PLATE I.

Fig. 1.

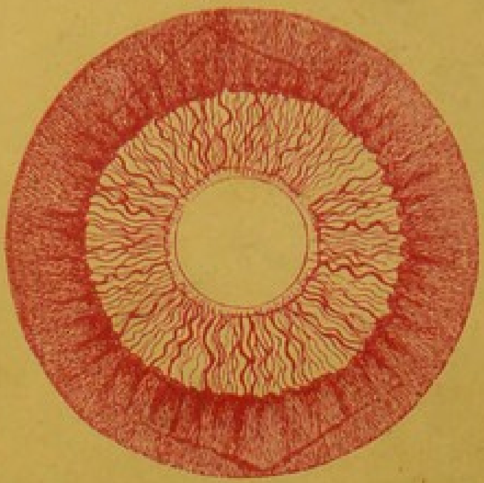

Fig. 4.

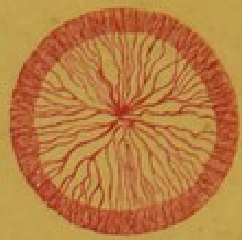

Fig. 2.

Fig. 3.

Fig. 5.

THE EYE

IN

HEALTH AND DISEASE;

WITH AN ACCOUNT OF

THE OPTOMETER, FOR THE ADAPTATION OF GLASSES, FOR IMPAIRED, AGED, OR DEFECTIVE SIGHT;

BEING

THE SUBSTANCE OF LECTURES DELIVERED AT

THE CENTRAL LONDON OPHTHALMIC HOSPITAL,

BY ALFRED SMEE, F.R.S.,

SURGEON TO THE BANK OF ENGLAND;

TO THE CENTRAL LONDON OPHTHALMIC HOSPITAL; TO THE ROYAL GENERAL DISPENSARY; FORMERLY LECTURER ON SURGERY, ETC., ETC., ETC.

Second Edition:

TO WHICH IS APPENDED, A PAPER ON THE STEREOSCOPE AND BINOCULAR PERSPECTIVE.

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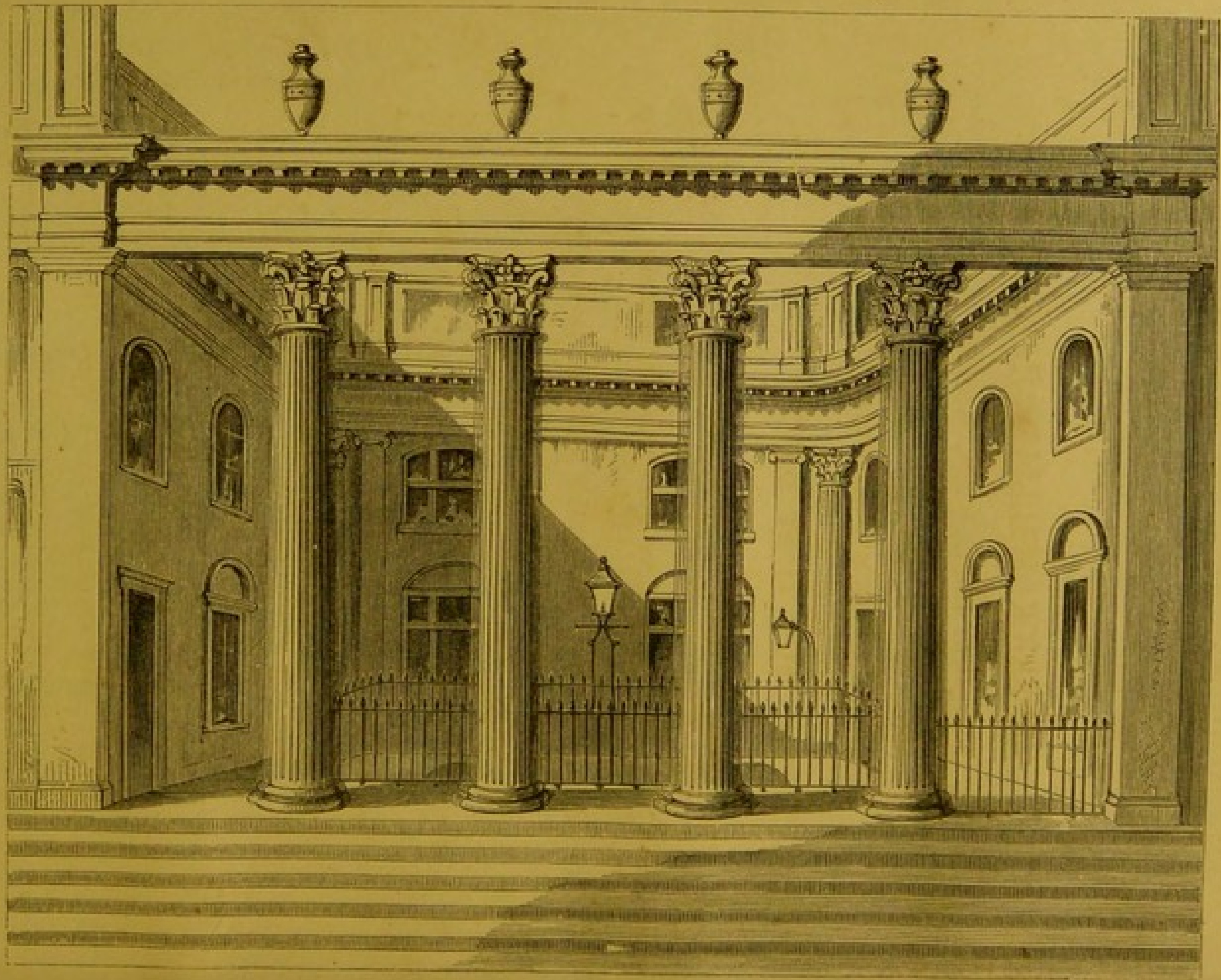


BINOCULAR PERSPECTIVE DRAWING OF A COURT IN THE BANK OF ENGLAND.

TO

SIR JOHN FREDERICK WILLIAM HERSCHEL, BART.,

K.H., M.A., D.C.L., F.R.S., F.R.A.S.,

ETC., ETC., ETC.,

WITH THE HIGHEST ESTEEM

FOR THAT NAME

WHICH PHILOSOPHERS UNITE TO HONOUR;

IN ADMIRATION OF THOSE TALENTS WHICH HAVE PRODUCED BRILLIANT DISCOVERIES,

AND HAVE CONFERRED IMPORTANT BENEFITS ON SOCIETY;

AS A VERY FEEBLE TESTIMONY TO THE VALUE

OF HIS NUMEROUS CONTRIBUTIONS TO OPTICAL SCIENCE;

AND AS A SMALL, BUT GRATEFUL, ACKNOWLEDGMENT

FOR HIS ACTS OF DISINTERESTED KINDNESS,

THIS TREATISE ON VISION

IS INSCRIBED

BY HIS OBLIGED AND FAITHFUL SERVANT,

ALFRED SMEE.

PREFACE.

I FEEL that some apology is due to the public for the long period which this little treatise has been out of print; the more especially as the large sale in this country, with its translation into the French language, would naturally make me more anxious to make it worthy of its extensive patronage.

Nevertheless, a press of business, an inability to bestow such an amount of time as the importance of the subject demands, and the delays required for the development of the system of binocular perspective, have prevented its publication till the present year.

The optometer described in the former edition has more than fully justified the opinion which I formed of it. I believe no optician should be without it, as it gives a more rapid insight into the functions of the eye than can be obtained by any other method. If the value of the optometer has exceeded my most sanguine expectation, the visuometer has fallen short of it for reasons stated in the text. The mode of gas illumination which I then recommended is gradually being adopted.

In the present edition, the more remarkable addition is that of the views which are propounded of binocular perspective. I am sanguine that this system will be of much utility; but I always find that it is impossible to predict the value of any discovery till it has been thoroughly sifted by the combined talent of many minds.

Although this treatise consists of but few pages, I could not have written it without considerable aid from several persons. I feel bound to return a public acknowledgment to my kind friend, Mr. Kennedy, for checking and making various mathematical

calculations connected with the subject, and extending, at intervals, over a period of some years. I have also to thank Mr. Price, of the Bank of England, for the pains which he has taken in carrying out the views of binocular perspective, and for making drawings as I required them for the purpose of studying the phenomenon. To Mr. Harrison, of the Bank of England, I am indebted for engraving in wood the first specimen of binocular drawing; and perhaps it will be found that the style will be far more difficult to represent by woodcut than by copper-plate engraving. Lastly, my warmest obligations are due to the publishers for rendering me every assistance in the necessary experiments, by placing at my disposal all the means which their extensive manufactory is so eminently enabled to afford.

7, Finsbury Circus,
December 31*st*, 1853.

EXPLANATION OF THE PLATES.

PLATE I.

1. Back view of the iris and ciliary processes in situ, shewing the blood-vessels, from a specimen of my own injection. The ciliary processes constitute the means by which, in my opinion, the refracting humours are altered to adjust them to objects of different distances. Magnified about $4\frac{1}{2}$ diameters.

2. Figure of the blood-vessels of the cerebellum of a cat, from a very beautiful carmine injection made by myself. The dark red streaks are the blood-vessels of the pia mater. The white parts represent the white fibrous part, and the loops of blood-vessels are vessels of the grey matter, in which the nervous fibres terminate. There are differences in the vessels of the different parts of the brain, but this specimen, copied from my work on "Instinct and Reason," shews well the highly vascular tissue in which the nerves terminate. Magnified a few diameters.

3. Vessels of the retina, from a carmine injection of my own preparation. Magnified about 2 diameters.

4. Vessels of the membrane pupillaris injected with carmine, from my own preparation. Magnified about $4\frac{1}{2}$ diameters.

5. A more highly magnified view of the blood-vessels of the iris, ciliary processes, and choroid, from Arnold.

PLATE II.

Diagram of interior court in the Bank of England, shewing in an exaggerated manner the way in which the edges of the columns become transparent under the influence of binocular vision. The point of sight is immediately behind the first lamp-post. If the diagram is steadily viewed by directing the eye to that spot, the pillars will appear to stand completely away from the back buildings, and the transparent edges will be lost. The effect is further increased when a reading-glass is employed.

PLATE III.

1. Healthy eye, shewing the form of the cornea.
2. Short sight from great dilatation of the anterior chamber of the cornea.
3. Far sight from diminution of the anterior chamber.
4. Arteria centralis retinæ, and the central spot of Soemmering, after Soemmering.
5. Vertical section of the human retina and hyaloid membrane. *h*, Hyaloid membrane. *c*, Layer of transparent cells connecting the hyaloid and retina or grey nervous matter with its capillaries. 1. Its fibrous lamina. 2. Its vesicula lamina. *g*, Granular lamina. 3. Light lamina frequently seen in Jacob's membrane (after Todd and Bowman).
6. Conical cornea.
7. Diagram shewing the muscles which move the globe of the eye. The recti or straight muscles and inferior oblique muscle are demonstrated.
8. Drawing of the retina expanded over the vitreous humour, with the lens in situ, exhibiting also the arteria centralis retinæ and central spot of Soemmering.
9. Front view of the eye, shewing cataract in the lens.
10. Front view of the eye in a healthy state.

PLATE IV.

Diagram shewing roughly the range of perfect vision, which is extremely small; the insensible spots of both eyes; the range of vision with two eyes, and the range of vision for each eye. This diagram explains how a small portion only of the range of objects viewed is distinctly seen at once.

PLATE 4

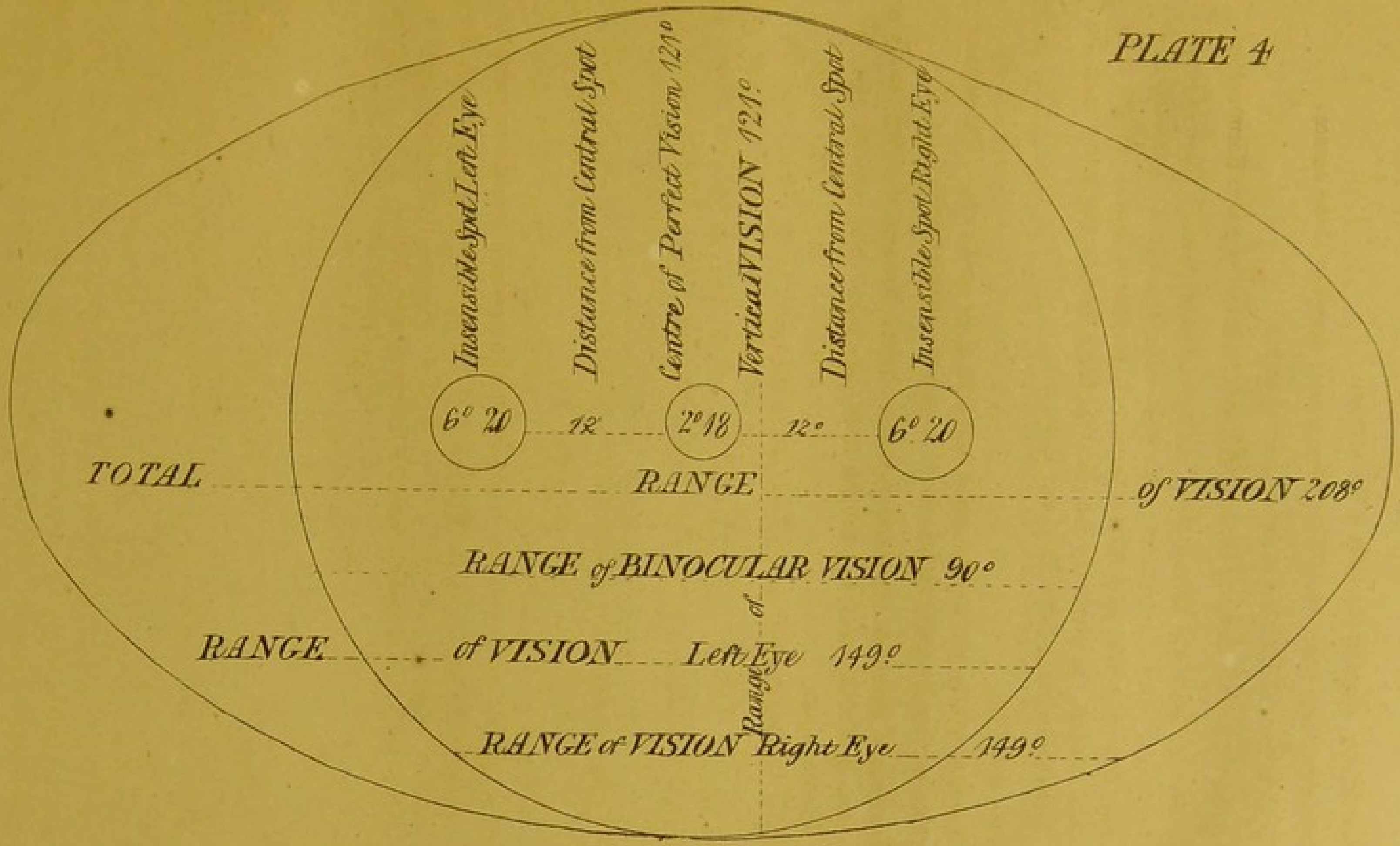

Insensible Spot Left Eye
Distance from Central Spot
Centre of Perfect Vision 121°
Vertical VISION 121°
Distance from Central Spot
Insensible Spot Right Eye
6° 20
12
2° 18
12°
6° 20
TOTAL RANGE of VISION 208°
RANGE of BINOCULAR VISION 90°
RANGE of VISION Left Eye 149°
Range of
RANGE of VISION Right Eye 149°

PLATE III.

Fig. 1.

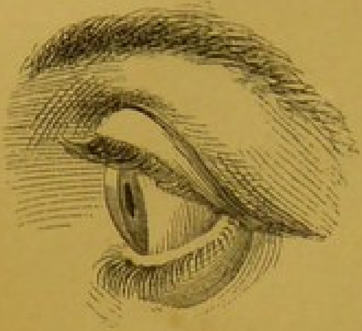


Fig. 2.

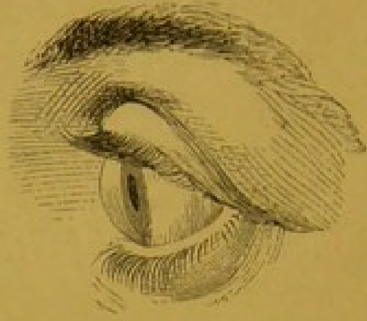


Fig. 3.

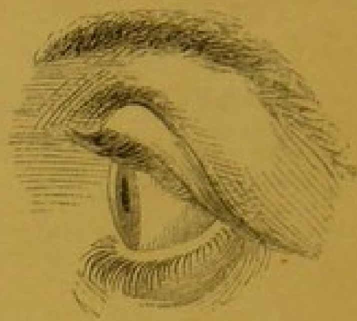


Fig. 4.

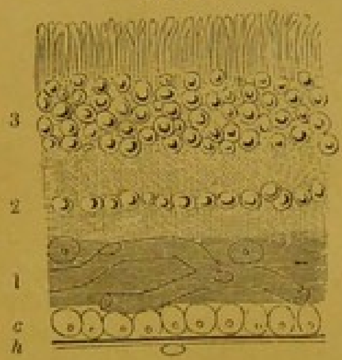


Fig. 5.

Fig. 6.

Fig. 7.

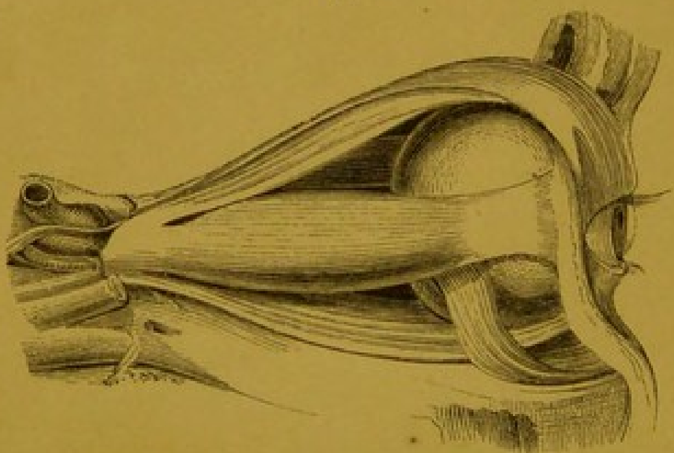


Fig. 8.

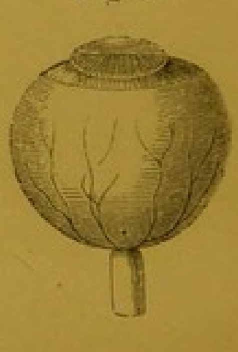


Fig. 9.

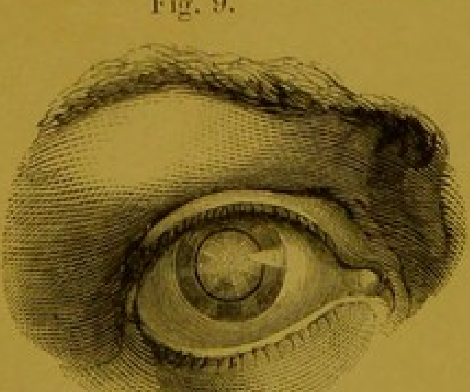


Fig. 10.

LECTURES ON VISION.

LECTURE I.

NORMAL VISION.

(2-8.) Physical requisites for healthy vision.—(9-12.) Range of vision.—(13.) Optic nerves.—(14,15.) Modification of vision by the use of two eyes.—(16-18.) In judging of distance.—(19.) Estimation of magnitude ;—(20,21.) of height.—(22.) Estimation by one eye.—(23.) Sense of measurement.—(24.) Inversion of image. —(25.) Single vision of the two eyes.—(26, 27.) Estimation of position and relation of objects.—(28.) Power of vision.—(29.) Sustainment of impressions.—(30.) Action of convex lenses.—(31.) Adjustment of vision for various distances. (32, 33.) Mechanism of adjustment ;—(34, 35.) for near objects ;—(36.) for distant objects.—(37, 38.) Vitreous and aqueous humours and ciliary processes, their use in adjustment.—(39.) Oblique vision.—(40.) Rate of adjustment.—(42.) Iris.—(43.) Estimation of motion.—(44.) Colour.—(45.) Time required for perception of vision.—(46.) Recapitulation.—(47.) Light.—Conclusion.

GENTLEMEN,

(1.) I HAVE in my former lectures described to you the various diseases which attack the numerous tissues composing the eye ; I have shewn you how they may injure its delicate fabric; and it only remains for me now to point out the various abnormal conditions of vision which arise either from the effects of traumatic injury, the alteration of structure produced by disease, from the decay of age, or from original congenital defect.

(2.) Before, however, I enter upon this important part of my subject, allow me briefly to recall to your mind the physical conditions necessary to vision, the parts of the body which are required for that purpose, and the leading phenonomena presented in its normal state.

(3.) For healthy vision various physical conditions are essential. In the first place, we require a nervous expanse, the retina, to receive a perfect image of the external object; and, moreover, to this nervous expanse must be continually supplied bright arterial blood, for if the supply of bright arterial blood fail, vision fails, as blood and nerve are conjointly necessary for this purpose.

(4.) Having a nervous expanse supplied with arterial blood, an apparatus is required to cause a perfect image of the object to fall upon the retina, which apparatus is made up successively of cornea, aqueous humour, lens, and vitreous humour, the combination of which may be regarded as a one perfect achromatic lens, which is free in great measure from the indistinctness usually consequent on spherical aberration.

(5.) The eye by itself, however, will give us no vision; it is requisite that the picture of the object formed upon the retina should be carried to the brain, where the physical impression becomes mental, is perceived, is registered or remembered, and tends to supply ideas or leads to action.

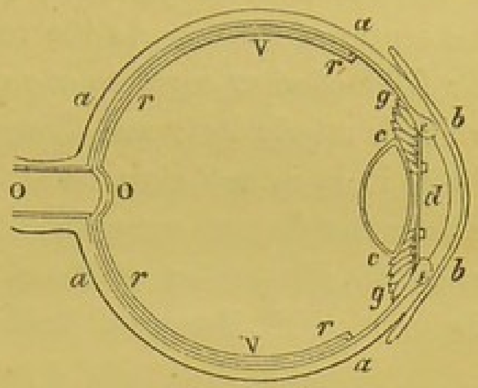
(6.) The arterial blood supplied to the retina is thought by some to be carried by the arteria centralis retinæ, an injected specimen of which I now shew you (Plate 1, fig. 3). I can but think, however, that the choroid really supplies that fluid for the purposes of vision, it being a tunic, as you well know, composed of one vast mass of vessels (Plate 1, fig. 5). The delicate arterial trunks on the surface of the retina appear to me to be destined rather for the nutrition of the vitreous humour.

(7.) The other parts of the visual apparatus are but subservient to these, such as the pupil, or curtain which regulates the amount of light admitted into the eye; the ciliary processes, to adjust the eye to different distances; the lachrymal gland, to secrete tears to lubricate the surface; the nasal duct, to carry off those tears; the muscles, to direct the eye to any given object; and the eyelids, eyelashes, and eyebrows, to serve as a defence to the organ, and to protect it from injury.

(8.) The following is a view of the parts shewn by a vertical section of the eye.

(9.) The range of vision of each eye is bounded by the projecting parts of the face: thus, upwards is limited by the eyebrows, downwards by the cheek; and, from actual measurement, I find that in my own case it amounts to 149°. Doubtless, this measurement may vary a little in different persons, but perhaps not to any important extent. In the same way lateral vision is bounded by the nose internally, and the cheek externally; and this range also extends to about 149°. If the eye be fixed, or steadily directed towards one point, it is sensible of the presence of objects over a vertical range of about 121°, and a lateral range of 149°.

Fig. 1.*



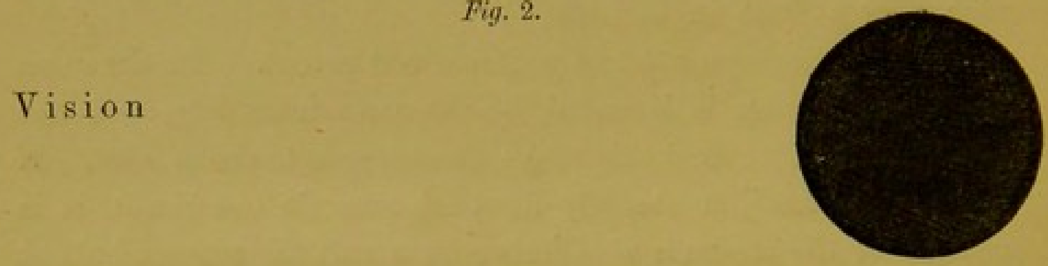
(10.) Although it be true that vision exists with more or less distinctness over this range, all parts are, nevertheless, not equally sensible; one very small portion affording us perfect vision, while the remainder only enables us to appreciate the presence of objects; and at that spot where the optic nerve pierces the sclerotic, there is hardly any appreciable vision.

(11.) Perfect vision is only obtained over a range of about 2° 18′, which, in practice, you will find to be in the relation to the distance of the object viewed as 1 to 25; that is to say, that at twenty-five inches distant you will be enabled to read a word one inch long without the slightest motion of the eye; and at twelve inches distant a word of half an inch may be read in the same way. Where the optic nerve penetrates the eye, the retina

* Vertical section of the Eye.—*a a a*, Sclerotic coat, or white of the eye. *b b*, Cornea, or glassy port through which we see. *r r r r*, Retina, or nervous expanse: the choroid lies between the retina and sclerotic. *o*, Optic nerve. In the diagram it appears to be in the axis of the eye, but in reality it is about the $\frac{1}{10}$th of an inch from the axis on its inner side, and a little above the median line. In the axis is a spot called the foramen of Soemmering, which is in fact the point of most distinct vision. *e f*, Iris, or curtain. *d*, Anterior chamber, or aqueous humour. *c*, Lens. *g g*, Ciliary processes, for the adjustment of the eye to distance. *v v*, Vitreous humour.

is insensible to light, which causes a total loss of vision over about 6° 20′, the commencement of the insensible spot being 12° from the centre of vision. As the result of this, there is a portion of the field of view equal to one-eighth the distance of the object which is utterly lost; and though it seems at first thought incredible, it is nevertheless true, that, in regarding a range of hills eight miles distant, one mile of the range is not perceived by the eye. In illustration of these principles, I have made you a diagram, which, if you will hold twelve inches from your right eye,

Fig. 2.

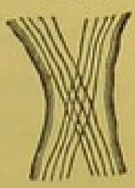


and your eye exactly opposite to the word Vision, you will find that you will perceive the entire word without the slightest motion of the eye; and whilst you look steadfastly at the letter V, you will observe that the black circle will be totally lost. The lost circle is always to the outer side of the object regarded, and its extreme margin is about one-third the distance of the object. In the range of hills before quoted, the end of the lost mile would be two miles and two-thirds from the point steadfastly looked at. Although perfect vision exists for only 2° 18′, good vision exists over a wide range; and architects inform me that in a perspective drawing of a building 18° are allowed for a visual angle, and 4° more are also allowed for the landscape on each side.

(12.) So much for the extent of vision enjoyed by one eye: but we have two visual organs, and each plays an important part in the phenomena of vision. They are set at a certain distance, or about two inches and a half apart, and give us collectively not only a more extended field of vision, but a different perspective of various objects. The total field of vision with two eyes is increased from 149° to 208°, of which a variable quantity, according to circumstances, is seen by both eyes at once; one portion is alone seen by the right eye, and another by the left eye alone.

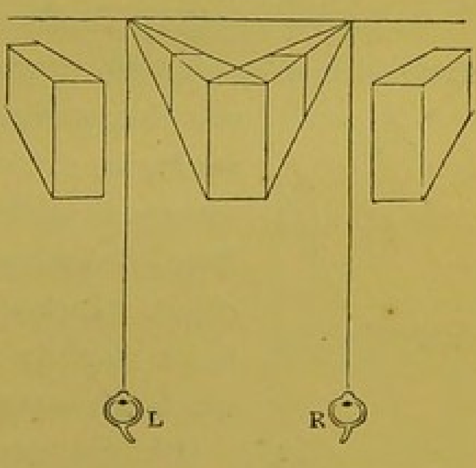
(13.) From the above facts we find that the inner part of each eye respectively sees that portion of the field which is not seen by the other organ. These remarks apparently militate against the views of physiologists, who dwell upon the importance of the doubleness of organs, though probably a compensation exists in the decussation of the optic nerve. It is generally agreed by anatomists, that the outer parts of the two optic nerves pass to the brain without decussation, but that the inner fibres pass over to the opposite side. Now, the two outer parts see conjointly the same part of an object, and, therefore, if the inner portions of the nerve of each eye pass over to the opposite side, a really double impression would be conveyed to the brain; that is to say, that the sum total of the field of vision would be represented in each side of the brain, where any further combination might be effected.

Fig. 3.



(14.) As each of our two eyes is an optical instrument, a camera obscura placed at an interval, it follows that we take a different view of objects from each side, and that a different image is formed of objects in each eye. You may try the experiment with two cameræ obscuræ, which are analogous to two eyes, and you will perceive that the image in each differs in form, because a different perspective is produced. In this manner a cubic body placed three inches off in the median line between the eyes, would shew the difference of perspective afforded by the two eyes; or, rather, I may say, we see more of a body, since we are able, with the use of two eyes, to see the three sides of a cube. Professor Wheatstone has shewn many curious facts of the kind, in an instrument which he terms the stereoscope, and which I shall further describe hereafter.

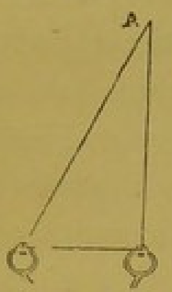
Fig. 4.



(15.) Paintings or drawings, in true perspective, represent the effect of vision with one eye alone. These representations are, therefore, always hard and unsatisfactory, which arises in a great measure from the nearer objects cutting sharply the more distant objects.

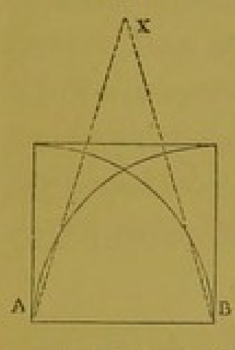
(16.) I have already told you, that from our two eyes not being in the same place, we see objects from two positions—a most important circumstance in practice, because by this arrangement we are in a condition to judge of distance and magnitude.

Fig. 5.



(17.) To estimate distance, the interval between the two eyes may be considered as a base line (fig. 5), which subtends the angle at which the object (A) is placed, and at each of which we can estimate the angle: a knowledge of the amount of these angles will enable us to appreciate the position of the object. I have here made a little card instrument, which I term an ophthalmometer, and which will illustrate my position. It consists of a piece of cardboard six inches square, at two points of which (A, B) is a small aperture or sight, which apertures form the centre of two radii of a quadrant, each of which is graduated. Two other pieces of movable card are so arranged that they can be adjusted across the two circles in a line with the object (X), when the angles can be read off. Having the two angles and the inclosed side, we can readily calculate, according to trigonometrical principles, the distance of the object (fig. 6).

Fig. 6.

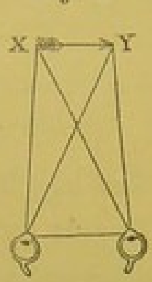


(18.) To illustrate the means by which we estimate distance by taking a view of an object from two places, the ophthalmometer may be simplified by making an angle, always a right angle, and estimating the angle at the other termination of the base line, by making one side fall in a line with the object. Instead of estimating the angle, the distance may be found if we know the relation which the second line has to A B (fig. 7).

Fig. 7.

(19.) So much for our estimate of distance. And I have now to consider how we obtain our ideas of magnitude; and, in reality, the subject may be discussed in a few words; for, as we can estimate the distance from one point of an object, so can we also estimate the distance from a second point, when we can estimate the distance between these two points. I must shew you a diagram how this is accomplished; and I may mention, that the idea, although it might easily have occurred from mathematical considerations, was first brought distinctly to my mind from looking at a pillar in a beautiful screen erected by Sir John Soane, in the court-yard of the Bank of England, through a window. In this way it will be seen that two angles are taken of an object (X Y), one with each eye; and, from the magnitude of these angles, taken in conjunction with the distance between the eyes, we are enabled to estimate the distance from X to Y, or the width of the object.

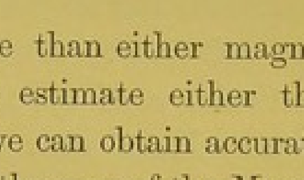
Fig. 8.



(20.) Height is more difficult to estimate than either magnitude or distance, because we must first estimate either the distance or magnitude of an object before we can obtain accurate notions of height. This fact is well seen in the case of the Monument and church near London Bridge; for in some positions there is considerable difficulty in comparing their heights, although considerable difference exists between them; and in one position the Monument will appear the highest, in another the church, or, in a third, they may both seem to be of equal altitude. To estimate the difference, you must, in reality obtain an accurate notion of either the distance or magnitude of the object, when their relative height will immediately become apparent.

(21.) Without entering into trigonometrical disquisition, I can prove to you that we really have the power of estimating heights, by adopting the same means which are employed by nature. For this purpose I have selected an object (X Z), which by the processes before mentioned was found to be three feet distant, when, by measuring

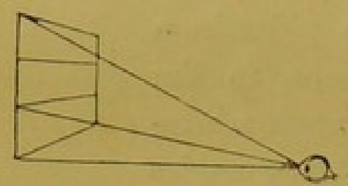
Fig 9.



the vertical angle, I am enabled to ascertain that the object is two feet high, by ordinary trigonometrical calculation.

(22.) So much for the knowledge which may be obtained from the conjoined use of two eyes; but you will find that we may obtain, although not so efficiently, a knowledge of the distance of objects with one eye alone. For that purpose, however, we must have one part of the object of some previously known magnitude; for instance, if it be a building, the size of the bricks should be known, and then we should be in a condition with one eye to appreciate the height, breadth, and distance. Let me demonstrate this fact to you by piling up six square blocks, each an inch square, two abreast, and three in height. From knowing that these blocks are an inch square, you first find the angle formed by one brick, afterwards the angles respectively of its width and breadth, when you will find it to be three inches high, two broad, and in this particular case one foot distant.

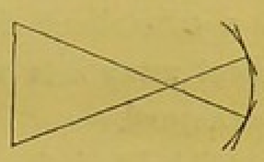
Fig. 10.



(23.) From what I have said of the functions of the eye, you will be prepared to ask by what means are these delicate angles known? and to this question I reply, that the angles are formed by the eyeball moving either downwards, upwards, inwards, or outwards, through the mechanism of the muscles. Now, these muscles, especially the internal rectus, are supplied by enormous nerves, and I can but think that it is by the consciousness of the action of the muscles through these nerves, that we know the angles which enable us mentally to obtain the measurements. Physiologists would reply that the third pair of nerves are nerves of motion, not of sense; but it appears to me that the idea of motion is obtained through the nerve of motion, and hence this pair of nerves would be nerves of distance and magnitude, besides their strictly motive power. This sense of distance and magnitude would not differ from our sense of other motions taking place in various parts of the body, though perhaps it forms one of the most exalted instances of this character. Besides the muscles of the eye, muscular movements of the head, trunk, and other parts of the body, have sometimes to be estimated by the brain.*

(24.) I have frequently told you that the eye is a camera obscura, to which the entire refracting media act as a lens. As a matter of necessity, the image is inverted; the top of an object is seen by the lower part of the eye, the bottom by the upper. Nevertheless, it is so arranged that the idea of vision is perpendicular to a tangent of the point of the retina excited, and thus, when the nervous expanse is acted upon, the object appears in its proper place, in its true position, and the entire mass does not seem to be in any way distorted.

Fig. 11.



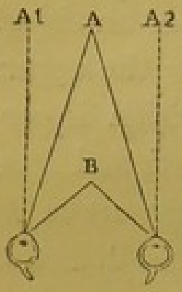
(25.) It is upon this power of viewing objects in their true position, that the illustrious Porterfield correctly considered that we did not see two objects, or, rather, that we obtained single vision with two eyes. Now, I may add, that we mentally know that two objects cannot be in the same place at the same time; and, therefore, if the two images formed in the eyes are both to our reason in the same spot, it of necessity happens that we see but one, and not two objects. In the same manner, when we hear a sound with both ears, we hear one sound and not two sounds; when we smell an odour by our two nostrils, we appreciate but one odour; if we taste with our two gastatory nerves, we notice but one flavour; and so also if we feel an object with both hands, we feel but one object, not two objects. It is right, however, to mention that there are not found wanting physiologists who have devised various circuitous explanations for a circumstance which to me, and, I hope to you, appears perfectly perspicuous.

(26.) For objects to appear in their true position, they must be viewed in such a manner that the axis of either eye is directed towards the same spot; and, perhaps, it is for this reason, as well

* Since the former edition of this work, Wheatstone has remarkably confirmed this idea of magnitude and distance being dependent on the motion of the muscles of the eyeball.

as for the estimate of angles, that perfect vision, is confined to a mere spot, or rather to the small angle which I before mentioned to you.

Fig. 12.



A pretty experiment demonstrates that single vision depends upon objects being seen in their true place; for if we regard a star or gas-light at a distance (A, fig. 12) with both eyes directed towards it, we see but one star. If, however, we suddenly look at B, an object but two or three inches off, the rays of light can still fall upon the retina, but in such a manner that the direction vertical to a tangent causes one star to appear at A1, and the second at A2. It is a marvellous sight to observe one star divide into two and shoot away into their false positions, if the experiment be well performed.

(27.) We judge of the relation of objects to each other, and whether they be horizontal or vertical, by the position taken by ourselves, as well as by the position of known surrounding objects.

(28.) There is a limit to vision: we cannot see objects which are below a certain size, or rather, which do not subtend a certain angle; thus, the largest object may be rendered invisible by removing it to a sufficient distance, and conversely the smallest may be rendered visible by increasing the visual angle. The inverted telescope will render objects invisible by diminishing the angle; and the microscope renders objects, which were previously invisible, apparent by increasing the angle. Doubtless, persons differ in the extent to which they can perceive objects: many cannot see below 40″; but I find that I can see the round head of a pin one-twentieth of an inch in diameter, at fifty feet distance, which will only afford an angle of 17″, and I have even been able to see a fine platinum wire under circumstances which did not afford an angle of more than 4″.

(29.) When we regard an object, we are enabled to receive a sustained impression, that is, we may look at it steadfastly, and see it for some time. This sustained impression only exists in the centre of the eye, and for strong contrasts of colour: at the sides of the eye it is intermittent, it becomes invisible, then visible again, a property which Sir D. Brewster first indicated. Even in the centre of the eye, after a long period, it will at last fail or fade away.

(30.) Inasmuch as I have avoided the details of mathematical disquisition, so shall I also avoid the minutiæ of optical science further than to demonstrate briefly to you the manner in which images are formed by convex lenses. It is a property of these lenses to bring parallel rays which fall on them to a focus, or point, (*f*, fig. 13; A, fig. 14,) and the distance between this point and the lens is called the focal distance. Divergent rays will cause the focal distance (fig. 16) to be lengthened according to the amount of divergence; and convergent rays will cause the focal distance to be shortened according to the amount of convergence: hence, rays from B become parallel, those from

Fig. 13.

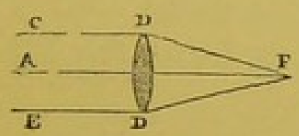
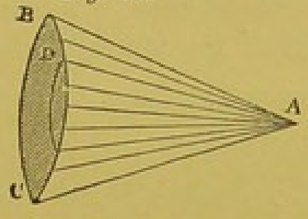


Fig. 14.



F focus at A, and those from H focus at G. These different foci are called conjugate foci. The rays of light from an entire object, after passing through the lens, form a perfect inverted image at the focus, or point where the rays meet. The rays (fig. 15) diverging from A focus at D, those from F at G, and from B at E. Oblique rays

Fig. 15.

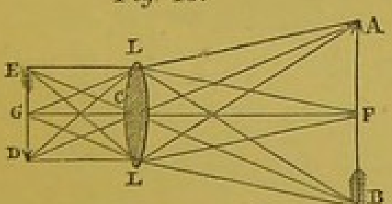
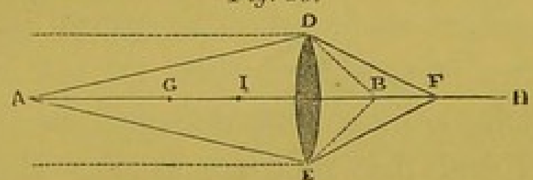


Fig. 16.



falling upon convex lenses do not form their focus at the same place as those rays which are parallel to the axis, a peculiarity which is termed spherical aberration. Rays less oblique would focus at K, (fig. 17,) while those more oblique would have their focus at H. Rays of different colours, moreover, have a different

Fig. 17.

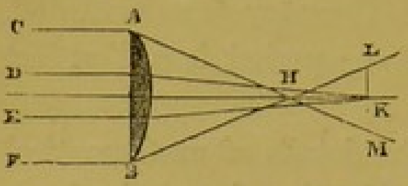
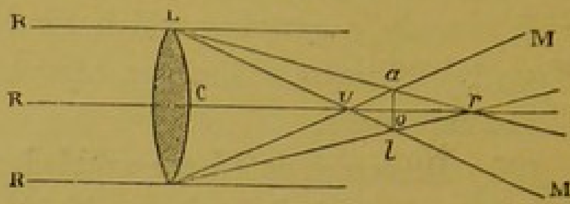


Fig. 18.



refrangibility; the red rays, for instance, would collect at r, (fig. 18,) the violet at v, whilst the circle at a b is the circle of least aberration. This variation for different colours is called chromatic aberration.

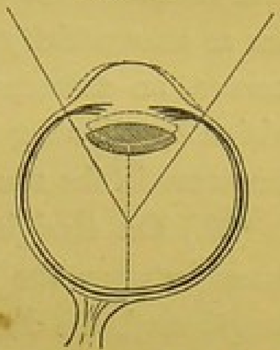
(31.) The eye being a camera obscura, it follows, that an object which would be apparent at a long distance, would not give a distinct image on the retina if it were near; and, in fact, a different adjustment would be required for each distance. I have here a camera obscura, and I can shew you that only at one distance can a distinct image be formed. Many have been the theories which have been framed to explain this adjustment for near and distant objects. Some have attributed the result to the action of the straight and oblique muscles, others to the iris; and others, again, have even erroneously denied that any adjustment was necessary.

(32.) Now this mechanism of adjustment is decidedly complex, though in result it is simply accomplished by the lens moving backwards and forwards; that is to say, for near objects it moves towards the cornea, for distant objects it moves from it.

(33.) In reference to this adjustment, we may observe, without reference to minute forms, that the eye consists of the segments of two circles, united at the external edge of the cornea, and, moreover, we find that the cornea has a contractile power, which causes it to shrivel when cut out from the eye. Now, if you watch the little images formed on the cornea by reflection, you will find that they are smaller when the eye looks at distant objects than when the eye regards near objects; consequently, the cornea becomes less convex, or has less refractive power at that period. In conducting this experiment, you must take care that the comparison of the image is made on the same spot of the cornea, otherwise you may be deceived, inasmuch as the cornea is not a perfect segment of a sphere, but is probably an ellipsoid. From the above facts it is manifest that the form of the globe of the eye changes during the adjustment, an effect which may be readily produced by the ciliary processes becoming fuller of blood.

(34.) Now, if the ciliary processes become fuller of blood, pressure would be made in two directions; in the first place, pressure would be made outwards against the elastic spring of the cornea, and perhaps the ciliary muscle, and pressure would be made inwards, towards the centre of the vitreous body, which would produce a resultant force, having the tendency to carry the lens directly forwards, the cornea and back part of the sclerotic being either fixed or having a slight tendency to have their distance elongated (fig. 19).

Fig. 19.

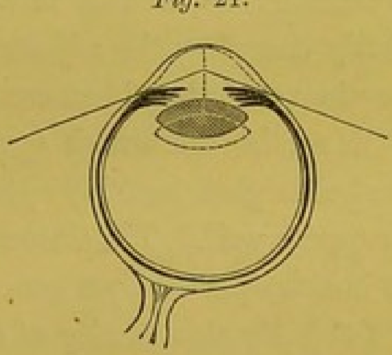


(35.) To illustrate my position I have made a model consisting of four pieces of card, connected at the extremities by a movable joint (fig. 20), and you will at once perceive that if I separate them at C and D, B would move towards A, which will explain the mechanism of adjustment to near objects, which is thus essentially an active operation.

Fig. 20.

(36.) For adjustment to distant objects, the ciliary processes have only to disgorge their blood, and then the elastic force of the cornea would act upon the aqueous humour so as to produce a resultant which would carry back the lens, which is in reality a passive operation, or one not requiring our own exertions (fig. 21).

Fig. 21.



(37.) This explanation of the adjustment to distance gives a particular use to the vitreous and aqueous membranes, which heretofore have never had a distinct necessity for their existence shewn. It gives also a use to the ciliary processes, which could hardly be supposed to have been made in vain.

(38.) My mode of explaining the adjustment of the eye to distances possesses one feature fraught with interest, for I have already told you that the cornea becomes less refracting, and that the lens advances towards the cornea when we look at near objects. In consequence of this arrangement, which must take place exactly to the same amount according to the theory advanced, the anterior surface of the lens would always be in the same relation, as far as concentricity is concerned, with the posterior surface of the cornea, an arrangement eminently calculated to ensure distinct vision by allowing the rays of light to pass through the refracting humours in the same direction.

(39.) On studying these effects, I observed, that, if the distance between the lens and the back part of the retina became lengthened, the distance from the lens to the lateral part of the retina was very slightly altered, which led me to infer that adjustment could not take place so perfectly for oblique vision; and I found on experiment, that, whether the centre of the eye was adjusted to convergent, divergent, or parallel rays, objects could be nearly equally well seen by the comparatively imperfect powers of the extreme lateral limits of vision; and from this cause we are always conscious of objects moving at a distance, although we are steadfastly regarding a near object.

(40.) In all cases, adjustment from near to distant objects takes a certain time, shorter in some individuals than others. In suddenly changing the adjustment from divergent to convergent rays, or *vice versâ,* the object comes into view at first apparently covered with a mist, but which speedily clears away and leaves it in its proper brightness. My optometer, fitted with half a lens, shews this property well. The time required for adjustment, although small in healthy persons, yet generally equals two or three seconds.

(41.) By this faculty of adjustment, we can, in some degree, estimate the distance and magnitude of objects when not too far distant; and in illustration of this fact, I can calculate the distance of near objects by the camera obscura by finding its point of adjustment.

(42.) As in the camera obscura stops (A B, C D, E F, fig. 22) are inserted to cut off the most oblique rays; so in the eye is the iris, or curtain, placed, which not only excludes the most oblique rays, but also regulates the amount of light. By its power of cutting

Fig. 22.

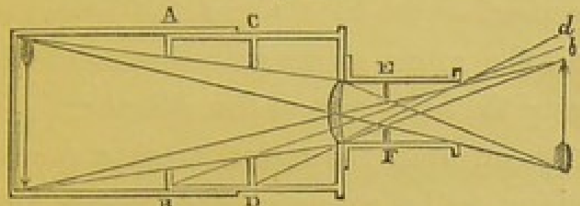
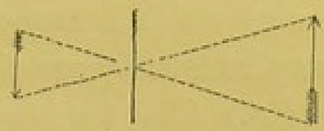


Fig. 23.



off the most oblique rays spherical aberration is diminished. From its excluding rays of light from the eye, an excess of rays is prevented from entering that organ and acting injuriously on the retina. Light reflected from any body will, after passing through a minute pin-hole, form an image of that body on any screen without the intervention of a lens (fig. 23). The iris also diminishes materially the angle of aperture for objects situated laterally, and hence contributes to prevent the necessity for adjustment to distance where they are so placed.

(43.) Our organs of vision enable us to judge whether an object be at rest or in motion. We appreciate motion from being obliged to move the eye to maintain a distinct image of the object; and in this case you also perceive that our sense of motion in the muscles gives rise to the idea of motion. The limited field of distinct vision must much contribute to the accuracy of our idea of the motion of a body. You may observe many curious effects of apparent rest and motion on the river steamers, whether other boats are at rest or in motion around you. To judge of motion in other bodies you must either be at rest or know your own rate of progression, or you may be led into curious errors. Motion directly towards or from you is a phenomenon very difficult to appreciate, but you will find that binocular vision assists you materially to judge of the effect. Besides our estimate of motion by the muscles of the eyeball, we must also take into consideration the action of the muscles of the head in some cases: hence, our idea of motion as deduced from our sense of muscular movements is a very complex affair.

(44.) The eye, in its normal state, is influenced by the seven colours of the spectrum, appreciates each colour, and views white light uncoloured. By the optical apparatus objects are depicted apparently free from spherical aberration, and act upon the retina. It is, indeed, a beautiful sight to observe the inverted image which is formed upon the retina of an animal, and which may be seen by scraping away the back part of the sclerotic.

(45.) After the image is formed upon the retina it takes a certain time for the idea of vision to be consummated, which has been determined to be the one-eighth of a second, on which account an object in rapid rotatory motion appears as a circle, because the impression endures till the object acts again.

The fact of time being required for vision has an important bearing upon railway accidents, as it is quite manifest that only a certain number of objects can be seen every minute. Under the present system, the engine-driver has to look out for signals, regulate his engine, and attend to its working. Now, when an engine is travelling at sixty miles an hour, an immensity of objects has to be focused and observed before the engine can be driven with safety, and practically we find that if anything is amiss it is frequently unobserved, and a frightful accident is the result. The laws of vision indicate that a man's entire attention is required to inspect the road for safe travelling, and probably fifty or sixty miles are the limit of inspection at one time.

When a fatal accident occurs from the engine-driver having too much to do, he should be liable for manslaughter, as he has no business to undertake duties which he cannot possibly perform. The directors who employ him in so murderous a manner should be held criminally liable, besides being compelled to make large pecuniary compensation for any damage which may ensue. There are some directors in most companies of an inferior mind and imperfect education, who are always boasting of cutting down expenses, and sacrifice of life and injury to individuals are too often the result of their ignorance and parsimony.

(46.) With healthy eyes, then, we see objects when they subtend a certain angle, and are illuminated with either of the seven prismatic colours. We perceive them in their true position, and are enabled to judge of their magnitude, distance, form, position, relation, and their state either of rest or motion. For distinct vision the object must be viewed by the centre of the eye, which must have its refracting media so adjusted that a perfect image is absolutely formed on the retina.

(47.) Magendie has pointed out, that although the optical apparatus be complete, yet vision is not perfect without the action of the fifth pair of nerves, a point of much interest, and one which requires full consideration. I cannot leave this part of my subject without recalling to your attention the consideration of the cause of vision. We have found that we see by the material mechanism of the eye, we have observed that vision is produced by light,—what is light? the light which may excite your retina may not excite mine. Take it by another test, by its heating properties, and we find that we heat by rays of the spectrum where light is not—by its chemical effects, and we can effect decomposition where darkness only reigns. Light is that action or force of matter which acts upon the human retina and gives us vision, or, in other words, light is that which is seen by the eye. Without light we can have no idea of vision; without taking vision as the test we have no idea of light; if the light which excites our eyes differs, our mental conceptions cannot perfectly agree. The eye is but destined to be acted upon by light; otherwise, in its special nervous apparatus it possesses no marked peculiarity, being capable of excitement by force, electricity, and even perhaps heat. When the retina, however, has been acted upon by light, that agent loses its physical character and becomes nervous: how that nervous impression is carried to the brain, has been a subject of much speculation.

The theory which appears to my mind most deserving of support, is that which I have propounded in my "Elements of Electro-biology" and further illustrated in my "Instinct and Reason." In my experiments and reasoning I am led to conclude, that the light acting upon the bloodvessels of the choroid at the back of the eye determines a photo-voltaic circuit, which acts through the different filaments of the optic nerve to make an impression ~~no~~ on the brain, which is there registered, and the voltaic circuit is completed through the motor nerves to muscles of the eye-ball. On this view, the retina constitutes one pole of voltaic circuit; the muscles, the opposite; while the nerves form the electric telegraphs to communicate the action of the batteries to the brain, where they again terminate in highly vascular tissue; and when the impression is registered in the brain, it is remembered and acted upon at distant periods.

LECTURE II.

ON DISEASED STATES OF VISION.

(49.) Veiled sight: its nature; origin; from disease; external injury; stings of insects;—(50.) from polypus; boil; cancer; melanosis, &c.;—(51.) from œdematous conjunctiva; pterygium;—(52.) from alteration in humours; interstitial deposition in cornea;—(53.) from effusion of blood in anterior chamber; lymph; pus, &c.;—(54.) from cataract; its treatment when partial; belladonna; atropine; eye-shade;—(55.) from glaucoma; alteration of vitreous humour.—(56.) Diagnosis.—(57.) Destruction of the eye.—(58.) Artificial eyes, by Gray;—(59.) by French artists; serious defect in the French eyes; its mischief.—(60.) Material and durability of.—(61.) Mode of adaptation; fixing; use of pressure.—(62.) Insertion of; principle of retention.—(63.) Great resemblance to the healthy eye; deception; singular instance of: importance of this invention.—(64.) Slow vision.—(65.) Dimness of vision: description of; its causes; its situation.—(66.) Night blindness: nature of; causes.—(67.) Day blindness: nature of; albinos; cataract, &c.; remedial agents; scrofula.—(68.) Vivid sight.—(69.) Diminished vision: description of; mischief done by improper spectacles; test of the existence of this condition.—(70.) Intermittent vision: nature of; treatment.—(71.) Persistent vision: its nature; causes.—(72.) Colourless vision: its origin.—(73.) Coloured vision: jaundice; other causes: many-coloured vision.—(74.) Painful vision: undue sensibility of retina; photophobia.—(75.) Description of skew-sight; causes of.—(76.) Eccentric vision; discriminated from squint.—(77.) Slowly adjusting vision: pathology of; treatment.—(78.) Partial adjusting power, as shewn by optometer; the two eyes not always uniform in; its simulation of short and long sight; illustration.—(79.) Immutable sight; improper glasses.—(80, 81.) Presbyopia and myopia: general remarks on their range; (82.) causes; altered focal distance.—(83.) Far sight in old age; its condition; other causes.—(84.) Far sight from removal of lens; natural power of compensation.—(85.) Short sight: its nature; causes; altered curve of cornea.—(86.) Effect of studious habits; treatment.—(87.) Improper use of spectacles.—(88.) Discrimination between myopia and errors of adjustment.—(89.) Irregular vision; nature of.—(90.) Double refraction; instance of.—(91.) Double sight: nature and causes of; temporary strabismus; external pressure; double pupil; division of cornea.—(92.) Treble vision; how occurring.—(93.) Manifold vision.—(94.) Half vision: instances of;—(95.) another instance.—(96.) Confused vision; its causes.—(97.) Moving vision: description; causes; inebriation; intense cold.—(98.) Distorted vision; nature of.—(99.) Perverted vision: explanation of; how produced.—(100.) Uncertain vision: nature of; cause of.—(101.) Contracted vision.—(102.) Imperfect sight; monocular sight; great importance of early operation in squint.—(103.) Apparent spots in vision; retina; their distinctness.—(104.) Probable causes of; condition of arteria centralis retinæ;

dilation of choroid veins; treatment.—(105.) Blindness;—(106.) great variety of its causes; (107.) from failure of circulation;—(108.) from pressure on nerves and arteries;—(109.) from causes acting on the brain; influence of the fifth pair of nerves;—(110.) from other diseased bodily actions; hysteria.—(111.) Voluntary blindness; general remarks on.—(112.) Peculiarities of vision dependent on various conditions of the mind.

(48.) In my last lecture I called your attention to the functions of the eyes, and to the powers which we enjoy through their agency; and I shall now describe to you the abnormal conditions of vision which arise from various causes.

(49.) You already know that for perfect vision a perfect image must be formed upon the retina; consequently, any opaque body interposed between the retina and the object would veil the object, and disordered vision would be a cause of veiled sight. Veiled sight, as a result of disease, may depend upon the union of the lids, or upon the union of the lids with the globe, in either of which cases the rays of light would be intercepted. Sometimes the patient cannot raise the upper lid, and is then unable to see till either an operation is performed, or the part is raised by a small piece of sticking-plaster fixed upon the eyelids or eyebrows. At other times the eyelids are continually twinkling, which produces an intermittent veiling of sight. Again, the eyelids may be puffed out with blood,—a circumstance which generally happens from the fist being smartly applied to that situation, or, if you can believe the vulgar report, from a fall against the handle or nozzle of a pump. The eyelids are occasionally distended with serum after the stings of bees, wasps, or hornets, or even the bites of gnats, and the sight continues veiled whilst the swelling lasts.

(50.) I once met with a polypus growing from the conjunctiva, which extended over the eye. This, however, I speedily snipt off, and restored vision. In another case, I successfully operated upon a singular and extensive growth from the uppe lid, which extended down the cheek, and veiled the eye. Occasionally, the skin of the eyelids is flaccid and pendulous, and obscures vision. Besides these cases, there are a variety of others, as inflammation, boil, cancer, melanosis, fungus, encysted and steatomatous tumours, which extend before the eye, and cause an interruption to perfect vision. Some of these cases of veiled sight, originating in the eyelids, are alarming to the patient, although but of little consequence in themselves, as surgery possesses the means, in the majority of cases, of rectifying the mischief.

(51.) Veiled sight may have its origin in the conjunctiva; which, in some cases, when greatly œdematous, will overlap the cornea, thus obstructing and sometimes completely veiling the eye. In purulent ophthalmia it is of very great importance in some cases to know whether the sight is merely veiled, or the organ destroyed; for, if only the former, the eye may perfectly regain its former condition. The peculiar growth called a pterygium, may take place over the cornea and veil sight.

(52.) We frequently find veiled sight originating in the various refracting humours of the eyes, which may cease to transmit light from being either altered in structure, and losing their transparency, or from having adventitious matter deposited in their texture. The cornea is apt to be the subject of interstitial deposition, in which case it becomes opaque. For these permanent opacities, which remain after all improvement has ceased, there is, unfortunately, no good surgical remedy; for we cannot substitute glass for this texture, nor have the curious attempts to transplant the cornea of animals into man been successful. There are thousands of individuals whose sight is completely veiled by total opacity of the cornea, and thus the discovery of any method for its relief would be a great boon to mankind. In cases of partial opacity, the operation of an artificial pupil is frequently practised with benefit; and there are instances in which a drop of a solution, containing one grain of atropine dissolved in water, may afford perfect relief, if used every morning, by reason of its dilating the pupil.

(53.) In the anterior chamber blood is sometimes effused; but it generally soon vanishes. Lymph, pus, the dislocated lens, hydatids, and animalcules, are sometimes found in this locality to veil sight. The iris having become fixed to the cornea, or anterior capsule of the lens, or the pupillary margin, it veils sight.

(54.) Cataract is a very common, but, fortunately, a remediable cause of veiled sight. It occurs most frequently in elderly people; but occasionally also in young persons. It consists in an opacity of the lens or capsule, or of both combined. Where this opacity is partial, as with the cornea, we frequently give our patient vision for a long period by dilating the pupil so as to unveil some part of the retina; and by this proceeding patients may sometimes go for years without requiring any further operation. The extract of belladonna is generally employed for this purpose; although I prefer in all cases to use a weak solution of atropine, of which one grain to two or three drachms of water, with a drop or two of acetic acid, will amply suffice. It is singular that this remedy never loses its power by use, and, therefore, may be continued for an indefinite period. A gentleman, employed in the Bank of England, who has an incipient cataract, obtains distinct vision by wearing a shade, which protects the eye from the light, and thus keeps the pupil dilated so as to afford him useful sight. Other contrivances may be used to obtain the same result, such as tubes set in spectacle frames.

(55.) Changes in the vitreous humour comparatively seldom veil sight; yet the disease called glaucoma is thought, by some, to be an instance of this kind; but the imperfection probably depends upon other changes in the eye. The vitreous humour occasionally has blood deposited in its cells, and sometimes a curd-like substance exists to veil sight.

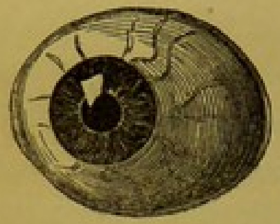
(56.) Such are all the situations at which sight may be veiled; and, if we ascertain that no change exists either at the eyelids, conjunctiva, cornea, iris, aqueous humour, lens, capsule, or vitreous body, we know that the imperfection of vision is not a case of veiled sight. In all cases of veiled sight there is more or less consciousness of the presence of light; because organic bodies are not generally so opaque but that they will allow a few rays to pass, and thus allow the sufferer to distinguish between strong light and absolute darkness. In cases of inflammation, more or less acute, of the conjunctiva and cornea, some change of structure occurs, or vitiated mucus is secreted, which prevents perfect vision. In chronic inflammation the patient suffers very considerably, in fact to an extent quite disproportionate to the nature of the malady, especially if he is compelled to use his eyes much at night. In these cases relief may generally be obtained by attending to the general health, and at the same time using a collyrium of half a drachm of alum with half an ounce of spirits of wine, in half a pint of rose water. At night a little ointment may be smeared on the edges of the lids, composed of one part of oxide of mercury of the Pharmacopeia, diluted eight times with the best lard. This eye-water and ointment may be regarded good standard applications for this class of diseases.

(57.) In certain conditions of the eye the patient becomes sightless: in fact, wherever the retina and choroid are destroyed, vision is utterly lost. A patient becomes sightless whenever total destruction of the eye ensues. The globe, after severe inflammation, or extensive traumatic damage, is apt to be so much injured that it collapses, shrivels up, becomes unnourished, and wastes away.

(58.) These cases exhibit a most unsightly appearance, especially where one eye is destroyed; and the ingenuity of man has been taxed to provide a remedy, in the shape of a false or artificial eye. The only maker in England, is, as far as I have the means of knowing, Mr. Gray; and to such exquisite perfection has he brought this art, so completely rivalling thereby the appearance of the healthy eye, that I have known the incipient surgeon, off his guard, to declare a false eye to be a remarkable instance of fixed pupil.

(59.) Our worthy neighbours, the French, although great adepts at little contrivances of this kind, are behind us in the manufucture of artificial eyes. Their form is not generally so perfect as that of Mr. Gray's, nor is their material so good. Moreover, there is a slight defect in all which come to this country, but which you would never discover unless you were told of its existence; in practice, however, this defect is of so much importance, that you should absolutely forbid their use, on account of the serious results which ensue therefrom. This defect is simply a slight roughness, of about the quarter of an inch in extent, upon the edge of the eye, which, when inserted into the orbit, acts as a file upon the conjunctiva, and causes inflammation to arise, and granulations to spring up, which may ultimately even preclude the further use of this admirable invention.

Fig. 24.



(60.) These artificial eyes are made of soft enamel and glass, and are tinted so as exactly to correspond with the colour of the sound eye. Owing to the fusibility of the glass, its composition is such that after a time it is acted upon by the tears, and thus the eye requires to be renewed every one or two years.

(61.) The artificial eye sits comfortably on the collapsed globe, and moves as freely as a sound eye. It can be readily taken out and replaced, so that it is the constant practice to remove it at night. If the globe be shrunk to a very small tubercle, a very small eye must at first be employed. If the globe be larger, a larger eye may be used. In cases where it will not readily adapt itself to its new locality, a little pressure may be used to assist it; and I have devised a little instrument, which was made for me by Mr. Ferguson, of Smithfield, which may act very usefully for such cases. It consists of a false eye, to which a spring is attached. This passes round the head, and reacts upon the tubercle, which forms by pressure a suitable bed for itself.

(62.) Some persons entertain the ridiculous idea that a painful operation is required for the insertion of a false eye; but the principle by which the eye is held in its situation is the same as that of a boy's sucker, which is held by a pressure equal to fifteen pounds to the square inch, from the pressure of the atmosphere; and, as in large eyes the eye hugs the globe so tightly as to be inconvenient, little superficial eminences are contrived by Mr. Gray, to prevent the undue force, which would render the withdrawal of the eye a considerable difficulty. Where the patient needs but a very small eye, it should always be well cupped, to prevent its sliding from its proper position.

(63.) Great nicety is required in the adaptation of false eyes; but the artist so exactly imitates the colour of the sclerotic, which is whitish, bluish, or yellowish, the tinting of the iris, the size of the cornea, and centres it in so faultless a manner, that you must take care and not be enamoured with the beauties of a false eye unwittingly, and afterwards find, to your astonishment, that the object of your choice carefully puts by her soft and captivating eye in a little cotton-wool before retiring to rest. Do not think that I am in jest in recommending you to beware of a false eye, for I have just heard of a case where a fair lady wore a false eye, which her husband never detected before marriage, and even up to the present time, when two years have elapsed, he has not discovered it. Before marriage she never dared tell him, and afterwards she feared to avow her concealment. I actually once met with a case, where a fair damsel, having two eyes with irides of different colours, desired a false eye to cover the colour of that which she disapproved. You will confer great good by pressing the use of false eyes in all suitable cases of lost eye; for, in the working classes of society, a lost eye, from its unsightly appearance, prevents the sufferer from obtaining occupation; and in the upper, it frequently forms a bar to social intercourse.*

(64.) *Slow vision.*—When we direct our eyes to any object, the image is instantly formed on the retina and carried to the brain, where it is appreciated. In some few rare instances I have been consulted in cases where the time required for the process is prolonged, and which I am in the habit of calling cases of slow vision. In cases of slow vision the state of the brain should be very carefully watched; and, as far as I can judge, slow vision generally depends upon some cause existing in the head.

(65.) The essentials to vision being present, we have various abnormal conditions to study. In the first place, vision may be dim, and really you will find that there is a disease which may

* False eyes are sometimes used for horses, as well as for man, and the appearance of the deformity of a collapsed globe may thus be corrected. In hospital cases, I have known many instances when Mr. Gray has, to his honour, furnished false eyes either gratuitously or at merely nominal price.

truly be called dimness of vision. By dimness of vision I mean, that the ordinary amount of light does not seem sufficiently to excite the retina; in fact, even in strong light the retina appears to be imperfectly stimulated to action. Such a state you will frequently find in those who try their eyes to a great extent with minute work, as, for instance, sempstresses, watchmakers, engravers, compositors of small types, and other trades requiring constant and minute use of the visual organs. This dimness of vision is in some persons confined to the axis, or part dedicated to distinct vision; hence, I have met with gentlemen who could not see a star unless they looked at it obliquely, when it became instantly apparent. Central dimness of vision, I believe, is a common affection. It is an interesting fact, that Sir John Herschel, in the use of his great reflecting telescope, discovered that many faint stars were often rendered visible by being viewed obliquely.

(66.) Somewhat similar to dimness of vision, we observe a class of cases which come under the denomination of night blindness. It is sometimes called hen blindness, because it is said that hens cannot well see at dark. Night blindness generally arises from intense excitement of the retina, either from the reflection of the sun from the water, which is so injurious to sailors and fishermen, or from the reflection which takes place from white chalky cliffs, or ground covered with snow. Few can imagine the distress occasioned by the reflection of light from snowy mountains, at high altitudes, unless they have actually experienced it, and this may be a frequent cause of night blindness. In these cases the sufferer sees perfectly well in the day-time, but loses his power as dark sets in. Good quotes a case recorded by Guthrie, wherein it is related that a party of Russian soldiers, whilst labouring under this affection, cut each other to pieces unconsciously, when ordered to attack the enemy.

(67.) In opposition to night blindness there is an affection of vision termed day blindness, because the party sees well in the dusk, but has very imperfect vision in the strong light of day. The deficiency of pigment in the eyes of albinos renders vision by daylight less distinct than at night. Many cases of day blindness depend upon the sight being veiled in the centre of vision, as in cases of partial cataract, opacities of the cornea, &c. When an opacity exists in the centre of vision, the contraction of the iris will cut off the power of sight; but on its dilatation from the light being diminished, the rays are admitted over a surface beyond the range of the opacity, an effect which may be imitated by belladonna, stramonium, or their alkaloids, atropine, and daturine. During the progress of active disease, I need hardly again mention that day blindness is common, and certainly the manner in which the scrofulous child hides its head all day long, and only comes forth at night, is abundantly curious.

(68.) In opposition to dim sight, before mentioned, we have occasionally vision preternaturally vivid. Plenk declares that he has known persons who could see the stars at noon-day. With the exception of the planet Venus, which any person may see even in the middle of the brightest day in June, I have, however, never myself seen an instance of such exalted vision; and, as, in fact, the stars are barely visible during the darkness of an extensive solar eclipse, such instances must be rare indeed.

(69.) In many instances cases occur of defective or diminished vision in which the ordinary visual angle was insufficient to excite the eye, so that it required to be enlarged for that purpose. I meet with such instances constantly in young people, who evidently are unable to see objects of the ordinary visible magnitude, but require the assistance of convex glasses to enlarge the visual angle. In general, the powerful spectacles thrust upon them by incautious opticians, were the very instruments best calculated to aggravate the disease. When patients are affected with this malady, they cannot see the objects which are visible to ordinary mortals; they cannot read very small type at any distance or by any light; and the best mode of testing their condition is to try the power of sight with very small type. This condition is also to be met with in old people occasionally; and in these cases we observe that they are neither short-sighted nor long-sighted, nor is there any defect in the power of adjustment. They simply require the object to be magnified, to render it perfectly distinct. Scarcely a month passes without a visit from a patient with this disease from various parts of the country; from whence I infer, that this state has but little occupied the attention of medical practitioners. Where the disease exists in young people as a congenital defect, the question of future employment is of very serious importance, as it is manifest that they are unsuited for the duties of a clerk, compositor, engraver, or other labours requiring perfect vision. Taking a large mass of individuals as a criterion, the affection cannot be very common, as I have only detected one case in about five hundred examinations of gentlemen, between seventeen and thirty years of age, who were candidates for a clerkship at the Bank of England.

(70.) When discussing the functions of the eye, I pointed out that in health we are enabled to regard an object and obtain a sustained impression; in some cases, however, vision is but transient and becomes intermittent, and although the patient look steadfastly at the object, it vanishes, it returns again, it vanishes, and again it becomes visible. Sir D. Brewster first demonstrated that vision in the more remote part of the retina is always transient; and, from my observation, the degree of transcience varies much in different cases. In the centre of the retina, however, it ought normally to be continuous. This malady, which is in some cases of great moment, may generally be remedied by quinine, iron, and mutton chops; in some cases, however, you cannot benefit it. This affection is rendered much worse when the object regarded is nearly of the same tint as those surrounding it.

(71.) An opposite condition of vision to that last described, is to be found in persistent vision, where the object seen remains too long upon the retina. When the sun is regarded steadfastly, its impression is retained upon the retina; and those who have tried the dangerous experiment have continued to see the sun when they ceased to look at it, and they have found it impossible to go into any spot where the image would fade away. The darkest cellar was not darkness, for the sun was there, and the impression has been known to last for two or three days and nights. In the healthy eye the object does not remain impressed upon the retina for more than the one-eighth part of a second, and if it remain for a longer time the case is one of persistent vision. A friend of mine, fond of astronomical pursuits, has lately had a persistent image of the sun from too intensely regarding it; this image has already lasted for some weeks, and even now a perfect integrity of sight has not recurred.

(72.) An object should be represented to our mind invested with its real colour; white light should appear white, coloured light should appear of its normal colour; but instances occasionally occur where parties are unable to distinguish all the colours of the rainbow. Owing to visual defect, a person has mended a hole in a green coat with a piece of scarlet cloth, conceiving that it matched perfectly. Sir J. Herschel has ascertained, by examining with great accuracy a party so affected, that the eye was acted upon by all the colours of the rainbow; and that, consequently, the disease must have its origin in the sensual organs being incompetent to distinguish the difference. This inability to distinguish colours might be called colourless vision. My excellent neighbour, Mr. Renton, the artist, informs me that he once met with a gentleman, who, having perfect sight in all other respects, could not distinguish any colour, as colours only gave the idea to his mind of light and shade. Such a case is extreme and unusual; but had he been educated as an engraver, he doubtless would greatly have distinguished himself, as in that branch his defect would have been a benefit to him. I have also lately heard of a pupil, who, on being desired to paint a green tree, made use of vermilion for the purpose, and was well pleased with his performance.

(73.) In contradistinction to colourless vision, we find persons who, under some circumstances, see objects coloured; thus the jaundiced patient sees everything yellow. Coloured vision also arises from looking at the sun through a coloured glass, when the complimentary colour becomes predominant. A still further extension of the last condition of vision may be observed where the patient sees many colours. This state may arise from various causes, such as the presence of little pieces of opaque matter on the lens or in any part of the eye, which will decompose the white ray and render it coloured. These instances would constitute cases of many-coloured vision. I have lately seen a case in which the prismatic colours were fixed upon the retina after the observation of any object; in this instance it appeared to be connected with some disease of the brain.

(74.) There is a disease called painful vision, which is found in various cases. In some instances preternatural sensibility exists from the state of retina: in other cases it arises from active disease in the eye. At one time it is a merely unpleasant feeling; at another it is exalted to absolute pain, constituting painful vision, or, as it has been termed by some writers, photophobia.

(75.) Ordinarily we direct our eyes towards the object to be seen, but in some cases the lateral portion of the retina appears alone to be capable of appreciating objects; the peculiarity is termed skew-sight. It is one of the most remarkable abnormal conditions of vision, and it is truly curious to observe the sufferer roll the eye about to obtain a side glance of the object viewed. A central opacity in the cornea will cause the patient to be skew-sighted; but in other instances the centre of the eye appears to have lost its power of distinct vision. I have met with a case of skew-sight where the disease appeared to run in a family, and in which no power of vision could be traced in the central part of the retina.

(76.) I have, in some few instances, seen cases where distinct vision appeared not to be in the axis of the eye, but at some other spot removed from it. Where these cases of eccentric vision exists, the patient, in viewing an object, appears to have a peculiar squint, which, however, is not likely to be benefited by an operation. It is very curious in some cases of eccentric vision to observe the patient, as he examines an object, directing the eye at a constant angle away from it. In the cases in which I have been consulted, I have found the vision has been materially and irremediably defective.

(77.) In my former lecture I entered minutely upon the consideration of the mode of adjusting the eye to vision, and mentioned that some little time was requisite to effect that change: I have now to state, that in some instances the adjustment is performed but feebly, and requires a much longer time for its performance; this, therefore, is a case of slowly adjusting sight. From physiological considerations we may infer that the adjustment to near objects takes place from the entry of blood into the ciliary body, and pathology shews that in feeble, weakly states it takes place more imperfectly. Where slow adjustment exists, I generally find that quinine, iron, meat diet, fresh air, and exposure to the light of the sun, constitute the best remedies. It is an affection exceedingly common. Some time since I devised a little instrument to determine this state, but I find my optometer will answer every purpose.

(78.) My optometer shews that it frequently happens that the power of adjustment either in one eye or in both takes place but partially, and even that this power may vary in the two eyes of the same individual. Sometimes this partial power is restricted to near objects, whilst distant objects are not perfectly seen. In other instances adjustment only takes place over a range more distant, whilst near objects are not perfectly seen; and, again, there is a third set of cases, where the adjustment takes place in the middle part of the scale. These cases are important, because they are apt to be confounded with the true short sight and long sight, which have for their origin a different cause. If we suppose four lines, one for normal adjustment and the other three for abnormal, we shall be in a condition to understand how the range in both cases is contracted:—

Healthy adjustment ————————————————————

Near partial adjustment } ———— ———— { Far partial adjustment.

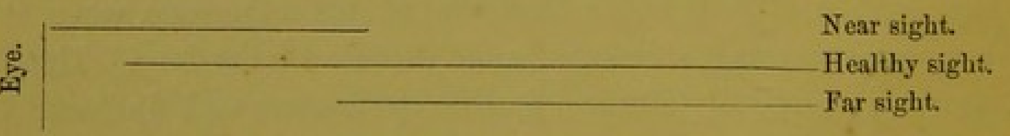
Middle partial adjustment ————————

These conditions are exactly similar to those of a camera obscura, which has its lens so fixed as not to allow the motions sufficient extent for the different adjustments. A fixed state of pupil does not interfere with adjustment, for I have found it to be quite perfect, or even slightly better than that of the other eye, when it has been universally adherent to the capsule of the lens. These states are easily determined by the optometer; and, in fact, I may say, that the optometer has given us a knowledge of these maladies which we did not before possess.

(79.) There are also cases, not so frequent as the last, where the faculty of adjustment to different distances is entirely lost or absent —a condition which has been called by the great Dr. Young "immutability of sight." I have seen a few such cases at various times; but for all these conditions of imperfect vision, the unlucky patients too frequently consult rafher the ironmonger, the pedlar, or other vender of glasses, than the surgeon, who is rarely called in till the former worthies have rendered the case almost hopeless by improper glasses.

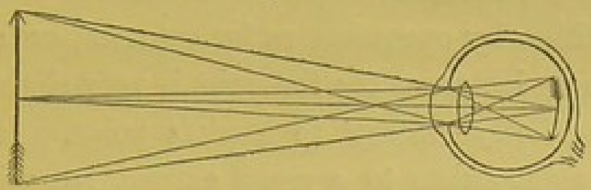
(80.) I have now to speak of two very important conditions of vision; namely, presbyopia or far sight, and myopia or near sight; conditions which arise from the refracting power of the eye being so arranged, in relation to its distance from the retina, that a perfect image does not fall upon the retina where the object exists at normal distances. In my physiological observations I stated that the eye should adjust itself to objects situated between five inches and infinite distance: but in far sight the eye cannot see objects so close; in fact, in some instances not within three feet distance, or even not within a more extensive range; and in near sight there are cases where the eye only properly sees objects between two or three inches and nine or ten inches.

(81.) In these cases the faculty of adjustment is generally perfect, or, at any rate, not necessarily imperfect; and it is the range of adjustment in pure cases of myopia and presbyopia which is alone interfered with. As in every case of far sight and near sight a difference exists, it is impossible to map out minutely the different ranges of distance at which objects are visible in each case, though the accompanying diagram will in some degree illustrate the three great classes, near sight, healthy sight, and far sight:—



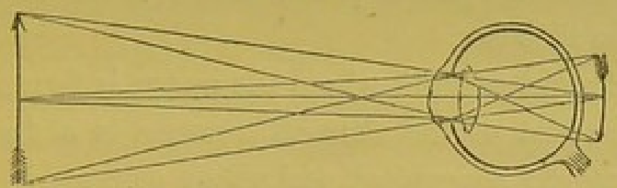
(82.) The cause of both near sight and far sight is an alteration in the length of the eye in relation to its refracting power. Thus, in near sight, from the length being too great, we find the picture would be formed before the retina (fig. 25). In far sight, on the

Fig. 25.



contrary, the distance is too short, and hence the picture would be formed behind the retina (fig. 26). In either case the indistinctness of vision arises from the rays not being brought to a true focus or point on the nervous expanse.

Fig. 26.



(83.) Far sight generally, indeed almost invariably, occurs as a process of natural decay in declining years, and the party first finds that he must hold objects at a greater distance to render vision distinct. In this case the whole eye seems to shrink, the anterior chamber becoming smaller, and the cornea flatter, and, coinciding with this defect, the power of adjustment is frequently impaired; so that thus we have a double disturbance of the functions of vision. The talented Wardrop has pointed out that feebleness sometimes leads to presbyopia; no doubt sometimes by the absorption of the aqueous humour, though more commonly, according to my own experience, by diminishing the power of adjustment, and thus constituting a case of partial far adjustment, with which we must be careful not to confound it. Although far sight occurs most commonly as a disease, yet I have been occasionally consulted by patients who have suffered from this abnormal state as a result of congenital defect. The patient in this case prefers to sit before a window with the light falling directly upon the pupil, so that by its contraction to a pin's point only the central rays impinge upon the retina, and thus fair vision may be obtained. Congenital far sight may exist with most perfect power of adjustment. The disease may be determined with great accuracy, instantly, by the optometer.

(84.) Far sight occurs to a greater or less extent when the lens is removed, either by operation, as for cataract, or from any other cause. In some instances the far sight is very slight, especially if the iris can perfectly contract to a pin's point. In other cases, however, far sight exists to a great extent, requiring very deep glasses to supply the defect. It is important in these cases not to begin glasses too soon; for the longer their use is delayed the better will it be for the patient, as Nature accommodates herself well to the abnormal state. It is really astonishing how her powers of compensation will conquer acquired defects, if we do not impertinently meddle with her.

(85.) Short sight or sight where the image is formed before the retina in some part of the vitreous humour, is a disorder which, doubtless, is mostly congenital, and which consists in a too great refracting power in relation to the distance of the nervous expanse. In some instances, the anterior part of the cornea, which ought to remain as a fixed point, appears to give way, and to be prolonged forwards, producing that condition which is usually called conical cornea, and which is apt to increase till vision is comparatively useless, from the impossibility of properly bringing to a focus the image upon the retina.

(86.) It has been observed that those who work in the fields, or soldiers, are not short-sighted; whilst, on the other hand, those who devote themselves to literary pursuits are almost invariably afflicted with this infirmity. The natural mode of overcoming this acquired difficulty is to place the party under circumstances opposite to those which produced the defect. The literary man should regard distant objects; and, instead of spending all his time over some work, printed, perhaps, with defective type, bad ink, or faulty paper, should spend a fair portion of every day in perusing the more profitable works of nature, which are situated at all distances, and of which the lines, colours, and harmonious combinations are faultless and beneficial to the eye, and furnish the means of exercising healthy vision. The study of morbid vision demonstrates the necessity of dividing our attention between the books of man and works of nature; and, if there be some who dare violate this great principle, they may rest assured that their vision will be impaired and their mind distorted.

(87.) You cannot too highly estimate the value of attention, care, and practice in rectifying the short-sighted state of the eye; and on several occasions I have dissuaded the parents of young persons from precipitately rushing to the opticians for short-sighted spectacles, and have frequently had the satisfaction of observing that after a year or two the sight has very materially improved; in fact, so as to render spectacles unnecessary.

(88.) Heretofore cases of short sight have been very extensively confounded with partial near adjustment, but in reality the states are very different; and the mistake is now quite inexcusable, as my optometer affords the means of instantly forming a correct diagnosis. The diseases of adjustment are far more common than short sight from an improper use of the organ; and without passing a very positive opinion, I am inclined to believe that true cases of near sight do not occur at all from the constant use of the eye to close objects.

(89.) Irregular vision exists in a very few cases. Mr. Mackenzie asserts that Mr. Babbage, the inventor of the celebrated calculating machine, has a defect of this character. Irregular vision depends upon the lens being either of incomplete figure, or of its refracting power being abnormal in its various parts. In irregular sight, one part of the retina may see an object at a given distance perfectly, whilst at other places it would be imperfect. It sometimes happens that the vertical refraction of the rays differs from the horizontal, so that the rays are brought to a focus at unequal distances.

(90.) Sometimes double refraction exists either horizontal or vertical, as though the refracting humours had two optical centres. I am acquainted with a gentleman of distinction, who has an affection of this character in both eyes, which causes him to see two objects when he looks at but one, and a line appears double, like the last words of this paragraph:—

The extent of separation varies in different cases.
The extent of separation varies in different cases.

(91.) Sometimes a single object appears double. According to the law of vision which I have already detailed, the defect always exists when the figure of the object is so thrown upon the retina, that the real position of it is not vertical to a tangent of the part of the nerve excited. Hence, whenever the optic axes are not acting in exact accordance, double vision ensues. When the axes of the eyes are not simultaneously directed to the same object, the affection is termed squinting, or strabismus; and whenever there is strabismus there will be double vision when both eyes are employed. Nature, however, practically gets over the difficulty by neglecting the impression of one organ. A slight derangement of the stomach will sometimes throw the eyes out of their true direction and cause squinting. Double vision may always be produced by gently pressing the eye out of its proper position with the finger. Double vision with one eye may occur if two apertures exist in the iris, or if the cornea be divided in the median line and the slit be not accurately joined together in the process of reparation. From my own experience I should say, that, however apparently exact the juncture of a slit in the median line of the cornea may be, the conjunction, nevertheless, is never absolutely perfect.

(92.) Treble vision may occur in one eye in certain cases where three apertures exist, or with two eyes if double vision exist in one, and the position of the object as seen by the other is not in its true place. It is, however, a state far more rare than that of double vision.

(93.) In one or two instances I have met with manifold vision, the party seeing numerous objects where one alone existed. This state of vision would be invaluable to the miser, who values gold more for its quantity than its utility.

(94.) In contradistinction to double, treble, and manifold vision, we have occasionally but half vision. The great Wollaston had once or twice this affection, for, in looking at the word "Johnson" over the door, he only saw son. This peculiar state sometimes occurs from indigestion, organic disease in the brain, or other causes. The case of Dr. Wollaston was one of internal hemiopia; that is to say, he saw with the external half of the retina, and not with the internal. But I have now a very curious case under my care at the Central London Ophthalmic Hospital, where the patient can read the name of Alfred if he looks steadfastly at the letter d. If, however, he regarded the letter A, he could only see Al ; and if he directed his eye to the centre of the word, he perceived Alfr , the rest being invisible. In meeting two people in the street, he is only conscious of one being present till he hears, to his astonishment, the other speak.

(95.) The case cited in the last paragraph differs from that of Wollaston, inasmuch as this one can only see with the outer part of the eye. Many years back he received an injury to the left eye, which nearly deprived him of its vision; but the cause of the present ailment does not satisfactorily appear. A friend of my own has often told me, that, during derangement of his digestive organs, he is subject, occasionally, for an hour at a time, to a derangement of vision somewhat similar to that just mentioned. In reading at such times, the half-inch of print directly in the line of vision is invisible, so that he is compelled, as it were, to read a little behind his direct sight all along; and he tells me that the sensation is particularly distressing, which I am not in the least inclined to doubt.

(96.) The quantity of light admitted to the eye is regulated by the pupil; and if the pupil be excessively dilated, vision is not perfectly distinct, in fact it is confused. If you refer to a diagram which I have before shewn, you will see that rays passing through a pin-hole would fall upon a screen in such a way as to afford a perfect inverted image, a phenomenon which I can shew by a camera without a lens. For near objects, much illuminated, this contraction of the pupil appears necessary; and where dilated pupil exists, the case is generally one of confused vision.

(97.) Moving vision, or that state where objects at rest appear to be in motion, is generally transitory, and will arise from any cause which will fuddle the head. An extra glass of wine or spirits will generally make that appear in motion which is in reality at rest. It is not always spiritous liquors which cause giddiness; for instance, cold will produce the same result, and various states of the constitution will lead patients to infer that the object regarded is passing away. If, when a person is in a state of semi-intoxication, you stand directly opposite to him, and slowly bend your body laterally, like a pendulum, and declare that he cannot see straight, it will produce the most uncomfortable sensation, and he will believe that he himself, and not you, are in motion; and the ridicule of his ludicrous position will make him wish that he were a disciple of Father Mathew rather than of Bacchus.

(98.) Distorted vision will occur when the regularity of the refracting medium is interfered with, or when the curves of the various refracting media are the least altered from any accidental or traumatic cause; hence it will always occur in cases of irregular refraction.

(99.) In some cases the object is not seen in its real place, but in some other situation,—an event which always happens when the rays fall upon the retina in such a manner that the object is not vertical to a tangent of the part of the retina impressed. This instance of perverted vision may always be produced by moving the eye gently to one side with the finger, when the object will appear in the wrong place. In the experiment of directing the eyes to a new object, when the rays of a star can fall upon the two eyes, this condition of morbid vision is explained, for neither of the apparent stars is in its true place.

(100.) There is a curious state of vision which may be called uncertain vision : it occurs when the patient cannot confidently judge of the distance of objects, and at one time seeks to touch objects which are yards from him, and at another receives a violent blow by coming in contact with a hard body which he believes to be distant. The incapacity to judge accurately of distance occurs when a person suddenly loses the use of one eye. A chemist of reputation, who is an intimate friend of mine, met suddenly with a severe accident, which, in a great measure, deprived him of the use of one eye, and he complained for a long period of the great inconvenience he experienced from this cause. Elderly people are very apt to be thrown down, from not being well able to judge the depth or height of a step.

(101.) The field of vision, or rather the range of the limits of vision, is in some instances contracted or lessened, and, with the power of using but one eye, the range is much diminished; also, if either eye be only partially veiled, the extent would be limited, and contracted sight would ensue. Imperfect vision always exists with monocular sight. With one eye we cannot thoroughly obtain a knowledge of solid or cuboid forms; and hence it is highly important for squinting eyes, where integrity of vision exists, to be set straight early in life. This admirable operation, if carefully performed in proper cases, is perfectly successful, causes very little pain, produces very little inconvenience, materially improves the appearance of the individual, and often the sight of the eye. During illness the globes of the eye sometimes wander, and are not directed to the same point of sight. This effect is particularly distressing, as two or more representations appear to jump over each other. For this reason bed-rooms are now frequently papered with a tertiary colour, without any distinct pattern, so that the overlapping may not produce any positive change. After railway accidents I have seen cases where this want of concert of the axes of the eyes has been very distressing to the patient, but the malady has not proved of any permanent importance.

(102.) Erroneous notions as to the solidity or hollowness of bodies are sometimes formed; and the cause is not very apparent. The die-sinker frequently finds that his intaglio to all appearance stands out in bold relief, and contrariwise a medal in relief occasionally appears as hollow to the observer. In the cases which I have seen, I have not at present been able to satisfy myself of the cause of this error.

(103.) One of the most common, and at the same time one of the less important, abnormal conditions of vision, is the presence of false spots, which move when the eye moves, and which remain stationary when the eye is fixed steadfastly on any object.

We may presume that the spot always exists on the same place of the retina. They have, moreover, sharp, clear, defined margins, and therefore cannot be from opacities in the vitreous body, lens, aqueous humour, or cornea; but must have for their cause some condition acting directly upon the retina. At one time these spots assume the form of threads, either single or contorted, so as to resemble a fine cobweb; at another, they assume the form somewhat of spiders and flies, and are so distinct that frequently our patients can make drawings of them for our instruction or their own amusement.

(104.) I am inclined to hold with the learned Mackenzie, whose most valuable work I particularly recommend for your perusal, that the disease probably exists from some abnormal condition of the arteria centralis retinæ, or its veins. In this disease the choroid veins are frequently dilated, which dilation may often be observed in sempstresses, engravers, watchmakers, and all other persons who enervate the eye by working upon minute objects. By attending to the general health you may frequently lessen the disease, but seldom entirely remove it. False spots, as I have hitherto described them, are dark, as though vision were prevented at certain places. In some cases, however, the converse is observed, and the patient has false sight of illuminated objects, or, rather, I may say, false illuminations. I have, at this hospital, a case now under my care, of a man who is afflicted with this diseased state of vision. False light always appears when a blow is inflicted over the eye, or a current of electricity is transmitted through the eye or surrounding parts. These luminous nuisances occur also during disordered states of the stomach or liver.

(105.) In all these abnormal states of vision I have simply described them as simple cases, but frequently, in actual practice, we find two or three states combined, which adds very materially to our list of varieties of diseases; thus we may have cases of short or long sight combined with impairment of adjustment or with diminished vision; and without entering more into detail, the practical surgeon finds, at times, every possible combination of malady.

(106.) In a former part of this lecture I have described to you the various cases in which veiled sight occurs; and I there mentioned that in almost all instances, although vision was lost, a partial translucency generally allowed more or less appreciation of strong light. I have also called your attention to cases of impossible vision, where the eye was destroyed, and I have yet to consider various other circumstances which prevent vision, or, in other words, render the patient blind.

(107.) Blindness has its origin from so many causes, and forms such an extensive subject, that whole treatises may be written upon it. I shall, therefore, content myself by simply recapitulating the leading conditions under which we have "wisdom at one entrance quite shut out." In the first place, amaurosis or blindness may ensue from causes emanating from the blood: thus, if the vital fluid in the system be diminished to a certain extent, blindness takes place; and I need hardly, in this place, inform you, that, after extensive hæmorrhage, blindness is a bad symptom. When the action of the heart fails, no blood is sent to the eye, and temporary blindness ensues; and, lastly, if the qualities of the blood be vitiated, as in certain cases of anemia, plethora, &c., the same condition arises.

(108.) I have told you that blood and nerve are requisite for vision; and, therefore, if anything press upon the nervous or vascular coats, vision is prevented. Blindness is frequently produced from pressure upon these parts, either acting within the eye, or upon the outer part of the sclerotic. Blindness may also ensue from causes preventing the conveyance of the impression to the brain, and hence it may arise from causes emanating from the optic nerve, optic track, or optic commissure.

(109.) Blindness may be dependent upon changes in the brain itself, or causes acting upon the brain, as the pressure of fluid in hydrocephalus, or from extravasation of blood, or other similar causes. In my former lectures I have noticed the mysterious and interesting influence of the fifth pair of nerves over vision, and we find that any cause which interferes with their action produces blindness. The curious influence which an action on one nerve has in influencing another is well seen in the nerve of vision, for we constantly find that irritating matter in the stomach impairs the sense of sight.

(110.) The various diseased actions which the body at times assumes, will produce blindness. In hysteria utter insensibility to light sometimes ensues. During the existence of the inflammatory process, a patient is also commonly unable to tell light from darkness. Several abnormal states of the body may produce blindness. During collapse vision is very imperfect. The state of coma renders the patient for the time totally blind; and during fits he is unable to see.

(111.) We also meet occasionally with cases of voluntary blindness, and this even among scientific men, who are unable, during the fit, to see a fact which happens to be disagreeable to them, magnify it ever so big; or, if they do see it, they will distort it to suit some preconceived idea, or to support some imaginary theory. Cases of obstinate blindness are also not very uncommon in workhouses, where the law provides a cure in the shape of the treadmill. This seems to be far too homœopathic in some cases, as it produces but a transitory benefit, and the patient comes out as blind as he went in; a misfortune much to be deplored, not by himself, who is a gainer by his malady, but by the community, who have to support him in his blindness, and who are contaminated by his bad example.

(112.) It is not within the province of this lecture to consider cases of insane thought, where the mind sees that which never happened, nor to dwell upon cases of poetic fancy, where the imagination conjures up places, persons, or things, for study, amusement, or contemplation. But as, in the physiology of the eye, we are upwards led to the consideration of the mystery of the personality of mind and life, so the pathology of the same subject elevates the thoughts to the consideration of the properties of that mysterious mind, which re-acts upon the organs of sense, and causes them to restore bygone events, which made a deep impression at the time of their occurrence. Our immortal Shakspere makes conscience bring to light a past event, and the murderer's accomplice to exclaim, "Yet here's a spot!" That which is *seen* he endows with *odour;* and she calls out, "Here's the *smell* of blood still!" And the *noise* which occurred at the same time as the event which re-appeared, he expresses by, "There is *knocking* at the gate!" Lastly, as if to complete the perfection of the visual apparition, he makes her to *act* upon the apparition, and endeavour to *wipe out* the ideal dye, and to exclaim, "*Out,* damned spot!" on which the doctor, in amazement, declares, "More needs she the divine than the physician."

LECTURE III.

ON SPECTACLES AND OTHER OPTICAL ADJUNCTS TO VISION.

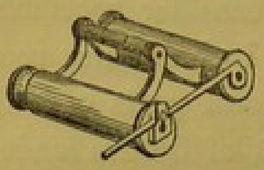
(113.) Optical contrivances as remedial agents.—(114.) Spectacles: constituent parts of: frames; material used for; silver-gilt, steel, German silver, brass, and horn.—(115.) Construction: the saddle; apertures, adjustment of the centres of; Visuometer, description of.—(116.) Mode of using.—(117.) Viewing distant objects with.—(118.) Form of apertures.—(119.) Frame-shafts.—(120.) Spectacle lenses: materials used for; amber, glass, pebbles, coloured glasses.—(121.) Use of spectacles for modifying light; various colours; form.—(122.) Remarks on the various uses of coloured glasses.—(123.) Their use in hay-fever; influence of light and heat in this disease.—(124.) Importance of parallel surfaces in these glasses.—(125.) Veils; advantages of.—(126.) Wire-gauze as a protection in railway travelling: to artizans.—(127.) Lenses: optometer, description of.—(128.) Adaptation of lenses to various degrees of refraction.—(129.) Lenses which shorten focal distance; various kinds of these.—(130.) Use of these lenses in old age.—(131.) Proper period for commencing their use; proper power.—(132.) Superiority of the meniscus lens for these cases: periscopic and pantoscopic spectacles.—(133.) Pernicious effects of the use of lenses for distant objects.—(134.) Peculiarity of glasses required after cataract.—(135.) Impaired power of adjustment.—(136.) Caliscopic spectacles.—(137.) The various lenses employed to lengthen focal distance.—(138.) Adaptation of lenses to short sight.—(139.) For near and for distant objects.—(140.) Great importance of the caliscopic or convergent spectacles.—(141, 142.) Effects produced by the non-coincidence of the centres of lenses with the pupils.—(143.) Importance of this adjustment.—(144.) Carelessness of opticians.—(145.) Focal-lengtheners in cases of conical cornea.—(146.) Single eye-glasses as toys; for practical purposes.—(147.) Superiority of double eye-glasses.—(148.) Cases of disordered vision where refracting power of the eye is not altered.—(149.) Reading lenses in these cases; plano-convex lenses, mode of using;—(150.) disadvantages attending;—(151.) means of overcoming. Amplifier;—(152.) construction and use of.—(153, 154.) Peculiar short sight, use of amplifier in.—(155.) Mode of adapting it to these cases.—(156.) Its adaptation in the form of spectacles.—(157.) Irregular refraction; cylindric lenses.—(158.) Microscope and telescope.—(159.) Single lens; theory of its action.—(160.) Forms of lenses used; Stanhope lens.—(161.) Parallel and divergent rays.—(162.) Power of sight in myopia.—(163.) Compound microscope.—(164.) Galilean telescope.—(165.) Opera-glasses; construction of; mode of using.—(166.) The common telescope; construction of.—(167.) Reflecting telescopes and microscopes.—(168.) Achromatic condition, &c.—(169.) Permanent injuries to vision from improper glasses.

(113.) We have considered the duties which the eye ought to be capable of performing in a state of health; we have studied the variation in its powers which is produced by disease; and it now remains for us to consider how far these abnormal conditions can be ameliorated by the use of optical contrivances.

(114.) Of these contrivances, I shall first consider spectacles; instruments so important to mankind, that I shall enter somewhat minutely into the description of the several parts of which they are constructed. Spectacles first consist of frames made of various materials, which enable the optical part to be kept in a suitable position before the eyes; and upon their correct manufacture the utility of the entire instrument to the wearer much depends. The material of which the frames are composed is usually silver, German silver, brass, steel, or horn, according to the fancy of the wearer. Silver frames, especially when gilt, are elegant, accommodate themselves well to the head, and do not readily become contorted. They are heavier than frames made of steel, a metal which is now most frequently used for this purpose, and which is sometimes employed extremely thin for the purpose of saving weight; when their thinness extends to the utmost limit which the manufacturing art admits, the spectacles are called invisible spectacles. These require care to prevent their falling out of shape. Frames made of German silver, brass, and horn, are only employed where economy is an object, preference being always given to silver, silver gilt, or steel.

(115.) The frames, of whatever substance composed, have two apertures to receive the glasses, a saddle to fit the nose, and two elongated portions to grip the head. The saddle for the nose, which, by the way, gave rise to the celebrated dispute, whether spectacles were made for the eyes or nose, is varied materially, according to the dimensions of that organ; and, at one time, merely rests upon the organ, and, at another, requires a peculiar curvature to enable it to fit the part. The centre of each aperture of the frame should be exactly opposite to the axis of vision of its respective eye; and the adjustment of the exact centre of the glass to the optical centres is so important in practice, that I have contrived an instrument to measure the width accurately between these centres (fig. 27). It consists of two tubes, so arranged that they can play perfectly parallel, and admit of approximation and separation. At one extremity of each tube cups are fixed to fit the globe, and at the other a hole of about the one-eighth of an inch is left, through which vision is allowed. At the cup another aperture is made, as small as we can conveniently see through; and at the distant end a diameter is struck by a moving bar, which revolves on one tube, and plays into a revolving joint placed on the second tube, and from which the measurement can be read off to the one-twentieth of an inch. The apparatus requires to be made with considerable exactness, and care must be taken that all the parts are so firmly constructed that the motions of the tube are perfectly parallel.

Fig. 27.

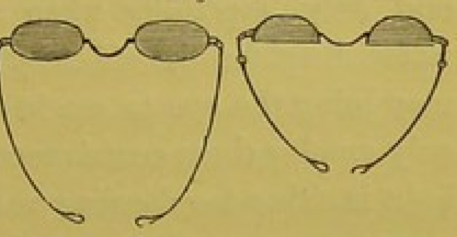


(116.) When we desire to measure the width of the eyes, the party has but to look through the tubes at any white surface: at that point where the two circles of light are most distinct, the true width between the visual axes is indicated. This instrument, with even ordinary care, indicates the width with minuteness, and, considering the facility with which it can be made, and the little trouble apparently required for its use, is an instrument, the employment of which I thought we should not be justified in neglecting in any case requiring the aid of glasses.

(117.) I have called the instrument itself the *visuometer*, a term which may, perhaps, be objectionable to the classic, because it is compounded of a Latin and Greek root; though, in my opinion, it is preferable, on grounds which I need not now consider, to other names which I constructed from the Greek alone. When the instrument is employed to look at distant objects, the rays from which are virtually parallel, as, for instance, the sun, moon, or other heavenly bodies, or even terrestrial objects situated a few hundred feet distant, it will be found that the object appears double at all points except one, which is the exact width of the optical centres. In using the instrument in this manner, or, rather, I may say, by bringing the two images exactly to correspond so as to form but one, the distance between the centres of vision may be learnt to the one-hundredth of an inch without error. The visuometer is only of importance in cases where the patient has an integrity of vision ; in every other respect but the refracting burners, and, in fact, an extended experience shews that with persons with any impediment of power of sight, it is very difficult to be employed. In practice I have been very much disappointed at the difficulty which patients, unaccustomed to optical experiments, have in using it ; and, except in some cases, we have been compelled, reluctantly, to abandon its use. The width of the eyes may be very simply and conveniently ascertained, by simply adapting the visuometer comfortably over the eyes ; but on this plan the measurement is not so accurate as when the width is taken by observing a fixed star.

(118.) The form of the apertures of spectacles varies under different circumstances ; generally in England they are employed of an oval form, and in America octangular. For reading and speaking sometimes one half is cut away.

Fig. 28.



(119.) The part by which the spectacles are held to the head is apt to grip the temples, which is very inconvenient, and causes pain. In the better spectacles it is elongated by means of a folding-joint, which is sufficiently long to form a gentle spring, and which, by pressing slightly on the side and back of the head, maintains the glasses in their proper position in perfect security.

(120.) The refracting or optical part of the spectacles is made of glass, pebble, or Brazilian quartz, and, it is said, occasionally of amber : this last substance, however, is soft, easily scratched, not perfectly clear, and very ill adapted for the proposed purposes.

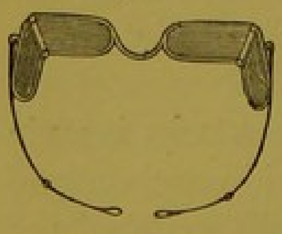
When glass is used for refracting purposes, it should be perfectly colourless, homogeneous, free from specks, veins, or air-bubbles; and whenever the glass manufacturer finds that he has made a peculiarly fine pot of glass, he generally reserves it for optical purposes. Pebbles should also be free from specks or veins. They are superior to glass, inasmuch as they do not scratch, but retain their polish. They are dearer, however, than glass, being much more difficult to work on account of their hardness. Sometimes, for particular purposes, we employ coloured glasses, such as those which have a green, blue, or neutral tint.

(121.) Spectacles are sometimes employed for the purpose of regulating the quality or quantity of the light. For this application the neutral tint, blue, or green, are most to be preferred, whilst the red and yellow are the worst. According as we desire to exclude more or less light, so do we select a glass possessing more or less colour.

These coloured spectacles are invaluable for the partial exclusion of the bright rays of the sun in the months of May, June, and July, especially when white chalky cliffs, or surfaces of water, heighten the effect by their reflection. As by practice we may bring the eye to see in the most feeble lights, so should we only employ these contrivances to cut off the sun's rays when the light is either too dazzling or distressing to the eye. When these glasses are worn, the spectacles should have two side parts of the same coloured glass, as, by this contrivance, the protection is ensured to the entire retina.

(122.) Coloured glasses should on no account be worn on a dull day, in the dusk of the evening, nor, as a general rule, with

Fig. 29.



artificial lights, or their preservative power in strong lights would be impaired by accustoming the eye to the impressions of feeble illuminations. Some persons who have delicate organs commonly employ spectacles of lightly tinted glass for reading or writing; though even here, as a general rule, they should be avoided. Coloured glasses are of great value to protect the eye from the brilliant reflection of the snow in mountain passes; they are also constantly employed by the chemist when he uses the oxy-hydrogen or voltaic light, for which purpose they cannot be too deeply coloured. They are employed by the mariner when taking his observations of the sun; and they are used when the eye has lately recovered from inflammation, and is liable to be injured by excess of light.

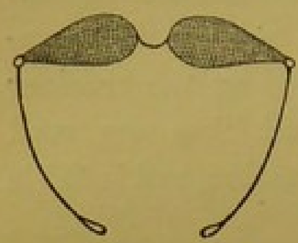
(123.) For some years I have employed coloured glasses for that singular malady known under the name of Hay Fever. This curious disease is greatly aggravated by intense brightness of the sun, when combined with heat, and assisted by dust. Light will not cause the malady alone; heat will not produce it alone; but light and heat appear to me to be the agents which operate most powerfully in producing it; and the presence of dust of every kind, such as the dust from the roads, the minute portions of chalk, or the pollen of flowers, much heightens the malady. You will find that a pair of dark-green spectacles will wonderfully alleviate the distressing symptoms which are incidental to this complaint. They should be worn only in the middle of the day, when the rays of the sun are unpleasantly powerful; and they should be studiously put aside when the sun is clouded.

(124.) In all cases where coloured glasses are employed, the two surfaces should be perfectly parallel, or more or less distortion will ensue. Glasses with parallel surfaces have no action on rays which strike the glass perpendicularly to the surface, though those which fall obliquely are reflected. In looking through them the object is neither increased nor diminished.

(125.) To exclude light we do not invariably employ tinted glass; we sometimes use gauze made of wire or other materials. Ladies placed under circumstances requiring the aid of contrivances calculated to diminish light, instead of using spectacles, prefer to employ a very thick veil, which they sometimes even double. This contrivance is, perhaps, much better than the employment of spectacles; because the veil can be so arranged that the air shall have free access to the eye.

(126.) Protectors of iron gauze are used for excluding foreign bodies during railway travelling. Occasionally we have to treat cases of injury done to the eye from red-hot cinders having flown into the organ. Whilst the poor are exposed to this damage in the open third class carriages, it is a question requiring some consideration, as to whether legal proceedings would not be a far better preservative than railway spectacles.

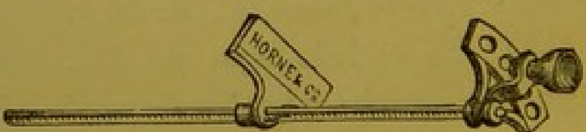
Fig. 30.



This Ophthalmic Hospital, from its locality in Gray's Inn Lane, is placed near very large factories in the great manufacturing district of Clerkenwell. Scarce a week passes without persons applying to have small pieces of iron removed from the cornea; and I have often thought that this mischief might be prevented by the workmen using a covering of magnetised gauze, although, generally speaking, artizans have a great and, perhaps, a very proper dislike to all incumbrances.

(127.) We frequently desire to alter the relation which exists between the power of the refracting humours and the distance of the retina; and for this purpose we employ lenses which magnify or diminish, or which, applied to the eye, lengthen or shorten its focal distance. Before any kind of spectacles are adopted which either magnify or diminish, it is very necessary that we should have a thorough knowledge of the optical properties of the eye, the defects of which we seek to remedy by optical contrivances. To effect this object I have contrived an optometer which should invariably be employed by the optician before spectacles are sold to the applicant. The instrument consists of a convex lens, to which a graduated scale is affixed, of such a length that convergent, parallel, and divergent rays may be brought within a reasonable scope, and thus the eye may be tested by it.

Fig. 31.



(128.) To suit all cases of refraction, I employ a geometric series of lenses:—1 of 20, 2 of 10, 3 of 5, and 4 of $2\frac{1}{2}$ inches focal length. No. 1 is only required for short-sighted persons; No. 4, for parties who have lost the lens of the eye; No. 2 is the best standard for both concave and convex glasses; No. 3 is employed for long-sighted persons. In effect, on a scale of a few inches, we represent all distances, even to infinity, within so small a compass that the eye can be very effectually examined with respect either to refractive power or to its faculty of adjustment. With No. 2 glass the distances on the scale correspond to the following distances, avoiding very minute fractions.

Ins.	1	2	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5	$5\frac{1}{2}$	6	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	$8\frac{3}{4}$	9	$9\frac{1}{4}$	$9\frac{1}{2}$	$9\frac{3}{4}$	10
	$1\frac{1}{9}$	$2\frac{1}{2}$	$3\frac{1}{3}$	$4\frac{2}{7}$	$5\frac{1}{2}$	$6\frac{2}{3}$	$8\frac{1}{6}$	10	$12\frac{1}{4}$	15	18	23	30	40	56	70	90	124	190	390	Infinity.

From the above table, when we ascertain the point of most distinct vision with No. 2 lens on the optometer, we can always tell the distance of most distinct vision in nature.

The graduated bar is from twelve inches to fourteen inches in length, and an adjusting plate is so contrived that a piece of small print may be inserted for examination. By calculation I have found the point at which vision should be most distinct for each case; and if any deviation from that exists, a correction is required by some optical contrivance.

If the point of distinct vision be further removed from the eye than in a state of health, the case is one requiring the use of convex glasses to bring the vision of the object to its normal position. If the point of distinct vision move nearer to the object, it requires concave glasses to restore it to its normal place. I have calculated the following table of the powers of convex and concave lenses, required to correct defects in various cases.

	Focal Distance=20. No. 1. Vision at			Focal Distance=10. No. 2. Vision at					Focal Distance=5. No. 3. Vision at			Focal Distance $=2\frac{1}{2}$ No. 4. Vision at		
	$2\frac{1}{2}$	10	*a*	$2\frac{1}{2}$	10	*a*	$2\frac{1}{2}$	10	$2\frac{1}{2}$	10	*a*	$2\frac{1}{2}$	10	*a*
Inches.	Concave.			Concave.			Convex.		Convex.			Convex.		
·25	$\frac{20}{71}$	$\frac{20}{77}$	$\frac{20}{79}$	$\frac{2}{7}$	$\frac{5}{19}$	$\frac{10}{39}$	...	...	...	...	...	...	...	...
·5	$\frac{20}{31}$	...	$\frac{20}{39}$	$\frac{2}{3}$	$\frac{5}{9}$	...	...	...	...	...	...	...	...	...
·75	$1\frac{7}{33}$	$\frac{20}{37}$	$\frac{60}{77}$	$1\frac{2}{3}$	$\frac{15}{17}$	...	...	...	...	...	...	...	...	...
1·	$1\frac{9}{11}$	$1\frac{3}{17}$	$1\frac{1}{19}$	2	$1\frac{1}{4}$	$1\frac{1}{9}$	...	...	...	...	...	...	...	...
1·25	$2\frac{6}{7}$	...	$1\frac{1}{3}$	$3\frac{1}{3}$	$1\frac{2}{5}$	...	...	...	...	...	...	*a*	...	...
1·5	$4\frac{8}{13}$	$1\frac{29}{31}$	$1\frac{23}{37}$	6	$2\frac{1}{2}$	$1\frac{13}{30}$	...	...	*a*	...	...	$7\frac{1}{2}$	...	...
1·75	$8\frac{4}{17}$	...	$1\frac{67}{73}$	14	$2\frac{9}{13}$	...	...	...	35	...	...	$4\frac{3}{8}$	...	...
2·	20	$2\frac{6}{7}$	$2\frac{2}{9}$	*a*	$3\frac{1}{3}$	$2\frac{1}{2}$	*a*	...	10	...	...	$3\frac{1}{3}$	0	...
$2\frac{2}{9}$	*a*	...	...	...	...	...	...	...	...	...	...	...	...	...
2·25	...	...	$2\frac{28}{71}$	...	$4\frac{5}{11}$	...	18	...	$6\frac{3}{7}$	...	...	$2\frac{13}{16}$	18	...
2·5	...	4	$2\frac{6}{7}$	...	5	$3\frac{1}{3}$	10	...	5	...	...	$2\frac{1}{2}$	10	
2·75	...	$4\frac{32}{47}$	$3\frac{13}{69}$	...	$6\frac{1}{9}$	...	$7\frac{1}{3}$	...	$4\frac{3}{13}$	...	...	...	$7\frac{1}{2}$	$27\frac{1}{2}$
3·	...	$5\frac{5}{11}$	$3\frac{9}{17}$	...	$7\frac{1}{2}$	$4\frac{2}{7}$	6	...	$3\frac{3}{4}$	...	...	$2\frac{1}{7}$	6	15
3·25	...	$6\frac{14}{41}$	$3\frac{59}{67}$	...	$9\frac{2}{7}$	...	$5\frac{1}{5}$	...	...	...	...	...	$5\frac{1}{3}$	$10\frac{5}{6}$
3·5	...	$7\frac{7}{19}$	$4\frac{8}{33}$	...	$11\frac{2}{3}$	$5\frac{5}{13}$	$4\frac{2}{3}$	...	$3\frac{2}{11}$	21	...	...	$4\frac{2}{3}$	$8\frac{3}{4}$
3·75	...	$8\frac{4}{7}$	$4\frac{8}{13}$	...	15	...	$4\frac{2}{7}$	...	...	15	...	...	$4\frac{2}{7}$	$7\frac{1}{2}$
4·	...	10	5	...	20	$6\frac{2}{3}$	4	...	$2\frac{6}{7}$	12	...	$1\frac{9}{11}$	4	$6\frac{2}{3}$
4·25	...	$11\frac{21}{29}$	$5\frac{35}{63}$	...	$28\frac{1}{2}$	...	...	...	...	$10\frac{1}{5}$	...	...	$3\frac{7}{9}$	...
4·5	...	$13\frac{11}{13}$	$5\frac{25}{31}$	...	45	$8\frac{2}{11}$	$3\frac{3}{5}$	...	$2\frac{11}{17}$	9	...	...	$3\frac{3}{5}$	$5\frac{5}{8}$
4·75	...	$16\frac{12}{23}$	$6\frac{14}{61}$	...	95	...	...	...	...	$8\frac{1}{7}$	...	...	$3\frac{5}{11}$	...
5·	...	20	$6\frac{2}{3}$	...	0	10	$3\frac{1}{3}$	0	$2\frac{1}{2}$	$7\frac{1}{2}$	*a*	$1\frac{2}{3}$	$3\frac{1}{3}$	
5·25	...	$24\frac{12}{17}$	$7\frac{7}{59}$	...	...	$11\frac{1}{15}$	...	105	...	7	105	...	$3\frac{3}{13}$	...
5·5	...	$31\frac{3}{7}$	$7\frac{17}{29}$	...	...	$12\frac{2}{9}$	...	55	...	$6\frac{2}{5}$	55	...	$3\frac{1}{7}$	...
5·75	...	$41\frac{9}{11}$	$8\frac{4}{57}$	...	...	$13\frac{9}{17}$	...	$38\frac{1}{3}$	...	...	$38\frac{1}{3}$	...	$3\frac{1}{15}$	...
6·	...	60	$8\frac{4}{7}$	...	...	15	3	30	$2\frac{4}{13}$	6	30	$1\frac{11}{19}$	3	$4\frac{2}{7}$
6·25	...	100	$9\frac{1}{11}$	...	...	$16\frac{2}{3}$	...	25	...	...	25	...	...	...
6·5	...	260	$9\frac{17}{27}$	...	...	$18\frac{4}{7}$	...	$21\frac{2}{3}$	...	$5\frac{4}{7}$	21	...	...	...
$6\frac{2}{3}$	...	*a*	...	...	...	...	...	...	...	...	...	...	...	...
6·75	...	...	$10\frac{10}{53}$	...	...	$20\frac{10}{13}$	...	$19\frac{2}{7}$	...	...	$19\frac{2}{7}$	...	...	...
7·	...	...	$10\frac{10}{13}$	...	...	$23\frac{1}{3}$	...	$17\frac{1}{35}$	...	$5\frac{1}{4}$	$17\frac{1}{2}$	...	$2\frac{4}{5}$	...
7·25	...	...	$11\frac{19}{51}$	...	...	$26\frac{4}{11}$	...	$16\frac{1}{9}$	...	...	$16\frac{1}{9}$	...	...	...
7·5	...	...	12	...	...	30	...	15	...	...	15	...	...	...
7·75	...	...	$12\frac{32}{45}$	...	...	$34\frac{4}{9}$	...	$14\frac{1}{11}$	...	...	$14\frac{1}{11}$	...	...	...
8·	...	...	$13\frac{1}{3}$	...	...	40	$2\frac{2}{3}$	$13\frac{1}{3}$	$2\frac{2}{19}$	$4\frac{4}{5}$	$13\frac{1}{3}$	$\frac{13}{27}$	$2\frac{2}{3}$	$3\frac{7}{11}$
8·25	...	...	$14\frac{2}{47}$	...	...	$47\frac{1}{7}$	...	$12\frac{9}{13}$	...	...	...	...	...	...
8·5	...	...	$14\frac{18}{23}$	...	...	$56\frac{2}{3}$	...	$12\frac{1}{7}$	...	...	$12\frac{1}{7}$	...	...	...
8·75	...	...	$15\frac{5}{9}$	...	...	70	...	$11\frac{2}{3}$	...	...	...	...	...	...
9·	...	...	$16\frac{4}{11}$	...	...	90	...	$11\frac{1}{4}$	...	$4\frac{1}{2}$	$11\frac{1}{4}$	...	$2\frac{4}{7}$	...
9·25	...	...	$17\frac{2}{43}$	...	...	$123\frac{1}{3}$	. .	$10\frac{1}{9}$	...	...	...	...	...	...
9·5	...	...	$18\frac{2}{21}$	...	...	190	...	$10\frac{5}{9}$	...	...	$10\frac{5}{9}$	...	...	...
9·75	...	...	$19\frac{1}{41}$	...	...	3 0	...	...	...	...	...	...	...	...
10·	...	...	20	...	...	*a*	$2\frac{1}{2}$	10	2	$4\frac{16}{21}$	10	$1\frac{3}{7}$	$2\frac{1}{2}$	$3\frac{1}{3}$
10·25	...	...	$21\frac{1}{39}$	...	...	...	...	...	...	...	...	...	...	...
10·5	...	...	$22\frac{2}{19}$	...	...	...	...	...	...	...	...	...	...	...
10·75	...	...	$23\frac{2}{37}$	...	...	...	...	...	...	...	...	...	...	...
11·	...	...	$24\frac{4}{9}$	...	...	...	...	$9\frac{1}{6}$	...	$4\frac{1}{8}$	$9\frac{1}{6}$	...	$2\frac{1}{3}$	...
11·25	...	...	$25\frac{5}{7}$	...	...	...	...	...	...	...	...	...	...	...
11·5	...	...	$27\frac{1}{17}$	...	...	...	...	...	...	...	...	...	...	...
11·7	...	...	$28\frac{16}{33}$	...	...	...	...	...	...	...	...	...	...	...
12·	...	...	30	...	...	...	$2\frac{2}{5}$	$8\frac{4}{7}$	$1\frac{29}{31}$	4	$8\frac{4}{7}$	$1\frac{17}{43}$	$2\frac{2}{5}$	$3\frac{3}{19}$

The range of adjustment in the healthy eye is very great. In No. 1 it is from $2\frac{2}{9}$ to 20 inches; in No. 2, from 2 to 10 inches; in No. 3, from $1\frac{2}{8}$ to 5 inches; and in No. 4, from $1\frac{1}{4}$ to $2\frac{1}{2}$. The point of most distinct vision is, according to my own experiments, about 10 inches: but it will vary with trifling conditions of the health, and an extra glass of wine the preceding night will lengthen the distance. To allow for any deviation of this kind, I have given three calculations: one for the nearest point at which objects are visible—namely, $2\frac{1}{2}$ inches; the best point for vision, or ten inches; an infinite distance, or parallel rays. When you have selected the spectacles by placing them before the glass of the optometer, the range of vision should be the same as with the healthy eye. Thus the optometer gives three tests of a proper selection of lenses.

The optometer* at once demonstrates any absence of power in the faculty of adjustment to distances, or whether the eye simply requires a magnifying-glass to increase the visual angle.

(129.) Having described to you the mode of ascertaining the state of the particular eye requiring optical assistance, we have to consider in detail the appliances to be used for correcting the

* To make the calculations required for the optometer, the following formulæ may be used. If b inches be the ordinary distance of distinct vision in a healthy eye, and if a lens, the focal distance of which is n inches, be placed close to the eye, an object which to the healthy eye is most distinctly visible at b inches must be removed to $\frac{bn}{b+n}$ inches. For let x = required distance of a most distinct vision when such a lens is used, then $\frac{1}{x} = \frac{1}{n} + \frac{1}{b} = \frac{b+n}{bn}$; and $x = \frac{b\,n}{b+n}$.

Ex. Let $b = 10$

$n = 10$ focal distance.

$$x = \frac{10\,n}{10+n} = \frac{100}{20}.$$

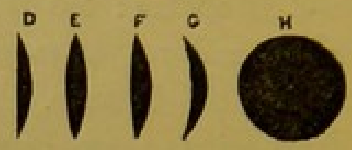
then $x = 5$, distance of most distinct vision.

Ex. Let $b = 10$

$n = 2\frac{1}{2}$ then $x = 2$.

When the eye is either short or long-sighted, this point of most distinct vision becomes nearer or more distant. The following general formula enables us readily error. Of these I shall point out circumstances to be observed with glasses which shorten the focal distance of the eye, and which I shall call in my work focal shorteners. Now, focal shorteners may consist of any lens which can bring parallel rays to a focus, as such a glass will heighten the refracting power of the eye, and shorten its focal distance. Lenses which thus act are spheres (H), plano-convex lenses (D), double convex (E), crossed lenses (F), and menisci (G); the double convex and menisci being almost exclusively employed for spectacles.

Fig. 32.



to ascertain to what extent such an eye varies in its refractive power from that of a healthy one.

Let a = distance at which a diseased eye sees most distinctly when looking through a lens, of which

n = the focal distance,

and b = distance of most distinct vision in healthy eye without lens,

and y = required focal distance of additional interposed lens to enable diseased eye to see distinctly at the same point as a healthy eye;

then $\frac{1}{y} = \frac{b+n}{b\,n} - \frac{1}{a}$, and $y = \frac{a\,b\,n}{a\,b + a\,n - b\,n}$ is the formula for all cases when a positive result indicates a convex lens, and a negative result a concave lens.

Ex. Let $a = 3$
$b = 10$ then $y = \frac{300}{30+30-100} = -7\frac{1}{2}$ = required focal distance of concave lens.
$n = 10$

Let $a = 5$
$b = 10$ then y = infinity or unrefractive glass.
$n = 10$

Let $n = 10$
$a = 6$ then $y = 30$, the focal distance of required convex lens.
$b = 10$

Let $n = 2\frac{1}{2}$
$a = 2$ then $y = a$, or unrefractive glass.
$b = 10$

Let $n = 2\frac{1}{2}$
$a = 1$ then $y = -2$, or focal distance of concave lens required for most distinct vision.
$b = 10$

Let $n = 2\frac{1}{2}$
$a = 4$ then $y = 4$, or focal distance of convex lens.
$b = 10$

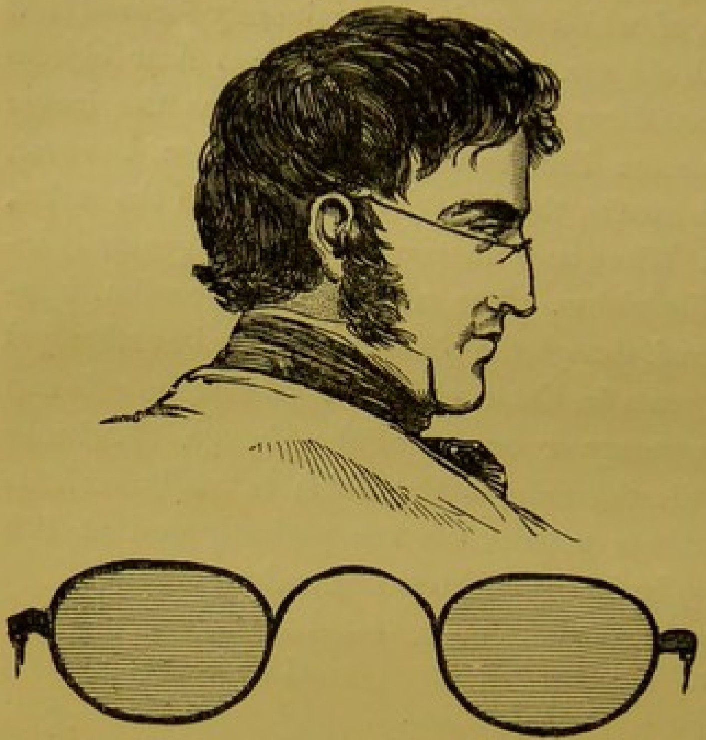
(130.) Focal shorteners are required for states of vision arising from various causes, of which stands pre-eminently forward that which comes on with old age. The eye cannot see near objects well, because it cannot focus them upon the retina, as the image would be formed at some distance behind it. As soon, however, as we add a focal shortener, the image is formed upon the retina, and the patient sees. When once this change begins it generally increases, and never diminishes. The rate of its progression, however, is uncertain; and, though the glasses require to be exchanged every two or three years for those of higher powers, no rule can be given for the frequency or extent of the change. Kichener has, indeed, given the following table, which is really of little value, because sometimes persons will see perfectly well at 100 years of age, and not be in the slightest degree long-sighted.

Age.	Convexes.	Age.	Convexes.	Age.	Convexes.	Age.	Convexes.
40	36	55	20	65	41	80	9
45	30	58	18	70	12	85	8
50	24	60	16	75	10	90	7
						100	6

(131.) When the far sight of advancing years becomes apparent, spectacles should at once be employed; nothing is gained but inconvenience and damage to the organ from not using them, because in their absence the eye would either not be able to perceive minute objects, or only by straining itself to the utmost. When glasses are commenced, the lowest power which is applicable should be selected; or, rather, I should say, that a power somewhat below that required for most distinct vision should be employed.

(132.) Formerly double convex lenses were invariably employed for focal shorteners. The great Dr. Wollaston, however, pointed out that menisci were far better adapted for that purpose; and, from the extensive range of vision which they afford, he termed them periscopic spectacles. Since his time these spectacles have been still further improved, and received the name of pantoscopic spectacles. Pantoscopic spectacles are menisci, and therefore periscopic; but the glasses are arranged in

Fig. 33.



a position highly favourable for the intended purposes.

The vertical extent of the field of vision varies in different persons, depending either upon the form of the eyebrows and cheek, or upon the prominence of the eyes themselves. In my own case I find, by direct measurement, that whilst my head remains stationary, I can see objects ranging over 149 degrees, by moving the eyes as far as possible. The extent is thus differently divided by the two kinds of glasses :—

	COMMON CONVEX.	PANTOSCOPIC.
Range above Spectacles	36	75
" through ditto	62	64
" below ditto	51	10
	149	149

An interval not far short of 5′ must be allowed as an interval of indistinct vision covered by the rim of the spectacle, half of which must be subtracted from the field of vision above the glass, half from that part occupied by the glass. In the common form of spectacle 5′ must, in a similar manner, be subtracted from the rim at the bottom of the glass. In the pantoscopic form, however, the lower interval falls at the extreme limit of the field, and is therefore of no consequence.

From these measurements we at once perceive that the pantoscopic differs from the common spectacles, on account of the great extent of the field of vision above the range occupied by the lens, in which objects may be seen in their natural condition. They differ, moreover, from the small extent of field which exists below the bottom of the lens; and, in fact, this would not have any existence, as the pantoscopic lens rests upon the cheek, did not the rounded and receding form of this part of the face have a small interval at the outer margin of the spectacle.

As a consequence of this arrangement, the pantoscopic spectables occupy that part of the field actually employed in the examination of near objects, whilst that part not required for that purpose is left uncovered for the wearer to examine distant objects.

These glasses were first introduced to my notice by Messrs. Horne and Thornthwaite, who requested my opinion as to their eligibility before they would sell them. Having minutely examined them, I reported favourably upon them: and to that report I may now add, that, as these glasses allow vision over their top for distant objects, the sight will be materially preserved by their use, and perhaps the time will come when no other form of spectacles will be employed for the far-sightedness of advancing years.

(133.) I can hardly overrate the injury which the far-sighted eye sustains from looking through the glass at distant objects; and I therefore warn you to caution your patients from pursuing such a course where they employ the common form of spectacles. Where patients, however, pay you your fee, and pretend to desire your advice, and take their own course after all, you will find that the effect of the malpractice is to cause the eye to lose its faculty of adjusting itself to distant objects, and the patient, instead of employing one focal shortener, will be compelled to use two of unequal focal power, one for near objects, one for distant objects, and, at last, he will be quite unable to dispense with this double optical contrivance.

(134.) After the operation for cataract, where the lens is removed from the eye, it is necessary for the eye to have a focus-shortener to take its place. In these cases we require two pairs, one for distant objects, less powerful than the other, which is required for near objects. In these cases, distant objects require the aid of glasses as well as near objects, and therefore the ordinary spectacles are better adapted than the pantoscopic. In some of these cataract cases a very deep power is requisite to compensate for the loss of the lens, so much so as to render the lens, unless of enormous bulk, so small as to require a black circle to be let in the frame into which the lens is inserted. Whenever the eye is placed in a medium denser than the air, its power of refraction is diminished. Hence, if we plunge our heads under water, we require powerful focal shortening glasses, to correct the effect of the water, and render the image distinct. If we were to plunge our heads into water exactly of the same refracting power as the cornea, the rays of light would suffer no alteration in the original direction in passing through that structure.

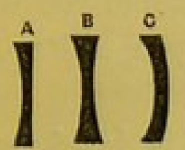
(135.) When the faculty of adjusting the eye to distances is impaired, without any change of physical structure, focus-shorteners are had recourse to by some parties. Beware, however, how you proceed in these cases, for they require much caution; and our object should rather be to restore the power than to tamper with the defect; and much mischief is frequently effected through the cupidity or ignorance of the spectacle-seller.

(136.) In all cases where we use focal shorteners for near objects, as for reading, writing, &c., it is as well so to arrange the glasses that the distance of the object to be viewed forms the radius of a circle, to which the glasses should be tangential to points of which the chord of twice the arc should be the width of the eyes, or nearly two inches and a half. These convergent spectacles I have termed caloscopic spectacles, because the appearance of the object is rendered more beautiful and distinct, from the rays passing vertically from the object to the eye.

(137.) I have now to consider another important part of my subject, namely, the application of focal lengtheners, a result which may be obtained by plano-concave (A), double concave

(B), or menisci (C), the convex surface of which consists of a segment of a larger circle than the concave. I do not wish you to take anything for granted; I wish you to observe with your own eyes that an image in the camera, which is indistinct, because the screen is too near to the lens, may be made perfectly distinct, when a focal shortener of any of the above kinds is placed before the glass.

Fig. 34.



(138.) In short-sightedness the image is formed anterior to the retina, and a focal lengthener is required to cause it to fall into its proper place. I must now refer you to my former lecture on the different cases of short-sightedness; and when you think it advisable to use glasses begin with those which barely suffice to effect the desired object, and in all cases leave the eye some work to do; otherwise the eye will gradually accommodate itself to the glass, and require a continual increase of its power. Very great mischief is inflicted on patients by allowing them to employ glasses too deep, and on that account glasses should always be used of such a power that some range of adjustment is left for the eye.

(139.) Short-sighted persons should have two pair of spectacles, one to be used for near, the other for distant objects, and the glasses should be so arranged that the light from the object shall pass perpendicularly through the lens to the eye. Short-sighted glasses for reading should be directed towards a point about fifteen inches distant; for distant objects, they should be on the same plane, or, to divide the error over every possible distance, a slight convergence may be allowed.

(140.) These convergent spectacles I have before introduced to your notice under the term of caloscopic spectacles, and I believe that their extensive application will save the vision of hundreds. From my own experience, I should say that nearly two-thirds of all who use focal lengtheners, or concave glasses, practically employ but one eye, because their spectacles have been so made that they could only adjust one glass to the axis of vision. In the manufacture of these spectacles care should be taken that each glass converges equally to the part viewed; and for this purpose I have pointed out one or two contrivances, which I do not think it necessary to describe here. The necessity of this mode of arranging glasses must be immediately apparent if you look through the lens obliquely at a book; for in one position you will increase the length of the letters, and in the other you will separate them.

(141.) Where focal lengtheners are employed, it is of very great consequence that the centre of each glass should be exactly central to the pupil of the eye. From neglect of this point alone I have been consulted, on numerous occasions, by gentlemen of sedentary habits, who neglect the use of one eye and employ but one organ for vision. You will now, gentlemen, perceive that the laborious and tedious minuteness with which I have dwelt upon the functions of the two eyes has not been thrown away; for, in this case, you find, that, from the careless application of glasses alone, extensive damage has been effected, and thousands of persons now exist who have been cut off from the full enjoyment of the beauty of external objects by the ignorance or carelessness of spectacle-sellers.

(142.) By using spectacles, the glasses of which are either too wide apart or too narrow, double vision is produced, to prevent the embarrassment of which the impression of one must be neglected, a result which is generally accompanied by a very slight squint. If you carefully examine many persons of sedentary habits who use focal shorteners, you will be astonished to find how extensive has been the damage which I amd irecting you to avoid. The same person who would scorn to buy the ready-made coat constructed at random, and not accurately fitted to his person, will, nevertheless, take the ready-made spectacles, apparently forgetting that the same personality which requires his coat to be accurately adjusted to his person extends to all parts of the body, and requires a peculiar adaptation for contrivances intended to fit the eyes.

(143.) I can tell you in a few words to adapt accurately the width of the spectacles to the width of the eyes, so that perfect vision may be obtained by both eyes at once; but you will find in practice, that each case will require great care: the width, however, being at once accurately ascertained, the same spectacle frames will last as a pattern for the rest of a man's life, as there is very little chance of the distance between the eyes expanding or contracting. To obtain, however, any good result from this careful adaptation, it must be done when spectacles are first employed; for, after mischief has resulted, your labours will be comparatively ineffectual to restore binocular vision.

(144.) I had hoped the visuometer, which I shewed you at an earlier part of this lecture, would prevent, in great measure, a repetition of the mischief; but the difficulties in its use are almost insurmountable. I must caution you to look sharply after the optician, or, with all your care to adapt the width of the frame, he may carelessly insert the glasses in such a manner that the optical centre is not in the centre of the frame aperture.

(145.) Focal lengtheners are contra-indicated in conical cornea, and in young persons, when the defect suddenly appears. In my former lectures I have explained to you the good results which attend the judicious exercise of the eye, and I have only again to enforce that spectacles are only to be employed for short-sighted persons, when all other means of rectifying the defect of vision have been tried and have been found to fail.

Fig. 35.

(146.) So much for the consideration of the employment of focal lengtheners in the shape of spectacles for short-sighted persons; but for this purpose eye-glasses are also frequently employed. The single eye-glasses, so frequently seen to be worn by the Regent-street exquisites, or, as "Punch" would have it, by the monkey-men, if used simply as a vulgar token of recognition, hardly come within the province of our consideration as surgeons. If these toys be glazed with plain glass, the damage which may result will be rather moral than physical; and if they be glazed even with focal lengtheners, I do not know that there is any law to prevent a man from damaging his vision if he pleases; nor do I see how such damage, when effected, can seriously interfere with the pursuits of this peculiar class. Where eye-glasses are required, they should be made on the principles already detailed, and should never be employed except absolutely essential.

(147.) The great objection to the employment of single eye-glasses is the effect which they are apt to produce upon one eye, in causing its focal distance to be shorter than that of the other, an inconvenience which may act seriously in some cases. On this account a double eye-glass should always be preferred; and, independently of this effect, you must always remember that binocular vision gives a more perfect form, renders the picture brighter, and causes the object to appear in its proper distance and magnitude. A pretty plaything in the form of a double eye-glass is sold; it has a tendency to open in one direction to its full limit, and in the other it is so contrived as to grip the nose.

(148.) The treatment of those cases of disordered vision in which the refracting power of the eye is not altered, and in which the eye simply requires the object to be seen under a greater visual angle, demands particular consideration. In these instances we have but to cause the object to be magnified, and the party sees perfectly. Ordinary spectacles are not well adapted for these cases, inasmuch as they do not afford to parties so afflicted distinct vision at convenient distances. Every convex glass arranged as a pair of spectacles would give at one particular point perfect clearness; but this point is extremely close for glasses which magnify sufficiently to be of real service. I find that calculation and experience coincide in assigning the following as the distinct point for convex glasses of different focal lengths:—20 in. at $6\frac{2}{3}$, 10 at 5, 5 at $3\frac{1}{3}$, and $2\frac{1}{2}$ at 2 in.

It will be seen that these distances are inconveniently near for the ordinary occupations of writing and reading, and thus lenses of such power cannot be conveniently employed for that object.

(149.) To obviate this inconvenience reading-glasses are used, which are large lenses fixed in a frame, and held at a distance from the eye, and at a suitable distance from the object; and, in this way lenses of higher powers can be advantageously employed. For this particular object a decided

Fig. 36.

preference must be given to the plano-convex lens, which is to be used with the plane side towards the object. The utility of thus turning the plane side towards the object arises from its affording in that position a large and uniform field, in which objects are perfectly distinct to the extreme margin or edge of the lens. If the plano-convex lens be reversed, so that the convex side be directed towards the point, distinct vision is only afforded at the centre.

(150.) Reading-glasses of such construction are found in practice to be extremely inconvenient, because if both eyes are directed to the object simultaneously, it is either doubled or rendered very confused, because two eyes cannot regard one object through a lens without its appearing double. Sometimes, indeed, the impression of one eye is instinctively neglected, and then but one object is seen; nevertheless, in all cases, and under all circumstances, if we really see any object through a lens with both eyes simultaneously, the two objects must appear in different places, and consequently double. In my peregrinations about London I have been surprised at seeing lenses labelled "Binocular," at some apparently respectable shops, which well indicates the knowledge possessed by even the better order of spectacle-sellers.

(151.) It becomes practically a serious and important affair to get over the indistinctness of these reading-glasses; and by far the best mode with which I am acquainted, is to place a large plano-convex lens in a tube about eight inches long, with its plane surface directed towards the object. The tube tapers to the ocular end, which has an aperture suitable for vision. The working-men amuse themselves by calling these tubes ear-trumpets for the eye, because they fancy that they are somewhat of that form, but the name which I have assigned to the instrument is "the amplifier."

(152.) In the manufacture of this instrument it is important that the lens be large, and, at the same time, that the tube should be constructed as slightly as is consonant with proper strength. It is very useful at times to fix it upon an universal joint attached to a reading-desk; and its employment will enable many elderly persons to read small print comfortably, who had previously been unable to attempt it. To healthy persons the amplifier is really a charming instrument. At first sight you may really fancy that there is nothing of importance in it; but the exquisite beauty with which it brings out the noble workmanship of the ancient coins or the modern triumphs of Wyon's art, entitles it to a place in every numismatic cabinet. Flowers, insects, and small plants appear of singular beauty through this really magical tube.

(153.) One of the most difficult classes of cases to treat, and cases which in reality frequently occur, are those in which the eye is very short-sighted, and at the same time has its power of seeing diminished ; that is to say, the object must be magnified to render it distinct. For years these cases used to consult me, and I tried all the combinations which occurred to my mind without being able to give relief; that is to say, I could not think of any means which could be employed to render an object, such as a page of print, distinct to the party so afflicted. I used to tell them that neither medicine nor surgery, neither science nor experience, had found a remedy for their special case. Every person so sent away was a great annoyance to me, for I thought it a disgrace to the surgeon not to be able to furnish a remedy. One day, however, I thought of using a concave glass sufficient to compensate the defect in the ordinary refracting power of the eye, and then I found that my amplifier before described answered admirably for the particular case, and enabled the party to see with facility.

(154.) I only wondered that such a ridiculously simple appliance had not occurred to my mind on any former occasion ; and the only consolation for my oversight was, that neither surgeon, philosopher, nor optician had to my knowledge ever employed it, and it is always a very difficult and most trying effort of the mind to resolve a point to its utmost simplicity. Thus there is reason to hope that my simple contrivance may be hereafter very much simplified.

(155.) In practice, to render the short-sighted amplifier perfect, the concave lens must be fitted at the upper part of the tube, which thus is rendered a species of opera-glass.

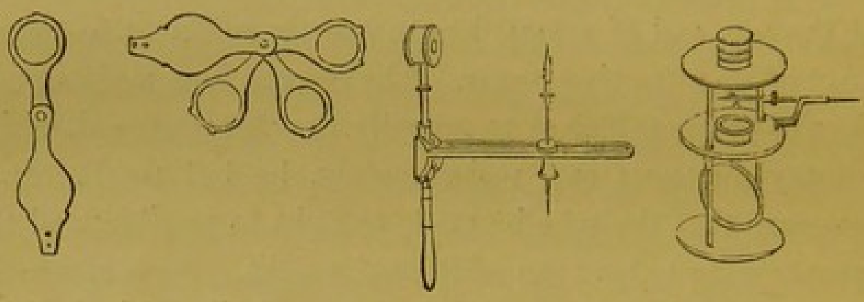
From the number of persons whose sight is short and whose vision is diminished, I believe that there are multitudes in real want of this instrument, did we but know how to find them out and render them assistance.

(156.) The consideration of the amplifier will lead you at once to understand that it is possible to make a pair of spectacles composed of a pair of little amplifiers, the concave glass being nearest the eye, and of a focal length exactly sufficient to correct the defect of its refractive power. The convex lens must consist of a glass of power sufficient to magnify the object viewed, which for ordinary distances can, unfortunately, be but small. It is also necessary that the tube be made as light as possible, and the other parts strong to bear the additional weight. Such spectacles are only applicable to the slighter cases of diminished vision occurring with short-sightedness. For severe cases the amplifier before described can alone be employed. The short-sighted amplifier is in many respects superior to the combination of a concave glass and reading-glass; nevertheless, the double action of such instruments is of considerable utility in many cases.

(157.) For irregular refraction I find it recorded that the Astronomer Royal devised lenses having a cylindrical curve on the one side and a spherical on the other, which would magnify or diminish more in one direction than the opposite. I have, however, never seen such a lens; and although I wrote to the party who is said to have constructed them, did not obtain an answer to my inquiries. Cylinders magnify in one direction, but not in the other; so that, in regarding print through their agency, the print is distorted into the form of the writing over marine-stores, provided the cylinder be parallel with the lines. If it be placed transversely, then the letters are made to appear ridiculously wide, and separated from each other by great intervals. An ordinary convex lens, placed obliquely, has the same effect.

(158.) I feel it necessary to make a few observations upon certain adjuncts to vision which we employ, not for the purpose of rectifying diseased sight, but of rendering objects visible which are so small, that at ordinary distances the angle they subtend is insufficient for vision, or which are placed at so remote a distance that the angle is diminished below the powers of sight. To increase this angle we employ two varieties of instruments, one of which is called the microscope, and is adapted for near objects; the other, set for distant objects, is termed the telescope.

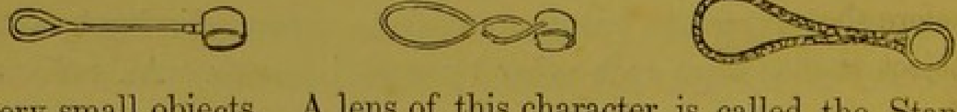
Fig. 37.



(159.) The simplest form of microscope which can be employed is a simple lens. When the object is placed at its principal focus, the rays diverging from each point of it are rendered parallel (fig. 13); and when these rays are brought to a point upon the retina, they form an image which is rendered very much larger than without its assistance, because the ray could not come straight from the object, but must have passed through the first lens, and in this way the visual angle is in reality much larger.

(160.) The lenses which are principally used for magnifying glasses are spheres, double convex and single convex lenses. Sometimes lenses are employed with such a thickness of glass in relation to its sphericity, that the object is in focus when placed in contact with the glass, a property which renders it very useful for

Fig. 38.



very small objects. A lens of this character is called the Stanhope lens, and generally has the spherical lens next the eye less convex than that which is directed towards the object. Sir D. Brewster has used half spheres in such a way as to cause them to have the same magnifying power as whole spheres; and there are other kinds of glasses which are occasionally employed for that purpose.

(161.) The eye, however, does not see objects most distinctly. In objects where the rays from each point are parallel, or nearly parallel, it is necessary that they should have a certain amount of divergence, such as those which come from a point about ten inches off. For this reason the object to be magnified is not placed exactly at the focal distance of the lens, but as much nearer as will allow for this peculiarity.

(162.) Many ophthalmic surgeons assert that short-sighted people see invariably things magnified, because they are visible at a much nearer distance than in ordinary healthy vision. It is most certainly true that a larger image is formed on the retina, but it appears to me by no means certain that the image really appears larger, because, if all parts of the eye are dilated, then no apparent difference of size would be afforded to the mind. I cannot myself affirm that I have ever seen a short-sighted person who could distinguish an object which I myself could not see; and, in fact, very frequently their sight is even less perfect when the effect remains uncorrected. Without, however, passing a very decided opinion upon the fact, I shall take every opportunity of directly examining it.

(163.) Two or more lenses may be combined together, and still constitute a simple microscope, the two glasses merely acting as one lens. The action of the compound microscope, as far as the eye is concerned, is similar to that of the simple, but, in the manner in which the effect is produced, differs, inasmuch as the image of the object reversed is received upon another lens, which still further magnifies it before the rays impinge upon the eye. The manner in which the object is illuminated is important in the use of this instrument. A set of achromatic lenses, to condense the light of a reflector, is not extolled; but I have used a lens formed like a Stanhope, but one-eighth of an inch short, for this object, and which is now commonly sold at my publisher's. Sometimes it may be advisable to view objects under a simple light instead of a compound, and I

Fig. 39.

have recommended a small contrivance, containing a yellow, blue, red, and green glass, that delicate objects may be examined under lights of various colours.

(164.) To give distinct vision of objects too far removed for perfect sight, we use telescopes of three general modes of construction. The first is the Gallilean telescope, which is always employed for objects at moderate distances, and is used as an opera-glass for the theatres, operas, &c. It consists of a combination of a convex object-glass with a concave eye-glass, of sufficient power to render the rays parallel or nearly parallel, and these glasses are fixed in a tube which allows of some motion for adjustment to various objects.

Fig. 40.

Fig. 41.

(165.) It is exceedingly desirable that opera-glasses should be binocular, or that there should be one for each eye; but it is also important that those who employ them should be acquainted with the manner of using them. The two sets of glasses are arranged upon a hinge to admit of a proper separation to accommodate them to the distance of the object; and when properly adjusted, the party should see but one circle of light. If the glasses have no hinge, they are absolutely useless for the intended purpose, or, rather, worse than useless, for, instead of improving single vision, they afford double vision. I have observed that, practically, numerous parties, who either use or sell binocular opera-glasses, do not understand either the importance of, or the mode of obtaining, single vision by using them. Some binocular glasses are sold with different eye-pieces, to adapt them to different distances.

(166.) The common telescope consists of two convex glasses, one of which, the object-glass, reverses the picture, whilst the eye-glass magnifies this reversed picture. The object in this case is presented to the eye inverted, and, therefore, such a telescope is only employed for astronomical purposes, or where light is defective, as at evening or night.

In cases where light abounds, another set of glasses is usually inserted in the tube, so that the object being thus again inverted assumes its normal erect position.

(167.) The visual angle may also be increased or diminished by using a concave or convex reflecting surface, as the case may be. Upon this principle reflecting microscopes and telescopes are made. The object, in these cases, is placed between the focus and the centre. In this instance the object is inverted.

(168.) For practical purposes, in compound microscopes or telescopes, it is an object of considerable importance for them to be achromatic, or free from the aberration of colour, and free also from spherical aberration. When the instrument is completely perfect, it is called aplanatic.

(169.) The adaptation of optical contrivances, to amend disordered vision, is one of the most exalted applications of high abstract knowledge for the relief of the infirmities of man; thousands in the metropolis alone, and over Great Britain tens of thousands, are suffering from damaged vision, caused by the improper use of glasses; and what would the sufferers not give if they could but retract their first wrong step? Vision has been insidiously and gradually damaged, and, therefore, the idea of its impairment has not been suddenly or forcibly brought before their mind; but had the defect come at once upon them, they would have been amazed and terrified. It was once my lot to severely injure my eye; and, knowing my fear for its loss, I can appreciate what others would feel under similar circumstances. At that time I totally regained my sight, through the kind and anxious attention of my former accomplished master and distinguished ophthalmic surgeon, Mr. Lawrence. To him I feel that I owe a debt of gratitude which I can never repay. If I, as a surgeon, as an ophthalmic surgeon, should, after the lapse of many years, still feel this obligation, how deep a debt of gratitude will your patients feel for you, if, through your attention, their vision is preserved, improved, restored.

For Vision

Choose good Glasses,

Evenly polished, perfect in figure,

and free from specks.

Adjust their power by the Optometer to each eye separately, and take care that they be not too deep.

Take care also that the centre of the glass be exactly centered in the spectacle frame.

Elderly people, who use focal shorteners or convex glasses, should never look through their spectacles at distant objects, but only over them.

Never wipe your spectacles with anything but the softest wash-leather, which you should always have at hand for that purpose.

Spectacles should never be worn without the party having accurately ascertained the nature of the defect for which they are sought, as in some instances they would be very injurious.

Persons who have unequal refraction require very peculiar forms of lenses, as the ordinary kinds are not adapted for that purpose.

If the spectacles are scratched, cracked, or damaged, or if the frames become twisted, they should be changed for new ones; and far-sighted persons require the power to be increased every year or two.

A person having selected a pair of spectacles, ought to be able to read this entire page; otherwise there is some defect in vision besides that which arises from an abnormal condition of the refracting humours.

This is the smallest type which is made but is seldom used as it would try the eyes

LECTURE IV.

LIGHTS, AND THEIR INFLUENCE ON VISION.

(170.) Gold-leaf, bromine, and abstract;—(171.) photometers.—(172.) Continuous and flickering flames.—(173.) Coloured lights.—(174.) Correction of lights by absorption;—(175.) by reflection.—(176.) Improper use of coloured lights.—(177.) Position of objects to be illuminated.—(178.) Rest of eyes.—(179.) Production of artificial light.—(180.) Naphtha.—(181.) Platinum, &c.—(182.) Candles: Palmer's, Price's.—(183.) Oils.—(184.) Gas-lights.—(185.) Arrangement of lights.—(186.) Ventilation.—(187.) Final resumé.

(170.) In my former lecture I have told you that light is that which is seen by the eye; and although light is not simple, but composed of several colours, yet each colour is light, and can excite vision even when, from some defect, our minds cannot appreciate the differences of these colours.

Moreover, as all colours are light, it follows that our eyes become tests of light, provided that they be neither preternaturally sensible from long exposure to darkness, on the one hand, or that the vision be rendered dim from too great exposure to light, on the other.

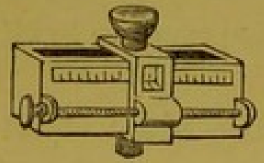
To judge, at one time, of the relative illumination of any object or the power of any light, and, at a second, of the sensibility of our organs to equal lights, instruments are employed called photometers, of which several have at various times been devised. A rough one, which I have found useful at times, is made of gold-leaf, so arranged between two pieces of glass that I could look through either one, two, three, four, or more layers. This instrument is perfectly abstract, as it marks the amount of an opaque body required to prevent the light from any object exciting the eye. In this country I do not remember to have observed that the direct light of the sun ever exceeded four layers, or somewhat less than the $\frac{1}{10,000}$th of an inch in thickness.

For abstract opacity I have also employed bromine; but it is such a substance for acting unpleasantly on the system, that I have almost entirely confined its use to experiments of comparison. I have a little flat cell made to hold it, and I find that half an inch of bromine is rather more than equal to two layers of gold-leaf. I have sometimes considered that pure water might possibly be used as a standard of abstract opacity.

(171.) Acting upon the idea of the bromine and gold-leaf photometers, I conceived the possibility of employing a piece of neutral-tint glass, the form of a wedge, a certain thickness of which should be equal to a certain thickness of these simple bodies; and by employing it we might be enabled to express the values of any light or any illuminated object by the value of the opacity of bromine or gold required to render it invisible.

In expressing results in thickness of gold and bromine, you must remember that the one substance is green by transmitted light, the other a deep red; and that, therefore, it will be desirable to determine on a clear day, with the sun in a certain altitude, and at a particular period of the year, the exact relation which the opacity of gold bears to the opacity of bromine: but the difficulty of determining this result with certainty is fully as difficult as that of the determination of any other standard of weight or measure. The glass used for the photometer should be strictly of a neutral tint, and the amount of thickness required to render any light invisible would then be expressed by the amount, respectively, of gold or bromine, it would require to render the sun's rays to such amount invisible. In this way monochromatic lights do not appear to interfere with a correct expression of the result.

Fig. 42.



The wedge of glass, to render it permeable to light without distorting the object viewed, is joined to another wedge of plain glass, so that the rays pass directly through the glass, and no refraction may ensue. I apprehend, that, when this instrument is brought fully to perfection, by ascertaining the abstract point as carefully as we have our other units, it will be found to be a valuable and universally applicable instrument, and it will exhibit, with the greatest nicety, the amount of illumination of any definite object and any given light.

In using the instrument the eye should be thoroughly protected from all extraneous light, and thus the rays of light should be admitted under an angle of definite aperture. I regret that this instrument is hardly ready to be issued to the public, but they will be sold as speedily as possible. All the instruments will be brought to one standard; and thus, if extended experience may cause a little variation in our abstract comparisons, an allowance may easily be made. This photometer will probably be found to be the best pyrometer, as we are enabled to judge of the heat by the light.

(172.) The amount of light is important, for the eye should neither be exposed to excess or deficiency. Nature, however, is wonderfully accommodating, and a party exposed to a very dim light, after a period, finds himself enabled to see, as the eye soon adapts itself to its new circumstances. Rapid transitions from brilliant light to darkness, or, more especially, from darkness to to light, are very injurious; so much so that it is asserted that one of the Roman emperors thought it good fun to incarcerate hapless victims in dark dungeons, to witness their being blinded from sudden exposure to strong light. What is true of these great variations is true also of lesser variations; hence, a flickering flame, which continually varies in intensity, should always be shunned, as a destroyer of vision.

(173.) Colour is an important attribute of light, for the eye is destined to be impressed by white light; and hence the light of day is preferable to that of all artificial illuminators, because the harmonious combination of the primitive colours is agreeable to the eye. Simple colours, if long continued, appear to act injuriously on the organ, and I always find that the use of yellow, red, or blue flames produces most uncomfortable sensations. To try these experiments, you may use a spirit-lamp, charged with naphtha, impregnated with salt, for the yellow flame. For the red you may substitute nitrate of strontia for the salt; and for green, the nitrate of copper.*

Experiments with coloured flames abundantly show the multitude of ideas which we obtain from the compound nature of light. Had nature provided us with the means of appreciating one colour alone, the world would be shorn of half its beauty. The eye is so susceptible of an harmonious mixture of colours, that it instantly detects any defect in the combinations, and passes condign judgment at once, either upon the dress of a lady or the painting of an artist, when they collectively do not make up white light. The dress of a lady of taste, or the artist's painting, if rapidly revolved before the eye, should represent white light; and if any colour is predominant, the effect is inharmonious. It is upon this point that the French so far excel the English, for the Parisian will not hesitate to effect an harmonious combination with the gayest colours; whereas the English lady, from ignorance of the details of the principle, dare hardly venture upon colours which have any positive tint.

(174.) In almost all our artificial lights there is a deficiency of the blue, and a preponderance of the yellow and red rays; hence, artificial lights are always more injurious than the natural light from the sun. In all our operations we should rather endeavour to generate a good light than to correct a bad one. When, however, we have produced an exceptionable light, we can correct its defect in two ways, by adding to the light the rays which are deficient by reflection, or by absorbing those in excess by transmitting it through a coloured medium. In this way a blue glass has lately been patented, which absorbs the red and yellow rays, and transmits the blue. This glass, unquestionably, improves the colour of the flame, but it has the disadvantage of

* The use of the following fires affords much instructive matter on the properties of coloured flames. *Red,*—nitrate of strontia, 40 parts; sulphur, 13; chlorate of potash, 5; charcoal, 3. *Green,*—nitrate of baryta, 70; sulphur, 13; chlorate of potash, 5; charcoal, 3. *Orange,*—nitrate of soda, 5; charcoal, 1; sulphur, 1. *White, Indian Fire,*—nitre, 24; sulphur, 7; realgar, 2. *White,*—nitre, 48; sulphur, 13¼; antimony, 7¼; *Purple,*—chlorate of potash, 2. *Black,*—oxide of copper, 1; sulphur, 1.

lessening materially the amount of light. Microscopists, however, seem to be nearly universally agreed as to the benefit of using these glasses. Coloured transparent media absorb all other rays but those of the same colour as their own substance; hence, we may always obtain monochromatic lights by absorption through coloured glasses. These blue glasses have been patented by Mr. Burley.

(175.) If a reflector be employed to any light, whether natural or artificial, it only reflects its own peculiar colour; thus, a red substance reflects red rays; a yellow, yellow rays; a blue, blue rays; a white, all the colours of the spectrum. When we desire to increase the illumination of any object, we reflect light upon it in addition to those rays which pass directly to it; and hence, by reflection, we can modify the colour of objects.

All artificial lights have a preponderance of the yellow and red rays; hence, by reflecting the blue rays, the object illuminated assumes its proper colour. You must remember, however, that by this plan you do not obtain as much light as you might by employing a white reflector, and from this cause you only adopt that course when you seek to improve the quality rather than the quantity of the light.

(176.) The use of a blue reflector is superior in principle to the use of a blue transparent medium for correcting inferior artificial lights, because in the latter case we add to the rays emanating from the flame the colours which are deficient, in the former we subtract those which are in excess.

At this place I must caution you against a practice which cannot be designated by any other name than that of a fraud. It consists in exhibiting for sale lace and other goods, which ought to have a perfectly white colour, under a blue transparent glass; and you may sometimes observe windows in show-rooms fitted with coloured glass for this object. Such goods are also wrapped in blue paper, which reflects the blue rays upon them, and causes them to appear of a much better colour than they really are; and, in fact, a yellow object might appear white under such circumstances. I have no doubt this practice has extended itself thoughtlessly; but it cannot be too soon abandoned, as it is no whit the less dishonest to sell goods, the value of which depends upon their colour, by coloured lights, than to sell those of capacity by contracted measures, or those of weight by faulty scales.

This custom has become universal, and therefore a certain time is requisite for its total eradication. It is imperatively necessary, to maintain credit, that it should be abandoned, and that all goods, where colour is an object, should be exposed to white light, that the glass through which the light passes should be colourless, and that no reflection be allowed from coloured surfaces which shall interfere with their proper appreciation.

The most perfect reflector ever devised, has been patented by Messrs. Sedgwick and Taylor, of Piccadilly, under the appropriate name of the diapharous reflector. It is constructed upon the principle of the total reflection of light which takes placc from the internal surface of transparent bodies when placed very obliquely. It consists of a concave glass dish, fluted on the outer side. This, when placed over a flame so that it is in its focus, reflects every ray of light impinging upon the internal surface of the flutings obliquely, and transmits all falling perpendicularly to the surface. As a result therefrom, the fluted glass becomes the best or most powerful reflector that can be constructed, and no appreciable light is lost by absorption. As the reflection takes place from the internal surface of the glass, there is no possibility of its being coated with dirt or other substance calculated to interfere with the result; moreover, by using pure white glass, white light is thrown upon the table; and if the flame be viewed through the shade its intensity is lessened, and it is rendered less injurious to the sight. The reflected rays are taken from that place where they are naturally in excess; and hence, the table is not only more brilliantly

Fig. 43.

illuminated, but the light throughout the whole room is equalized. The only care required in the employment of the shade is the necessity of placing the light in its focus.

(177.) There is a certain position in which objects should be placed in relation to the centre of light from which it is illuminated, which is in the highest degree important for the preservation of the organs of vision. I need hardly tell you that light is reflected from objects in such a way that the angle of reflection is equal to the angle of incidence. It is upon this principle that we obtain an image of an object from a looking-glass; and, although we cannot obtain a perfect image from the surface of paper, yet more light is reflected in that position. Wherever that reflection occurs it is destructive to vision, whether you sit by the sea-shore, and obtain the reflection from the sea, or are fishing on the banks of a river, and have the rays of the sun reflected to the eye, or are writing or reading from white paper at the reflecting angle. Opaque bodies, as paper, &c., are found to reflect a greater amount of light if the rays fall very obliquely; hence the light ought to be placed nearly directly above the object viewed.

(178.) The centre of light in the flame should on no account be enabled to fall directly upon the eye, especially obliquely upon the under surface of the eye, or other lateral parts of vision, as in that position it is calculated to do much mischief. I was much surprised lately to observe that at one of our best libraries the light fell directly upon the inferior part of the eye, and caused much distress; and at another large establishment the parties employed complained most grievously of all the lights being similarly placed. This difficulty with artificial lights is usually overcome by an opaque shade, so arranged, that, whilst it shields the eye, it allows the object to be illuminated; or what is better, by the elegant glass shade before described.

Exeter Hall may be regarded as one of the worst lit places in London. The distress which is caused to the eye, by its improper mode of illumination, to those sitting in the gallery, has only to be felt to be thoroughly appreciated, as the lights are between the orchestra and the observer.

With the natural light of day, a north aspect, beyond all compare, is to be preferred, inasmuch as in that situation you obtain the light from a clear sky, and the direct rays of the sun never fall upon the object on which you are engaged.

Whenever your attention is fixed upon any subject, the eyes should not continue to regard the same object for a long period; and a short rest should be frequently allowed, by directing your eyes to some more distant object, of a colour calculated to act pleasantly on the organ. The vegetable world, in the shape of green leaves, affords that rest in the most perfect manner; and, even if you live in the most confined situation of this most murky metropolis, you may procure that repose by growing plants in the Wardian cases. Engaged every night in reading, writing, or other occupations trying to vision, I find the benefit, independently of the pleasure which is afforded, by attempting to grow a few plants, even such as the gardener might despise as the commonest weeds.

(179.) All artificial lights are produced by intensely heating solid matter, for without solid matter we cannot have the effect of light. I have entered so fully into these considerations in my "Sources of Physics," that I must refer you to that book for further explanation upon the subject. I may mention, however, that the combustion of pure hydrogen evolves no light, because there is no solid matter to be heated; whilst hydrocarbon gives off abundance of light, because the carbon is deposited in the solid form, and becomes heated. "The rapidity of the consumption of carbon, or attracted matter, materially interferes with the colour of the flame. If it is consumed with sluggishness we get a red flame; if with greater energy, a yellow flame; but if still with greater energy, we obtain a white light; and lastly, if the energy is further increased, we have only a pale and colourless flame."*

(180.) The hydrocarbons, which afford a beautiful artificial light, are oil of turpentine and naphtha. They are both so volatile, that they are almost sure to cause an unpleasant smell in the room in

* Sources of Physics, 365.

which they are burnt. From an excess of carbon, however, unless they be most carefully consumed, much smoke is eliminated. It is not an uncommon thing to mix turpentine with oil; and I have extracted as much as 33 per cent. from a suspected sample. A little turpentine may, perhaps, however, be added advantageously to oil, as it improves the colour of the flame, and renders the oil more fluid. The camphine lamp has been found to afford the best flame for photographic purposes.

It is not impossible, that within a few years solid and liquid hydrocarbons, of the same chemical composition as coal-gas, will be made in such quantities that they will entirely supersede wax, stearine, oil, and gas. Science has attained such results, but the manufacturer has not succeeded in a mercantile way to its full extent. We are evidently very near this discovery, and perhaps before this edition of the book is sold, we may find that every difficulty will vanish. Men of capital, talent, and science, are at work; and with such a combination a satisfactory end may safely be predicted.

(181.) I believe you will find that the best standard of light which can be employed is platinum in a state of fusion, as the light is most intense, and the colour most brilliant. Lime intensely heated by the oxy-hydrogen flame also produces a most intense light, and is the light which we always employ for all purposes requiring a very intense and a very perfect illumination.

(182.) Ordinarily we obtain light for practical purposes from candles, oil, or gas. The old rush-light, made by simply dipping rushes in the skimmings of fat and bacon, is nearly lost, the ruthless hand of time, except in very rustic districts, having brought to a termination the ancient chimney-corner, with its concomitant rush-light suspended over-head. In common candles no real improvement took place, till Mr. Palmer adopted means to make the candle snuff itself, by placing a little oxide of bismuth along one surface of the wick, which throws it out and renders the light perfectly steady. The tallow is prepared for these candles by subjecting it to a very powerful hydraulic press, which presses out the elaine, which is employed in the manufacture of soap. These metallic-wick candles are always burnt in a tube; and a party who visits Mr. Palmer's extensive manufactory would be at a loss to determine whether he should most admire the curious machinery by which the candles are prepared, the value of the result obtained, or the exquisite taste displayed in the designs of the more elegant candlesticks. From the steadiness and excellence of the light, Palmer's candles should entirely supersede the common forms. The following varieties are sold:—

1 wick	6 to 1 lb.	burns 9 hours,	equal to 1 mould.	2 wick Palm	10 to 1 lb.
2 ,,		5 ,,	,, 2 ,,	2 ,,	6 to 1 lb.
3 ,,	½ lb.	8 ,,	,, 8 ,,	Common candles adapted to the poor, and give very great light.	
4 ,,	15 to 12 lb.	8 ,,	,, 8 ,,		

There is a very beautiful candle, which has been contrived by Price, and is known under the name of "Price's Composite Candle." It is of a pure white alabaster colour, well adapted for the drawing-room, and it burns in common candlesticks. The light is steady, brilliant, and well-adapted for illumination. These candles have nearly superseded the wax, from being cheaper.

I must caution you against employing various candles which contain arsenic in their composition. This deadly poison is added to certain candles for the sake of rendering stearine amorphous or non-crystalline. Science, however, has furnished other means of obtaining the same result, and, therefore, it is believed that this dangerous substance is not now employed. In burning, the arsenic is given off, and is imbibed by the lungs, and thus injures materially the human frame. All candles which do not snuff themselves are hurtful to vision, inasmuch as the light is inconstant.

(183.) The oils in use are of two kinds, vegetable and animal. The former contain large quantities of stearine, which may be readily separated by pressure. In consequence of the presence of stearine, they do not burn well in cold weather; hence there are various contrivances to keep the oil hot, in the shape of hot oil lamps. If well managed, they give a good light, and are economical; but the trouble attending their employment forms a great bar to their universal application. Of the animal oil lamps, the common Argand for sperm oil is an excellent, but, at the present time, very expensive light; and the solar lamp has also a high repute.

(184.) Gas is an excellent source of light, and its use is daily increasing in private dwellings. There are so many kinds of burners at the present moment, that I cannot spare time to describe them all. The following is a small table, with the rate of consumption, which has been carefully ascertained for me by Mr. Smith:—

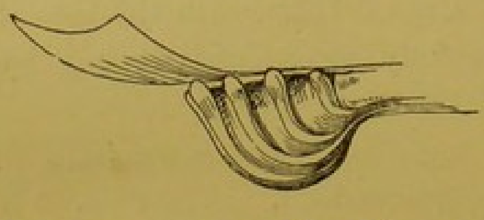
	Feet per hour.		Feet per hour.
12 hole Argand	5	Bynner's, No. 1,	5
15 ditto	6½	Ditto 2,	5½
Middle, 30 holes	6½	Ditto 3,	7
Large, ditto	7½	Ditto 5,	10
Fish-tail, No. 1,	2	Universal	10
Ditto 2,	2½	Low's	5
Ditto 3,	3½	Small steel top, or Shadowless	6½
Ditto 4,	4½	Bat's-wing	5
Radiant	8	Bude, various.	

The price of gas varies according to the consciences of the directors of the works. With us it is 4*s*. per 1000 cubic feet.

My excellent neighbour, Mr. Low, the distinguished gas engineer, has made a great improvement in the qualities of the gas by passing it through naphtha, to render it richer in carbon. I was called as a witness before the Privy Council, when the question of the extension of his patent was confirmed, and I gave evidence to the effect that his invention conferred upon gas the qualities of naphtha without the inconvenience, and, from the brilliancy and perfection of the light, was a vast improvement over the poor gas usually distributed in the London streets.

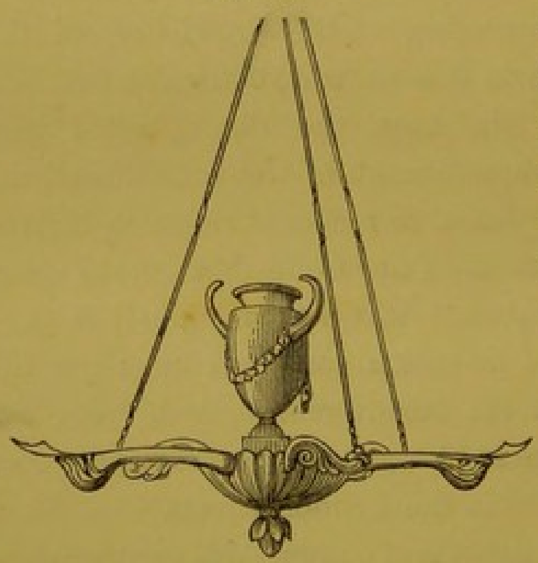
(185.) The arrangement of lights is of considerable consequence. By the ordinary mode of proceeding we illuminate the ceiling and the walls of the room, and the part which ought to be properly lighted is generally completely in the shade. The rays of light, from being vertical, pass with greatest readiness perpendicularly through the glass to the walls of the room, whilst those which attempt to pass obliquely to the table below are in great part reflected. To obviate this difficulty, it occurred to me that the light should be placed at about an angle of 45 degrees if placed about the centre of the room, or if near the ceiling, almost horizontal. In my own library I am using a star with three fish-tail burners, so arranged that the gas passes out horizontally, a direction which causes the flame to assume a curve eminently calculated to illuminate the table. An enormous increase of light is obtained by these means. From the very great superiority of the illuminating power obtained by this very simple arrangement, I feel but little doubt that it will be at last generally adopted.

Fig. 44.



After the first edition of this book was written I introduced this system of lighting at the lecture-table of the London Institution, where it has attracted the attention of most of the lecturers who have been at the institution, for the perfect manner in which the table is illuminated. The diagram illustrates the manner in which my dining-room is lit. We find that the whole room is well lighted at less than a halfpenny an hour; and I can but think that this mode of lighting, assimilating as it does to the ancient Roman lamp, is a model of taste, which contrasts with the ordinary chandeliers at the shops.

Fig. 45.



It is stated in the blue books that this system has also been brought into operation at Liverpool, at the Mechanics' Institution, and in many churches, but the witnesses did not know its origin. Notwithstanding the extraordinary difference which exists between this mode of lighting and the common ground glass lamps, I have been unable to obtain such an extension of its use as its great superiority demands. I find that this is owing to the eye being accustomed to the ground glass shade; and I remember, after many arguments with my late distinguished neighbour, Dr. Pereira whose loss the profession so much deplore, the doctor came to me, and laughingly said, "Smee, I am so far a convert to your theory of lighting as to adopt it in my library, and so I hope that will satisfy you." "No," I replied, "I never shall be satisfied till I see every ground glass shade removed from every artificial light in every dwelling-room; and prejudice will surely at last give way to utility."

It always appears to me that the quality of the light from the use of ground glass is vitiated to a greater extent than can be accounted for, simply from a diminution of the quantity of light. Any person, by experiment, may ascertain that the clearness is marvellously impaired by the use of ground glass shades; and so it is apparent that by employing ground glass we do not merely lessen the quantity, but we injure the quality of the light; and I believe that ground glass shades have a deleterious influence upon the eye, and should be entirely abolished.

(186.) There is no mode of illuminating a room for company more in accordance with my own taste than the employment of a powerful central light, with great multitudes of wax or composite candles by the walls. Where gas is employed, a certain amount of sulphurous compounds is always exhaled, which renders it advisable to carry off the products of combustion. Dr. Faraday has contrived an ingenious mode of effecting the object, by using two glasses, and causing the foul air to descend between them, and afterwards to ascend into a tube connected with the chimney. The objection is the double glass, extra trouble, and less perfect combustion; otherwise, all the foul air is perfectly carried off, and more light is produced from the same amount of gas. The same result, but in many cases with considerable sacrifice of appearance, can be obtained by a tube placed over the light, and conducted to a chimney; and there are several modes now adopted, which also help to ventilate the room at the same time, which I need not describe, because, according to circumstances, a preference would be given to each of the different modes of proceeding.

(187.) The subjects of these lectures, however inefficiently treated, must appear to you to be in the highest degree important, inasmuch as upon their right understanding the sense of sight in many cases depends. Whether we consider the eye as the medium which affords to us a glimmer of the gorgeous firmament displayed in a starlight night, or which reveals to us the existence of the innumerable beings shewn by microscopic aid; whether we estimate it from giving us a view of the cloud-capped towers or rugged rocks, or allowing us to observe the stillness and repose of the quiet lake; whether we delight in the silent glade or woody glen, the shady dingle or flowery mead, the foaming cataract or wondrous glacier, the eye stands forth prominently to declare its value to man. Without its aid light ceases to confer knowledge, colour, pleasure, form, delight. The sublime and the beautiful are merged in darkness; and the grandest view, the most perfect form, the loveliest combination of colour, would be made to man in vain. The exquisite harmonies of colour, form, proportion, invariably to be seen in nature's works, may well be termed the music of the eye; and its enjoyment indeed confers the highest of all sensual gratifications. As much, however, exalted as mind is above matter, so is the pleasure of our mental conceptions over sensual delights; hence, the blind have left still the consolation of mental power, and can rejoicingly declare,

> "So much the rather, then,
> Celestial light, shine inwards, and the mind
> Through all her powers irradiate."

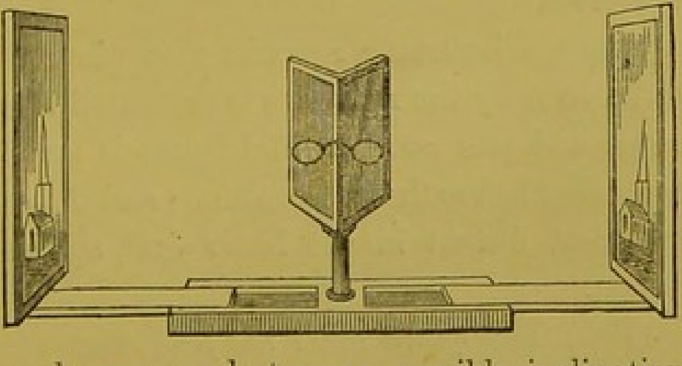
LECTURE V.

ON STEREOSCOPES, BINOCULAR PERSPECTIVE, &c.

(188.) To Wheatstone must be awarded the honour of having made one of the most brilliant discoveries of modern times, namely, the stereoscope, an instrument whereby drawings of objects of nature and art can be represented, with the perfection of light, shade, and appearance of solidity, as they are seen by the healthy individual directing both eyes to the same object.

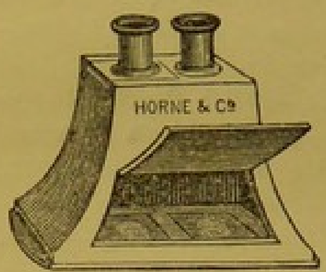
(189.) The first instrument devised by this ingenious philosopher, consists of two reflecting surfaces, joined at right angles, with arms on each side to hold a perspective drawing. When the two perspective drawings are rightly adjusted, and viewed in the mirrors by both eyes conjointly, each eye has represented to it an image such as it would have seen in nature, and the conjunction of the two represents to the mind an object of three dimensions. This form of instrument is called the reflecting stereoscope, and is perhaps best adapted for investigation, as it is suitable for drawings of all sizes, which can be arranged at every possible inclination of the optic axes.

Fig. 46.



(190.) Sir David Brewster has made an elegant stereoscope, on a refracting principle, which is generally used for photographs and daguerreotypes, as it is particularly applicable for small drawings. It is made by two semi-lenses, fixed in a frame, $2\frac{1}{2}$ inches apart and, practically, a semi-lens is found to be a convenient and cheap form of prism, which renders the rays parallel, and also slightly displaces the pictures towards each other. By the use of this instrument, two perspective daguerreotypes give to the beholder a picture with all the beauty of nature; and, certainly, the representations of groups of figures, as prepared by M. Claudet, are the most wonderful examples of the triumph of science to imitate nature.

Fig 47.



(191.) Other forms of stereoscopes are described by Sir David Brewster and Mr. Wheatstone; and even small perspective drawings can be superimposed stereoscopically without any instrument by an extreme convergence of the eyes. Sometimes Sir David Brewster's stereoscope is mounted upon a stand, and is then an elegant addition to the drawing-room; and Mr. Kilburn has constructed a very portable form of instrument, which is well adapted for stereoscopic portraits.

(192.) The pictures for the stereoscope are taken at two stations, at a greater or less distance apart, according to the distance at which they are to be viewed. For a distance of 8 inches, the two pictures are taken at an angle of 18 degrees; for 13 inches, 10 degrees; for 18 inches, 8 degrees; and for 4 feet, 4 degrees.

(193.) Wheatstone remarks that when the drawing intended to be seen by the right eye is presented to the left, in the stereoscope, and *vice versâ*, a solid figure is perceived totally different from that before the transposition; and those objects which appear the most distant in the latter case, appear the nearest in the former.

(194.) This philosopher has also constructed an instrument by which phenomena of the same kind may be elicited by regarding objects themselves. It is formed of two rectangular prisms of flint glass, which are placed in a frame, with the hypothenuses parallel, and 2·1 inches from each other, with proper mechanism for adjustment. This contrivance is called the pseudoscope; and, certainly, to a person examining objects by it for the first time, nothing can be more astonishing or perplexing. A medal is converted into a die; a die into a medal; a bust is converted into a hollow mask; and, most curious of all, a china vase looks like a vertical section of the interior, with painted hollow impressions. Near objects appear remote, and remote objects near; a tree standing outside the window may be brought visibly within the room in which the observer is standing.

(195.) In the last edition of this book, I stated that "From the above facts, we now know that it is impossible for any painter to delineate a picture in the manner in which we see it with both eyes, because two eyes give us a view of three sides of a cube, and he can paint but two. I conceive it possible, that for objects at moderate distances, painters may, in some cases, take a certain liberty with perspective and depict the two perspectives; but it certainly cannot be attempted with near objects."

(196.) Notwithstanding the assertion of the impossibility of delineating a picture as seen with two eyes, which was the correct opinion of the time, certain abstract considerations, with which I need not trouble my readers, induced me to believe that such a delineation was more practicable than at first sight was supposed; and, after much thought and studious experiment, I trust that I am enabled to submit the laws by which painters may represent, to a great extent, objects as seen with both eyes, and consequently in all their natural beauty.

(197.) In studying the phenonema of binocular perspective, it must be remembered that the two eyes, being placed at two inches and a half apart, give a different perspective view; and, as in nature the eyes are directed to the same point, it follows that the same part of the same object must be the same point of sight for the two perspectives.

(198.) The picture in a binocular perspective drawing really consists of two drawings overlapping each other, the point of sight in both being the same. By this overlapping lights, and shades, tones and the effect of breadth, are produced, such as the eyes really observe in nature.

(199.) The following may be regarded as the leading rules or laws of binocular perspective, which may be useful to the painter as a guide in the production of the drawing, or as a test for the detection of error when it has been made. Much judgment and skill are no doubt requisite for the painter so to construct his picture, that the effect of solidity may be suggested to the mind rather than hardly delineated; and, as far as I can judge, from the observation of paintings of some of our great artists, they have, as an effort of genius, really depicted objects as seen with two eyes.

I. The point of sight appears the same to both eyes as to one.

II. Small objects of less width than the distance between the pupils of the eyes, when placed in a plane before the point of sight, are increased in width and rendered either wholly or in part transparent, according to their distance from the eyes.

III. Large objects, in a plane before the point of sight, are increased in width, and their lateral edges become transparent and allow objects to be seen through them.

IV. Objects or parts of objects on either side the point of sight are increased in width, and the edges become transparent.

V. Objects in a plane, behind the point of sight, are seen in two places, but indistinctly, because they are out of focus, and because their images fall upon the internal surface of the retina at a greater or less distance from the point of distinct vision.

VI. Solid bodies or parts of solid bodies, appearing transparent, modify the tint of objects seen through them.

VII. Bodies of a light colour throw a light veil over objects seen behind them. Bodies of a darker colour throw a dark veil.

VIII. Colours of different character, as yellow and blue, when superimposed according to the preceding law, produce a tint different from either, and yet not the colour which would arise from their admixture.

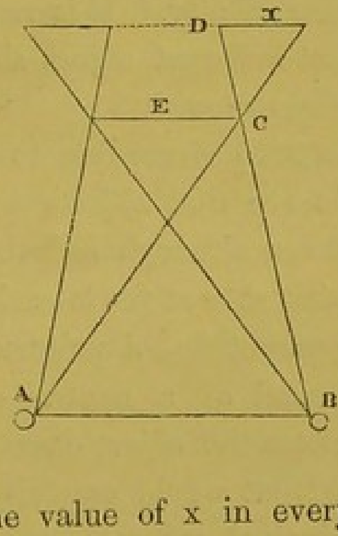
IX. In cases where objects or parts of objects are widened and rendered transparent, the breadth of the distinct or solid part is narrower than when viewed by one eye alone.

X. Small objects placed some distance before the point of sight and near the eyes, appear in two places, but one impression is generally neglected.

XI. Parts of objects becoming transparent have frequently much light reflected from them, and where the image is seen in two places sometimes the light is only reflected from one image.

(200.) The following figure will serve to give an illustration of the interpenetration of objects when seen by two eyes, and will also explain the geometrical law on which it is founded. It will be seen that by two eyes we are enabled to see a greater amount of the back object than would be discernable by one eye alone. This amount may be called X, and the quantity denoted varies directly as the base A B and the line C D, and inversely as the line B C. By similar triangles A B : B C :: X : D C ; therefore

Fig. 48.



$X = \frac{A B \times D C}{B C}$, an equation which gives the value of X in every position.

(201.) In studying these principles nothing has more astonished me than the fact of the colours which overlap to the two eyes not giving the compound colour, which would result if they were mixed and seen by one eye. In all those parts of a picture where colours overlap, much skill will have to be exercised by the painter, as the appearance in nature is that of a film or coloured gauze overlapping other colours, and the result is not the ordinary compound colour.

(202.) One of the few artists who have seen "Turner" paint, stated to me that in painting the near objects he lightly touched with his brush and then placed his finger over it, whereby he produced a semitransparent streak instead of a line. This streak enabled the more distant objects to be seen behind it, and thus the conditions of binocular perspective were in part fulfilled.

(203.) Another curious phenomenon connected with binocular perspective is observable in the case of a landscape viewed through a window, for in that instance the vertical bars become either wholly or partially transparent, and the objects behind them are seen with a shade over them. The horizontal bars retain their solidity and obscure all the parts they shade. This phenomenon occurs when the head remains in its ordinary position; but when the head is turned so that the eyes are one above the other, the horizontal bars become transparent and the vertical bars retain their solidity. It is requisite for the observance of these effects, that a distant object should be the point of sight, and not the window-bar.

(204.) According to the laws which have been detailed, we observe that objects behind the point of sight are seen in two places, although indistinctly, from being out of focus, and from being seen at the lateral part of the retina. From these facts it is apparent that a painter should depict the objects in the background of a neutral or tertiary tint and very indistinct. In nature the object directly viewed is alone seen in perfection, and he that would carefully study nature should contrive that his principal subject should be the brightest in colour and most distinct in detail, when it will stand forth in all its beauty.

(205.) The outline effects of binocular perspective may be readily obtained by placing two candles at 2½ inches apart, from flame to flame, and examining the shadows which are produced upon a white screen. It will then be seen that objects near the screen will have a light shade at each lateral border. Small objects will, at a greater distance, appear double; and the double images being superimposed a body different from either will be produced. A finger held horizontally across the flames will have the end prolonged by its shadow, but it will be observed that no change takes place at the upper or lower edges. By this experiment only the outline effect is produced; but I cannot too highly recommend to the painter to shut himself up with two candles and study these effects.

(206.) As a general rule, when a small object near the eye and before the point of sight appears in two places, one of the images is neglected, because it is received on the margin of the retina. Sometimes the images overlap, and a third object totally different from either is seen. An example of this nature occurs in an experiment communicated to me by Professor Edward Solly. If the tips of two fingers are placed in contact between the eyes and a candle, and the attention be directed from the fingers to the candle, a globe or oval body will appear between the fingers, and the last joint of the finger will appear to be shortened. There are many modifications of this experiment, but none of them must be represented by the painter or photographer, for their unnatural character would only distract the observer. As a rule, the image of an object in two places is not appreciated entirely, because one object falling upon the margin of the retina is scarcely visible. These considerations curiously bring before our mind the fact, that even the apparent imperfections in the construction of the parts of our body are necessary for the highest integrity of their functions.

(207.) It occurred to me, that if the laws of binocular perspective were correct, pictures might be obtained by photography which should represent the appearances observed with both eyes. The conditions required for binocular sun pictures are similar to those required for binocular drawings or paintings. As it is requisite that there should be one point of sight for the two perspective drawings, considerable nicety is required in the production of binocular photographs, as the slightest deviation from correctness produces doubleness or great distortion. To obtain a binocular picture of any body, the camera must be employed to take half the impression, and then it must be moved in the arc of a circle of which the distance from the camera to the point of sight is the radius, for about 2½ inches, when a second picture is taken, and the two impressions, conjointly, form one binocular picture.

(208.) There are many ways by which this result may be obtained. A spot may be placed in the ground glass, on which the point of sight should be made exactly to fall. The camera may then be moved 2½ inches and adjusted till the point of sight falls again upon the same spot on the ground glass, when, if the camera has been moved in a true horizontal plane, the effect of the double picture will be perfect.

(209.) For obtaining this motion in the true arc of a circle, Mr. Hensman, the engineer to the Bank of England, recommended me to adopt a carriage with two moveable axles, with wheels of which the front pair is a little smaller than the hinder pair. The idea of the construction is, that the carriage should revolve on two cones which run round a circle, and the diameter of the circle is determined by the distance between the larger and smaller wheels and the convergence of the axles. In practice, on a surface adjusted by spirit levels, it answers well, and probably may be found useful in some cases. At Messrs. Horne and Thornthwaite's photographic room, an apparatus has been fixed, which allows the motion of the camera to be made perfectly horizontal in the arc of a definite circle. From experiments which we have made, I rather give the preference to pictures made with the camera in continual motion, backwards and forwards, for 2½ inches, as the picture is, in this case, even more beautiful than if the two images be superimposed. This experiment is very remarkable, for who would have thought formerly, that a picture could possibly have been made with a camera in continual motion? Nevertheless, we accomplish it every day with ease, and the character of the likeness is wonderfully improved by it.

(210.) Whenever a solid body is depicted in binocular perspective, a suitable back-ground should be arranged behind it to exhibit the interpenetration. If this be not considered, the picture has an increased width with double edges, and does not exhibit that glorious delicacy of shading which nature gives to objects seen with both eyes. In all cases of binocular perspective we must be careful not to imitate nature by endeavouring to depict an excessive range of distances. In practice, the eye can only focus objects within a certain range; hence in pictures we still take nature as our guide when we only depict a moderate range.

(211.) I have seen good results from placing two stereoscopic pictures in the dissolving view apparatus and throwing the two images on a screen. For this purpose the stereoscopic pictures should be made with exactly the same point of sight; otherwise the delicate shading will not come right on the screen.

(212.) It is not easy to predict the extent or the importance of this mode of drawing, because an extensive experience is required before artists can judge of these matters. From the best consideration which I can give to the subject, I am inclined to believe that, with regard to paintings, it will reduce to rule the methods intuitively practised by our great and honoured masters; and with respect to photographs, it may be possibly found to supply the desideratum so long required of delineating a delicately shaded picture, instead of, as at present, a hard perspective drawing.

(213.) In viewing these binocular representations, the best effect is produced by examining them with one eye when they are tolerably close; or if two eyes be employed, by viewing the representation at such a distance that we are not enabled to detect the flatness of the picture, and thus discover the cheat. How far we may take liberties with the distance between the two sights, for the camera, will be a subject of future investigation under various circumstances.

(214.) The light falling upon the edges of bodies obliquely, is reflected to a considerable extent. This effect must be carefully noted by the painter, as this phenomenon much increases the appearance of of the rotundity of bodies. In this case the light is the colour of the source from which it arises. Sometimes it is white light, in the evening it is red.

In the case of bodies in a plane either before or behind the point of sight, which from their size and position are seen in two places at once, the impression of one is generally neglected. In these instances it does not follow that the light reflected from one image should be reflected from the other, because, from the position of the eyes, the position may not be congenial for reflection in both cases. This effect of light is extremely difficult for the painter to represent, because white or yellow paint is a very poor substitute for the glorious light of day.

(215.) The investigations which I have conducted upon binocular perspective, have afforded instructive and interesting views of the mental image which results from the combined physical pictures of both eyes. To represent this mental image so that it may be visible at one glance, has been a work with me of much thought; and its practical application has been a deduction from my electro-biological speculations. I venture to hope that the result will be as useful in practice as it has been agreeable as a mental effort. In that case I shall be twice recompensed; recompensed by the pleasure of its development—recompensed by hereafter witnessing the success of my labours.

SHORT RULES

FOR THE

PRESERVATION OF SIGHT AND CHOICE OF SPECTACLES.

HEALTHY VISION.

1. When an object is viewed, care should be taken that it is seen in the highest perfection, and not carelessly.

2. As only a portion of an object is perfectly seen at one time, the eye should be directed slowly and gradually to all its parts.

3. It is important that we should observe everything which comes before us; otherwise a habit is induced of neglecting to see that which is really visible.

4. For distant vision the eye should be accurately focused, which is known by the object appearing perfectly clear.

5. The two eyes must be directed to the same point to appreciate the full effect of solidity, and the lights and shades and colours of nature. The young should be taught to practise binocular vision by the stereoscope.

6. Near and distant objects should be equally examined, that the eye may preserve its power of adjustment to various distances.

7. The eye should be practised to view the smallest objects; but it should not be strained by regarding them too long at once.

DISEASES OF VISION.

8. The eye, when inflamed, should be kept in absolute rest.

9. Foreign bodies between the eyelids should be immediately removed by everting the lids.

10. When foreign bodies are imbedded in the eye they must be cut out by the surgeon.

11. Sudden impairment of vision portends serious mischief, and requires the immediate aid of the surgeon.

12. Mattery eyes are highly contagious and dangerous. Squirt between the eyelids a lotion made of a drachm of alum to the pint of water every quarter of an hour.

13. States of debility, from all causes, are liable to be followed by disease of the eye.

14. Accidents to the eye should be treated by cold cloths, darkness, and rest, till the arrival of the surgeon. On no account touch the eye, as pressure may destroy it.

15. When the lining membrane of the eyeball is irritated by injudicious use, an eye-water may be employed, consisting of a scruple of alum, a tablespoonful of spirits of wine, in half a pint of rose-water.

16. Irritation of the eyelids may be treated by smearing their edges with an ointment composed of one part of the ointment of the red oxyde of mercury diluted with ten parts of lard free from salt.

SPECTACLES.

17. Spectacles should only be worn to correct the errors of the refracting humours.

18. The error of refracting power should be carefully ascertained by the optometer before any spectacles are employed.

19. Spectacle frames should be exactly adapted to the width of the eyes.

20. It is necessary that the glass should be central in the frame.

21. When the spectacle glass is properly selected, the eye indicates by the optometer its healthy range of adjustment if no other disease be present.

22. Spectacle glasses should only be wiped with the softest washleather.

LONG SIGHT.

23. For long sight the glasses should not be too deep; otherwise vision is apt to become more impaired.

24. Distant objects should not be viewed through the glass in the long sight of declining years.

25. It is detrimental to use glasses continuously to near objects, where the adjustment to distant objects is not complete.

26. Spectacles should not be employed to increase the size of objects, but reading-glasses and microscopes should be substituted in their stead.

SHORT SIGHT.

27. Glasses may be safely employed to completely rectify the optical defect of short-sightedness.

28. When the adjustment of the eye is imperfect, some latitude of compensation must be allowed for the exercise of the eye.

29. Short-sighted spectacles should have their axes directed to the object viewed, if the highest perfection is sought.

READING-GLASSES.

30. Reading-glasses are useful in those conditions of vision where the size of the object is required to be enlarged.

31. One eye can only be employed with a reading-glass at one time; for the employment of two eyes would cause it to appear double.

32. The aged find reading-glasses serviceable, and short-sighted persons derive advantage from the use of a reading-glass in addition to their spectacles.

EYE-GLASSES.

33. Single eye-glasses are injurious, because the work is thrown upon one eye.

34. Double hand glasses should always be employed in preference to spectacles by persons who, when engaged in conversation, have occasionally to view writing or small print.

OPERA GLASSES.

35. The opera glass is useful to give a clear view of a moderately distant object.

36. To have the stereoscopic effect, a double opera glass should be used, which should be exactly adapted to the width of the eyes.

37. Short-sighted persons require opera glasses to be specially adjusted to meet their defect.

SQUINTING.

38. Squinting, when occurring from an imperfection of sight, should not be interfered with until the impression on the damaged eye is neglected, or the vision will be damaged.

39. Care should be taken by medical or surgical means to rectify squinting when the vision of the eye is not seriously impaired.

LIGHTS.

40. The eye should never view an intense light.

41. The light of a flame should never fall upon any part of the eye during use.

42. Bodies of all colours should be equally viewed, and after regarding a bright or primary colour, repose should be sought by looking at a tertiary colour.

43. An unsteady flame is hurtful during reading or writing.

44. The eye is liable to damage from being employed on black objects by artificial light, because it is insufficient for the purpose.

45. The observation of objects at the reflecting angle is hurtful, from the intensity of the light.

46. All coverings to lights are injurious, as the clearness of the flame is diminished; and ground glass shades are particularly detrimental.

47. Reading during railway travelling is hurtful, because of the constant unsteady motion which is imparted to the book.

48. The observation of close objects during rapid locomotion is trying and detrimental to vision.

49. Glasses of neutral tint, blue or green colour, may be em ployed, to protect the eyes from a bright sun in the middle of the day; but they are injurious when the light is not painfully intense.

50. Rapid transition from darkness to intense light is liable to be followed by blindness.

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Fig. 1. Fig. 2. Fig. 3.

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Ditto ditto, with gold-mounted Tortoiseshell or Pearl cases (Fig. 2) £4 4 0	5 5 0	&	6 10 0
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