The Science of Optics.

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Emmetropia.

Rays of light entering the eye pass through :

(1) The cornea ;

(2) The aqueous humour—by the opening in the iris ;

(3) The crystaline lens ;

(4) The vitreous humour ;

and, reaching the retina, form there an inverted picture. From the retina communication is made to the brain, by the optic nerve, of the impingement of the rays, and the sensation of light is caused.

The cornea and the humours through which the rays pass form and are termed the dioptric or refractive media of the eye. The three factors which, in addition to the perfect transparency of the media and the nervous power of the retina and the optic nerve, are necessary for perfect binocular (single) vision are :

(1) Refraction. The bending of parallel rays of light so that they come to a sharp focus at the retina.

(2) Accommodation. The combined action of the ciliary and crystalline lens, by which the refraction of the eye is increased so as to bring divergent rays to a sharp focus at the retina.

(3) Convergence. The action of the motor muscles, by means of which the two visual axes are converged to the same point, so that the rays of light from the one object form an image on and around the macula in both eyes at the same time, and a single object is seen.

THE TEST CASE—TEST TYPE—TESTING AND RECORDING V.

A test case consists of a complete series of + and - sphincter lenses numbered from 0.125 to 20D., + and - cylindrical lenses from the weakest up to 6 or 8D. Prisms from 1 to 20°, or 30°, and various discs and colored glasses. All these lenses and discs are conveniently mounted in rings with handles. The opaque disc is a black plate. The translucent disc is a piece of frosted glass. Both are used for covering one eye while the other is being tested. The former blocks out the light entirely, while the latter transmits a certain quantity without permitting vision of objects, and is, as a rule, preferable.

The stenopaic slits are plates of black rubber or metal, with a narrow opening running across them. They are used in astigmatism.

The pin-hole disc is a plate with a very small central aperture. It is used for determining the possibility of improving the sight with lenses.

The half opaque disc is used in connection with the testing of the field of V.

The red glass is used in connection with tests of the motor muscles.

The blue and smoke glasses are for those cases where diminished light is requisite.

The power and application of prisms will be found in the chapter devoted to that subject, and more complete explanation of the employment of the various discs will be met with in the descriptions of the several defects to which they are applicable.

For testing V the use is universal of a series of various sized letters based upon scientific measurements which are commonly called distance test cards. The largest letter is marked 200, the next is 120, and then 80, 60, 40, 30, 20. These numbers represent the distance at which the letters should be read in feet, and at which they can be read if the eyes be normal. The card was originally devised by Snellen according to the angle under which the smallest object is discernible. The angle formed by drawing lines from the extremities of these letters to the nodal point is exactly the same with each sized letter (as in Fig. 30). Therefore, if line No. 20 is legible at 20 feet, the line No. 200 must be visible at 200 feet, and *vice versa*. The letters are formed in square blocks of the proper size, according to distance, and each division or arm of any letter is just one-fifth of the whole. A great improvement on the original card is the addition of lines Nos. 15 and 10, legible respectively at 15 feet and 10 feet.

The smallest object visible to the average eye is one that subtends at the nodal point an angle of 5', the parts of the object being not less than one-fifth the size of the whole subtending an angle of 1'.

To test V, the customer must be comfortably seated, so that his face is 20 feet from the distant test card, which should be fixed on the wall, so that a good light falls on it, and avoiding, if possible, the light falling upon the face of the customer, let it come over his shoulder. Put on the trial frame and cover the eye nearer to you with the disc, and ask which is the smallest line legible, or make him read from the largest line to the smallest he can. When you know the extent of his visual power for the one eye, note it, and move the disc to the one further from you, and find out and record the vision of the other eye.

The visual acuteness is recorded in this way. If the person read the 20-foot line, his $V = \frac{20}{20}$; if he could not read that line, but only something larger, his $V = \frac{20}{40}$, or $\frac{20}{70}$ of whatever it might be. The numerator of the fraction is the distance at which the test is made, and the smallest line read is the denominator. This fraction is not reduced. Sometimes $V = \frac{20}{15}$, or even $\frac{20}{10}$, that is to say, that the visual acuteness is better than the average, this occurs usually with young people; but if $V = \frac{20}{20}$ it is up to the average, and must be considered normal. In old people $V = \frac{20}{30}$, or $\frac{20}{40}$, must be taken as normal.

The letters O.D.—oculus dester—are used for the right eye, and O.S. -oculus sinister—for the left eye ; so in a given case you would record

O.D. $V = \frac{20}{40}$.
O.S. $V = \frac{20}{20}$.

When a line is very clearly seen it might be recorded also with a + sign, or, if only partly distinguishable, with a - sign. Thus, O.D. $V = +\frac{20}{20}$; O.S. $V = \frac{20}{40}$.

If, as in the above, the one eye be found better than the other, test the better one first, but if both be about equal test the one nearer to you. Do not cover the one eye with your fingers or allow the customer to do so, as it influences the sight by the pressure on the globe ; use the translucent or opaque disc. If the sight be so defective that the card itself is not visible, let the customer approach until it can be seen and record the V as, say, $\frac{5}{200}$, he reading the 200-foot line only at 5 feet, but he must be returned to the 20-foot distance if his sight is by lenses to be made better to any reasonable extent. If V be very defective, instead of using the card let the patient count your fingers as far away as possible, say this be one foot, then his $V = \frac{1}{200}$, your fingers taking the place of the largest letter on the card. If he can only see movements of the hand, it might be so recorded, or only perception of light—P.L.—or V might be *nil*—that is absolute blindness.

If the room or store cannot possibly permit of a 20-foot test, but, say, only 15 feet, then the V is recorded as—$\frac{15}{15}$, or $\frac{15}{10}$, as the case might be. It is, however, very much better to make the test at 20 feet, as at that distance the rays of light from the test card are parallel.

Some test cards are marked in metres 60, 36, 24, 18, 12, 9, 6, 4.50, 3. As 6 metres are equivalent to 20 feet, then normal V is that of $\frac{6}{6}$. Scientifically, and for means of calculation, the metric system is the better one, but I shall use the inch system of measurement in this book, as I think the majority of people are so much more conversant with it.

The refraction of the eye, apart from the accommodation, is tested at 20 feet, because at this distance no accommodation is, or rather should be, exerted, and convergence also is at rest.

The accommodation is tested at the P.P., or, more generally, at the reading distance. This is, in the great majority of people, 16 inches, but a few short people might use a slightly closer point, and some tall people a rather further point. The natural distance of anyone is that found by placing the arms at right angles, the elbows being close to the sides. Of course, where there are visual defects a person might be using a shorter or a longer distance, but the right-angled arms form the natural distance.

The hand reading card is formed of variously sized type based on the principle similar to that of the distance card, that