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AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF 1.06 MICROMETERS--ETC(U)
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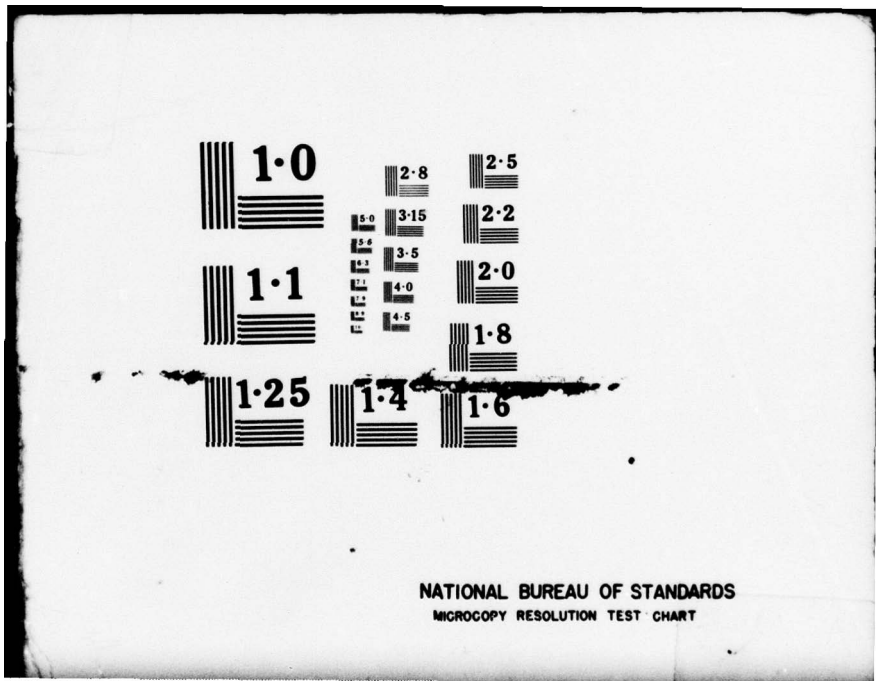
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6 AN EXPERIMENTAL INVESTIGATION OF THE EFFECT OF 1.06 ~~μm~~ micrometers LASER LIGHT ON THE TRANSPARENT OCULAR MEDIA.

9 FINAL REPORT. 1975-77

11 June 1977 | 12 13p.

By

10 Norma D. Miller

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

A unique camera attachment for a Zeiss Slit Lamp is described. The purpose of the camera is to provide a means of quantifying changes in the scattering properties of the lens. The film plane is tilted at an angle to the axis of the biomicroscope to permit sharp imagery of the entire illuminated cross section of the cornea and lens. A photographic step wedge is included in the film plane and is illuminated by a sample of the slit beam after passing through the microscope and camera optics. Typical photographs are presented.

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1. INTRODUCTION

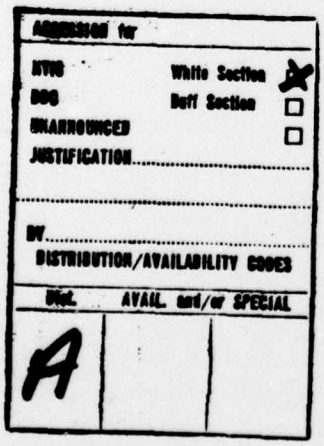
During a previous investigation of the effect of 1.06 μm laser light on the preretinal ocular media, an increased scattering in the rabbit lens was observed following certain exposure conditions[1]. The earlier evaluation of lenticular changes was accomplished by visual slit lamp examination. The changes were of a subtle nature with a slightly increased opalescence as the only effect of the exposures. No discrete lenticular opacities were induced for exposure levels an order of magnitude greater than that required for the production of minimal retinal lesions. While the lenticular changes were slight, they were consistently produced at exposure levels comparable to retinal lesion thresholds and above. For a few animals followed for six months post-exposure, the changes were not reversible.

It was the purpose of the effort herein reported to develop a method of quantifying the relatively subtle changes observed *in vivo*. Commercially available slit lamp biomicroscopes represent a high state of development of a specialized instrument ideally suited to the purpose of detailed examination of a cross section of the refractive media *in vivo*. Visual examination by the slit lamp biomicroscope provides a sensitive but qualitative technique for examining the ocular refractive components. Conventional photography of the slit lamp image provides a permanent record of the optical section but due to normal variations in exposure and processing conditions, it is also qualitative. Due to the obvious advantages of the instrument, however, it was decided to use it as the basic component in a system for quantifying the observed lenticular changes.

Photography can be used for precise radiometric comparisons if proper control of exposure and development conditions is exercised. A useful

technique for calibration of photographic densities when process variables are not subject to ideal control is the incorporation of a standard density step wedge into the photographic record. Brown described a slit-image camera which utilized such a standard density[2]. In his system a specially designed camera was substituted for the observing optics of a slit lamp instrument. The standard density step wedge was projected onto the film plane by a subsidiary lens and illuminated by a sample of light from the flash tube source of the slit illuminator. This arrangement provided a means of eliminating the effects of variations in flash tube intensity and film processing but not the effects of variations in slit width or illuminator and image forming optics.

Careful analysis of the possible variables in slit-lamp photography and the requirements for their control led to the design and construction of a system which will be described in detail in the following section.



2. PHOTOGRAPHIC SLIT-LAMP BIOMICROSCOPE

The photographic system utilizes a Zeiss Series 100/16 Slit Lamp with tungsten filament illumination. The viewing optics are a stereomicroscope consisting of a Galilean system to provide 5 magnification steps over a range from 6.3 to 40X. Five sets of dual objectives with a working distance of 100 mm are mounted in a housing in front of a pair of telescopes of fixed magnification. Inasmuch as the image formed by the objectives is at optical infinity, a well corrected photographic objective can be substituted for a viewing telescope to form an image with negligible degradation of quality. Care must be exercised in the selection and positioning of the photographic objective to reduce vignetting effects. A Schneider 18-cm lens was selected for the camera objective. It has a maximum aperture of f/4.5.

The slit-illuminating system forms a narrow beam of light which illuminates a thin cross section of the anterior ocular structures when the eye is properly positioned. The final photographic image is formed by light scattered from the beam by structures in the ocular media. The angle between the illuminating beam and the optical axis of the viewing system can be varied over a wide range, but for accurate comparisons of the amount of scattering at different pre- and post-exposure times, the angle must be constant. A 45^{o} angle was selected as giving the optimum separation of ocular structures on the photographic record. This results in a photograph which is in focus over a limited area of the ocular cross section for the normal condition of the film plane normal to the photographic objective axis. The depth of field can be increased by decreasing the lens aperture but this solution is unacceptable because of the increased vignetting and reduction in illumination in the image. The alternate solution of tilting the film

plane to coincide with the image plane was adopted. Figure 1 is a schematic drawing of the illuminated cross section, lens and film relationships. The slit illumination beam cuts across the ocular cross section AP. Light scattered from B, the focal point of the slit lamp, is at the anterior focal point of L_1, the biomicroscope objective, and emerges as a parallel beam which is brought to a focus at the principal focus of the photographic objective L_2 at B'. The light scattered from A in the cornea emerges from L_1 as a divergent bundle and is brought to a focus by L_2 at A'. By tilting the film plane to F', the entire portion of the scattering cross section is in focus in the photograph. The angular relationships were calculated by paraxial ray trace formulae using the schematic rabbit eye developed by Hughes[3]. The angle of tilt of the film plane is 32.2^{o} from the normal position.

It was considered essential to form an image of the standard density step wedge on the film with light which represented a true sample of the light in the ocular image. The arrangement for accomplishing this objective is shown in the schematic of the slit-lamp camera system in Figure 2. A sample of the slit illumination beam is reflected from a glass plate P, mounted at 45^{o} to the illuminator prism face. A first surface mirror at M_1 reflects the light through an aperture placed over the second objective of the biomicroscope. The photographic objective is centered over the exit pupil of the other biomicroscope objective, thus forming the image of the ocular structures on the tilted film. The light from M_1 passes through the photographic objective at the edge of the lens and is reflected from the first surface mirrors M_2 and M_3 to illuminate the standard density mounted in the film plane aperture. This design provides a contact print of the standard density on the film near the ocular image for each exposure. Thus, the

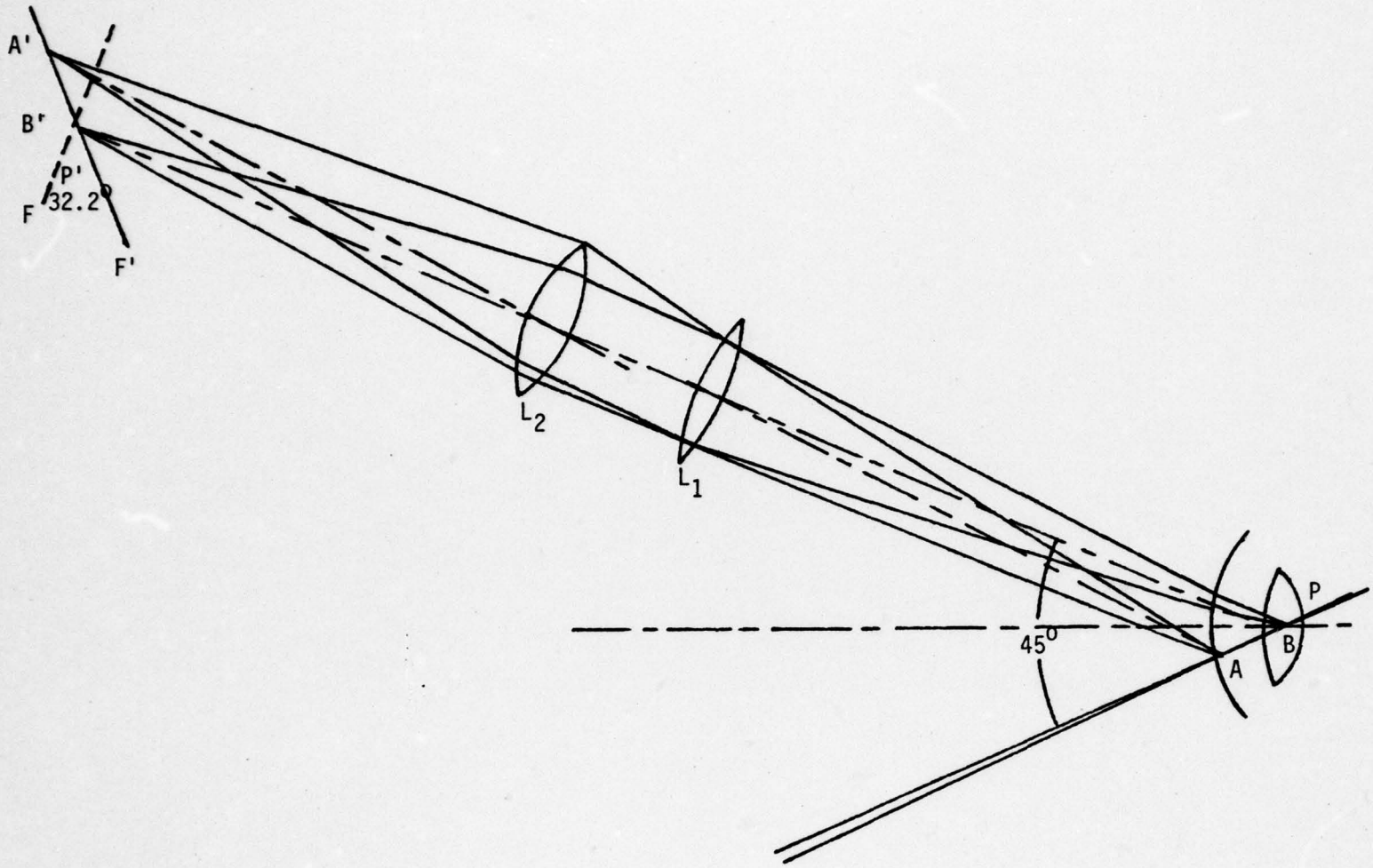


Figure 1. Schematic diagram of the arrangement of ocular cross section, lens and film plane.

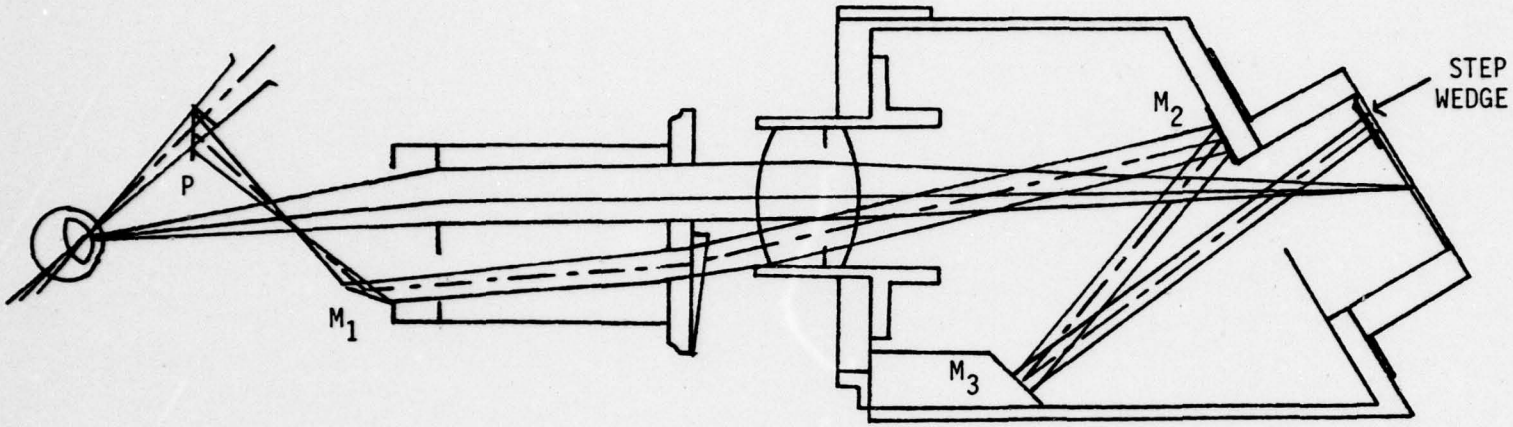


Figure 2. Schematic of slit lamp camera for quantification of changes in ocular scattering.

light used to illuminate the standard density is subject to all the variables affecting the exposure of the ocular image. The position of the standard density image adjacent to the ocular image insures that it is also subject to the same processing variables.

A representative photograph of a rabbit eye taken with the slit lamp camera is shown in Figure 3. Due to the restricted density range of photographic paper compared with film, the photograph contains only a portion of the standard density. The illumination in the film plane has two discrete levels over the area of the step wedge, providing a sufficient number of density levels for an accurate exposure-density calibration curve to be plotted for each frame.

The internal calibration feature of the slit lamp camera provides the means of accurate quantification of lenticular scattering changes over prolonged post-exposure periods.

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Figure 3. Photograph of a normal rabbit eye taken with a slit lamp camera showing a portion of the standard density step wedge.

3. CONCLUSIONS

An instrument has been constructed to provide precise quantification of changes in the amount of scattering from the anterior ocular media. The basic component of the instrument is a Zeiss Slit Lamp with a specially designed camera substituted for the binocular telescope tubes. A standard density step wedge is incorporated in the film plane of the camera and is contact-printed onto each exposed frame to provide a means of eliminating the effects of exposure and processing variables.

The film plane of the slit lamp camera is tilted to coincide with the image plane of the ocular cross section insuring sharp focus for the entire depth of the cross section. The optical quality of the resulting photographs is demonstrated in Figure 3. The photograph clearly shows the structures in the normal rabbit lens that are characteristic of such lenses. Of particular interest is the slight transverse opacity in the form of a filament extending from the posterior pole of the capsule toward the lens nucleus. The filament provides a useful landmark for the accurate positioning of the slit beam for insuring that the same section of the eye is photographed on each occasion.

It is of interest that the structures visible in the photograph of the normal rabbit eye seem to have been described in the literature for the first time in 1976 by Pitts[4]. In his description of the biomicroscopic findings he states:

> "Some of the descriptions of the long-term ocular effects of ultraviolet radiation closely resemble the above biomicroscopic description of the normal rabbit eye. Therefore, it appears that a re-evaluation of the literature would be necessary for the conclusions to be valid."

The slit-lamp camera constructed during this investigation provides a means of precise measurements of long-term changes in the scattering from the ocular structures to differentiate between the normal eye and post-irradiation alterations.

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