The History of the Invention and Development of the Ophthalmoscope

With a Descriptive List of Ophthalmoscopes

Harry Friedenwald, M.D.
Baltimore, Md.

Hermann von Helmholtz

The Inventor of the Ophthalmoscope

Casey A. Wood, M.D.
Chicago

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THE HISTORY OF THE INVENTION AND OF THE DEVELOPMENT OF THE OPHTHALMOSCOPE.*

HARRY FRIEDENWALD, M.D.
BALTIMORE, MD.

The marvelous advance that modern medicine has made is due in great part to the invention of instruments of precision. They have lent delicacy and accuracy to our methods of examination and have opened new fields that were closed to our unaided senses.

When early in the last century Laennec invented the stethoscope, he gave us the means of discovering morbid processes within the body and thus revolutionized internal medicine. Helmholtz's invention of the ophthalmoscope did the same for ophthalmology. In both cases the field had long been cleared and there was no reason why the instrument should not have been invented earlier, but that in the one case it required the genius of Laennec and in the other the versatile and profoundly scientific talent of Helmholtz to lay bare simple facts which every tyro saw plainly after they had once been pointed out.

As the invention of the stethoscope enabled us to perceive deep-seated morbid processes by means of the sense of hearing, so the invention of the ophthalmoscope

* At the Meeting at Atlantic City, Drs. Harry Friedenwald and Casey Wood were appointed a committee to arrange exercises and an historic exhibit for the St. Paul Meeting, to commemorate the 50th anniversary of the invention of the ophthalmoscope.

gave us the means of recognizing by the sense of sight the normal or abnormal conditions of the fundus of the eye which had been hidden from view during all the ages. Auscultation might have reached a high state of development without any instrumental aid, but no one could ever have seen the details of the fundus oculi without some instrument based upon the principles which Helmholtz discovered.

It is now fifty years since Helmholtz announced his invention in the unpretentious monograph which I here show. It is most fitting that this body representing ophthalmology in America should commemorate the jubilee, and show its grateful appreciation of the work of Helmholtz and of the value of his gift.

It is of special interest to us to take a glance at the gradual accumulation of facts and observations, the building stones which were needed before even a Helmholtz could rear his structure. The most important of these was the observation of the luminous appearance of the pupil. The ancients had observed this in the eyes of certain animals.[1]

The first mention of the observation in the human eye was made in 1796 by Fermin, who found that the pupils of an Ethiopian albino were luminous. Other cases were published, as rare and curious during the first quarter of the 19th century. The statement was made that the light radiating from such eyes illumined the objects on which it fell and enabled the fortunate individual to read in the dark!

The bright yellow appearance of the pupils in certain forms of disease, first mentioned by Scarpa in 1816, was classically described by Beer in 1817 under the title of "Amaurotic Cat's Eye."

We find no mention of luminosity in other than albinotic or diseased eyes until 1837, when Behr observed it in a case of total irideremia and it was not until the forties that the observation was made on normal eyes.

It is interesting to learn the theories that were offered to explain these observations. First it was regarded as a phenomenon of phosphorescence; by some as the light absorbed during the day and given off at night, and later by others as the result of an internal activity similar to that of the fire-fly. It was described as varying with the seasons, with the age of the individual and with his nervous state. Electricity was also called upon to assist in explaining the luminosity of the eye. It was the "naked electricity emitted by the retina, for nowhere in the animal organism is the brain substance exposed to the naked eye as clearly as in the open interior of the eyeball" (Pallas, 1811). But Prevost in 1818 pointed out the true cause: it was the reflection of the light which entered the eye, and Gruithuisen about the same time came to a similar conclusion.

In 1821 Rudolphi added the observation that success of the experiment depended upon having the light thrown in, in a definite direction and that the eyes of the decapitated head of a cat were as easily made luminous as the living.

Esser in 1826 showed that such eyes shone even brighter than the living, because of the larger size of the pupil, and Johannes Mueller expressed the same view.

In 1836 Hasenstein showed that he could make the pupil luminous by compressing the eyeball in its antero-posterior diameter, and in 1845 Bruecke gave the correct explanation of the red color of the luminous pupil in that the light was reflected by the choroidal blood vessels.

In 1846 a most important communication was published by Cumming in the Medico-Chirurgical Transactions. He showed that every healthy human eye can be made luminous. The person is placed at a definite distance from a light, this distance varying with the intensity of the light, and the observer places himself close to the straight line between the course of light and the eye examined. He showed that the luminosity of the pupil varied with the intensity and the distance of the light and that when the distance was decreased to a few inches it vanished because the light is cut off by the head of the observer. He reported a number of cases in one of which only could he not produce the luminous appearance. In this case the pupils were very small. It was Cumming who first suggested and used this method for examination of the porterior portion of the eyeball, making the endeavor to draw conclusions concerning the retina as well as the media from the conditions of the reflex.

About this time Bruecke's attention was directed to this subject by accidentally observing a young man's eyes become luminous, and in 1847 he invented independently the same method as that of Cumming. He also mentioned an observation of Erlach, that eyes could be made luminous by the bright light reflected from his concave spherical spectacle glasses, a fact which Bruecke substantiated by experiments on others.

About the same time an instrument was constructed by Babbage, of calculating machine fame, which almost made this scientist take Helmholtz's place as the inventor of the ophthalmoscope. Almost! The account was not published until three years after Helmholtz's invention had been made and appeared in an article by Wharton-Jones[2] in which he reviewed Helmholtz's publication and several that appeared subsequently. He says: "It is but justice that I should here state, however, that seven years ago Mr. Babbage showed me the model of an instrument which he had contrived for the purpose of looking into the interior of the eye. It consisted of a bit of plain mirror, with the silvering scraped off at two or three small spots in the middle, fixed within a tube at such an angle that the rays of light falling on it through an opening in the side of the tube were reflected into the eye to be observed and to which one end of the tube was directed. The observer looked through the clear spots of the mirror from the other end. This ophthalmoscope of Mr. Babbage we shall see is in principle essentially the same as those of Epkens and Donders, of Coccius and of Meyerstein, which themselves are modifications of Helmholtz."

What a pity that Babbage did not devote a little more time to this invention! He could hardly have missed being the inventor of an instrument whose value is a thousand times greater than that of all the calculating machines ever invented.

To return a moment to another aspect I must point out that as early as 1704, Mery observed that the fundus of cats' eyes became distinctly visible when the animal was placed under water. LaHire explained this phenomenon five years later: "When a normal eye is in the air the rays of light issuing from a point in the fundus are so refracted that they leave the eye in parallel lines. For this reason we should be able to see the point in the fundus clearly, for parallel or almost parallel rays always produce a distinct perception in our eye; nevertheless, we do not see the object. On the other hand, when the eye is under water the rays leaving the eyeball diverge and in passing from the water into the air they are made to diverge still more. The result is that where-ever we place our eye these divergent rays give us a clear picture of the point in the fundus from which they emerge." He does not attempt to explain the problem why parallel rays emerging from an eye exposed to the air can not be seen.

LaHire's profound statement was too advanced; others receded from it and it required almost 150 years before the problem was solved.

In 1851[3] a little pamphlet was published by Helmholtz, then a young professor of anatomy and physiology in Königsberg, under the title of "Beschreibung Eines Augen-Spiegels zur Untersuchung der Netzhaut im Lebenden Auge." In this he demonstrated the fundamental facts that *the rays pass out of the eye in the same lines in which they have entered and that they can be made to form a distinct image in an observer's eye.* He explains Cumming's and Bruecke's observations as being due to the fact that the eye is not exact focus for the light and thus rays pass out by lateral dispersion. But what was most important he added the *practical* to the *theoretical* and invented an instrument with which the details of the retina could be examined. He described the ophthalmoscopic appearance of the retina, calculated the enlargement under which it is seen, pointed out the value of the instrument as a measure of the refraction and of the accommodative changes of the eye. His short monograph was thorough and complete and gave into our hands a means of examination of which no one had yet dreamed. In his modest way Helmholtz thus prophesies its usefulness:

"I do not doubt, judging from what can be seen of the state of the healthy retina, that it will be possible to discern all its diseased conditions, so far as these, if seated in other transparent parts such as the cornea, would admit of diagnosis by the sense of sight. Distension or varicosity of the retinal vessels will be easily perceptible. Exudations in the retinal substance, or between the retina and choroid, will be seen precisely as in the cornea, by their brightness upon a dark ground.

. . . Fibrinous exudations, usually much less transparent than the ocular media, will, when lying upon the fundus, considerably increase its reflection. I believe also that turbidity of the vitreous body will be determined with greatly increased ease and certainty. In brief, I do not consider it an overstrained expectation that all the morbid changes of the retina or of the vitreous body that have been found in the dead subject will admit of recognition in the living eye; an expectation that appears to promise the greatest progress in the hitherto incomplete pathology of the organ."

It will not be out of place to tell the story of the invention of the instrument in Helmholtz's words: "I was endeavoring to explain to my pupils the emission of reflected light from the eye, a discovery made by Bruecke, who would have invented the ophthalmoscope had he only asked himself how an optical image is formed by the light returning from the eye. In his research it was not necessary to ask it, but had he asked it, he was just the man to answer it as quickly as I did and to invent the instrument. I turned the problem over and over to ascertain the simplest way in which I could demonstrate the phenomenon to my students. It was also a reminiscence of my days of medical study that ophthalmologists had great trouble in dealing with certain cases of eye disease, then known as black cataract. The first model was constructed of pasteboard, eye lenses, and cover glasses used in the microscopic work. It was at first so difficult to use that I doubt if I should have persevered, unless I had felt that it must succeed; but in eight days I had the great joy of being the first who saw before him the living human retina."

How peculiarly applicable are the lines of Weir Mitchell:

How keen the mind-thrill of delight
  When some new sun illumes our lessening night,
And problems, dark for many a weary year,
  Shine, simply answered—luminous and clear.

THE HELMHOLTZ OPHTHALMOSCOPE.

This interesting instrument, of which there are five models in the exhibit, consists of a little metallic box with plates set at an angle which act as reflectors. In the back of the instrument correcting lenses were placed to neutralize the refractive and accommodative conditions of the eye examined and of the eye of the observer. In the early cases these lenses were all concave[4] and ranged from —12 in. to —6 in. which Helmholtz[5] says "suffice for all conditions of the accommodation." He himself usually used —10 in. spherical glass to examine normal eyes, and for high degrees of myopia he combined two concave glasses.

For the purpose it was invented, this instrument is optically perfect, and Helmholtz not only recognized all the possibilities of pathological discovery which it offered but he also saw the value that it possessed for the determination of the refractive condition of the eye examined.

"One can easily convince himself objectively with the ophthalmoscope of the presence and the degree of short-sightedness and of far-sightedness." His method consisted in having the observer first determine the concave glass required for examination of a normal eye and subtracting this constant from the glass required for the examination of other eyes, a method which we all use in teaching beginners.

No instrument used in medicine was destined to undergo a greater number of changes and modifications than the ophthalmoscope. In the same year in which Helmholtz's monograph appeared, Epkens constructed a plain silvered mirror with the silvering removed at a spot in the center.

RUETE'S OPHTHALMOSCOPE.

In 1852 Ruete[6] announced the invention of an ophthalmoscope by means of which the fundus was rendered visible in an inverted image by what has since been known as the indirect method. It is true that Helmholtz discussed the question of examining the fundus in this manner by means of convex spheric glasses placed between the observer and the observed eye, but he placed his lenses behind the ophthalmoscope, between the reflecting surface and the eye of the observer. After making careful and interesting calculations, he described that "in experiments with such lenses the proper position of the instrument for the examination of the retinal image was very much more difficult to find and to hold." Helmholtz himself therefore only used the direct method.

Ruete's instrument, which through the kindness of Dr. B. Joy Jeffries, I have the good fortune of being able to show in the exhibit, is most curious and interesting. As reflector, Ruete introduced a concave perforated mirror placed at a distance from the observed eye and he interposed between this mirror and the eye examined one or two spheric convex lenses.

Ruete therefore deserves the credit for having introduced a practical method for examining the inverted image of the retina and too great praise can not be bestowed upon him. Helmholtz himself said of it: "I consider the invention of his instrument an important advance in the examination of the fundus." In his article Ruete describes a few pathological cases examined by means of his instrument; these, so far as I am aware, are the first on record.

Ruete's paper soon called forth another from Helmholtz[7] in which he explained the theory of the indirect method and described his "simplest ophthalmoscope" which required nothing but a screen, a candle and a convex spheric lens.

The observer's head is placed close to the candle and shaded by a screen and the lens is held near the eye examined. This and Ruete's method he showed were practically identical. Helmholtz also mentioned an addition made to his original instrument by Rekoss, an instrument-maker of Königsberg. Rekoss placed two discs which had lenses inserted in their periphery in the instrument; by turning these the lens desired could be obtained. This device,[8] the Rekoss disc, has been used in most modifications of the instrument.

In 1853[9] Coccius invented an instrument which consisted of a plain mirror upon which the light was thrown through a convex spheric glass. The mirror and the lens were firmly attached to each other, but their distance from each other admitted of change. In this manner the plane mirror acted as a concave mirror of variable focus. (Several forms of this mirror are found in the exhibit.)

Eduard Jaeger[10] in 1854 modified the instrument of Helmholtz. The three plates of unsilvered glass were retained for the direct method, but these could be replaced by a concave silvered mirror for the inverted image; thus he made a combination of the Helmholtz and the Ruete instruments. In 1871 Dr. George Strawbridge[11] of Philadelphia further modified this instrument by adding three Rekoss discs which were interchangeable.

We have now seen that plain and concave mirrors were used. In 1854 Zehender[12] used a convex mirror with a convex spheric glass attached in the same manner as that of Coccius. But this does not exhaust the mirrors used. Lenses were employed, both convex and concave and concavo-convex of varying strengths, which were silvered on one side and thus acted as both correcting lenses and mirrors. In the exhibit you will find several such mirrors made of silvered biconvex lenses and known as Burrow's[13] ophthalmoscopes. All of the instruments thus far mentioned are found in the exhibit.

Prisms were employed as mirrors by Ulrich, Froebelius, Meyerstein, Coccius and Zehender,[14] but I have been unable to obtain any of these forms.

A very simple ophthalmoscope was early invented by Liebreich, first in the form of a concave metallic mirror, later of perforated glass. You will find a long series of these in the exhibit. Liebreich also invented an instrument in which the various parts were fixed and the head of the patient likewise made stationary.[15]

Follin also constructed an instrument in which the mirror and the collecting lens were stationary—and Galezowski[16] invented one in which the lens and the mirror were placed at the two ends of a telescopic tube. The stationary instruments were especially intended as demonstrating ophthalmoscopes. Special demonstrating ophthalmoscopes were also constructed by Schweigger,[17] in which the rays returning through the opening in the mirror were in part allowed to proceed to the observer's eye, in part deflected by a prism to the eye of another to whom the demonstration was to be made. Graefe and Peppmueller[18] described an instrument for the same purpose in which a small piece of mirrored glass was placed on the mirror at the side of the opening.[19] All of these instruments are found in our exhibit. We have also a Schoeler[20] demonstrating ophthalmoscope in which a minute mirror is placed obliquely behind the opening of the ophthalmoscopic mirror.

Numerous attempts were made to obtain a binocular view of the fundus. A number of modifications of

Giraud Teulon's binocular ophthalmoscopes are found in our exhibit.

Of the half dozen electric light ophthalmoscopes that have been invented I am only able to present one model, that of Schweigger.

REFRACTION OPHTHALMOSCOPES.

The first to invent a refraction ophthalmoscope was Helmholtz when he added the Rekoss discs to his instrument. This same device has been used in numerous forms of instruments.

No one has contributed more to perfecting this than our fellow-countryman, Loring. I am very fortunate in being able to show the various steps which led up to the present instrument, which is known to you all. Loring first inserted three interchangeable discs behind the mirror, later he placed all the lenses in one disc making a double circle of glasses and by moving the disc up and down he could place either circle before the eye. Finally he secured all the strengths necessary by means of a single disc and a super-added segment. Wadsworth of Boston first suggested a mirror set obliquely before the observer, so as to enable the latter to look directly through the lenses and not at an angle. This instrument we have in our exhibit, loaned by Dr. Wadsworth. Loring adapted the same modification in an ingenious way by cutting off a segment at one edge of his round mirror and still later he found that he was able to take off a segment on each side and thus came about the modern Loring tilting mirror.

Another method of placing a great number of lenses in an instrument was invented by Cooper of London. He formed a long chain of lenses sliding in a groove. Morton modified this and his instrument is also in the exhibit.

A number of instruments have the correcting lenses arranged in a line and placed in a narrow metal plate which slides in a groove. Several are in the exhibit.

I should like to devote a little time to the consideration of skiascopy but time will not permit, and I shall only call your attention to a number of varied mirrors for this purpose to be found in the exhibit. Nor dare I spend any time on ophthalmoscopic photography.

The days of invention of new ophthalmoscopes are not over. In 1900 two important instruments were invented, one a demonstration ophthalmoscope by Thorner, the other an electric light ophthalmoscope by Oscar Wolff. I regret that we were unable to obtain these for the exhibit.

It would have been impossible to make this collection complete. But a sufficient variety is shown in the 140 instruments making up the exhibit to afford a good demonstration of the development of the ophthalmoscope and of its many modifications. All have been collected in this country, and I trust that the section will agree with me in urging the Surgeon-General of the United States to arrange a permanent historic exhibit at the Army and Navy Museum in Washington. Many of these instruments are already very rare and will otherwise be lost in a few years. I feel confident that many who have loaned their instruments to us will be willing to loan them, and some, perhaps, to give them, to the Surgeon-General's Museum.

In conclusion I desire to give thanks to Dr. Casey A. Wood, my colleague on the committee and to the following gentlemen who have kindly loaned their instruments:

LOANERS.

Dr. B. Joy Jeffries, of Boston (eight instruments).
Dr. Charles H. Williams, of Boston (eight).
Dr. Hasket Derby, of Boston (six).
Dr. D. W. Hunter, of New York (six from the collection of the late Dr. Noyes).
Drs. F. M. Chisolm and Herbert Harlan, of Baltimore (five).
Dr. Casey A. Wood, of Chicago (four).
Dr. William Thomson, of Philadelphia (four).
Dr. Conrad Behrens, of Philadelphia, Wills Eye Hospital (four).
Dr. Webster Fox, of Philadelphia (three).
Dr. Charles H. May, of New York (two).
Dr. Lucian Howe, of Buffalo (two).
Dr. Jackson, of Denver (two).
Dr. Dudley Reynolds, of Louisville (two).
Dr. Callan, of New York (two).
Dr. Edward Morrow, of Canton, Ohio (one and Montnieja's Atlas).
Dr. Flemming Carrow, of Ann Arbor, Mich. (one).
Dr. C. Barck, St. Louis (one).
Dr. Hermon Thomas, of Philadelphia (one).
Dr. Alex. Stirling, of Atlanta, Ga. (one).
Dr. K. Koeller, of Pittsburg (one).
Dr. C. M. Culver, of Albany, N. Y. (one).
Dr. Samuel D. Risley, of Philadelphia (one).
Dr. Shallus, of Philadelphia (one).
Dr. Jessop, of Philadelphia (one).
Dr. Zimmerman, of Philadelphia (one).
Dr. G. Edgar Dean, of Scranton, Pa. (one).
Dr. William C. Bane, of Denver, Colo. (one).
Dr. H. B. Young, of Burlington, Iowa (one).
Surgeon-General's Museum, through Dr. Caloni DeWitt (one).
Dr. Brown Pusey (seven), and Chambers, Inskeep & Co., Chicago.

I feel that Messrs. Tiemann & Co., of New York, Messrs. Bonschur and Holmes, of Philadelphia, and Mr. Alex. Shaw, successor of

Mr. H. W. Hunter, of New York, and Mr. E. B. Meyrowitz, of New York, deserve our special gratitude for the interest and pains they have taken in collecting old instruments. Messrs. Tiemann & Co. sent twelve instruments, Messrs. Bonschur & Holmes collected fourteen and added four more from their stock, and Mr. Alex Shaw sent two made by Hunter.

REFERENCES.

1. There is doubtful mention of it by Aristotle, and Pliny says: "The eyes of nocturnal animals, such as cats, are brilliant in the darkness." See Mauthner's Ophthalmoscopie, p. 2.
2. British and Foreign Medical Review, October, 1854.
3. From certain statements in Michaelis' "Life of v. Graefe" (Berlin, 1877, p. 34), it would appear that the invention was really made in 1850.
4. Since higher degrees of hypermetropia than 4 Ds are not of common occurrence, Helmholtz required no convex spheres.
5. Nederl. Weekblad voor Geneeskundigen, Dec. 21, 1851.
6. Der Augenspiegel und d. Optometer, Göttingen, 1852.
7. Vierordt's Archiv, 1852, p. 827.
8. Each disc contained four lenses: one those from 6 in. to 9 in., the other those from 10 in. to 13 in., all concave.
9. Ueber d. Anwendung d. Augenspiegel, Leipzig, 1853.
10. Ueber Staar und Staar-operationen, Vienna, 1854.
11. Amer. Ophth. Soc., 1871, p. 120.
12. Graefe's Arch. f. Ophth., vol. i, pt. I, p. 121.
13. Arch. f. Ophth., iii, 2, p. 68, 1857.
14. See Graefe Saemisch Handbuch, vol. iii, p. 155.
15. Arch. f. Ophth., vol. i, 2, 1854.
16. Acad. de Med., Jan., 1862.
17. Berl. Klin. Woch., 1871, p. 585.
18. 50 Versammlung Deutscher Aerzte und Naturforscher, 1877.
19. Most all are familiar with the device as adapted by laryngologists to demonstrate the larynx and known as Noltenius' demonstrating instrument.
20. Jahresbericht d. Augenklinik for 1876, pp. 51-56.