles and diagonal lines so as to be able to register the limits of the visual field more accurately. It is also useful to have a string attached to the board, to readily indicate the distance at which the patient should be placed.

Such a method as that just described is accurate only up to a limit of 55°, for it is evident that, the eye being a hollow sphere, the visual field cannot with exactness be projected on to a plane surface.

In order to map out correctly the field of vision, a perimeter is necessary. In such an instrument the field is projected and measured on practically a hollow sphere, and this is obtained by using an arc working on a pivot which serves as the fixation point.

The perimeters most generally employed are Priestley Smith's and M'Hardy's. Each has its advantages, but the former, though meeting all the necessary requirements, is much less costly than the latter. Priestley Smith's perimeter, and the mode of taking the field of vision with it, is illustrated in Fig. 59.

The patient rests the cheek corresponding to the eye to be examined against the upright rod of the perimeter, and he is directed to look steadily at the spot in the axis of the arc. He should support

FIG. 59.—Taking the field of vision with Priestley Smith's perimeter.

himself by placing his arms on the table, and avoid unduly pressing against the instrument. The surgeon should watch the patient to see that his eye does not wander from the fixation point. The other eye is excluded by a shade.

The quadrant is rotated by a wooden hand-wheel attached to its axis, and balanced by a weight so that it will stand in any position. The chart is placed upon the hinder surface of the hand-wheel, and rotates with it, so that, in whatever position the quadrant stands, the corresponding meridian of the chart comes opposite to a scale which is fixed behind the hand-wheel. The operator holds a black wand which carries the test object in one hand, while, with the other, he rotates the wheel and pricks the chart. He can thus prick off his observations with rapidity, and can keep the chart constantly under inspection, so that any portion of the field can be brought under examination at pleasure, and can be re-examined at any future time.

In mapping out the field of vision with Priestley Smith's perimeter, a start is generally made above. It is not a matter of any moment, however, at which meridian the chart is commenced. To get the field on the nasal side to the absolute limit, the eye may be turned to fix a point 30° to the temporal side of the fixation spot. "In glaucoma simplex this suggestion has value. Sometimes the light must be greatly reduced to discover either defects within, or encroachments upon, the periphery of the field. Another device sometimes helpful, is to make the patient face a window, and the glare of the light will sometimes bring out a limitation which would not occur in a normal eye" (Noyes).

M'Hardy's perimeter is an excellently devised and well-constructed instrument. Its chief advantage is that it registers the field automatically. This is effected by a most ingenious mechanism, which causes the test object on the quadrant, and the pointer which pricks out the chart, to move simultaneously.

Schweigger's perimeter (Fig. 60) is a smaller instrument. It can be carried in the hand, and has advantages, therefore, when it is necessary to make observations at the bed-side.

Method of using the perimeter.—Having selected a perimeter, proceed to map out the visual field in the following manner:—Carry the test object from the free end of the quadrant towards the centre, and mark upon the chart the point at which it first becomes visible to the patient. Repeat this process along successive meridians, and when all have been completed, remove the chart, and connect with pen and ink the different marks which have been made upon it. A map of the field of vision is thus displayed, as shown in Fig. 61.

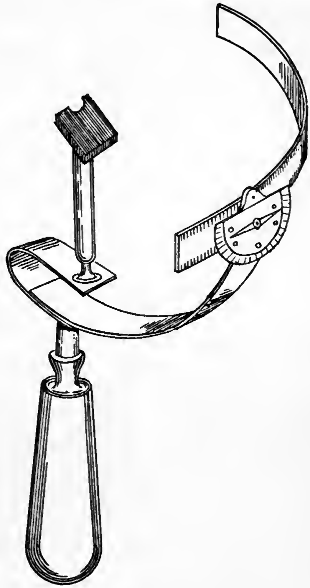


FIG. 60.—Schweigger's hand perimeter.

The size of the test object generally used is 10 mm. square, but it is sometimes desirable to employ smaller objects, especially when taking the colour field.

In some cases it is advisable to sweep the field, or parts of it, in circles rather than in meridians; for instance, in hemianopic or sector-like defects in which the boundary line of the field runs in a meridional direction. The test object may, for such cases, be fixed in a clip on the quadrant, and carried round the field in successive circles.

The test objects used in ordinary perimetric examination subtend an angle of 2° to 4°, and must therefore

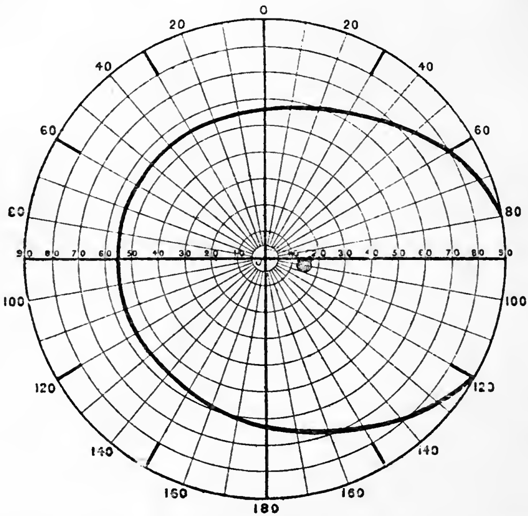


FIG. 61.—The area within the dark line represents the normal field of vision.

cover many thousands of retinal elements. The test is thus a rough one compared with those in use for estimating direct vision. Bjerrum has adopted smaller test objects, placed at a greater distance from the patient. Berry, who has had experience with this method, describes it as "capable, in many cases, of affording data of considerable diagnostic importance. A large black screen, 2 metres broad, which can be let down from the ceiling to the floor, should be used — the screen is most conveniently placed on the wall opposite the space between the windows, so as to get good light all round. It has to be pretty large, as the projection of the blind spot at a distance of a couple of metres, instead of measuring about 1 in., as on an ordinary perimeter, where the distance of projection is 1 ft., or 30 cms., measures 7 in. in diameter, and everything else is, of course, in the same proportion. A screen, 2 metres broad, will admit of testing up to about 27° from the point of fixation, if that be in the middle of the screen; while, by removing the point of fixation to the edge of the screen, a larger field can be measured. When the test object is small, the central point of the screen can be used, and this, of course, is the most convenient arrangement. The test objects used by Bjerrum are small circular discs of ivory, fixed on the end of a dull long black metal rod. They are of different sizes, from 10 mm. to 1 mm. in diameter. The examination is begun with a disc of 10 mm. diameter at the ordinary distance (30 cms.), and afterwards continued in suitable cases with one 3 mm. in diameter at the distance of 2 metres. In the first case, the visual angle is $\frac{10}{300}$, in the second $\frac{3}{2000}$, or approximately 2° and 5′ respectively. In the case of the 5′ visual angle, the boundaries of the normal field instead of being as extensive as they are found to be by the ordinary method of examination, average 35° outwards, 30° inwards, 28° downwards, and 35° upwards. Too much weight must not be attached to what appear to be slight concentric limitations got from an examination by the small visual angle method. It is the irregular limitations, the more or less sector-shaped defects and blind areas (scotomata), which are of the greatest importance. Concentric limitations

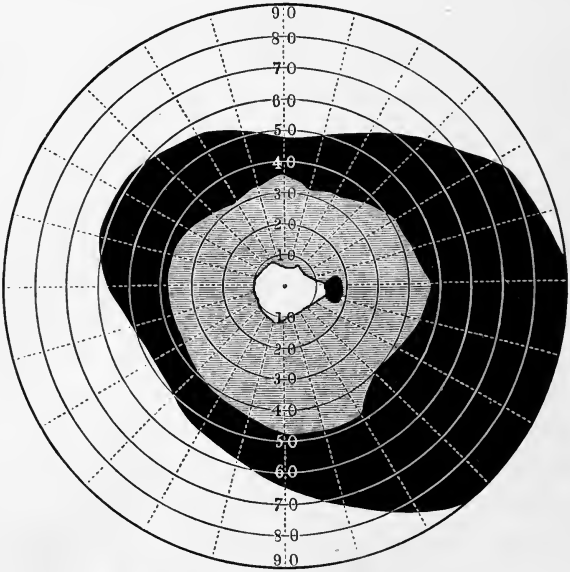


FIG. 62.—Field of vision from a case of glaucoma in which $V = \frac{20}{30}$. Shaded area marks extent of field by ordinary perimeter test; white area field for small object by Bjerrum's method.—BERRY.

are met with by this test as individual peculiarities. Under normal conditions, however, there are never found to be marked indentations, or scotomata, in the diminished field. Variations in illumination, it must be remembered, too, have a somewhat greater influence on the results got by testing with the small images, than in the case of the ordinary perimetric method."

The colour field of vision is taken by substituting a coloured test object for the white one. It is passed from the edge towards the centre, just as was done in the case of the white test, and the point where the colour is recognised is noted.

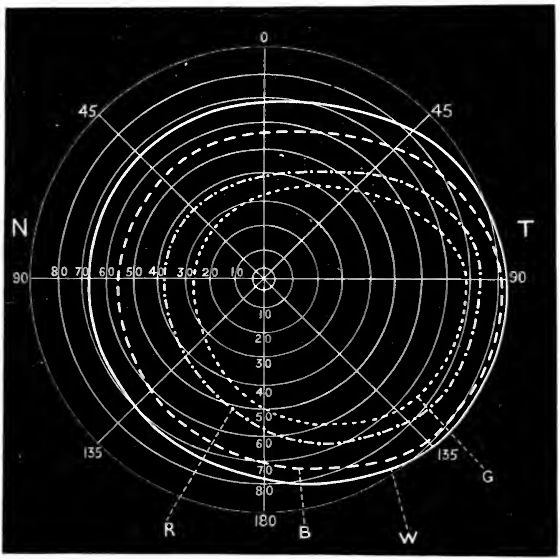


FIG. 63.—Perimetric chart showing field of vision of right eye—for... white (W), blue (B), red (R), and green (G), as projected on the inner surface of a hemisphere whose pole is the point of fixation. N denotes the nasal or inner, T the temporal or outer half of the field.—LANDOLT.

The field for colours is smaller than that for form; and, further, the fields for the various colours are not equal in size, but diminish usually in the following order :—(1) Blue, (2) yellow, (3) red, (4) green, (5) violet. The field for the different colours is represented in Fig. 63.

The colours are not seen at first in their own true colours. Yellow looks at first white; red looks brown, and green appears whitish grey or greyish blue. The fields for red and green are the two most frequently affected. The limits of the colour fields are subject to variations, but the chart (Fig. 63) gives the mean limits, deduced by Landolt, from the examination of a number of normal eyes.

All colours are perceived most vividly at the fixation point.

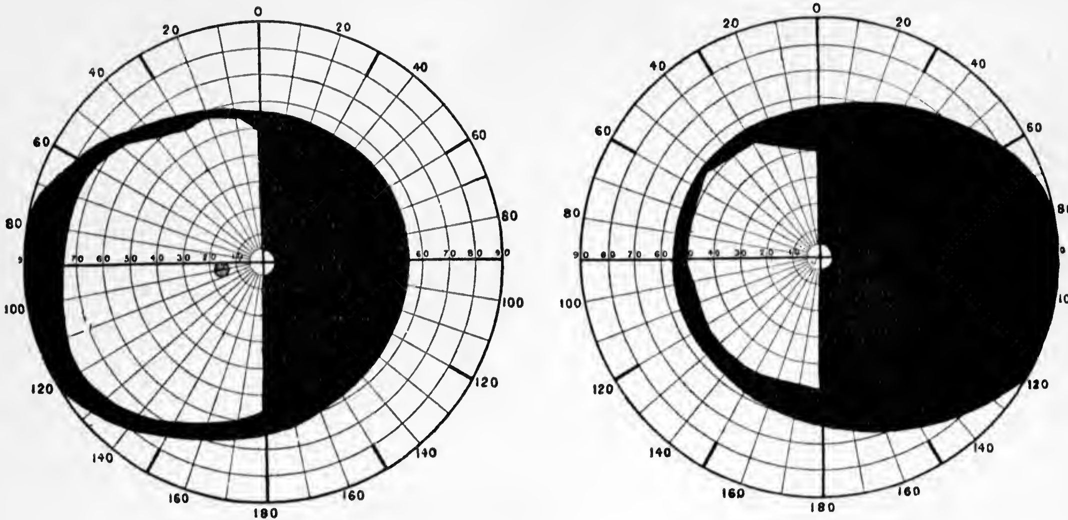
Defects in the Field of Vision.

Defects in the field of vision of the following kinds may be looked for. The field may be contracted either concentrically, or in such a way as to involve especially one or the other side; a segment or quadrant of the field may be wanting; or an entire half may be absent. In addition to these alterations of the field as a whole, there occur other defects called *scotomata*, which are island-like areas of blindness or amblyopia in a field which may otherwise be entire.

The contraction of the colour fields may often be greater than that for form.

Hemianopsia is the condition in which one-half of each visual field is wanting, and is met with under the following varieties:—

1. Horizontal hemianopsia.
   (*a*) Superior hemianopsia.
   (*b*) Inferior hemianopsia.



R. L.

FIG. 64.—Right lateral homonymous hemianopsia. The blackened areas represent the retinal portions which are blind. The right lateral field on each side is wanting, viz. the nasal half on the right side, and the temporal half on the left side.

2. Vertical hemianopsia.

(*a*) Homonymous hemianopsia.—In this, the most frequent form of hemianopsia, both right or both left lateral half fields are wanting (Fig. 64). Absence of the right half fields means blindness of the left half of each retina, and to this condition the term "right homonymous hemianopsia" is applied. Conversely, "left homonymous hemianopsia" implies blindness of the *right* half of each retina. It is beyond the scope of this work to enter upon the causes of disease, but it may be mentioned that hemianopsia of this homonymous variety can be occasioned by a lesion on either side, situated at any point in the course of the visual nerve fibres, from the commencement of the optic tract to the cortical centre in the occipital lobe.

(*b*) Bi-temporal hemianopsia.—Both fields are wanting on the outer side, corresponding to blindness of the inner half of each retina (Fig. 65). A lesion, to effect such an alteration in the field, must be situated at the chiasma.

(*c*) Bi-nasal hemianopsia.—The inner half of each field is absent, indicating loss of function in the outer half of each retina. It is the rarest variety of hemianopsia. In order to explain such

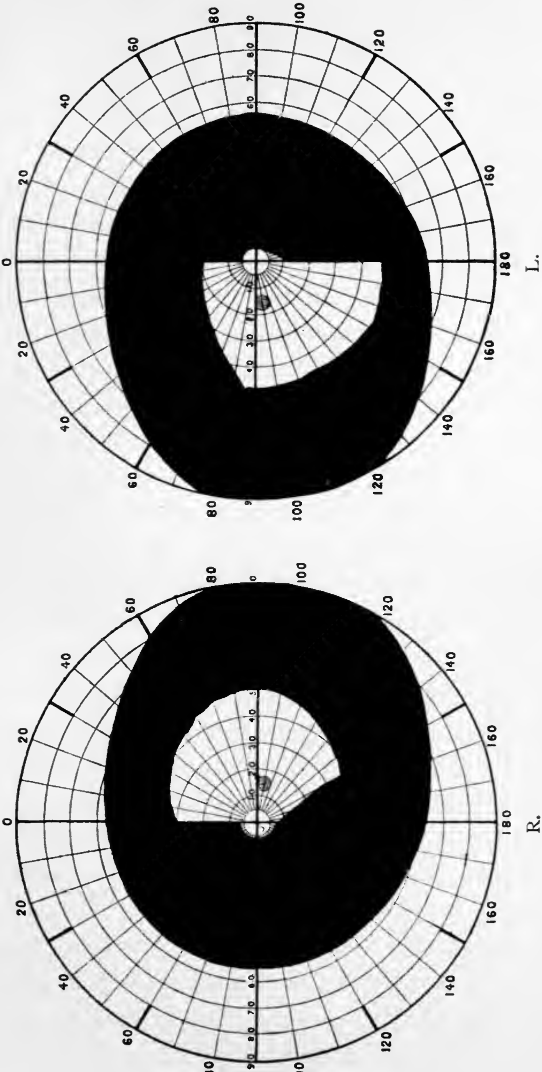


FIG. 65.—Bi-temporal hemianopsia. The blackened areas represent the retinal portions which are dark, showing thus the loss of the temporal field on each side.

a defect in the field, one must assume the existence of a lesion, or lesions, involving the outer angle of the commissure on both sides, or the outer side of each optic nerve.

Charts in hemianopsia may show an absence of an entire half, or only a corresponding quadrant at fault in each field. The remaining half of the field may be contracted. The line of demarcation does not always run directly through the fixation point. Not infrequently it goes over to the other side, leaving the macula entirely in the seeing half. Cases of double homonymous hemianopsia, in which a small central area in the field is left, have given rise to the supposition that there is a special centre for the macular region.

Scotomata.—In addition to the alterations of the periphery of the field which have been already mentioned, gaps in the visual field itself are met with. These are called scotomata. The entrance of the optic nerve, Marriotte's blind spot as it is named, is a natural scotoma. Its situation is 15° external to, and 3° below, the fixation point. Scotomata in other parts of the field are due to pathological conditions, and have an important significance. Scotomata are divided into positive and negative.

1. *Positive.*—A dark spot is perceived by the patient. This may be due to opacities in the refractive media, or to retinal or choroidal disease. Such spots will be especially noticeable on looking at a white surface, as, for instance, the ceiling, or a sheet

of white paper. Muscæ volitantes, as well as actual vitreous opacities, are included in this group.

2. *Negative.*—In this class the scotomata are real islands of blindness or dim vision in the visual field. Not being recognised by the patient, they are, as a rule, only discovered by examination. A negative scotoma, however, may also be a positive one. The varieties met with are the following:—Central, ring, and peripheral.

A negative scotoma may further be—(*a*) *Absolute*, in which the perception of light is wanting; or (*b*) *Relative*, in which the perception of light is only diminished. In order to detect the latter, it is desirable to examine the field, and especially the colour field, with small objects. About $\frac{1}{4}$ cm. square is the best size of test object to use, and the spot where it begins to disappear, or to change colour, is noted.

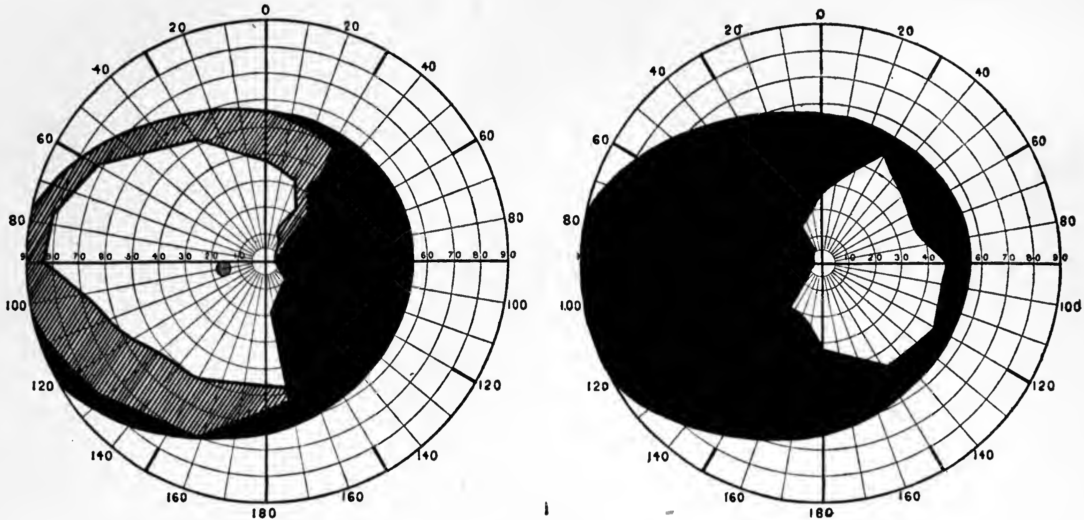
It may be mentioned that, in mapping out a field, if the test object is advanced from the periphery, and only the spot at which it first becomes visible be noted, scotomata within the area of the field itself will escape detection. The examination should therefore be continued within the field. The point where the test object becomes lost or obscured should be marked, and then the test object should be carried farther on, and the spot at which it is again clearly seen should be noted. Positive scotomata are best tested in a subdued light.

Scotomata are often better seen on a dull, plane surface than with a perimeter. A scotoma may be detected by looking at a row of letters, as Noyes suggests, at 20 in. distance. Thus in the line O H S V E, the S pointed out to the patient may be declared to be less distinctly seen than the letters before and after it.

The perimeter may be employed for testing the acuity of vision at the periphery of the retina. For this purpose small squares of black paper, with intervals between them equal to their own width, are placed in the clip of the instrument, and the position ascertained for each meridian in which they are first recognised as distinct objects.

The indications of the visual field in some conditions have already been sufficiently alluded to. Others remain which require further mention. In acute glaucoma, vision is so much and so rapidly reduced, that the state of the field of vision is scarcely of account; but in *chronic simple glaucoma*, the indications are of the highest moment. The contraction of the field will show itself first and chiefly on the nasal side (Fig. 66, *A*.), and this may be considerably contracted, whilst central vision is by no means diminished in corresponding degree. The upper and lower parts of the field generally next show contraction; and, lastly, the temporal side is lost until the field is reduced to the fixation point, and ultimately that is lost also.

Bjerrum's method of taking the field of vision has been mentioned. The form of restriction in glaucoma is claimed to be always characteristic. "The shape of the field is by no means always the same in all cases, but the defective area is always found to extend up to the blind spot in one direction or another" (Berry). (See Fig. 62.)



A. *B.*

FIG. 66.—*A*. Field of vision in a case of chronic primary glaucoma in a patient, æt. 57. The first examination of the field showed a loss represented by the black area. A second examination, three months later, showed a further loss represented by the shaded area.

B. Field of vision in a case of locomotor ataxy, with atrophy of the optic nerves, in a patient, æt. 41.—PRIESTLEY SMITH.

In *optic atrophy* the field (Fig. 66, *B.*) is contracted concentrically, or it presents sector-like defects, and the diminution of the area of the field is in accordance with the progressive deterioration of central vision. Colour defects are also present. In certain cases of this affection a central scotoma is met with, with or without peripheral narrowing of the field. *Retinitis pigmentosa* is associated with a progressive narrowing of the field concentrically, which proceeds very slowly until the field is obliterated. Cases of *functional (hysterical) amblyopia*, in which the appearance of the optic nerve is normal, may show concentric contraction of the field with, or without, associated colour defects.

In *detached retina* the field will be found wanting in the part corresponding to the situation of the detachment. A detachment below will cause a defect in the field above.

The affections in which scotomata are met with may be thus briefly summarised:—

1. *Positive scotoma.* — Choroiditis — disseminate; the dark spots noticed may be numerous, so as to give the appearance of a sieve (Fuchs); syphilitic retinitis, either as ring, central, or peripheral scotomata; neurasthenic asthenopia, or retinal anæsthesia; central punctate retinitis; "floaters" in the vitreous of all kinds; muscæ volitantes; hæmorrhage at, or disease of, the macula.

2. *Negative scotoma.*—Retro-bulbar neuritis; toxic amblyopia; certain cases of optic atrophy, a central scotoma (with or without concentric contraction of

the field); central punctate retinitis (relative scotoma), in which there is a central area of lowered vision.

Cases of tobacco amblyopia afford good examples of central scotomata. The field, taken with a white test object, may be of normal extent, but if a small red test object be employed, a small area will be found in

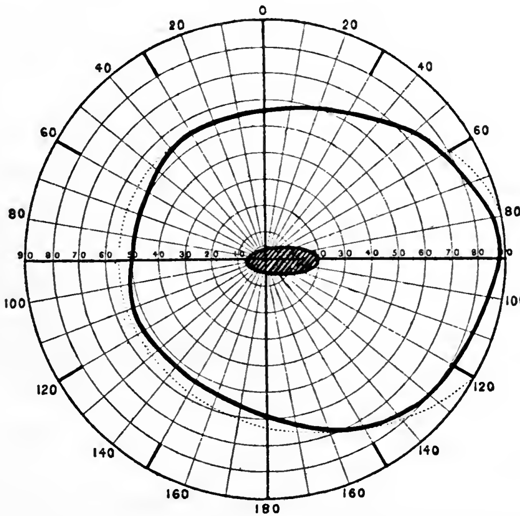


FIG. 67.—Perimeter chart, from a case of tobacco amblyopia, showing central scotoma.

the centre of the field in which it is not recognised as red (Fig. 67). A scotoma is not only present, but it is a central scotoma (colour scotoma); and, further, a scotoma for red. Such a scotoma is usually oval in shape with its long axis horizontal, and extending from the fixation point towards the blind spot. Over this area red appears brownish, and green looks dirty white. It is then called a "paracentric scotoma";

but if it is much larger, and surrounds the fixation point, it is spoken of as a "pericentric scotoma." Other substances besides tobacco occasion a similar form of toxic amblyopia. Bisulphide of carbon, dinitrobenzol, and iodoform may be mentioned. A similar scotoma is met with in certain cases, also, of optic atrophy.

Light shades of red and green are to be preferred for testing in cases of tobacco or other varieties of toxic amblyopia.

According to Berry, Bunge has found a central, or paracentral scotoma in four out of a hundred cases of glaucoma. The examination was made by Bjerrum's method (p. 120). The presence of a scotoma in these cases is associated with contraction of the peripheral field.

In optic atrophy, with central scotoma, there is also usually contraction of the peripheral field.

The size of the blind spot is sometimes increased in myopia and optic neuritis. It may be mapped out with the perimeter "by using a bright test object" (Noyes).

CHAPTER VIII.

THE MOVEMENTS OF THE EYEBALL AND THEIR ANOMALIES.

The Field of Fixation.

The movements of the eyeball are affected by the straight and oblique muscles. The degree of motility

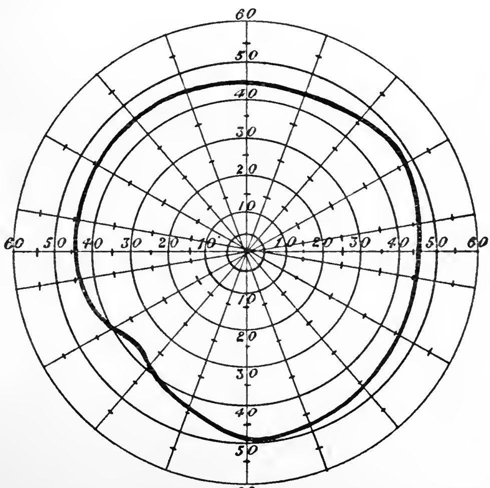


Fig. 68.—Normal field of fixation.—After Landolt.

varies in different directions, the greatest being downwards. The field of fixation includes the limits to which the two eyes can be directed whilst the head is maintained in a fixed position. It can be ascertained by one or other of the methods to be now mentioned.

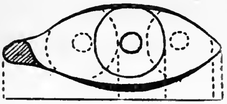


FIG. 69.—Linear measurement of the lateral excursions of the eye.—After A. GRAEFE.

A perimeter may be used, and the field recorded on the same chart as that employed for the field of vision (Fig. 68). The patient is placed in the usual way at the instrument, the eye not under examination being covered. The piece of white paper used as a test object is replaced by large test letters. These are advanced from the periphery towards the centre until the patient, on looking towards them, recognises the letters distinctly. These different points are marked in the ordinary way on the perimeter chart. A line uniting these points will indicate the limits of excursion of the eye, or the field of fixation. It is essential that no movement of the head should take place.

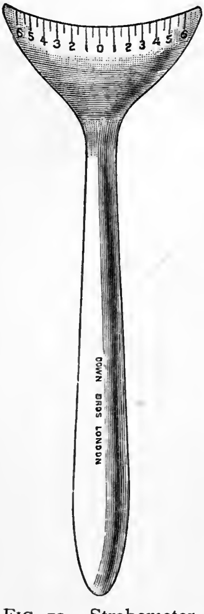


FIG. 70.—Strabometer.

Another is Alfred Graefe's linear method. It is simpler and more readily used, but it is only applicable to lateral excursions of the globe. "The patient is first made to look straight forward at an object which has been placed at quite a distance from the eye in the middle line of the face. With the eyes in this middle position, the distance between the outer margin of the cornea and the outer angle of the eye (*cm.*, Fig. 69) is measured with a scale. This distance is also measured when the eyes are turned as far inward and as far outward as possible (*ci* and *ca*). The difference between these values and the value for the middle position gives the magnitude of abduction and adduction of the eyeball. Suppose we have found *cm* to be 8 mm., *ci*, 18 mm., and *ca*, 1 mm. Then the adduction $= ci - cm = 10$ mm., and the abduction $= cm - ca = 7$ mm. The adduction and abduction together constitute the total range of lateral movement, which, in the example selected, would amount to 17 mm" (Fuchs).

A strabometer (Fig. 70) may be employed, or a millimetre scale, held close to the lower eyelid, will suffice to give the measurements in the manner just mentioned. The pupilometer already described (p. 27, Fig. 20) is made to be used also as a strabometer.

Disturbance of Muscle Balance.

In the normal condition of the eye muscles there is complete equilibrium, that is to say, no muscle, or set of muscles, exerts an undue influence on the eyeball. This normal state of balance may be disturbed by a preponderance of certain muscles over their opponents, and this condition was formerly spoken of as "insufficiency" of the weaker muscles.

Stevens has introduced terms which more accurately describe the anomalies of the ocular muscles than did the older names, under which they were referred to as "insufficiencies" of the inner or outer recti, etc. His proposals have met with general adoption.

The condition in which all adjustments are made by muscles in a state of physiological equilibrium is called *orthophoria.* Disturbances of equilibrium are known as *heterophoria.*

The deviating tendencies of heterophoria may exist in as many directions as there are forces to induce irregular tensions.

The following system of terms is applied to the various tendencies of the visual lines:—

I. Generic terms—*Orthophoria.*—A tending of the visual lines in parallelism. *Heterophoria.*—A tending of these lines in some other way.

II. Specific terms.—Heterophoria may be divided into—

(1) *Esophoria*—a tending of the visual lines inward.

(2) *Exophoria*—a tending of the lines outward.

(3) *Hyperphoria* (right or left)—a tending of the right or left visual line in a direction above its fellow.

This term does not imply that the visual line to which it is referred is too high, but that it is higher than the other, without indicating which may be at fault.

III. Compound terms.—Tendencies in oblique directions may be expressed as *hyperesophoria*—a tending upward and inward; or *hyperexophoria*—a tending upward and outward. The designation "right" or "left" must be applied to these terms.

The following are some of the tests adopted for heterophoria :—

1. Advance the finger close up to the patient in the middle line. As the finger gets nearer to the eyes, one eye may be noticed to fix more than the other, and when a closer point still is reached, this eye remains fixing while the other diverges. This test indicates insufficiency of the inner recti (exophoria), and, roughly, the muscle which is the weaker.

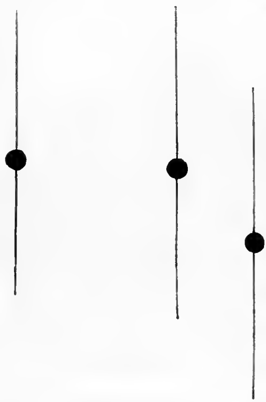
2. Hold the finger about 20 cms. from the patient in the middle line; let him fix the finger with one eye, say the right, while you place a hand or a card as a screen in front of the left; observe, behind the screen, whether the left eye has converged or diverged, and also note, on removing the screen, the movement made to bring it into line with the right eye. One millimetre of deviation corresponds to 2 degrees of insufficiency (heterophoria) as measured by prisms (de Schweinitz).

3. The lateral muscles can be tested by producing vertical diplopia. Let the patient look at a candle 6 metres distant, with a dark background. In front of the right eye place a prism of 8° base downwards. Should the double images so produced be in the same vertical line, the lateral balance is correct. The upper image belongs to the right eye. Should it deviate to the left, the indication will be insufficiency of the internal recti (exophoria); if the deviation be to the right of the median line, insufficiency of the external recti (esophoria) is present.

4. The vertical muscles may be tested in a similar manner. Place in front of the right eye a prism

(8°), with its base towards the nose. If the two images of the candle are on the same level, the vertical balance is correct, but if the right is on a lower plane than the left, insufficiency of the vertical muscles (hyperphoria) is indicated.

In both the foregoing tests, the prisms placed before the left eye, either base in or out in the first (3), and base down in last (4), which brings back the images to the vertical or horizontal planes, will indicate the amount of deviation in each case.



FIGS. 71, 72.—Graefe's test for insufficiency of internal recti (exophoria).

In employing these tests care must be taken that the patient's head is kept quite straight. The slightest inclination of the head to one side produces deviation of the double images.

5. Graefe's test for insufficiency of the internal recti (exophoria) is as follows:—On a sheet of paper a dot is drawn with a line running through it vertically (Fig. 71). The patient looks at this at his reading distance, and before the right eye a prism of 10° or 12° is placed, with the base downwards. Normally a line with two dots should be seen, but, if insufficiency (exophoria) be present, two separate figures will be noticed, one line and dot being placed somewhat higher than the other; this latter is the image seen by the right eye, and appears displaced to the left (crossed diplopia).

Should the diplopia be homonymous, insufficiency of the external recti (esophoria) is present.

A single word printed in very small type may replace the dot and line if desired. Maddox's test for near vision is mentioned later (p. 147).

6. The power of abduction and adduction may be tested by allowing the patient to look at a candle, as in the preceding trials, and, for abduction, finding the strongest prism, base inwards, through which the flame will still appear single; for adduction, by finding the strongest prism with its base outwards through which the flame will look single. In the latter (adduction), a prism up to between 30° and 50° may be required, but for the former (abduction), 6° or 8° will usually suffice. The relation between adduction and abduction is about 6 to 1. The power of sursumduction is tested by placing prisms base downwards, and finding the most powerful through which single vision is maintained. The degree is usually about 3°.

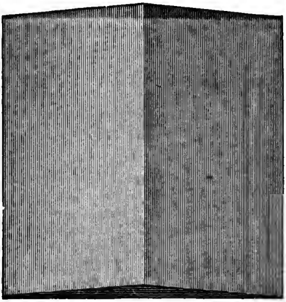


FIG. 73.—Maddox's double prism.

7. Maddox's double prism is another test. It consists of two prisms of 3° or 4°, with their bases together (Fig. 73), placed in a cell. This is put in a trial frame, and the patient is directed to look at a distant flame. Three images will be visible (Fig. 74), the true in the centre, and a false one above and

below. They should, if there be equilibrium, all be in the same line, but, if the true image stands to the right or the left, there is lateral heterophoria, and if it stands above or below the mid-distance between the other two, or is confused with either the upper or lower image, there is vertical hyperphoria. The examination is facilitated by placing a red glass in front of the left eye, which will render the true image red. The deviation may be measured by finding the

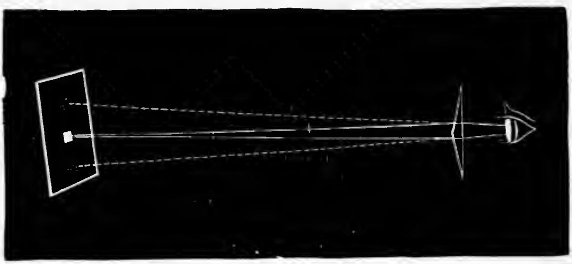


FIG. 74.—Maddox's double prism, illustrating the three images.

prism which brings the images all into vertical line. If the Risley rotary prism (Fig. 81, p. 150) is put in front of the left, while the Maddox double prism is before the right eye, a rapid determination of the degree of the deviation may be made. If the two false images stand to the left of the real image, that degree of prism, found by turning the base of the revolving prism toward the nose on the left side, which brings the three images in line measures the amount of divergence; if the two false images stand to the right of the real image, that degree of prism found by turning the base of the rotary prism towards the temple indicates the amount of convergence (de Schweinitz).

8. Duane's test.—The patient is placed with the head erect, and eyes straight forward. The object of fixation should be 20 ft. distant, and consists preferably of a white spot 1 cm. in diameter, upon a dull black surface of considerable extent. A card is placed before one eye, and passed alternately from that to the other, the patient being asked at the same time if the spot appears to move, and in what direction. If it remains perfectly stationary, the position of fixation is perfect. If the spot moves, it must occupy a different position, as seen by the two eyes; or, in other words, there is diplopia present, which the method of observation has unmasked. If, when the left eye is uncovered, the spot appears to move toward the left, there is really a homonymous diplopia, the two images being seen alternately. If the object moves to the right, there is crossed diplopia. If it moves up or down, there is vertical diplopia. In order to determine the amount of this diplopia, we place prisms of appropriate direction and strength before one eye until the movement is abolished. Thus, if, when the left eye was uncovered, the object appeared to move downwards and to the left, two prisms are placed before this eye, with their bases respectively downward and out, and increased in strength until the movement becomes nil.

This test is almost always applicable, since there are very few persons who cannot be got to note the fact that the spot moves and the direction that it takes. The test is delicate, a prism of $\frac{1}{2}$, or less, sufficing to overcome quite a decided parallax.

9. Maddox's rod test. — Transparent cylinders occasion the apparent elongation of objects, and this feature is employed to dissociate the images seen by one eye from those perceived by the other. Thus a cylindrical rod placed before one eye will cause a

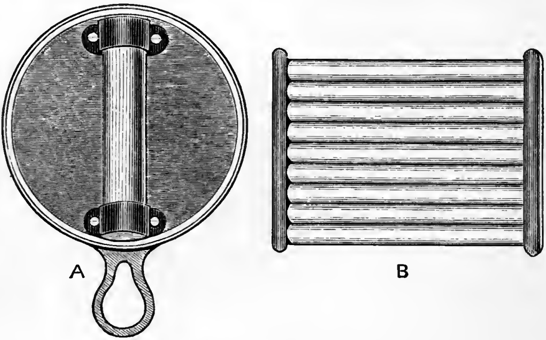


FIG. 75.—*A*, Maddox's rod.
B, Series of rods.—From BERRY.

point of light, as seen by the naked eye, to appear as a line of light. For testing, a rod 5 or 6 mm. in diameter (Fig. 75, *A*), or, better still, a series of such rods side by side, as in Fig. 75, *B*, is fixed in a metal plate, of a size to fit in a trial frame. It is used in the following way:—

The patient is placed at a distance of 5 metres from, and on the same level as, a candle flame. Behind this is a tangent scale, graduated in degrees for the distance at which the test is made, the candle flame corresponding to zero.[1] Adjust a trial frame to the face, and before the right eye place the Maddox rod. It is well to use a blue glass before the other eye, and the rod itself may be red. To the right eye, a line of red light will be visible; to the naked eye, the candle flame. A darkened or partially darkened room will facilitate the testing.

To test the lateral muscles place the rod horizontally;

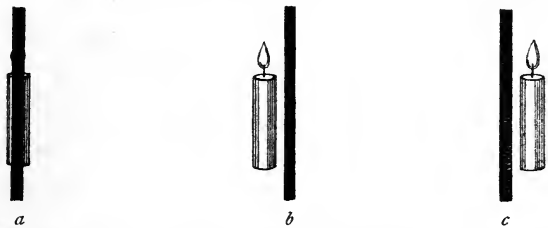


FIG. 76.—Maddox's rod test for the lateral muscles. The position of the "line" to the flame indicates :—
a, Corrrect balance (orthophoria).
b, Excessive convergence (esophoria).
c, Excessive divergence (exophoria).

if the vertical line of light cut through the flame (Fig. 76, *a*), the muscle balance is correct (orthophoria).

If the line be to the right—homonymous—there is excess of convergence, or esophoria (Fig. 76, *b*). If the line be to the left—crossed—there is excess of divergence, or exophoria (Fig. 76, *c*.) The number on the scale extending horizontally behind the flame which is crossed by the line of light, indicates the deviation in degrees; or it may be estimated by the prism

[1] Instead of a candle flame, Maddox now prefers to use a tiny paraffin lamp, made by fixing a small lamp-head to a test tube, and he has greatly improved the definition of both the flame and the streak of light by placing a piece of black velvet behind the lamp.

which, placed before the left eye, base out and base in respectively, is necessary to bring the line of light into the middle of the flame (orthophoria).

To test the vertical muscles, place the rod vertically before the right eye. The left (naked) eye sees the candle flame, but the flame, to the right eye, is replaced by a horizontal line of light. If, with both eyes open, the horizontal line of light cut across the flame (Fig. 77, *a*), there is no vertical deviation. Should the

FIG. 77.—Maddox's rod test for the vertical muscles (before right eye). The position of the "line" to the flame indicates:—

a, Through the flame (no deviation).
b, Below the flame (right hyperphoria).
c, Above the flame (left hyperphoria).

line be below the flame, there is right hyperphoria (Fig. 77, *b*). Should the line be above the flame, there is left hyperphoria (Fig. 77, *c*).

The vertical deviation may be estimated by the prism, adjusted before the left (naked) eye, which brings the line of light to cut through the flame of the candle; or, if the scale behind the flame be placed vertically, the figure crossed by the line of light will indicate the degree of the deviation upward or downward. A vertical scale, specially for this purpose, can be obtained, furnished with directions for decentering.

The following rule (Maddox) will indicate the faulty eye in hyperphoria. " If the flame is lowest, there is a tendency to upward deviation of the naked eye; if the line is lowest, of the eye before which the rod is placed."

If desired, a strong plano-cylinder, 10 mm. radius, may be substituted for the rod in this test.

The tangent scale employed (Fig. 78) with Maddox's rod is graduated in degrees for a distance of 5 metres, and the diplopia revealed is indicated in degrees by the figure through which the band of light passes. Smaller figures are given for use at 1 metre. These latter are intended for objective strabismometry (p. 157).

FIG. 78.—Maddox's tangent scale (reduced).

Ametropia, if present, should be corrected, and the appropriate spectacles adjusted in the trial frames when applying the " rod test."

For the accurate measurement of deviations at near distances Maddox has also devised a tangent scale.

The scale is held at a ¼ metre (25 cms.) distance, and a square prism 12° base upwards is placed before the right eye. To save repeated adjustment, the prism may be permanently fixed in a spectacle frame, and a black thread attached to the test card, to indicate the distance at which it is to be held. The patient will observe two lines, one below the other, and the figure to which the lower arrow points will indicate latent convergence in degrees of deviation to the left, or latent divergence to the right.

The figures under the waved line are teens (Fig. 79), and the capital letters A B C D represent metre-angles. If the arrows are in line, there is equilibrium; if the lower arrow points to *black* A, convergence exists for $\frac{1}{5}$ m.; to B, for $\frac{1}{6}$ m.; to C, for m.; and to D, for $\frac{1}{8}$ m.; so that there are $+1$, $+2$, $+3$,

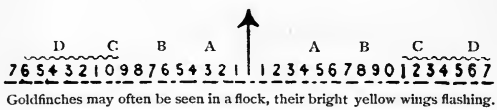


FIG. 79.—Maddox's tangent scale for measuring deviations at near distances (reduced, and not to be used for testing).[1]

and $+4$ metre-angles of excessive convergence respectively. If the lower arrow points to the *red* letter A, convergence occurs for a greater distance than the scale, namely, $\frac{1}{3}$ m., so that there is 1 metre-angle of insufficiency or divergence. If it points to red B, convergence occurs for $\frac{1}{2}$ m.; to C, for 1 m.; and to D, for infinity; so that there are respectively, 1, -2, -3, and -4 metre-angles of insufficiency of convergence. In the last case the visual axes are parallel. In normal eyes there is an average divergence of from 3° to 4°. A printed sentence is affixed to the scale to secure accurate accommodation. For full deviation to occur takes about half a minute.

[1] In the original scale the figures to the left of the arrow are red, and those to the right black.

Should the patient be ametropic, his refraction should be corrected before these muscle tests are used; or, should they form part of a routine examination, the results should be verified after the patient has been furnished with the appropriate glasses.

For all the muscle tests a set of prisms is essential. The number provided in the usual trial cases is inadequate. It is necessary to have a larger selection than the trial case affords, and to have them in pairs. The series used by me is the set suggested by Dr.

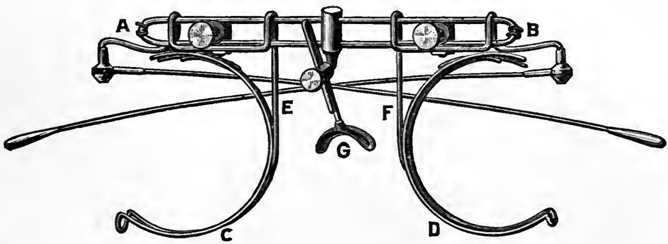


FIG. 80.—Risley's frame for prisms.

Risley, of Philadelphia, and comprises pairs numbered in degrees as follows:—1, $1\frac{1}{2}$, 2, $2\frac{1}{2}$, 3, 4, 5, 6, 7, 8, 9, 10, 12; and single prisms 15, 18, 20. It is also desirable to have a frame into which the prisms will readily fit, and which can be placed over the ordinary trial frames, or over the patient's spectacles. Risley's frame, illustrated in Fig. 80, is a very useful one.

A further adjunct is a rotary prism. Risley's (Fig. 81) consists of two prisms, working one over the other, and together constituting a total of 45°. The milled edge allows of rotation in opposite directions, and it is fitted in a cell which permits of the base or apex being placed in any position which may be required.

When noting results in the examination of eye muscles, it is well for the observer to face the same way as the patient, otherwise he may fail to understand, or will record incorrectly, the data obtained.

STRABISMUS.

Strabismus comprises those conditions in which the visual axes are not directed to the same point. The eye which is directed to the fixation point is called the *fixing eye*, and the other the *squinting eye*. The deviation may be inwards, outwards, upwards, or downwards. Strabismus may be either *concomitant* or *paralytic*, and these two forms must be distinguished from one another. Broadly speaking, whilst both agree in that the two eyes are not directed to the same point of fixation, they differ in this, that, in concomitant squint, the motions of the squinting eye are not restricted, whereas, in paralytic strabismus, there is restriction, or loss of the movement normally effected by the paralysed muscle. The primary and secondary deviations are also equal in concomitant squint; while the secondary deviation is greater than the primary in paralytic strabismus.

FIG. 81.—Risley's rotary prism.

The "primary deviation" is that of the squinting eye when the sound eye fixes; the "secondary deviation" is that of the sound eye when fixation is effected by the squinting eye. This is ascertained by covering the good eye, and noting the deviation which takes place behind the screen. The primary and secondary deviations can be measured by a strabometer, or by one of the linear methods to be presently described (p. 152).

The distinguishing features between concomitant and paralytic squints are enumerated in the following table (de Schweinitz):—

Concomitant Squint.	*Paralysis of an Ocular Muscle.*
1. The movements of the squinting eye can follow those of the other eye in all directions.	1. There is limitation of the movement of the affected (squinting) eye in the direction of the paralysed muscle.
2. The angle of squint always maintains the same size (Mauthner).	2. The angle of squint increases if the eye is moved in the direction of the paralysed muscle, but decreases if the movement is in the direction of its antagonist (Mauthner).
3. The secondary and primary deviations are equal.	3. The secondary deviation is greater than the primary deviation.
4. There is no characteristic carriage of the head.	4. There is usually faulty carriage of the head, which is turned toward the side on which the diplopia is least annoying.
5. Diplopia is uncommon.	5. Diplopia is the rule.
6. There is no false projection of the field of vision.	6. There is false projection of the field of vision.
7. In the permanent variety the squinting eye is often amblyopic.	7. The squinting eye may often have the better vision of the two.
8. Considerable degrees of refractive error are common (H in convergent, and M in divergent squint).	8. There is no special relation between the refractive condition and the squint.

An idea of the degree of convergent strabismus can be obtained roughly by noting the relation an imaginary perpendicular line through the centre of the cornea bears to the lower punctum. To estimate it more accurately, one or other of the following methods may be accepted.

THE MEASUREMENT OF STRABISMUS.—*The linear method.*—A rule adapted to the curve of the lower eyelid should be used; it is called a strabometer (Fig. 82). On it is a millimetre scale, with zero in the centre. Cover the sound eye, and whilst the other looks directly forwards, place the strabometer on the lower eyelid, in such a position that the O on the scale corresponds with a vertical line through the centre of the cornea. Then remove the screen, whilst the eyes are both directed forward, and make a note of the point on the scale to which the centre of the cornea of the squinting eye now corresponds. The linear deviation is represented by the distance on the scale between this point and the centre O.

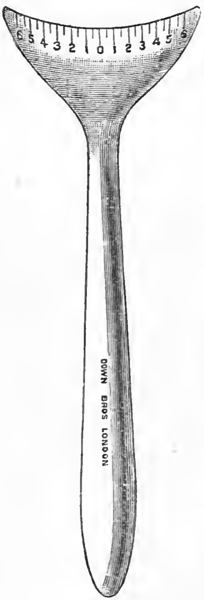


FIG. 82.—Strabometer.

Another linear method (Fuchs) is the following:—The patient is directed to look at an object placed in the median line between the two eyes at a distance of some metres. Suppose the left eye, L (Fig. 83, *A*), fixes correctly, and the right, R, squints inwards, the position of the outer margin of each cornea is marked by an ink dot upon the edge of the lower eyelid, *m*, and *s*. Next, cover the left eye with a screen, S (Fig. 83, *B*), and, on the patient again directing his gaze to the object, the right eye will be used for fixation, and then the position of the external border of the cornea is marked on the lower lid, *m*, with an ink dot. The space between the two dots will give the linear deviation of the squinting eye—the *primary deviation*.

When the left eye is screened and moved inwards,

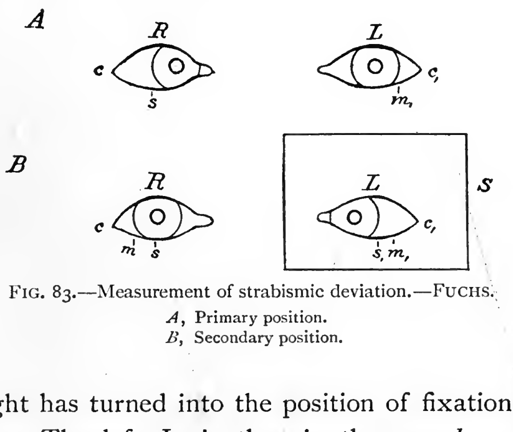


FIG. 83.—Measurement of strabismic deviation.—FUCHS.

A, Primary position.
B, Secondary position.

the right has turned into the position of fixation (Fig. 83, *B*). The left, L, is then in the *secondary deviation position*. A dot is made on the lower eyelid corresponding to the position of the outer edge of the left cornea, *s*, and the space between these indicates the linear amount of the secondary deviation, *s*, *m*.

The two deviations, primary and secondary, in concomitant strabismus are equal, a fact which constitutes a difference between it and paralytic squint.

With an eye of normal size, 1 mm. of linear deviation corresponds approximately to an angle of 5°.

Mr. Priestley Smith uses a *tape measure*. The position of the patient's deviating eye is estimated by the position, centric or eccentric, of the corneal reflex

FIG. 1.

FIG. 2.

FIG. 3.

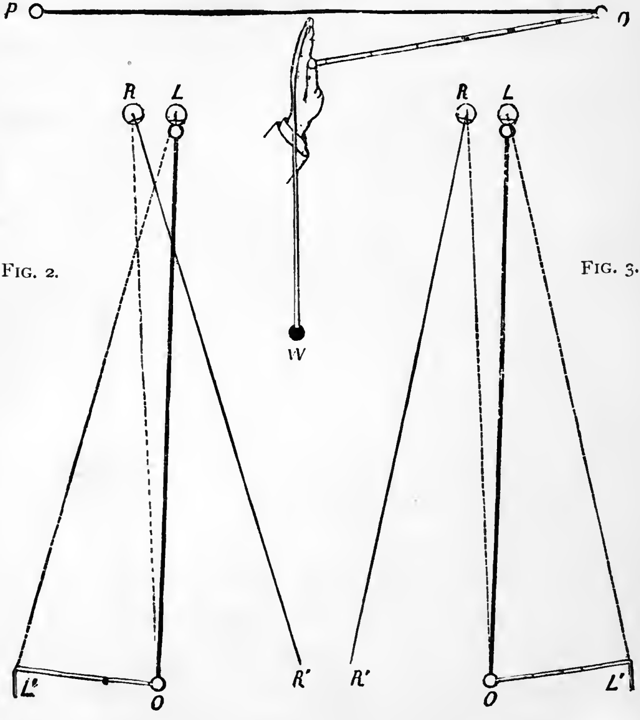


FIG. 84.—Priestley Smith's tape measure for strabismus.

of a flame. An ophthalmoscope held either before or below the observer's eye is the immediate source of the light. A double tape is employed, the use of which is explained by the accompanying figures (Fig. 84):—

"Fig. 1.—The ring O is placed by the observer on his forefinger, or on the handle of his ophthalmoscope. To it are attached two tapes, each 1 metre in length, one black, the other coloured. The black tape ends in a ring, P, which the patient places on his forefinger, and holds against his cheek below either eye, or against his chin; it determines the distance between observer and patient, and has no other purpose. The coloured tape is divided by lines into twelve parts, and figured 5, 10, 15, and so on up to 60; it ends in a small weight, which keeps it stretched when the hand of the observer passes along it in either direction, the tape sliding between the fingers.

"Fig. 2 illustrates the measurement of a convergent strabismus of the right eye. The patient, seated below the ophthalmoscope lamp, and holding the tape as above described, is told to look at the mirror. The observer, holding the ring, O, and the mirror in the right hand, throws the light on the left eye, L. He sees the corneal reflection in the centre of the pupil, and knows thereby that this eye is fixing properly. He then throws the light on the right eye, R, and sees the reflex situated eccentrically outwards, and knows that this eye deviates inwards. Taking the graduated tape between the fingers of his left hand, and telling the patient to watch this hand, he moves it outwards along the tape (see Fig. 1), and meanwhile watches the corneal reflex in the right eye. When the reflex reaches the middle of the pupil, he reads the position of the hand upon the tape. The axis of the deviating eye, R, has moved from R′ to O, through the angles R′ R O. The axis of the non-deviating eye, L, has moved through an equal angle O L L′. The angular movement of L, as measured by the tape, equals the angular deviation of R.

"Fig. 3 illustrates the measurement of a divergent strabismus of the right eye. In this case the observer sees the reflex of the deviating eye, R, situated eccentrically inwards. Taking the mirror and ring O in his left hand, he takes the graduated tape in his right, tells the patient to look at the hand, and moves it outwards along the tape until the reflex of R lies in the centre of the pupil. Then, as before, the position of the hand upon the tape indicates the angular deviation.

"The hand should in all cases be held edgeways towards the patient; in this position, and at the distance of 1 metre, it forms a sufficiently small fixation object.

"It is obvious that since the position of the measuring tape does not exactly correspond with the arc of a circle round the non-deviating eye, the angular measurements will not be absolutely precise; but if the observer remembers to keep both his hands as nearly as may be at the same distance from the patient's face, no important error will arise."

The angular method (Landolt).—A perimeter is necessary. Direct the patient to fix a distant point in the median line with both eyes (Fig. 85). Then move a taper or candle along the arc of the perimeter, until its reflection is seen in the centre of the pupil of the squinting eye. The degree on the arc at this point will indicate the size of the strabismus angle.

Tangent strabismometer.—Maddox has devised this method, and thus briefly describes it:—

The scale in Fig. 78, p. 147, provides its lower series of smaller figures for this purpose. The only

FIG. 85.—Measurement of the angle of a squint with the perimeter.

addition required is a piece of string, 1 metre long, suspended from the candle. "Stand the patient 1 metre away, as measured by the string held up to his eye, place your own head between him and the flame, but a little lower down, so as not to intercept the light, bidding him look at the candle, note which eye exhibits an aberrant corneal reflection, and, therefore, squints, guess the amount and bid him look at the figure guessed. If the guess be correct, the squinting eye will be straight for the flame, as shown by its corneal image occupying a normal position. The squint is therefore measured. If the guess be wrong, try succeeding figures, till correct.

"In principle this strabismometer is a perimeter flattened out against the wall, but differs in that the surgeon's eye is between the scale and the patient. The patient's height is immaterial, so that the time wasted in adjusting the perimeter is saved. It is well, however, to stand children on a chair. Should it be desired to measure the secondary deviation, the concomitancy, and the angle gamma, they can be measured with almost equal ease; the first by half covering the fixing eye with the hand so as to make the squinting one fix, the second by turning the patient's head to right and left, the third by making the patient fix that number which brings the corneal image just before the exact centre of the cornea."

The method of tangents (Swanzy).—This is a subjective test. The patient is placed at about 3 metres from the wall of a room on which tangents of angles of 5° each are marked in a horizontal line as seen from the place where the squinting eye is. Exactly opposite to the squinting eye is 0°, and to the right and left the points are marked up to 45°, or more. A candle is placed at 0° and a red glass held in front of one eye of the patient, who is then asked to state the position on the scale of the image of the squinting eye. The corresponding number gives the angle of the strabismus. The scale must be on the same level as the patient's eyes.

Paralytic Strabismus.

There are two principal indications :—

1. Limitation of movement towards the paralysed muscle.

2. Diplopia—which increases in the direction of the affected muscle.

If, for instance, the right external rectus be paralysed, the distance between the double images increases towards the right.

The diagnosis of paralysis of either of the lateral recti muscles is generally made very easy by the marked strabismus present. In cases of slight paresis, or in cases of paralysis affecting the upper or lower recti, and the oblique muscles, an exact diagnosis is more difficult. Careful observation of the relative position of the double images will usually reveal which muscle is at fault.

The following points should be noted :—

1. Whether the diplopia is *homonymous*, or, in other words, if the image corresponding to each eye is on the same side as that eye; or if it is *crossed* (heteronymous), the image of the right appearing on the left, and *vice versâ*.

2. The position of the diplopia in the visual field,

i.e. whether it is present above the horizontal line, or below it when the eyes look directly forwards.

3. Whether the false image is tilted, and the direction of the movement which more widely separates the images.

Gowers' rule may be borne in mind, that, when the prolonged axes of the eyes would cross, the double vision is not crossed.

The two images are called the *true image* and the *false image*. There is a marked difference between the two; the *true image* belongs to the fixing eye, the *false image* to the deviating eye. The false image is less distinct than the true, as the former is perceived by a more peripheral portion of the retina.

In palsy of the ocular muscles, the head assumes a compensating position, in order to diminish the vertigo; thus the face will be found to be turned in the following positions, with the palsies of the muscles mentioned :—

External rectus.—Towards the affected eye, and on its vertical axis.
Internal rectus.—Towards the affected eye, and on its vertical axis.
Superior rectus.—Upward.
Inferior rectus.—Downward, and slightly towards the affected side.
Superior oblique.—Downward, and towards the sound side.
Inferior oblique.—Upward, and slightly inclined towards the sound side.

The following rule (Landolt) will assist in determining the muscles paralysed :—" The affected eye is that in the direction of the image of which the diplopia increases. The paralysed muscle is the one which would have given the position and direction of the false image. The direction of the patient's head corresponds in every way to the physiological action of the paralysed muscle."

It will be useful to differentiate the two images by placing a red glass in front of one eye, and converting the image seen by that eye into a red one. A Maddox rod (p. 144) may equally well be employed.

The examination of the diplopia may be thus proceeded with :—

The patient is seated at about 3 metres distance from a lighted candle, which should be on the same level as the patient's eyes. Before one eye, in the trial frame, place a red glass. If diplopia be present, the patient will at once recognise a white and a red flame. If the diplopia be—

(*a*) *Homonymous*—one of the following three muscles is affected, namely, *external rectus*, *inferior oblique*, or *superior oblique*.

(*b*) *Crossed*—one of the following three muscles is affected, namely, *internal rectus*, *inferior rectus*, or *superior rectus*.

The differentiation is further aided by the position of the images in the visual field.

(*c*) If they are *side by side*—the muscle affected is either the external rectus or the internal rectus. As has been already shown, paralysis of the former is associated with homonymous, and paralysis of the latter with crossed, diplopia. The consideration of these two muscles is, therefore, completed.

Four muscles still remain to be differentiated—

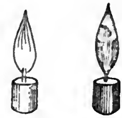
DIPLOPIA.	1. Homonymous	External rectus.
		Inferior oblique.
		Superior oblique.
	2. Crossed	Internal rectus.
		Inferior rectus.
		Superior rectus.
	3. Images side by side	External rectus.
		Internal rectus.
	4. Images in upper field, one above the other; the affected one the higher	Superior rectus.
		Inferior oblique.
	5. Images in lower field, one above the other; the affected one the lower	Inferior rectus.
		Superior oblique.

THE KIND OF DIPLOPIA ASSOCIATED WITH PALSY OF

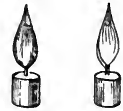
Note.—The dark candle represents the false image.

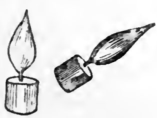
Left-sided Palsy. | *Right-sided Palsy.*

{Diplopia on looking towards paralysed side.}

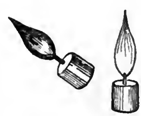


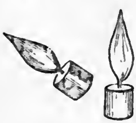
{Diplopia on looking towards sound side.}



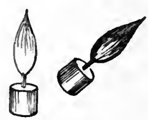


{Obliquity increased on adduction. False image inclines to healthy side, and vertical distance between images increased on elevation and abduction.}





{Obliquity increased on abduction. False image inclines to affected side, and vertical distance between images increases on elevation and adduction.}



{Obliquity increased on adduction. False image inclines to affected side, and vertical distance between images increases on depression and abduction.}

{Obliquity increased on abduction. False image inclines to sound side, and vertical distance between images increases on depression and adduction.}

EACH OCULAR MUSCLE, ARRANGED IN A TABULAR FORM.

(*d*) The *double images are in the upper field*, that of the affected eye being the higher. The indication is that either the *superior rectus*, or the *inferior oblique* is affected. The diplopia in the former instance (*superior rectus*) is crossed, in the latter (*inferior oblique*) it is homonymous.

(*e*) The *double images are in the lower field*, that of the affected eye being the lower. The indication is that either the *inferior rectus*, or the *superior oblique* is affected. The diplopia in the former instance (*inferior rectus*) is crossed, in the latter (*superior oblique*) it is homonymous.

(*f*) Differentiation is further assisted by considering *the tilting of the false image.* If the image inclines to the sound side, the indication is that the *superior rectus* or the *superior oblique* is affected. In the former (*superior rectus*) the diplopia is crossed, and the images are in the upper field. When the latter (*superior oblique*) is at fault, the diplopia is homonymous, and the images are in the lower field.

(*g*) Movement affects the *vertical distance between the images* thus:—

Superior rectus.—Increased on elevation and abduction.
Inferior oblique.—Increased on elevation and adduction.
Inferior rectus.—Increased on depression and abduction.
Superior oblique.—Increased on depression and adduction.

In the foregoing table (pp. 162, 163) the different points just mentioned are arranged in a tabulated form.

Werner's diagrams (Figs. 86, 87) facilitate the diagnosis of the ocular muscle which may be at fault. The form of diplopia which characterises paralysis of each muscle is expressed by the position of the dotted line bearing the name of the muscle. The dotted lines represent the "false images," the continuous line the "true images."

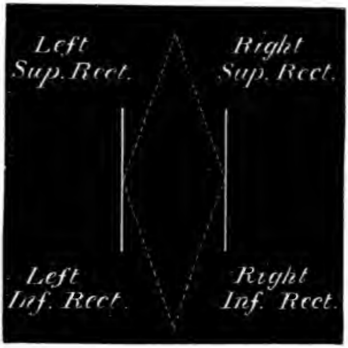


FIG. 86.—Werner's diagram for diagnosing palsy of recti muscles.

"In the case of the recti (Fig. 86) the false images enclose a lozenge-shaped space situated between the true ones; whereas, in the case of the oblique muscles (Fig. 87), the true images, which, for the sake of simplicity are combined in one line, lie between the four 'false images,' which diverge from one another so as to form an X. It will also be noted that the dotted lines extend upwards and downwards beyond the others, indicating respectively that the 'false images' are higher or lower than the 'true images.' Another fact which the diagrams indicate is, that, in the case of the muscles represented in the upper halves of the figures, the diplopia occurs in the

FIG. 87.—Werner's diagram for diagnosing palsy of oblique muscles.

upper part of the field of fixation, or, in other words, in upward movements of the eyes. A similar rule holds good with regard to the lower halves.

"The method of using the diagrams will be better understood by taking a particular muscle as an example. Suppose, for instance, that we wish to know what kind of diplopia results from paralysis of the *left inferior* rectus, it is simply necessary to look at the *left inferior* portion of Fig. 86 (recti), which gives the diplopia. If we analyse this, we find—(1) That the diplopia is *crossed*, for the false image corresponding to the *left* eye is on the *right* of the true image, *i.e.* the right image corresponds to the left eye; (2) that the false image has its *upper end inclined towards the true one*; (3) that the false image is *lower* than the true one, for the dotted line extends *lower* than the other one; (4) that the diplopia occurs in *downward movements* of the eyes, for it is in the *lower* half of the diagram that the false image lies.

"The same method applies to the other recti: the diplopia for the *right upper* rectus is found in the *right upper* quadrant, and so on for the rest.

"The same rules also apply to the obliques (Fig. 87), with one difference. The recti move the eye in the direction indicated by their names, the superior moving it upwards, and the inferior downwards; but, in the case of the obliques, the reverse takes place, the superior oblique moving the eye downwards, and the inferior upwards. Therefore, for the *superior* obliques we must look at the *lower* half of Fig. 87, and for the *inferior* obliques at the *upper* part" (Swanzy).

CHAPTER IX.

SIMULATED BLINDNESS.

COMPLETE blindness of both eyes is seldom pretended, but monocular amaurosis is frequently so.

The simulation of binocular blindness is often difficult to convict. The ophthalmoscope will give no indications. The action of the pupils should be noted, remembering that contraction accompanies convergence. If they be found dilated, and if they do not expand more fully when shaded, the use of a mydriatic may be suspected. Frequently, simulated binocular blindness can only be detected by careful observation of the patient, especially without his knowledge. The manner and bearing of a truly blind individual is characteristic. Ask the blind man to look at his hand held up, and he will do so without hesitation, but the pretender will assert his inability, or turn his gaze in another direction.

Feigned blindness, when monocular, is more easy of detection. The success of the investigation will depend greatly on the examiner's skill in not conveying to the patient his desire or intention to convict him of fraud. The result of each test should be received as if it were precisely as expected. The following are tests which may be adopted :—

1. A simple test is to hold a cedar pencil, or small ruler, perpendicularly and midway between the patient's eyes and the page he is set to read. Should binocular vision exist, the reading will not be interfered with, but, should there be only monocular vision, reading will be interrupted behind the pencil or ruler. Anyone can test this for himself by holding a pencil in the way mentioned, and then reading the page with both eyes open, and afterwards with one eye shut.

2. Prisms afford a variety of tests for malingerers.

(*a*) Place a prism of 7° in a frame before the sound eye, and direct the patient to look at a distant candle; the resulting diplopia will demonstrate the presence of binocular vision. The test may be varied by placing the prism before the avowedly blind eye.

(*b*) Hold a prism of 10° or 12°, base in, before the blind eye. If the eye sees, it will turn inwards to avoid the crossed diplopia produced by the prism. Or, place before each eye a prism 7°, base outwards, and direct the patient to look at a candle 20 ft. away; if binocular vision is present, convergence of the visual lines will take place, and can be noticed by the observer.

(*c*) Screen the blind eye with the hand, and advance the edge of a prism towards the centre of the pupil of the good eye, while the gaze is directed towards a distant object, a candle for instance. Monocular diplopia will be admitted by the patient. By a slight movement, now bring the prism over the whole of the pupil, and simultaneously withdraw the hand from before the blind eye. If two images are still seen, the deception is exposed.

(*d*) Place a prism with the base vertical before either eye, and get the patient to walk a distance. The confusion occasioned by the double images will necessitate the closure of one eye "if stones or steps are in the way. Going down stairs will be a sharp test when wearing spectacles of this sort" (Noyes).

(*e*) The Maddox double prism may be employed (p. 141). Place it before the sound eye—if three images are seen, binocular vision is proved.

(*f*) A prism of Iceland-spar, which occasions two images, may be used. It will give rise, if binocular vision is present, to three images (triplopia); a fact very confusing to the patient.

3. The patient is put before the test types in the ordinary way, and a frame is fitted on the face, armed with a strong + glass (+ 14 D) before the sound eye, and a plane, or weakest concave, glass (.25 D) before the blind eye. Should he then read the types, he will be using the blind eye, and the conviction may be brought home by covering the blind eye, and then the patient will discover that he is unable to read with the strong + glass before the sound eye. By means of a reversible frame, armed in this way, or by a rapid interchange of lenses, it is often easy to confuse the most wary malingerer.

4. Snellen's coloured types may be used. They are printed in red and green. A pair of glasses is placed before the patient, one glass being red and the other green. The eye with the red glass will see

only the green. Should, therefore, both the red and the green letters be visible through the glasses, the person tested must have binocular vision.

5. The Maddox rod may be used (p. 144). It is better to have it, for this purpose, of red glass. If placed before either eye, and a candle or gas jet at a distance be looked at, in addition to the flame, a long red line will be visible. It is better to place the rod

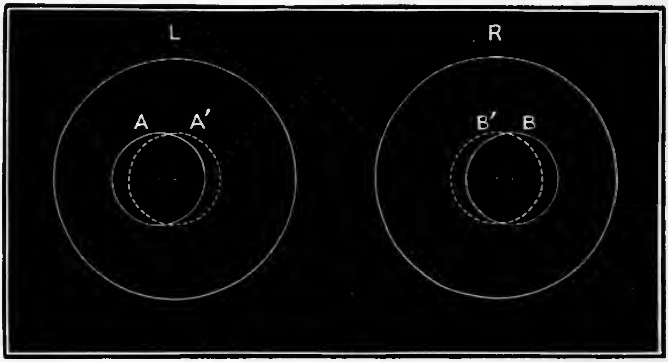


FIG. 88.—Changeable stereoscopic test for binocular vision.—BERRY.

vertically, as the red line, cutting through the flame horizontally, will be more likely to attract attention than if it be vertical. If the patient acknowledges to seeing both the flame and the red line, proof is afforded that both eyes are being used.

6. The stereoscope may be employed in many ways. Berry's test for binocular vision " consists in altering simultaneously the pictures presented in the stereoscope to either eye, so that the impression given also varies. If, for instance, in Fig. 88 the small

circles occupy the positions A and B respectively, the stereoscopic impression is that of a hollow cylinder or cone, with the small circle appearing farther away than the large one. On the other hand, when the small circles come into the positions A′ and B′, the cone appears in relief and solid, the small circle appearing next the eyes. If all stages of the transition between these two positions be presented to the eyes (as is done by a simple mechanism causing a lateral approximation and separation of the small circles), the stereoscopic effect is one of movement in the third dimension. The small circle then appears to rise from a plane lower than the picture to one which lies nearer the eyes. This apparent movement is so evident, especially if the experiment be made in semi-darkness, that young children can at once say whether they can see it or not. Seeing it implies the existence of binocular vision."

Another plan is to use the two letters L and F, which, combined, make E. If, then, these two letters are placed in the stereoscope, and the patient acknowledges to seeing the E, binocular vision is proved. Of course it is essential that the patient does not see the figures for this, or other stereoscopic tests, before they are placed in the instrument.

7. Hering's experiment with falling bodies is another test. The patient should look through a long tube at a slender thread stretched vertically. Small bodies, such as glass beads or peas, are then dropped, both in front of, and behind the thread. Should the patient possess binocular vision, he will answer at

once correctly whether the beads fall in front of, or behind the thread; should he have monocular vision only, he will often make mistakes.

As many of the tests are apparently directed to the sound eye, a patient will sometimes assume that the blind eye may be closed, but he must be assured that, as he does not see with it, there is no object in shutting it, and that it is as well to keep it open. The observer will do well to remember this point, or he may find his tests in some instances frustrated. The results ascertained by any test should be corroborated by others.

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