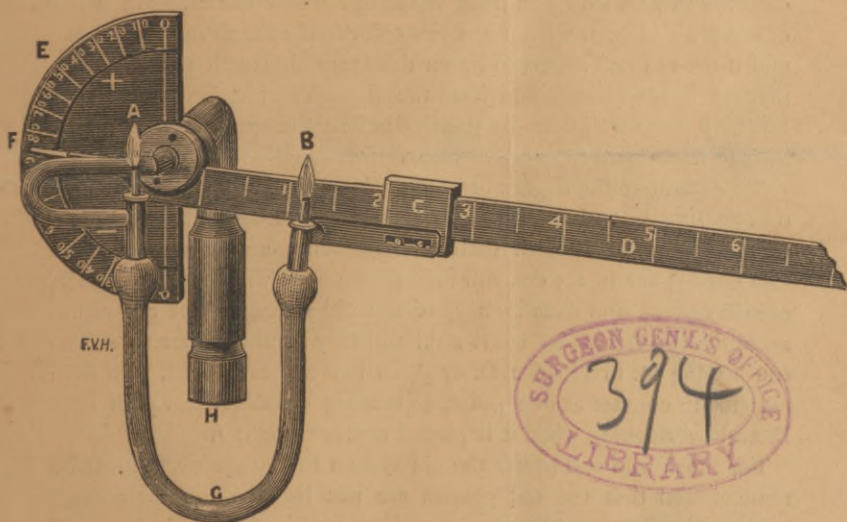


Dr. Otis W. A.
April 8, 1879.

A PRACTICAL AND RAPID METHOD, WITH AN INSTRUMENT, FOR THE DIAGNOSIS OF THE REFRACTION. By WM. THOMSON, M.D., Philadelphia.

THE method which I have the honor to submit to your notice, and the instrument which I venture to call an Ametrometer, are intended to enable us to recognize promptly the presence of ametropia and determine its degree without the aid of test-types or test-glasses, the empirical use of which is attended by such serious expenditure of time. The full and entire paralysis of the accommodation with atropia is essential in this as in every other exact study of the refraction. The instrument is shown in the woodcut, and consists of



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a small fixed gas-jet A, a second one B, attached to a box C, which slides upon a bar D, the jets connected by a flexible rubber tube G; the end of the bar F forms a pointer, which, by elevating or depressing the other end of the bar, can be placed at any part of the graduated half-circle E, which is fixed firmly to the thimble H, by which means the entire instrument can be attached to a common gas-burner, and the lights regulated by its stop-cock. We have here a

portable and simple instrument, giving one fixed light A, and a second B, which can be placed at our pleasure in contact or at any distance from the first, depending on the length of the bar, which is 30 cm., and at any possible angle with it, by moving the bar on a pivot opposite to the light A.

The jets having been lighted and turned down into two small flames about 5 mm. in diameter, the patient, placed 5 metres away, is directed to observe the flames, and to say whether he sees them as small points of light separated, or as diffused, enlarged circles which can be made to come in contact at their margins by sliding movements of the box on the bar, by the hand of the surgeon; bearing in mind that an emmetropic or corrected ametropic eye will resolve the lights into two until they pass one behind the other and become fused, whilst in ametropia the circles will seem to touch; whilst a distance, depending upon the degree of ametropia, remains between the small light points. To determine the kind of ametropia, the patient is directed to pass slowly in front of the eye under examination a slip of red glass in such a manner as to color half of each diffused circle, and if the red half seems to be on the same side with the red glass, myopia is recognized, and if on the opposite side, hypermetropia; this may be as well done by passing before the eye a card or paper in such manner as to exclude from view one-half of each circle.

To determine the degree of ametropia, the bar has been divided on one side into spaces of 2.5 cm. with a half-space between, and on the other into English inch and half-inches, and it will be found that each space of 2.5 cm. will indicate an ametropia of one dioptric, metric system, and each inch $\frac{1}{36}$ of the old system. The cut represents the two flames as apart 2 d., and they would appear to a person having M. or H. of 2 D. or $\frac{1}{36}$ as two circles of light, with their margins in contact at one point, separating on the removal of light B, and overlapping when it is placed nearer to light A.

For those who still prefer the old system to the metric, it must be remembered that the old glasses are not based upon their exact powers of refraction, but are ground on *radii* of Paris inches, and that, owing to the index of refraction of the glass commonly used, they by a happy chance correspond in focal length almost exactly with the English inch; hence, each inch of distance between the test-lights, as determined by the use of the inch scale on the bar, will indicate an ametropia of very nearly $\frac{1}{36}$; and the higher degrees can be found instantly by dividing 36 by the number of inches between the lights when their margins seem to have come into contact.

When astigmatism is suspected, the patient should be directed to observe whether the flames are longer in one direction than the other, and if so, by the rotation of the bar on a pivot opposite to light A, the two lights being placed some distance apart so that they do not appear to touch, we have one of the most accurate means of ascertaining the meridians of greatest and least refraction, since it will become easy for the patient to say when two elongated points or ovals of light are placed so as to have the same direction; and when this has been fixed, the pointer F will indicate on the half-circle the exact angle at which the lights are placed, and hence the position of the meridian of greatest ametropia.

On bringing the flames into contact at this angle, the real distance of the lights apart will indicate the degree of ametropia, and having thus found one meridian, the lights can be placed at right angles to it and the refraction of the second be ascertained. In difficult cases, or with poor observers, it may be an aid both in simple M. or H. and A. to color one of the flames by placing a slip of red glass in front of it, held by the surgeon.

Some experience in the correction of ametropia enables me to know how convenient it is to have more than one method of examination, and great care has been taken to perfect and simplify the method now proposed, in the hope that it might take the place of a rapid and accurate method of diagnosis, and thus greatly extend the benefits of careful corrections of ametropia.

For obvious reasons, based upon the rationale which follows, a distance of 5 m. between the patient and the instrument has been assumed, but others may be chosen; neither is it at all requisite to have so perfect an instrument, since examinations can be made with wax tapers or other small points of light, or they may be obtained at will from properly chosen reflecting surfaces.

To understand the method proposed, and make the best practical use of it, it must be remembered that an emmetropic eye only when at rest can receive on the sensitive portion of its retina a perfect image of a small light point placed at or beyond 5 m., and that it brings to a perfect focus on its retina rays of light only that are parallel; when the retina lies beyond this point, as in M., or within it as in H., a section of a cone of light must replace the point on the retina; and could the size of this circle of diffusion be measured clinically, the distance from the base of the cone to its apex, whether in front or behind the retina, could be calculated, and hence the degree of M. or H.

To estimate the size of this circle of diffusion the law of *projection* has been invoked, and by the method proposed, the dimensions of one are found by placing two circles on the observer's retina, choosing a fixed known distance between the patient and the test-lights, and measuring the real distance between the lights when their diffused images touch on the patient's retina, and appear to be in contact in space in front of him. Clinically this can be done by this instrument, the theoretical reasons being as follows :

Since all calculations based upon the optical constants of the human eye, composed of two complete and complicated dioptric systems, are and must be difficult to demonstrate, we have the highest authority for these purposes, for adopting the well-known simplified and reduced diagrammatic eye of Prof. Donders, consisting of but one curved surface of 5 mm. radius, a coefficient of refraction of $\frac{4}{3}$, a posterior focus of 20 mm., and anterior focus 15 mm.; since it is conceded that from these cardinal points by calculations we can trace any ray of light, ascertain conjugate foci, estimate the size of retinal images, etc., with confidence that the results will agree with those phenomena which occur in the human eye under like circumstances. As a consequence of clinical and theoretical study with this method, I venture to propose another to the constants of Donders' eye, in the diameter of its pupil, viz., 5 mm.

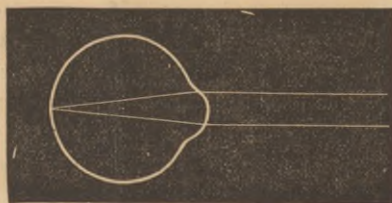


FIG. 1.—Donders' eye, showing the course of a beam of light arising from a distant point.

Finding within Donders' eye, a fixed quantity in the triangle of 20 mm. radius and 5 mm. sine or arc, we are justified in choosing a second one outside of it for purposes of comparison, and this is afforded by one of 5 m. radius, and arc of 125 cm. Could we regard the sides of the long beam of light in this figure as rigid wires 5 m. long, passed through holes in a metal cornea 5 mm. apart, and brought to an apex 20 mm. from it, we would have the outlines of a mechanical tool, like a pair of pincers, with the long handles without and the jaws within the eye; it would be evident that any separation of the ends of the wires

anteriorly would put asunder the posterior ends and imitate a circle of retinal diffusion; also that the wires would either diverge or converge at a distance from the cornea depending on the anterior separation; hence, any change in the arc of the large angle must produce changes in both angles, and finally that any separation of the two wires at the distant point would resemble the enlargement of a small light as seen by an ametropic eye.

The possibilities as to size of a circle of diffusion when projected, would be any diameter between 5 mm. and 125 cm., since, if the two wires were made to cross at the anterior focus of Donders' eye 15 mm., their distant points would be apart 125 cm. and the two points within the eye would be apart 5 mm.; the similarity of the large and small angles being assumed as the basis for these hypotheses.

The apparent enlargement of a small distant point of light to an ametrope metaphorically resembles the separation of the two wires anterior to the eye, whilst the divergence at the points within the eye is like the circle of diffusion which falls on the ametrope's retina. The directions of the anterior wires, whether they diverge from the cornea and if continued backwards would meet behind the retina, or converge in front and cross at some point, give us the direction of the rays of light in H. or M., and the distance from the eye to such points of junction would be the *punctum remotum*.

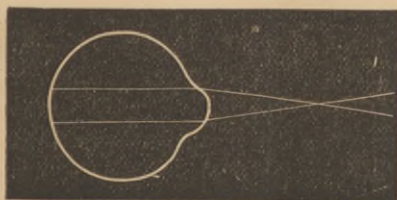


FIG. 2.

The convergence of the wires at a distance of 15 mm., the anterior focus of Donders' eye, resembles a M. of that degree, and would render parallel the jaws within, separate the ends 5 mm., and be attended by a separation of the anterior extremities of 125 cm., vide fig. 2.

Assuming that a small light at 5 m. is focussed on the retina of Donders' eye, let us reason upon the results of a condition of M. artificially produced by a + glass giving a *punctum remotum* of 25 cm.: the image of the light would now be a circle of diffusion, which would diminish as the light point was brought near, and come to a

focus when it reached a distance of 25 cm. or about 10", and the rays had become divergent. We may now say as 250 mm. the length of the induced radius : 5000 mm. the length of the large radius :: 5 mm., the arc of small angle : the answer, being 100 mm. ; and hence we find by calculation that the circle of diffusion should appear by projection to be 100 mm., or 4" in diameter. It will also be observed that if an ametropia with *p. r.* of 25 cm. gives rise to a circle of 10 cm., in like manner a *p. r.* of 100 cm. or 1 meter would cause a circle of 2.5 cm., and hence indicate an ametropia of precisely 1. dioptric.

Having thus demonstrated the probable diameter of a diffused circle as projected with an induced known ametropia, we can by reversing the process discover the very essence of ametropia viz., the *punctum remotum* of a myopic or hypermetropic eye by measuring the projected circle of diffusion at the fixed distance of the radius of the large angle, viz., 5 m.

Two lights now become essential, and when their diffused circles seem to be brought in contact, the distance between the lights will give the diameter as projected of either of the circles ; and should the distance, for example, be 5 cm., what then is the *punctum remotum*, and hence, the degree of ametropia? We may then say as 50 mm. : 5 mm. :: 5000 mm., and multiplying the second and third terms together and dividing by the first, we find 500 mm. as the *punctum remotum*, and ametropia = 50 cm., or to glass = 2 D., or $\frac{1}{18}$.

It is now evident that this method simply enables a circle of diffusion to be measured clinically, and that a comprehension of Donders' eye gives a simple rule as follows : *Rule.*—Multiply the radius of the large angle by the arc of the small one and divide by the diameter of the circle as found by observation, and the result will be the *punctum remotum* positive + or negative —, and hence the degree of either M. or H., and the power to select glasses + or — spherical or cylindric which will restore the eye to emmetropia.

To permit the use of the English instead of the metric system, the following are the constants of Donders' eye in inches : radius of curvature 0.2", anterior focus 0.6", posterior focus 0.8"—and for this method, size of pupil 0.2", radius of large angle 200" or $16\frac{2}{3}$ feet, arc 50". A single case will illustrate the process of reasoning : C. is found to be myopic, and the lights are apart 5" when their circles touch ; we then say 5" are to 200", the long radius, as 0.2" arc small angle to the radius of desired angle. We now multiply 200 by 0.2 = 40.0 and divide by 5" and we have 8" as the result, and the *punc-*

tum remotum—or an ametropia to be corrected by $-\frac{1}{3}$, or more accurately $-\frac{1}{4}$ placed $\frac{1}{2}$ " in front of cornea, which glass will render parallel rays which diverge from a point 8" away.

Since algebraical formulæ are sometimes passed over by the reader without due interpretation, they have been avoided and the process reduced to the more familiar arithmetical law of simple proportion. With either the metric or the inch system the calculation for the glass required is too simple to need a table, since a separation of the test-lights of 2.5 cm. or 1" will indicate either 1 dioptric or $\frac{1}{36}$.

In using for this demonstration the reduced eye of our great master Donders, we but pay a new tribute to his genius and industry, which leave so little for his followers to glean in the field of applied optics which he has cultivated so well; and it is not the least interesting result of the numerous clinical observations made with the instrument here described, that we can venture to propose to the distinguished author of the "Accommodation and Refraction of the Eye," a fixed quantity for the pupil of his reduced eye, which so well represents the properties of the complicated human organ, but simplifies all its optical problems in so wonderful a manner.

The practical use of the instrument has been recently tested in the examination of a number of deaf-mutes, one needing $+3 \text{ } \textcircled{C} + 4^{\circ}$, another $-4 \text{ } \textcircled{C} - 3.5^{\circ}$ corrected to $\sqrt{\frac{1}{3}}$, without the very tedious use of glasses aided by the ophthalmoscope; and in a case of aphakia needing 11 D. corrected in a few minutes, and a high myopia brought to $\sqrt{\frac{50}{225}}$ by -15 D. with a very short examination.

