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ZEISS
Retinal Camera
after Dr. Nordenson

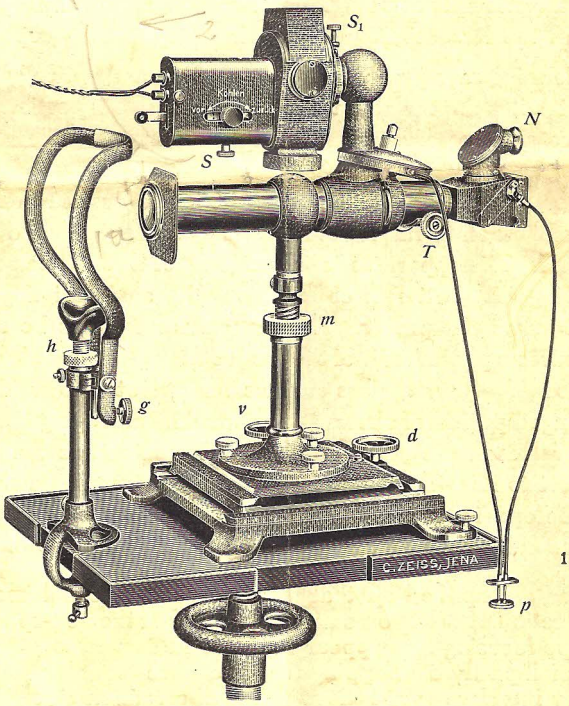


Fig. 1. The Nordenson Retinal Camera on the Instrument Table with Chin and Head Rests.

Photographs of the fundus of the living healthy or morbidly affected eye are of great value in ophthalmic practice no less than in scientific research and for the purposes of teaching. They provide an excellent means of obtaining demonstrable records of morbid changes of the retina in the various stages of the disease. Such photographs may be of the utmost value in the diagnosis and prognostic observation as well as the treatment of many affections of the eyes and the system in general. A good photograph is always far more complete and reliable than the most detailed and precise description and inevitably surpasses the most excellent drawing in the matter of faithfulness.

The chief problem involved in the construction of an apparatus for photographing the fundus of the eye consists in devising a combination which may be capable of producing a distinct image without flares due to reflections. In the retinal camera devised by Dr. Nordenson this requirement is realised by the application of the principle of Gullstrand's non-reflecting *central* ophthalmoscope, as embodied in the large simplified Gullstrand ophthalmoscope.

The image-forming rays pass through the median and optically more valuable portion, while the illuminating rays traverse the peripheral portion of the patient's pupil. The two systems of rays are sharply separated while passing through the refracting surfaces of the eye. This ensures the complete absence of flares due to reflection as well as the freedom of the image from haziness, and enables the optical combination to furnish distinct images of the finest details up to the edge of the field. The apparatus is in the form of a reflex camera with a new form of revolving slit shutter in conjunction with an illuminating arrangement of great light-transmitting power. The apparatus may thus be used for taking at short exposures a photograph of the fundus at any favourable moment, while the interposition of a greyed glass enables the operator to moderate the light during a prolonged period of observation and while arranging the image. When the shutter is released the greyed glass recedes automatically. With the sectorial shutter set to its widest opening the time of exposure is about $^1/_8$ second. By reducing the opening and disengaging the brake action it may be shortened to about $^1/_{20}$ second. The size of the photographic plate is 6×4.5 cm.

As in the large simplified ophthalmoscope, the two small images which are formed by reflection at the two bounding surfaces of the non-spherical aplanatic ophthalmoscope focusing lens appear in the field of view on the fundus in the form of two small partly overlapping white patches together with the principal image, but they interfere very little with the observation since they can be unmistakably recognised as reflections. They may, moreover, be transposed to a region outside that portion of the retina which is under observation by causing the patient to look in an appropriate direction.

The Path of the rays in the Nordenson Retinal Camera.

The condenser D_1 in conjunction with the prisms P_1 and P_2 and the converging lens D_2 forms a minified image L' of the radiant carbon crater L within the slit S, the latter being situated about 1 cm. above the optic axis of the photographic combination D_4. At the same time an image of the luminous aperture of the condenser D_1 is projected into the ophthalmoscope lens D_3 (D_1'). This causes the lens to be uniformly filled with light throughout. The ophthalmoscope lens D_3 forms in the marginal portion of the patient's pupil an aplanatic image S' of the luminous slit S, which is three times smaller than the slit itself, similarly a three times smaller image B' of the objective stop B of the photographic camera is formed in the middle of the patient's pupil and sharply separated from the slit image. This arrangement ensures the freedom of the image from flares and haziness.

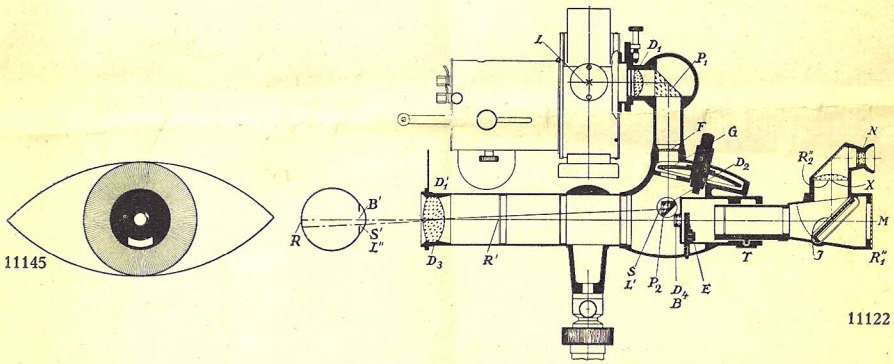


Fig. 2. The trace of the rays in the Nordenson Retinal Camera and the position of the images of the objective stop B and the slit S in the patient's pupil, shown diagrammatically.

The optical system made up of the patient's eye and the ophthalmoscope lens D_3 forms an inverted image R' of the illuminated fundus of the eye R. The photographic objective D_4 should be focused upon this image by means of the milled screw head T. A magnified image of the retina R_1'' will then be formed in the plane of the photographic layer M or, with the mirror J in position, in the plane of the eyepiece cross-lines X (R_2''). The latter image, magnified about five times, may be viewed through the finder and focusing lens N.

A faintly blue-green ferrous oxide glass *F* serves to cut off the heat rays. while the intensity of the light may be moderated by the interposition of the grey glass *G* when a prolonged illumination is required for adjusting the image.

In the case of pronounced ametropia and in that of eyes operated for cataract as well as eyes with marked elevations on the retina it will be necessary to introduce in front of the objective one of the compensatory lenses in the revolving metal disc by the rotation of the latter. These lenses range from ±0.75 to ±1.5 D.

The apparatus is not much larger and heavier than the large simplified Gullstrand ophthalmoscope. Its management and the procedure of setting the optical portion occasions no difficulties even to an inexperienced operator. The Nordenson retinal camera embodies a very simple and inexpensive yet highly efficient photographic apparatus for use in ophthalmological practice as well as for scientific investigations.

Much valuable information is to be derived from a careful study in the photographic image of the various reflections produced by the fundus of the eye which arise upon the veins and arteries, along these, and at the fovea and macula (which, of course, are not to be confounded with the undesirable and therefore carefully to be avoided flares due to reflection at the refracting surfaces of the system of the eye). The great advantage of the photographic image is that the reflections arising on the fundus are well marked, whereas when seen by the ophthalmoscopic method of examination with the usual means by the erect or inverted image, they can only be viewed during brief intervals owing to the continuous movements of the ophthalmoscope, in consequence of which they are diffuse and lacking in contrast. By causing the patient to look in certain directions the foveal and macular flares as well as a third flare situated between the macula and papilla can be made to appear in striking distinctness on the photographic plate.

Since the rays which are reflected from the fundus comprise in the main rays of small chemical intensity it is essential to use highly sensitive orthochromatic plates.

J. W. Nordenson: Demonstration eines nach den Principien des Ophthalmoskops für vereinfachte reflexlose Ophthalmoskopie von Gullstrand gebauten Apparate für zentrische Ophthalmographie (Augenhintergrund-Photographie) und Projektion von Aufnahmen. Bericht über die 45. Versammlung der Deutschen Ophthalmologischen Gesellschaft, Heidelberg, 1925.

Directions.

Putting in the Carbons.

1. Release the clamping screws *K* on either side of the casing *G*, detach the clockwork *U*, the key *Sch* and the screw *S*, and withdraw the lamp. The two carbons to be used in the case of the continuous current have the following lengths and diameters: Homogeneous carbon 100×5 mm., cored carbon 60×6 mm ; in the case of an alternating current their dimensions should be: 100×5 mm. and 60×8 mm., both being cored carbons.

2. The long thin carbon should be set horizontal, the short stout carbon vertical. Before putting in the carbons set the lever *Hb* to its lowest position. Turning the key *Sch*, move the two carbon holders *H* into their extreme positions (up to their limit stops) on the right and left respectively. Put in the carbons, noting that the vertical carbon should not protrude through the lower end of the holder. The clamps on the holders serve for fixing the carbons by means of the key *Sch*.

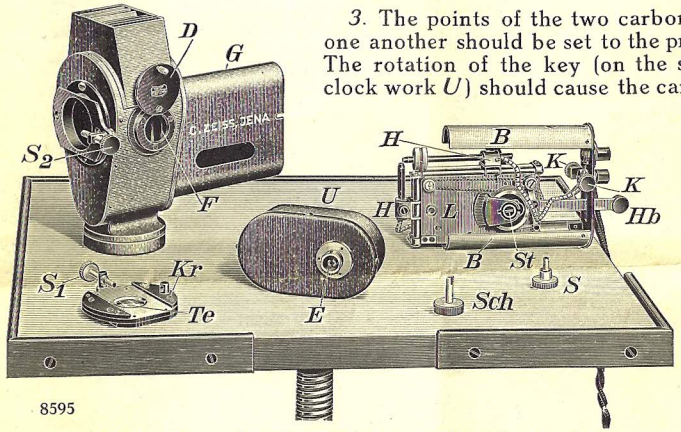


Fig. 3. The small arc lamp as it appears when taken apart.

3. The points of the two carbons at right angles to one another should be set to the proper distance apart. The rotation of the key (on the side opposite to the clock work *U*) should cause the carbon points to come into contact, that is to say, neither carbon should project beyond the other.

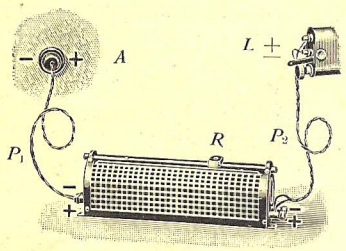
4. *Fresh* carbons of undiminished length, if put in in accordance with art. 2, will touch at their points as the key *Sch* is turned. If this be not the case the probability is that the vertical carbon protrudes a little from the holder, or the carbon holders are not in their extreme positions. The position of the carbon may be rectified within small limits by drawing up the setting lever *Hb*. In the case of partly used carbons of diminished lengths it may happen that one carbon pushes beyond the other. When this happens the carbons may be brought into their proper positions in the following manner: First, by turning the key *Sch* move the horizontal carbon up to the point where it crosses the vertical carbon. Should the latter then project beyond the horizontal carbon, release the clamp and push it down within its holder. It may in this case protrude a little below the holder. In the event of it not reaching up to the point of the horizontal carbon raise it by pushing the setting lever *Hb* upward.

5. Replace the lamp in its casing *G*. While doing so ensure that the flexible conductor may not be caught or clamped anywhere. Re-tighten the clamping screws *K*, replace the clockwork *U*, and at the opposite side of the casing the key *Sch*.

Attach the clockwork in such a way that the two pins and the toothed coupling in the holder on the clockwork may engage with the corresponding recess and elastic toothed coupling *St* in the side of the lamp. Turn the toothed coupling *St* with the aid of the key *Sch* on the other side of the lamp so that the teeth may engage and the clockwork lie close to the lamp casing.

Connection to the Supply Circuit and Regulation of the Carbons.

6. The arc lamp has been designed to operate with a continuous current of 4 ampères or an alternating current of 5 ampères and may be connected to any circuit provided with a fuse blowing at 6 ampères together with a resistance of 50 ohms (5 amps.) for a supply current of 150 volts or less, or 70 ohms for a supply current up to about 250 volts.



8419 Fig. 4. Diagram of connections. *R* Regulating resistance. *L* Terminals at the sides of the lamp. *A* Plug socket in the supply circuit.

7. Connect the resistance *R* (Fig. 4) to the supply circuit *A* by means of the flexible conductor P_1 with its plug connectors, while the other flexible conductor P_2 should be clamped by its two pointed ends to the terminals on the resistance. In the event of the supply current being *continuous* determine with pole-finding paper in the usual way the polarity of the two other ends with hooked contacts and connect the *negative* contact to the *lower* and the *positive* contact to the *upper* terminal of the lamp *L*. Push the regulating slider *R* up to the stop on the side of the resistance bearing the inscription '*stark*' (strong), the stop being fixed by us to suit the voltage of the available supply system. Respecting the method of verifying the direction of the continuous current see art. 10. In the case of the *alternating current* no attention need be paid to the polarity of the ends of the flexible conductor.

8. When switching on the lamp place the carbon points in contact by turning the key *Sch*. As soon as the arc forms turn the carbons a short distance apart and establish the requisite length of arc. In the event of the carbons being separated too far place their points once more in contact and slowly turn back the key. The arc should have a length of 4 to 5 mm.

9. In order to ensure a uniformly bright radiant field it is most important that the carbons should maintain their correct position while burning. In the event of the horizontal carbon protruding too far forward the crater will shift toward its lower side, whilst, if it recede too far back the vertical carbon will soon occupy too high a position and gradually assume a position in front of the horizontal carbon until it completely covers the crater. The position of the carbons may be watched through the dark glass window *F* (on either side of the casing *G*), and, if necessary, it may be rectified. This is done by turning the key *Sch* or also by pushing up the setting lever. When using a **hand feed** arc lamp the carbons require watching and regulating from time to time to prevent the arc from breaking as the carbons burn down. In the arc lamp with **clockwork** the carbons are self-regulating. The clock should be wound with the key *a* and set going and stopped by turning the button *n* (see Fig. 6).

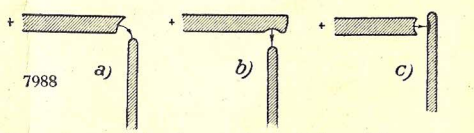


Fig. 5. Correct *(a)* and wrong *(b, c)* positions of the carbons when operating with a continuous current.

8061 Fig. 6. The Clockwork Attachment to the Arc Lamp.

10. The luminous crater in the case of a continuous current forms at the upper (positive) carbon. It is therefore more intensely luminous than the other carbon. Should the reverse be seen to arise with a continuous current it is to be inferred that the current is flowing in the wrong direction, in which case the plugs should be reversed in their sockets.

Adjustment of the Arc Lamp.

11 **Before adjusting the lamp open the shutter, putting the ground glass *G* out of operation.** This is done as follows: To begin with, set the button *f* (Fig. 7) to '*aus*' (off), which has the effect of pushing the brake spring to one side. Wind the button *a* up to the first ratchet (where it engages for the first time) and open the shutter by depressing the releasing button *p* (Fig. 8). The room should be darkened.

12. **Direct the luminous crater *L* (Fig. 2) into the optic axis of the illuminating system.** To this end project in the first instance an image of the crater *L'* upon the ophthalmoscope lens D_3. The image may be received upon a piece of white paper placed upon the lens. Release the clamping screw *S* and displace the luminous crater. Then alternately turn the upper and the lateral set screws S_1 and S_2 until the image of the crater appears approximately at the middle of the ophthalmoscope lens.

13. **Form an image of the luminous crater *L* within the annular slit *S*.** Release the clamping screw *S* and move the luminous crater *L* away from the condenser D_1 until the image of the crater expands upon the piece of paper (in front of D_3) into a uniformly bright and circular patch of light. A dark coloured border will remain at the lower edge of the luminous field only. Finally re-tighten the clamping screw *S*.

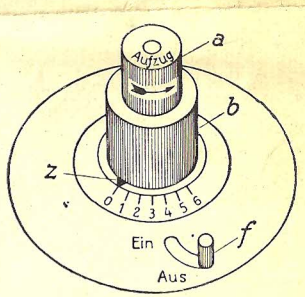
14. Hold the piece of paper about 7 cm. from the ophthalmoscope lens. The curved and intensely bright image *S'* (Fig. 2) of the slit, reduced in size to a length of about 4 mm. and a width of 1 mm., will then be seen on the paper. The minified (invisible) image *B'* of the objective stop *B*, which has a diameter of about 2 mm., is situated about 3 mm. above the slit image.

15. **Close the shutter, at the same time putting the ground glass in operation.** This is effected by the following manipulations in succession:

a) Turn the upper winding button *a* (Fig. 7) from the first ratchet position (art. 11) to the last ratchet, i. e. until it refuses to be turned further.

b) Lift out the lower setting knob *b* and turn it so that the index *z* may point to zero (conforming to the largest aperture) or to one of the figure 1 to 6 (conforming to smaller openings; see art. 22).

c) Release the shutter by depressing the releasing button *p* (Fig. 8). During this process the index *z* of the setting button *b* will always return to its initial position.



11126 Fig. 7. The Shutter Winder.

Method of Setting the Apparatus to the Patient's Pupil.

16. **To Set the Finder and Focusing Eyepiece *N* (Figs. 1 and 2) to the Observer's Eye.** Displace the eyepiece cap until the cross-lines appear distinct in the eyepiece. Persons with pronouncedly ametropic or astigmatic eyes should retain their distance spectacles when setting the eyepiece.

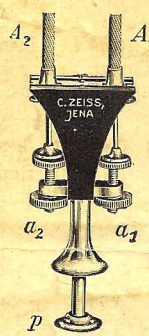
17. **To direct the slit and stop images *S'* and *B'* into the patient's pupil.** Let the patient place his head upon the chin and head rests, the latter being adjustable with the aid of the screw nut *h* and the set screw *g* (Fig. 1). Look past the camera

and by turning the milled head *d* of the compound slide and the screw collar *m* in the vertical extension direct the slit image *S'* upon the lower sclerotic or the iris of the patient's eye. The slit image may then be sharply focused by the displacement of the apparatus with the aid of the milled head *v* in the compound slide (Fig. 1). The image which appears sharply defined in the sclerotic or iris should have the appearance described in art. 14.

18. Now direct the slit image with the aid of the vertical extension *m* into the artificially expanded pupil of the patient, which will cause it to vanish to the observer. The circular invisible image of the objective stop *B* (Fig. 2) will be situated in the middle of the patient's pupil.

The Photographic Exposure.

19. **To accurately focus the image of the retina R_2"**, look through the finder and focusing eyepiece *N*. With the slit and stop images properly set, the fundus of the eye will be seen as a bright red patch. With the aid of the milled head *T* focus the camera accurately upon the blood vessels of the retina. This is greatly facilitated by the five-fold magnification afforded by the eyepiece.



11121 Fig. 8. The Double Shutter Release.

20. Cause the patient to look into the direction which furnishes the required photographic picture, using a small filament lamp as a fixation mark. With restless patients the observer's field of view is liable to become wholly or partially extinguished or marred by reflections, in which case the slit image will completely or partially leave the patient's pupil. The observer will, however, experience no difficulty in following these movements with the aid of the compound slide motions *s* and *v* and the vertical extension *m*.

21. Exposure is made by depressing the knob *p* of the double shutter release (Fig. 8). This causes first the branch A_1 of the release to raise the mirror *f* (Fig. 2) and thereby to give a free path for the light to the photographic plate *M*. At the instant when the mirror arrives at its top position the other branch A_2 of the release sets the sector shutter together with the bright glass in motion. Exposure then takes place in accordance with the shutter opening which has been set by means of the winding knob *b* (Fig. 7). With the brake *f* in or out of action, the exposure can be made to vary from $^1/_8$ to $^1/_{22}$ second.

22. **The Times of Exposure (in seconds) are:**

Winding knob *b* (index z) set to	Largest opening 0	1	2	3	4	5	Smallest Opening 6
Brake spring *f* in action . . . . . about	$^1/_8$	$^1/_9$	$^1/_{10}$	$^1/_{11}$	$^1/_{13}$	$^1/_{14}$	$^1/_{16}$
Brake spring *f* out of action . . . about	$^1/_{11}$	$^1/_{12}$	$^1/_{13}$	$^1/_{15}$	$^1/_{17}$	$^1/_{19}$	$^1/_{22}$

Pull forward the winding knob *b* before setting it to the corresponding number.

In every case, however, first wind the shutter in accordance with arts. 15 a to c).

23. The double shutter release (Fig. 8) is supplied with the apparatus in its properly adjusted condition. The set screws a_1 and a_2 should not be touched, as otherwise the phases of the release, as described in art. 20, are liable to be affected. When renewing a release wire, the required sequence in the motion of the mirror and that of the shutter should be established by means of the screws a_1 and a_2.