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Physiology. — *"Photography of the fundus of the human eye"*. By Prof. I. K. A. WERTHEIM SALOMONSON.

(Communicated in the meeting of April 27, 1917).

Since the discovery of the ophthalmoscope by HELMHOLTZ, disclosing the interior of the living human eye, many different attempts have been made to keep a permanent record of the aspect of the retina on a photographic plate. This proved to be much more difficult than viewing the background of the eye. The greatest difficulty was caused by the reflexes given off on the surface of the cornea and the anterior and posterior surface of the lens. Different ways have been tried to get rid of these reflexes and after more or less successful attempts by BAGNÉRIS, GUILLOZ, GERLOFF and others, DIMMER succeeded in obtaining satisfactory results. Shortly afterwards THORNER and also WOLFF, working on different lines, showed photographs of the living human retina which were nearly as good as those of DIMMER. His photographs are generally excellent.

Of the eyes of animals NICOLAEW was also successful in obtaining good negatives. But his method did not yield satisfactory results with the human eye, the fundus of which is infinitely more difficult to photograph than the animal fundus.

For practical purposes as yet only DIMMER's and perhaps WOLFF's method have to be considered. But DIMMER's method necessitates a costly instrumentarium, requiring much room and skilled assistance. I do not know of its being used outside his own clinic, except by a very few specialists (e. g. Hess.).

The different methods for obtaining a reflexless image of the fundus have been ably discussed by GULLSTRAND, who gave a clear and critical review of the general and special conditions necessary for getting clearly defined ophthalmoscopic images, free from any reflex. Finally his results were embodied in his large demonstration-ophthalmoscope, constructed by ZEISS, which shows the ophthalmoscopic appearance of the human eye with less difficulty, more extensively with a higher magnification and yet more clearly than any other instrument of the same kind. As yet this instrument cannot be used for photographic purposes. But it seemed to me that it

might possibly be rendered suitable for such. After a few preliminary trials I had an instrument made for me, differing in many respects from the original one.

The Nernstlamp was discarded and was replaced by a lamp of greater intrinsic brilliancy. The arrangement of the illumination-tube was slightly changed so as to allow a relatively greater part of the light reaching the eye.

In the ZEISS instrument the image of the Nernst filament is projected upon a slit and by means of a second condensor into the pupil of the eye. The light, after leaving the second condensor is deflected by a glass plate, making an angle of 45° with the axis of the tube. The optical system for viewing the fundus looks through this glass plate. With this construction about 8.5 % of the light leaving the second condensor is projected into the eye and 91.5 % of the light leaving the eye reaches the objective of the viewing-tube. I placed the glass-plate so as to make an angle of 65° with both tubes, which allowed about 21 % of the light to enter the eye and 79 % to reach the observing eye. In this way the amount of light falling on the photographic plate was about doubled.

The Nernstlamp has an intrinsic luminosity which I measured as of 3.1 Hefnercandles per square millimeter. By the use of a specially constructed halfwattlamp of low voltage I got an intrinsic brilliancy of nearly 29 units per square millimeter. A suitable small camera having been adapted to the instrument I got, after a few failures, usable negatives of a diameter of 26 to 30 millimeters, showing about 27 degrees of the fundus and covering an area of $4^1/_2$ times the diameter of a normal optic disc.

The negatives were sometimes good, though very often blurred, owing to the long exposure of 0.4 to 0.5 of a second. I have tried to get better results with a small arclamp of about 5 amperes but without much success. Though the intrinsic intensity was 3 times greater, the area was notably smaller. With an entirely modified construction and with an arclamp of 25—30 amperes better results might be expected as the exposure might have been reduced to $^1/_8$ of a second. As the angle of view was also rather small and could only be enlarged by a complete reconstruction of the apparatus, I have kept the instrument as it was, and have tried to get more satisfactory negatives in quite another way.

With the indirect ophthalmoscopy we can entirely eliminate the reflexes on the cornea and the lens by following GULLSTRAND's method. But we always retain two reflexes on the ophthalmoscope lens. These do not hinder visual observation as they are rather small and

by slight movements of the ophthalmoscope lens can always be removed from any part of the real image of the fundus.

But their presence is an absolute hindrance to photography They cause the appearance on the negative of one or two large spots, covering its central part and having a diameter of nearly $^1/_3$ of the whole negative. The brightness of these reflexes is several hundred times larger than that of the image of the fundus. I have tried in many different ways to eliminate these reflexes and have found that they could be reduced so as to be almost invisible by means of two small screens.

In accordance with this principle I constructed a new photographic ophthalmoscope. The diameter of the negative is 40 mm. The retina is photographed with a magnification of 4.7 times, over an angle of 33 degrees, giving an image with a diameter of about $5^1/_2$ times as large as the normal optic disc. The small arclamp of 4 to 5 Amperes with which the instrument is fitted allows of exposures of $^1/_{14}$ of a second, though this may be reduced to $^1/_{20}$ of a second in some cases. However as the reflex time for the orbicular muscle reflex is much longer there is no advantage in further reduction of the time of exposure. The exposures are short enough to give sharp negatives even in a case of nystagmus.

The quality of the negatives is generally sufficient. They are sharply defined. Generally the middle part is more strongly impressed than the marginal parts, as was to be expected. Yet direct enlargements or prints can nearly always be made without any retouching.

The whole apparatus, which will be fully described elsewhere can be used for both eyes without any alteration except the ordinary focussing. The dimensions are only slightly larger than those of the GULLSTRAND-ZEISS demonstration-instrument. Its use is not much more difficult than the making of an ordinary photograph with a studio-camera.

Fig. 1.
Normal fundus.

Fig. 2.
Normal fundus.

Fig. 3.
Normal fundus with choroidal vessels.

Fig. 4.
Secundary atrophy of the optic nerve.

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