Another point to which the motion of a visible body within the eyeball may be referred is the bright image of the flame as seen reflected at the front of the cornea. This bright reflex is always seen at the point on the cornea which lies nearest to the eye of the observer, and affords, therefore, an approximately fixed point of reference.

Still holding the mirror at a distance of about 20 cm. from the observed eye, it may happen that we obtain a distinct view of the details of some part of its fundus. This can occur only in myopia of a very high grade, in which the observed eye forms an inverted image of its fundus at some point within a few inches of its cornea, or in a somewhat high grade of hypermetropia. In such a case we may make a slight rotary movement of the handle of the mirror, and so change the position of the image of the flame at the fundus; as this image passes across the field of view in the direction in which the mirror is turned, its inverted image, in front of the eye (in myopia), will move across the pupil, in the opposite direction; in hypermetropia the movement of the virtual image of the flame will be in the direction in which the mirror is rotated. If, while looking at the inverted image, we bring the mirror nearer to the eye, we presently reach a point at which the details of the picture are lost. We next advance the mirror to the usual position for the observation of the fundus in the erect image, about 5 cm. from the observed eye (Figs. 3673 and 3676). At this short distance the field of view is much enlarged (see Figs. 3651, 3652, and 3654; *cf.* Fig. 3653), and the conditions are at the best for the detection and observation of fixed or floating opacities lying deep in the vitreous, as well as for the observation of a detached retina, or a tumor growing from the fundus. It may also happen that on approaching the observed eye the details of its fundus are seen sharply defined, indicating the presence of hypermetropia of a grade in excess of the power of the convex glass behind the hole in the mirror. In such a case we may at once measure the degree of hypermetropia, by bringing progressively stronger convex glasses into position behind the mirror. If, on approaching the eye, the details of the fundus are not seen, or are seen but indistinctly, through the convex glass of 5 dioptries, we may change to successively weaker convex glasses, or to concave glasses of progressively increasing power, until, by noting the particular glass which first affords a perfectly distinct view, we have obtained a definite measurement of the refraction. If, in the course of successive observations with glasses of different power, we at first get a distinct view of only such of the retinal vessels as correspond in direction to one of the ocular meridians, and with some other glass we obtain an equally distinct view of the vessels corresponding in direction to the meridian at right angles to the former, we have both established the presence of regular astigmatism and obtained the data for the determination of its type and the measurement of its grade. If, as sometimes happens, we see the same vessels, or parts of vessels, under different degrees of definition, according as we view them through different parts of the cornea, we have to do with a case of irregular refraction (irregular astigmatism) dependent probably upon some irregularity in the contour of the cornea. In such a case the bright reflex from the cornea may show variations in size and in shape, dependent on differences in the contour of the reflecting surface. In keratoconus (conical cornea), of even low grades, the distortion of the retinal picture and the changes in the form and size of the corneal reflex are especially characteristic.

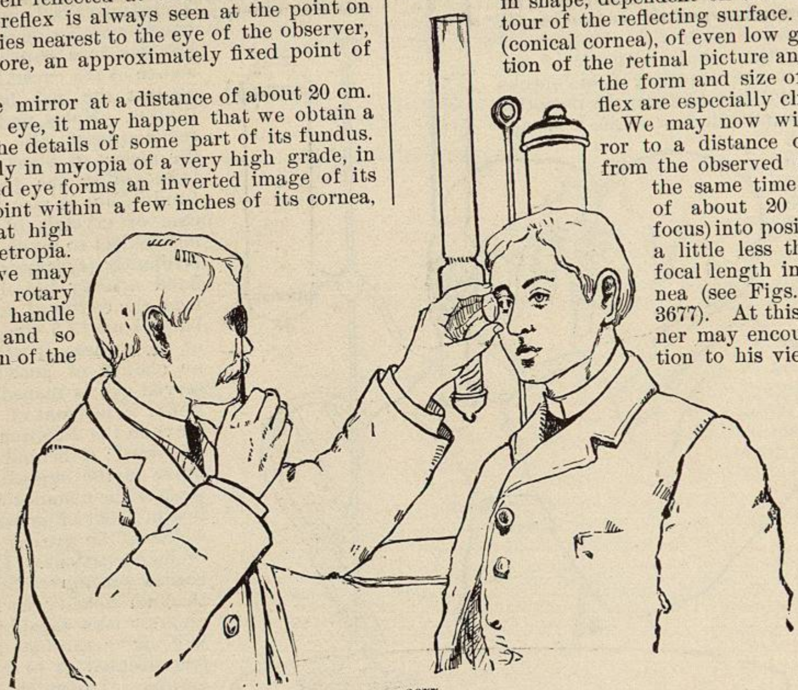


FIG. 3677.

We may now withdraw the mirror to a distance of about 40 cm. from the observed eye, bringing at the same time the convex lens of about 20 dioptries (5 cm. focus) into position at a distance a little less than its principal focal length in front of the cornea (see Figs. 3672, 3674, and 3677). At this stage the beginner may encounter an obstruction to his view of the interior of the eye arising from the bright reflex images of the flame or mirror formed by the two surfaces of the convex lens, the one virtual, behind the lens, the other real, in front of the lens. When the lens is held exactly concentric with, and at right angles to, a line connecting the pupils of the observing and the observed eye, the two reflex images lie also in this line, and may thus completely cut off the view into the eye. Both images are, however, easily got out of the way, either by moving the convex lens a little to one side, or by slightly rotating the lens so as to displace the two images in opposite directions. The strong convex lens, held at somewhat less than its focal distance in front of the eye, considerably magnifies a spot in the cornea, or in the field of the pupil, as seen from behind the hole in the mirror, and the conditions are favorable, generally, to the inspection of these parts

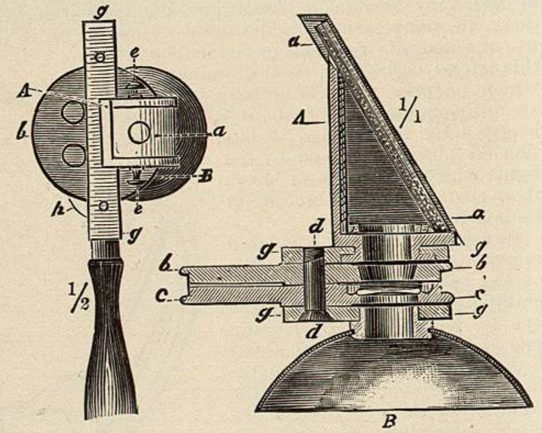


FIG. 3678.

of the eye. We may next turn our attention to the details of the fundus as seen in the inverted image, at about the position of the anterior principal focus of the convex lens, looking at it, for reasons already given, through the

convex glass of about 5 dioptries (20 cm. focus), placed behind the hole in the mirror. Having got rid of the two reflex images formed by the convex lens, either by moving it a little to one side or by turning it a little obliquely to the line of sight, we may encounter a further obstacle in the reflex image formed by the anterior surface of the cornea. This will, however, give no serious trouble, except in the particular case in which the vertex of the cornea of the observed eye is directed exactly toward the hole in the mirror; a slight turning of the eye in any direction sufficing to displace the bright reflex from the central region of the pupil. Inasmuch as the inspection of the region of the macula involves the turning of the observed eye exactly in the direction of the eye of the observer, the indirect method is not favorable to obtaining a good view of this part of the fundus. Nevertheless, we may often succeed in eliminating much of the disturbance from the corneal reflex by making lateral movements of the convex lens in different directions.*

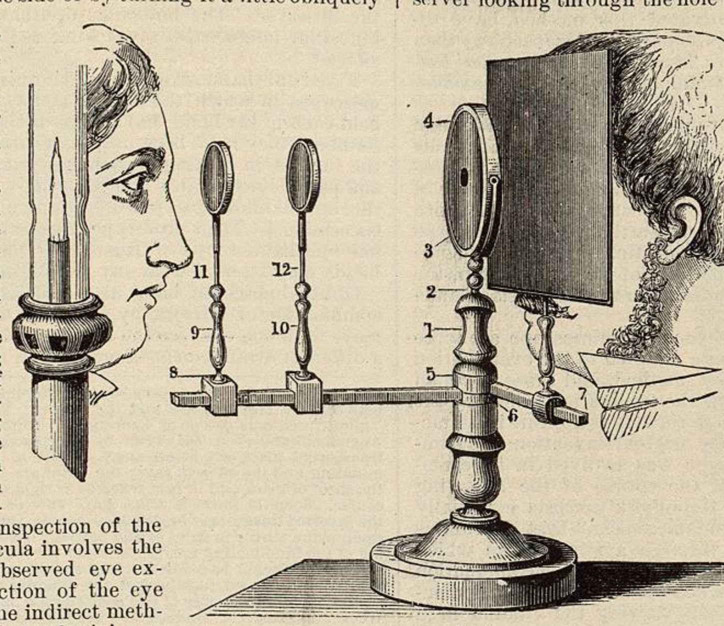


FIG. 3679.

It happens not infrequently that in moving the convex lens in a lateral direction a loop of a retinal blood-vessel appears to change in form. This is an effect of parallax, and is dependent on the fact that, by the lateral movement of the lens, the line of sight is considerably deflected, so that we see the vessel as from a different point of view. A loop of a retinal artery or vein, lying in a plane perpendicular to the general surface of the fundus, may thus appear as a straight line when viewed directly from in front, but will show something of its actual curvature when viewed from either side; the amount of the apparent curvature depending on the actual height of the loop and the extent of the lateral excursions of the lens.

For the inspection of the fundus generally, in the inverted image, including the disc of the optic nerve, the conditions are altogether favorable. To see the optic disc, which is situated to the nasal side of and a little below the posterior pole of the eye, the patient must turn his eye in the same direction, which he will most easily and surely accomplish by looking a little to the temporal side and slightly downward with the eye not under examination. To obtain a view of the peripheral regions of the fundus, the patient must turn his eye in the direction corresponding to the part to be examined, the details of which, as seen in the inverted image, will appear to move in the same direction.

If the concave ophthalmoscopic mirror is taken of very long focus (about 75 cm.), and held at a distance from the lamp and from the observed eye about equal to its radius of curvature (1.5 metres), the illuminating flame and the observed eye will be nearly at conjugate foci of the mirror, and the pupil of the latter will appear strongly illuminated. If, now, the observed eye is myopic in any degree in excess of one dioptrie, it will form an inverted aërial image of its fundus at a distance of 1 metre or less and some details of this image will be visible to an observer looking through the hole in the mirror. Inasmuch as, at the great distance of the mirror, the visible portion of the fundus is very small, the patient may have to turn his eye slightly in different directions in order to bring one of the retinal vessels into view. The observer looking through a convex lens of 5 dioptries (20 cm. focus), placed behind the hole in the mirror, may calculate pretty accurately the distance of the image from the observed eye by noting the distance at which he sees the blood-vessel sharply defined. In simple myopic astigmatism (Am) and in mixed astigmatism (Amh or Ahm), only those retinal vessels whose direction is approximately at right angles to the principal ocular meridian of greatest refraction are visible in the inverted image; in hypermetropia (H), and in simple or compound hypermetropic astigmatism (Ah or H + Ah), the image is virtual, and the method is inapplicable.[1]

A plane mirror, at the distance of 1 metre, gives but a very small image of the flame at the fundus, and the field of view is also very small (see Fig. 3653). Neglecting entirely the details of the fundus, and regarding only the image of the flame, the distinction between hypermetropia and myopia may be made by simply observing the direction in which the image appears to move when the direction of the illuminating beam is changed by slightly rotating the mirror. This test turns on the fact that in hypermetropia the image which we see is virtual, and is situated behind the observed eye, while in myopia it is a real image, and is situated in front of the observed eye. Hence, in hypermetropia the image is seen to move into, across, and out of the field of view in the direction in which the (plane) mirror is rotated; in myopia the apparent movement is in the opposite direction. As the details of the image are disregarded, it is unnecessary to use a correcting glass behind the mirror, unless it be needed to correct a very high grade of ametropia in the eye of the ob-

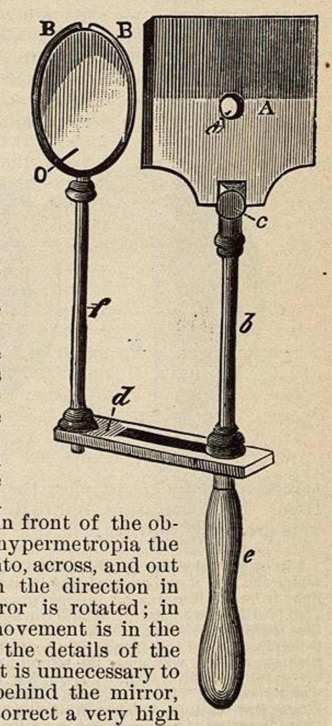


FIG. 3680.

* The geometrical axis of the cornea does not exactly coincide with the line of sight, the latter cutting the cornea a little to the nasal side of its vertex. Hence the corneal reflex does not, as a rule, exactly cover the image of the fovea. The angle which the axis of the cornea makes to the line of sight is known as the angle α (Donders): it is greatest in hypermetropic eyes, and least, sometimes even negative, in myopic eyes.

server. In this test it amounts practically to the same thing whether we speak of the movements of the bright image, or of the border of the unilluminated area surrounding it. It happens, however, that the writers who have especially cultivated this method have directed attention rather to the dark border (shadow) than to the image of the flame; hence the name, *shadow-test*, by which this method is commonly designated (see *Shadow-Test*).

As a rule, an eye under ophthalmoscopic examination relaxes its accommodation. Hence measurements made with the ophthalmoscope not infrequently show a somewhat higher grade of hypermetropia, or lower grade of myopia, than is revealed by subjective tests made with test letters without the resort to artificial mydriasis. In the case of certain careless or obstinate patients, of some illiterate persons, and especially of young children, the ophthalmoscope is indispensable in the diagnosis of ametropia in all its forms.

Two principal types of the ophthalmoscope are to be distinguished, namely, those adapted to the examination of the fundus by the direct method, and those in which an inverted real image of the fundus is formed by the aid of a convex lens. The former type appears in a practically perfect form, in the original invention of Helmholtz (1851); the latter type was evolved in its essential features by Ruete, in the course of the following year. The invention of Helmholtz consists essentially in the discovery of the fundamental fact that the fundus can be seen by looking through a mirror from which light is reflected into the eye; Ruete, by the combination of a concave mirror and a convex lens or lenses, demonstrated the practicability of viewing the fundus in a strongly illuminated real image. Helmholtz, in turn, by a development of the experiment of Brücke (see Figs. 3659 to 3661), showed that it was possible to see the details of the fundus, in the inverted image, by direct illumination, and with no other apparatus than a screened lamp or candle and a convex lens. The subsequent development of the ophthalmoscope has been confined essentially to changes in details, and to modifications designed to facilitate certain special uses.

It is entirely practicable to illuminate the fundus by direct light, and view its reflected image in the mirror. Thus in the arrangement shown in Fig. 3651, it is possible, though less convenient, to place the lamp at L', and to view the image, as reflected on the mirror, from L. With the lamp (preferably a small electric incandescent bulb) at L or at L', it is possible for two observers, sta-

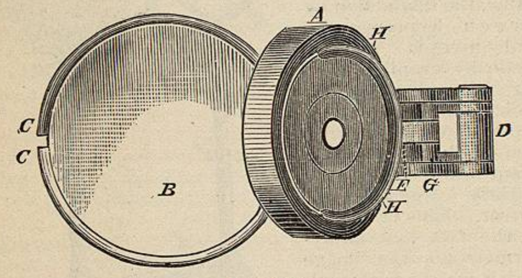


FIG. 3681.

tioned at L' and L, to view the fundus of O at the same time. Demonstrating ophthalmoscopes for two observers are based on this principle.*

Again, the efferent pencils emanating from different parts of the illuminated area at the fundus may be severally divided behind the mirror, so that each half, after two reflections, shall enter the corresponding eye of the observer. The binocular ophthalmoscope, like the binocular microscope, gives some degree of stereoscopic effect.*

Fixed ophthalmoscopes, as distinguished from ophthalmoscopes in which the mirror and the convex lens are held each in the hand, have been devised in considerable number; they have been used in measuring the details of the fundus, in making drawings of the fundus in normal and pathological states, and, especially, in demonstrating the ophthalmoscopic picture to a number of persons in succession.† Their prototype is to be found in the original ophthalmoscope of Ruete (Fig. 3679). The camera lucida may be used with any fixed ophthalmoscope.‡

Ophthalmoscopes have also been constructed with a combination of mirrors, by means of which an observer may, with one eye, see the fundus of his other eye. By a different arrangement of mirrors an image of the optic

* In every reflecting ophthalmoscope there are two points of view at which the eye of an observer may be stationed so as to receive rays of light from the illuminated fundus, namely, the usual and most favorable position immediately behind the mirror, and a less favorable position close by the side of the lamp. The use of an electric lamp makes it possible to see the details of the fundus from a station in its immediate vicinity whenever the efferent rays reflected from the mirror are parallel or divergent, as is ordinarily the case when a plane or a slightly convex mirror is used. With a concave mirror of a focal length less than its distance from the place of the inverted image, a twice inverted (*i.e.*, erect) image of the fundus may be seen at some point between the mirror and the lamp. A third point of view may be obtained by deflecting a part of the efferent rays at some point between the observed eye and the mirror. This is effected in the "ghost" ophthalmoscope of Laurence ("Klinische Monatsblätter für Augenheilkunde," S. 534, 1863) by interposing a sheet of polished transparent glass, set at an angle of 45°, in the path of the illuminating and the efferent rays; the latter are in part transmitted by the sheet of glass, and in part reflected at right angles to their original course. Some of the rays which have entered into the formation of the inverted image may be deflected to one side by reflection from a small plane mirror in front of and partially covering the central opening of the illuminating mirror; or some part of the same rays may be similarly deflected by a small reflector, preferably a totally reflecting right prism, placed just behind the illuminating mirror. Demonstrating ophthalmoscopes of this construction have been devised by De Wecker and Roger ("Bulletin de l'Académie des Sciences," 1870), and by Sichel *fils* (Annales d'Oculistique, 1872). By slightly separating the two totally reflecting glass rhombs in the binocular ophthalmoscope of Giraud-Teulon, and cutting them off square at their ends, an ophthalmoscope for three observers has been constructed (Monoyer: Revue médicale de Nancy, 1874); a fourth observer may see the fundus reflected on the illuminating mirror in the direction of the light.

* Coccius was probably the first to construct a binocular ophthalmoscope; a small perforated plane mirror, set, at an angle of 45°, behind the hole in the illuminating mirror, deflected a part of the efferent rays in a direction at right angles to the line of sight, and a second plane mirror, parallel to and about six 6 cm. distant from the other, reflected these rays into the second eye of the observer. The two retinal pictures were necessarily of unequal size, but notwithstanding this defect, the instrument is said to have given a somewhat better view than when but one eye was used (Snellen und Landolt; Graefe-Saemisch, "Handbuch der gesammten Augenheilkunde," iii., i., S. 160). The first binocular ophthalmoscope of good construction is that of Giraud-Teulon, in which the rays which have traversed the right half of the hole in the mirror are reflected to the right, and the other half to the left, and both are again reflected, at right angles, to enter the two eyes of the observer. All this is very simply accomplished by total reflection at the two obliquely cut ends of two rhombohedra of glass enclosed within a small metallic box behind the mirror (Annales d'Oculistique, xlv., 1861). By a slight change in the construction of this instrument, by Laurence and Heisch, it is made of a little lighter weight, although more fragile and more costly. A further modification, by Coccius, consists in the application of the principle of the common opera-glass, by which the image is seen considerably magnified (Report of the Fourth International Ophthalmological Congress, London, 1873). The latest change in this ophthalmoscope is by its inventor, who has notched the proximal ends of the two rhombohedra so as to make a small central opening, behind which he has placed a very small electric lamp, thus dispensing with the mirror (Giraud-Teulon: Annales d'Ocultistique, xcvi., December, 1886).

† Th. Ruete: "Der Augenspiegel und das Optometer," Göttingen, 1852. The Epkens-Donders ophthalmoscope (1853) is a fixed ophthalmoscope designed for the measurement of the details of the fundus as seen in the erect image. Ulrich (Henle und Pfeuffer's Zeitschrift für rationelle Medicin, 1853) combined the mirror and object lens in a short metal tube, to the side of which a candle was attached. Hasner (Prager Vierteljahrsschrift, 1855) made the tube longer and used a separate lamp. R. Liebreich (Archiv für Ophthalmologie, 1855) constructed his larger ophthalmoscope by mounting an instrument essentially like Hasner's upon a standard and fixing the head of the patient by means of a special rest. With this ophthalmoscope he made the elaborate colored representations of the fundus figured in his "Atlas der Ophthalmoscopie" (Berlin, 1863). Burke ("Ophthalmoscope réflecteur," Havre, 1871) constructed a fixed ophthalmoscope in which a second concave mirror, of 19 cm. focus, was substituted for the usual object lens in examinations by the indirect method. Carter (Report of the Fourth International Ophthalmological Congress, London, 1873) mounted the several parts of the ordinary hand ophthalmoscope, all on an enlarged scale and with correspondingly increased radii of curvature, upon separate standards resting on a table four feet long.

‡ The camera lucida was used with the Epkens-Donders ophthalmoscope and with the large ophthalmoscope of Liebreich: Noyes (Transactions of the American Ophthalmological Society, 1873) also applied it to the fixed ophthalmoscope of Carter.

disc is formed at the macula of the same eye. These are curiosities of ophthalmoscopy.*

The ophthalmoscopes which have won a permanent place in the armamentarium of the ophthalmic practitioner are all based directly upon the simple reflecting ophthalmoscope of Helmholtz and the compound ophthalmoscope of Ruete. A few typical forms must be briefly noticed.

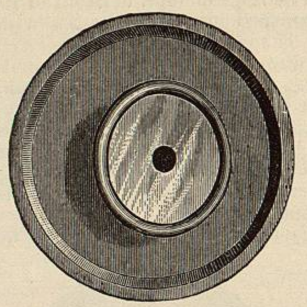


FIG. 3682.

The ophthalmoscope of Helmholtz (1851), perfected in some of its details by the instrument maker Rekoss, is shown in Fig. 3678. The two revolving discs, at the back of the mirror, have each five openings, in four of which are mounted concave glasses, giving twenty combinations ranging from – 3 dioptries to – 13 dioptries. The mirror, made up of three layers of very thin glass, is set at an angle of 56° to the plane of the revolving disc. The lamp is placed a little behind the plane of the observer's face, necessitating the use of a screen, to shade the observed eye from the direct light. The purpose of the concave glasses, in the two discs, is to permit the details of the fundus to be distinguished notwithstanding the presence of myopia of the observing or of the observed eye, and also to neutralize any disturbing effect arising from the possible exercise of the accommodation in either eye.[2]

The ophthalmoscope of Ruete (1852) consists of a perforated concave mirror and two vertical standards for holding lenses, all mounted in line on a fixed horizontal bar (Fig. 3679). With a convex lens of 4 cm. focus, mounted on the first standard at a distance of about 3 cm. in front of the cornea of the observed eye, an inverted image of its fundus, magnified about two and a half diameters, is formed about 4 cm. in front of the lens, and is viewed by the observer looking through the hole in the concave mirror. A second convex lens, mounted on the second standard at a distance somewhat beyond the position of the inverted image, affords the means of viewing this image under an increased amplification. A concave lens, mounted on one of the standards, is used in the examination by the direct method.[3]

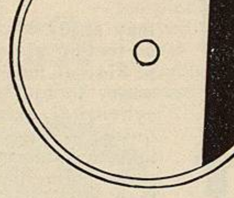


FIG. 3683.

Coccius (1853) attached a convex lens to a plane mirror in such a position that the illuminating rays pass through the lens before impinging upon the mirror (Fig. 3680). The conjoined effect of the convex lens and plane mirror is essentially that of a concave mirror.[4]

Ruete's fixed ophthalmoscope becomes an ordinary hand ophthalmoscope when the mirror and the convex lens are dismounted, and are held in the two hands of the observer.

Zehender (1854) substituted a convex mirror of 16 cm. radius of curvature for the plane mirror in the instrument of Coccius, thus making it possible to obtain from a single convex mirror the effect also of a plane, or of a concave, mirror (Fig. 3681).[5]

A convex mirror offers a slight theoretical advantage over a plane mirror, as does the latter over a concave mirror, in examinations by the direct method, and the instruments of Coccius and of Zehender have been special favorites with some excellent observers. They are, however, more difficult to manage than the concave mirror, and are at present but little used. In practice the perforated concave mirror of 23 cm. focus suffices for most examinations, whether by the indirect or the direct method; in a few special cases the polarizing plane mirror of Helmholtz maintains its superiority over all rival inventions.

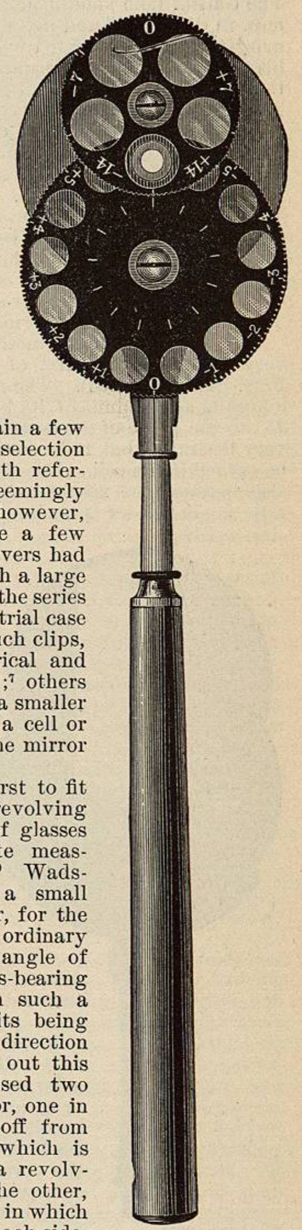


FIG. 3684.

The ophthalmoscope of Helmholtz, with the two Rekoss discs, includes all that is required for the convenient measurement of the refraction by the direct method, provided only that the discs are made larger, so as to contain a few more glasses, and that the selection of the glasses is made with reference to this use. This seemingly obvious development was, however, long deferred. Meanwhile a few exceptionally careful observers had ophthalmoscopes made with a large clip, to receive any one of the series of glasses in the oculist's trial case (Donders),[6] or with two such clips, intended to hold a spherical and a cylindrical glass (Noyes);[7] others contented themselves with a smaller series of glasses, fitted to a cell or small clip at the back of the mirror (Jaeger).[8]

Loring (1869) was the first to fit the ophthalmoscope with revolving discs containing a series of glasses sufficient for the accurate measurement of the refraction.[9] Wadsworth (1876) substituted a small mirror, of 15 mm. diameter, for the larger concave mirror in ordinary use, setting it at a fixed angle of 20° to the plane of the lens-bearing disc, and mounting it in such a manner as to admit of its being turned in any required direction (Fig. 3682).[10] Following out this suggestion, Loring devised two modifications of the mirror, one in which a segment is cut off from one side of the mirror, which is hinged at this border to a revolving setting (Fig. 3683); the other, the so-called tilting mirror, in which a segment is cut off from each side, and the mirror is swung on pivots at the two extremities of its vertical diameter (Fig. 3687).[11] The ophthalmoscope of Loring, as perfected by its inventor, is the type of a thoroughly good instrument for all practical uses; as made under his direction, by Mr. H. W. Hunter, of New York, it has not been surpassed as a model of good construction and fine workmanship.

* Helmholtz ("Beschreibung eines Augenspiegels," Berlin, 1851) described a simple method by which an observer may, by looking in a mirror, see the illuminated pupil of one of his own eyes with the other eye. Coccius ("Ueber Glaukom, Entzündung und die Autopsie mit dem Augenspiegel," Leipzig, 1859) devised an arrangement of light and mirror by which an eye may receive a defined picture of its own optic disc. Heymann ("Die Autoskopie des Auges," Leipzig, 1863) combined a perforated plane mirror, a reflecting prism, and three convex lenses in such a manner that with one eye a view is obtained of the fundus of the other eye in a twice-inverted (*i.e.*, erect) picture. Similar arrangements have been devised by Giraud-Teulon (Annales d'Oculistique, xlix., 1863) and by Coccius.

The essential points in the construction of a good ophthalmoscope are few and simple. The best material for the concave mirror is silvered glass, which should be very thin, in order that the margin of the central perforation may encroach as little as possible upon the effective area of the opening when the mirror is turned obliquely to the line of sight; any excess of thickness above 0.3 mm. is both unnecessary and injurious. The central hole should be about 3.5 mm. in diameter,* and its unpolished margin should be coated with a dull black pigment; the alternative expedient of removing the silvering from a small central area of the mirror is not to be commended. A mirror made of polished metal is more difficult to keep in order, and, unless in very perfect condition, reflects much less light than a mirror of silvered glass. The focal length of the mirror should be about 23 cm.; this is a convenient focal length for examinations by the indirect method, and in the direct method the effect is not very different from that of a plane mirror (*cf.* Figs. 3652 and 3654). The mirror should be so mounted as to admit of its being inclined about 25°, to the plane of the correcting glass, and it is very desirable that it be so arranged that it can be turned in its cell. For the latter reason, and also because the mirror, when lying flat in its cell, is in closer proximity to the correcting glass, the writer prefers the hinged mirror of Loring (Fig. 3683) to his tilting mirror (Fig. 3687).

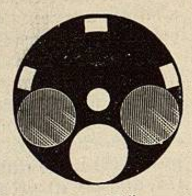


FIG. 3685.

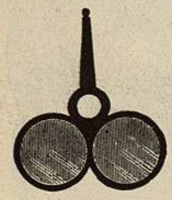


FIG. 3686.

The correcting glasses should be so mounted as to admit of their automatic centration, and of the easiest possible change from one glass to another without interrupting the observation by removing the instrument from the eye. The series of lenses should be sufficiently large to include the entire range of hypermetropia and of myopia, with intervals as small as can be taken note of by the observer; a common interval of 1 dioptrie will suffice for most practitioners, others may be able to utilize an interval as small as 0.5 dioptrie. A combination of a larger and a smaller Rekoss disc, or of a full disc with a quadrant of another disc, is sufficient to meet these requirements; the glasses in the principal disc should be of somewhat greater diameter than the hole in the mirror (about 5 mm.); those in the second disc or quadrant should be a little larger (about 7 mm. in diameter). The two discs should be as thin as the curvature of the glasses will permit, and they should be mounted in the closest possible proximity to each other and to the back of the mirror.

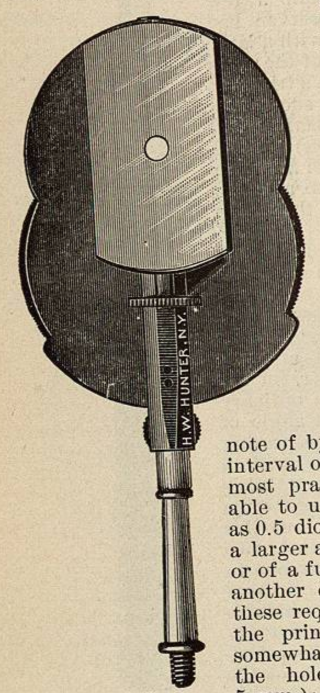
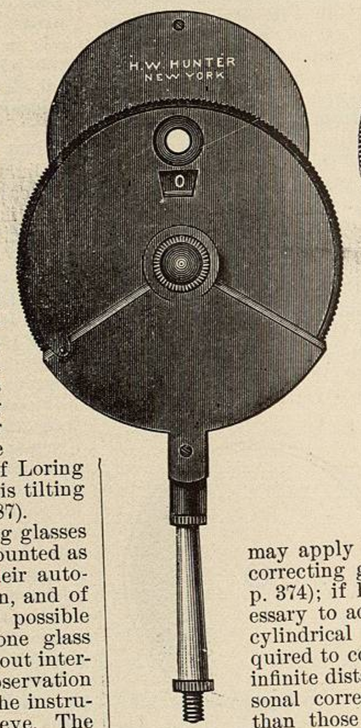


FIG. 3687.

The handle of the ophthalmoscope should be not less than 14 or 15 cm. in length, measured from the centre of the mirror, and it should be large enough to admit of its being easily and firmly grasped by the hand. As, with this length of handle, it is somewhat difficult to reach the edge of the principal disc with the finger, a rack-and-pinion mechanism (Crétès), a cog-wheel (Loring), a train of cog-wheels (Noyes), or a cog and cam device (Meyrowitz), has been added; a very full series, of no less than seventy-four glasses, has been mounted, after the manner of an endless chain, in the place of the usual revolving disc (Couper);[12] a smaller series, similarly mounted, is used in the ophthalmoscope of Morton.

If the observer is simply hypermetropic or myopic, he may apply his personal correction to the correcting glass found by observation (see p. 374); if he is astigmatic, it may be necessary to add to the ophthalmoscope such cylindrical glass or glasses as may be required to correct his vision in either eye for infinite distance. The glasses for this personal correction should be a little larger than those in the second disc (about 9 mm. in diameter) and should be mounted immediately behind it; in astigmatism, of even as low a grade as 1 dioptrie, its correction adds appreciably both to the sharp definition of the picture and to the observer's quickness of perception.



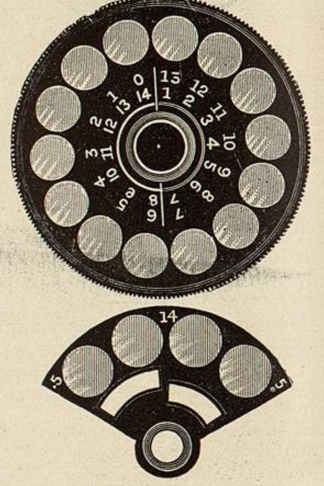


FIG. 3688.

Fig. 3684 shows the back of an ophthalmoscope made for the writer, in 1876, by Hunter.[13] It is, in fact, one of Loring's smaller ophthalmoscopes, with the addition of a second smaller disc—a construction adopted, a little later, by Badal, in France. Substituting + 13 and − 13 for + 14 and − 14, the order in which the glasses are brought into use becomes precisely the same as in the ophthalmoscope of Badal and in the later ophthalmoscopes of Loring; with +0.5 and −0.5 in the place of + 7 and − 7, as figured, an interpolation of 0.5 dioptrie may be made between the limits + 6.5 and − 6.5. A third disc, with two glasses, serving also as a cover to the smaller disc (Fig. 3685), or a setting of the form shown in Fig. 3686, affords the means of applying such correction as an astigmatic observer may find advantageous. The ophthalmoscope of Loring, with the tilting mirror, in the construction finally adopted by its author, is shown in Figs. 3687 and 3688.[14]

John Green.

* H. Knapp (Archives of Ophthalmology and Otology, iv., i., p. 41, 1874) made comparative trials of a number of mirrors with holes varying from 1 to 5 mm.; "the best illumination is obtained by an opening in the mirror of 3.5 or 3.75 mm. in diameter."

Plate XLVII., by Jaeger, shows the fundus of a normal eye as viewed by means of the ophthalmoscope.

[1] Couper: Report of the Fourth International Ophthalmological Congress, London, 1873.

[2] Helmholtz: Beschreibung eines Augenspiegels, Berlin, 1851.
[3] Th. Ruete: Der Augenspiegel und das Optometer, Göttingen, 1852.
[4] A. Coccius: Ueber die Anwendung des Augenspiegels nebst Angabe eines neuen Instrumentes, Leipzig, 1853.
[5] W. Zehender: Archiv für Ophthalmologie, I., i., 1854.
[6] F. C. Donders: On the Anomalies of Accommodation and Refraction of the Eye. The New Sydenham Society, p. 106, London, 1864.
[7] H. D. Noyes: Transactions of the American Ophthalmological Society, 1869.
[8] Ed. Jaeger: Oesterreichische Zeitschrift für practische Heilkunde, 7. März, 1856.
[9] E. G. Loring: Transactions of the American Ophthalmological Society, 1869.
[10] O. F. Wadsworth: Boston Medical and Surgical Journal, January 25th, 1877.
[11] E. G. Loring: Report of the Fifth International Ophthalmological Congress, New York, 1877.
[12] Couper: See description of Couper's new Ophthalmoscope, with illustration, in Juler's Handbook of Ophthalmic Science and Practice, London, 1884.
[13] J. Green: Transactions of the American Ophthalmological Society, 1878, p. 476.
[14] E. G. Loring: Transactions of the American Ophthalmological Society, 1878, p. 489.

OPIUM.—(U. S. P.; B. P.; P. G.) *Succus Thebaicus. Lachryma Papaveris, Extractum thebaicum, Meconium, Laudanum.*

DEFINITION.—Officially considered, under the authority of the United States Pharmacopœia, opium is "the concrete milky exudation obtained by incising the unripe capsules of *Papaver somniferum* L. (*P. officinale* Gmel.; *P. album* Mill., fam. *Papaveraceæ*), and yielding, in its normal moist condition, not less than nine per cent. of crystallized morphine" when assayed by the United States Pharmacopœia process. This definition is to be read in connection with the description given below, which more closely delimits the article. It is also to be considered in connection with the provisions for *Opii Pulvis* (see the section on Preparations), which has a different alkaloidal standard, and with those for the alkaloidal standardization of the preparations made from the latter.

FIG. 3689.—The Opium Poppy (var. nigrum). Plant much reduced. (Baillon.)

The definitions of other pharmacopœias differ considerably from that of ours. The German requires, as ours formerly did, that opium be produced in Asia Minor; also that it contain from ten to twelve per cent. of morphine and not more than eight per cent. of moisture. The British Pharmacopœia requires different amounts of morphine for the opiums used in the different preparations; not less than seven and a half per cent. for the tincture and extract, and between nine and a half and ten and a half per cent. for other uses. For diluting a higher with a lower grade, the United States Pharmacopœia requires that the morphine percentage of the latter be between seven and a half and ten per cent. In view of the standardization of the preparations, it would at first thought appear superfluous to impose rigid standards for the drug, but important commercial and tariff considerations are involved, aside from the fact that large downward variations in morphine percentages are liable to be accompanied by important upward variations in the percentage of other, perhaps undesirable, alkaloids.

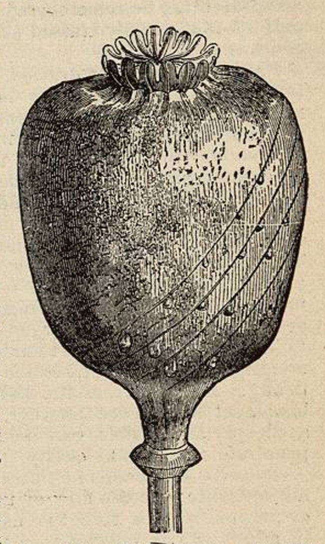


FIG. 3690.—White Poppy. Showing the incisions made in the green capsule for the extraction of opium. (Baillon.)

Origin.—All opium is now regarded as the product of the one species named in our definition, though some botanists have been inclined to regard its varieties as distinct species. Although the plant grows abundantly in a wild state about the eastern Mediterranean, and in adjacent regions, opium is wholly the product of cultivated plants. Although the *var. glabrum*, having red flowers and usually dark seeds, is preferred and more largely grown in Turkey, and the *var. album*, with white flowers, is more commonly grown in Persia, such distinctions are not rigid, since flowers of all intermediate colors may usually be seen in a Turkish plantation. The opium plant here figured (Fig. 3689) is an annual herb, nearly a metre (a yard) high, somewhat branched above and bearing from five to twenty large flowers and capsules (see Fig. 3690). The latter is about as large as a small apple, and yields the opium by the process described below. (See section on Production.)

Almost every country possessing a suitable climate has yielded opium of fair to good quality, including Europe as far north as Sweden and North America as far north as New England, though most of these operations have been purely of an experimental character. Financial success in opium production requires a special combination of conditions affecting soil, climate, population, and cost of labor, and has been attained, to a noteworthy extent, only in Turkey, Persia, India, China, and Egypt. Of these products that only of Turkey answers perfectly to the official description, and it supplies practically the entire medical demand, except for purposes of morphine manufacture. For this, any product rich in morphine and easily worked is selected, the most of it, with the exception of Turkish opium, being Persian, so far as United States manufacturers are concerned. All other opium is consumed in the vicious practices of smoking and chewing. Of this, the Egyptian product is probably somewhat greater than the whole of the Turkish product, though smaller now than formerly. That of India is probably from ten to twenty times as great as that of Turkey, and that of China at least double that of the