ON

AN IMPROVED OPTOMETER

FOR ESTIMATING

THE DEGREE OF ASTIGMATISM

AND OTHER

ERRORS OF REFRACTION.

BY

JOHN TWEEDY, F.R.C.S. Eng.

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ON

AN IMPROVED OPTOMETER.

ABOUT nine years and a half ago I published a description of a cheap and simple form of optometer for estimating the degrees of astigmatism.[1] Since then at least one new method of ascertaining the existence of astigmatism and estimating its amount has been introduced, and many improvements have been effected in the older methods. The novel plan is that which was first employed by M. Cuignet of Lille, and is commonly called keratoscopy or retinoscopy.[2] The introduction of this method has had almost as great an influence upon ophthalmic practice as that of the ophthalmoscope itself. It is at once simple, certain, and *objective*, and in the majority of cases it is sufficiently precise. In young children it is almost the only avail-

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1 THE LANCET, Oct. 28th, 1876.

2 For an excellent account of so-called "retinoscopy," see article by Dr. Charnley, Royal London Ophthalmic Hospital Reports, vol. x., p. 344.

able plan. There are, however, some conditions in which it is less applicable—such as nebula, or leucoma, or irregularity of curvature of the cornea, small pupil, anterior or posterior synechia, uvea on the capsule of the crystalline lens, haziness of the lens itself or of the vitreous, or a darkly pigmented fundus. It is true that many of these disqualifications may be removed by the use of atropine or other mydriatic. But there are not a few objections to the indiscriminate employment of mydriatics for working out errors of refraction. The temporary abolition or embarrassment of the power of accommodation for some hours, or even days, is by no means the worst of these objections. At least two cases have lately come under my observation in which a solution of atropine applied to the eyes for the purpose of dilating the pupil in order to facilitate the estimation of hypermetropic astigmatism by retinoscopy very speedily gave rise to an outbreak of subacute glaucoma in both eyes. Even without this untoward experience, I have always, as far as possible, endeavoured to avoid using mydriatics for the purpose of estimating errors of refraction, but especially in hypermetropes in whom the tendency to glaucoma is greater. In all cases in which retinoscopy is difficult, or where great precision is desirable, other methods must be employed. Personally, I prefer Green's tests or my own optometer. With the latter I can in most cases obtain trustworthy results without the use of atropine, though in some instances the result is only approximately correct. But this objection applies to any other single plan or to any combination of plans. In difficult cases it is, therefore, always well to employ at least two different methods, each corrective or confirmatory of the other.

Though the optometer which I now employ is in principle the same as that which I originally described, I have from time to time introduced modifications calculated to increase its efficiency. These modifications have, however, never been formally described, but have been for the most part suggested to various opticians and instrument-makers, who, wishing to copy the optometer, have asked me for information about the working out of some of the details.

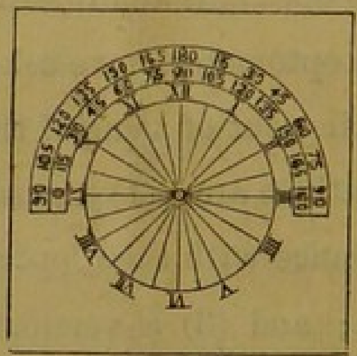
The chief modifications are—(1) a graduation of the horizontal bar, in accordance with the dioptrical system; (2) an improved dial card; and (3) a vertical bar of adjustable cylindrical lenses. These may be more particularly but briefly described.

(1) Since the year 1879 the horizontal bar has been divided on its upper surface not only into inches and tenths, but also into *focal lengths* of dioptrical lenses and quarters, from three dioptres to forty. These focal lengths I call *dioptrostadia.*

(2) The radiating lines on the dial card are indicated not only by the Roman numerals I. to XII., but also by a double row of Arabic numbers. Each number of the lower

row records the angle which the corresponding line makes with the horizon, beginning from the left; and each number of the upper row serves the twofold purpose of indicating—first, the line which is at right angles to its fellow in the lower row; and, second, the position of the axis of the correcting cylindrical lens. (Fig. 1, and Fig. 2, *j.*)[3] For example, the line at right angles to 135°, running from between I. and II., is seen to be 45°, which will be found to run from between X. and XI. As the two principal

FIG. 1.



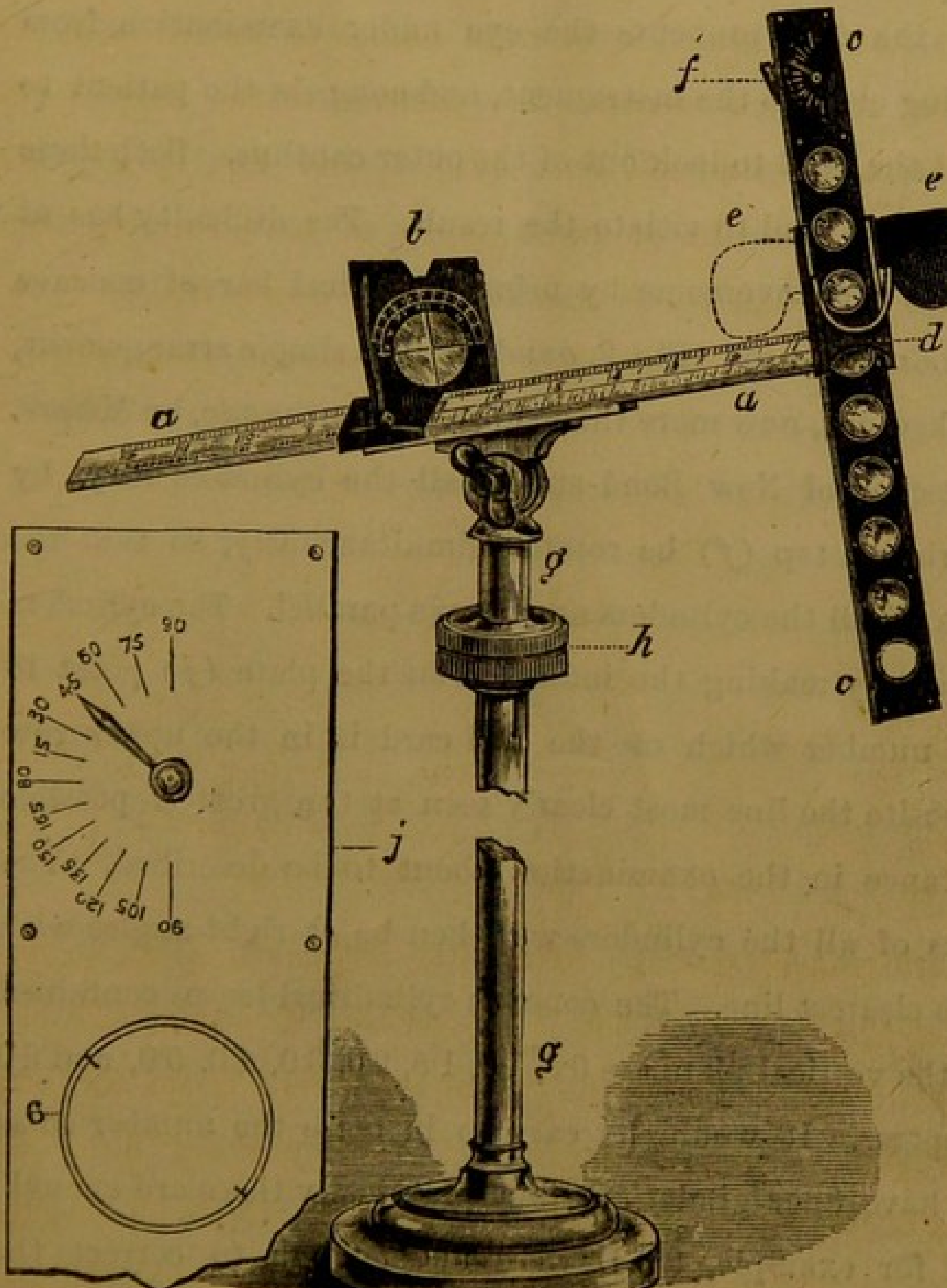
Reduced rather more than one-half.

meridians of the eye in regular astigmatism are at right angles with each other, it follows that if the line 135° be in one principal meridian, the line 45° will be in the other principal meridian, and so for every other line. The radiating lines may be fine and of equal thickness throughout, or, preferably, they may gradually increase in thickness

[3] Optometers containing most of the improvements in the marking of the bar and in the card were, I believe, first made by Messrs. Pickard and Curry, of Great Portland-street, about six years ago.

from the centre to the periphery, as in one of Green's astigmatic disks.

FIG. 2.



(3) I have always recognised the advantage of having cylindrical lenses affixed to the instrument, but for a long time

there seemed no way of carrying this into effect except by a disk like that on Javal's original optometer. To any such arrangement I have always objected, chiefly for the reason that the disk prevents the eye under examination from getting close to the instrument, and compels the patient to twist the head to look out of the outer canthus. Both these conditions tend to vitiate the result. The difficulty has at length been overcome by using a vertical bar of concave cylindrical lenses. (Fig. 2, *c* and *j*.) By a simple arrangement, worked out, now more than eighteen months ago, by Messrs. Pillischer of New Bond-street, all the cylinders may, by turning a tap (*f*) be rotated simultaneously, so that the axes of all the cylinders are always parallel. The cylinders are set by making the indicator on the plate (*j*) point to the number which on the dial card is in the upper row opposite the line most clearly seen at the greatest possible distance in the examination about to be described. The axes of all the cylinders will then be at right angles with this clearest line. The concave cylindrical lenses contained in the vertical plate are 0·5, 1·0, 1·5, 2·0, 3·0, 4·0, 5·0, and 6·0 dioptres. It would be easy to increase the number so as to have finer gradations, but practically these are enough. If, for example, 2·0 D were not enough to correct the astigmatism, while 3·0 D over-corrected, it is clear that 2·5 D would be within 0·25, or $\frac{1}{160}$th of an inch of perfect correction.

The optometer should be used in the following way:
1. A convex lens having been slipped into the clip at *d*, in order to make the eye about to be examined artificially short-sighted, the eye is placed as close as possible to this lens and made to look, with head erect, straight through its centre at the dial card beyond on the plate (*b*). (See also Fig. 1.) The lens (myopising lens) which will be required will vary with the refraction of the eye. It is best to select a lens which brings the far point to about 8 in., or 5 *dioptrostadia* from the eye. In hypermetropia 8 D to 12 D, or even more, may be required; in myopia 1 D to 3 D may suffice; and in high degrees of myopia—that is, more than M=8 D—no lens will be needed. The opposite eye should be excluded by the screen (*e*). The height is adjusted by means of the telescopic stem (*g*) and the screw collar (*h*).

2. The dial plate (*b*), placed at first beyond the point of distinct vision, is slowly approximated to the eye until at least one of the radiating lines is seen *clearly and distinctly* throughout its whole length. After this the plate should not be moved, and its distance from the eye should be noted in dioptrostads (δ). Under the circumstances the line is seen at the greatest distance from the eye, and therefore in the principal meridian of *least curvature*.

If *all* the radiating lines come into view with equal clearness at the same greatest distance, there is no astigmatism; but if *one or two* lines be clearly seen, while the others, and especially those at right angles to them, are blurred, there is astigmatism, which may be corrected by placing a suitable concave cylindrical lens in front of the eye, with its axis at right angles to the clearest lines. The suitable lens is the weakest which makes all the lines equally clear. This is ascertained by sliding the vertical bar of cylindrical lenses, properly adjusted, in the groove at *d*, till correction is accomplished. The weakest cylinder that will do this represents the *amount* of astigmatism.

This completes the examination. It only remains to interpret the results.

1. As already stated, if *all* the radiating lines come into view at the same greatest distance there is no astigmatism.

(*a*) If the greatest distance in dioptrostads (δ) equals the number of dioptres (D) in the myopising lens, there also is no other error of refraction: $D = \delta$.

(*b*) If the greatest distance have *fewer* dioptrostads than there are dioptres in the myopising lens, there is hypermetropia equal to the difference between the two: $H = D - \delta$. For example: If D have 8 dioptres and δ 5 dioptrostads, then the hypermetropia will be $8 - 5$, or 3 D, and the patient will require a correcting lens of this strength.

(*c*) If the greatest distance have *more* dioptrostads than there are dioptres in the myopising lens, there is myopia equal to the difference between the two: $M = D - \delta$. If D be 5 dioptres and δ be 8 dioptrostads, M = 5 - 8, or - 3.D; and the patient will need a concave lens of this strength.

2. If only *one line or two lines* are clearly seen at the greatest distance, there is astigmatism. The refraction of the meridians in which these lines are seen will depend upon whether the distance at which they are seen be *beyond* or *within* the focal length of the myopising lens, as shown above; $x = D - \delta$.

(*a*) The astigmatism is, as already stated, represented by the *weakest* concave cylindrical lens which set at right angles to the clearest line makes all the lines clear.

(*b*) The correcting lens for distance will be the combination of the spherical lens found by the above formulæ and the weakest concave cylinder which corrects the astigmatism. If $D = \delta$, no spherical lens will be needed, and the cylindrical lens alone will suffice; if D be greater than δ, a convex spherical lens will be needed in addition; and if D be less than δ, a concave spherical lens.

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