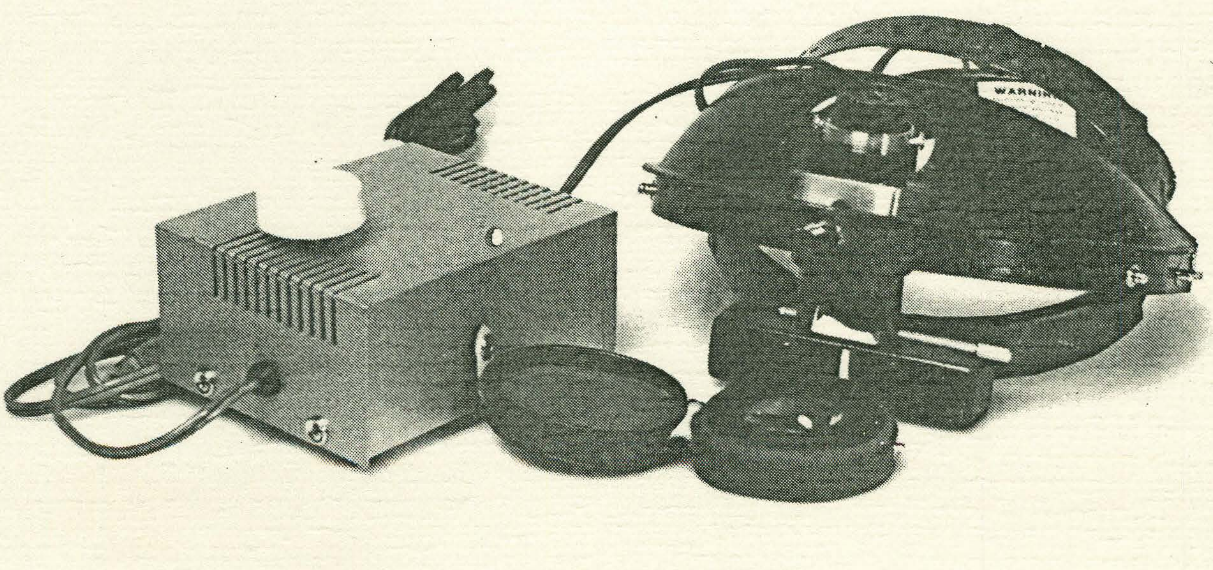
THE DESIGN AND CONSTRUCTION OF A HOMEMADE BINOCULAR INDIRECT OPHTHALMOSCOPE



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CLASS OF 1985

CLINICAL NEED OF INDIRECT OPHTHALMOSCOPY

As the scope of optometric practice expands toward a more comprehensive type of eye care, the need for additional skills and instrumentation is also required. One such skill is the examination of the peripheral fundus. The peripheral fundus is the area of the retina anterior to the equator and encompasses 40% of the ocular fundus. The binocular indirect ophthalmoscope (BIO) is the instrument of choice when examining this area. This instrument has many favorable features that make its use essential in order to do a complete and thorough fundus evaluation.

As the number of states allowing diagnostic pharmaceutical agents (DPA's) increase, the utilization of the BIO becomes more and more practical. Not only does the BIO allow the practitioner to view the peripheral fundus, but it also permits him to observe a much larger area with a single view. The BIO provides a viewable area of approximately eight disc diameters compared to that of only two disc diameters with a direct ophthalmoscope. In addition, the indirect ophthalmoscope, with its lesser magnification and aerial imagery, greatly reduces the visual distortions present when trying to view the peripheral fundus. The BIO also provides the examiner with stereopsis, invaluable when localizing and understanding the pathophysiology and progression of various fundus lesions and media abnormalties.

OPTICS OF THE BINOCULAR INDIRECT OPHTHALMOSCOPE

Even though the BIO appears to be a highly sophisticated instrument, the actual optics of this instrument are quire simple in nature. The BIO consists of three basic components: a hand-held condensing lens, an ocular head unit, and a light source powered by a transformer.

The condensing lens has a dual purpose. It is first used to produce a bright, flat, three-dimensional, undistorted aerial image. The image is real, inverted, and located between the condensing lens and the examiner. (See figure 1.) Secondly, it serves as a condensing lens, gathering light from the light source and converging it to a precise, non-aberrated image of the filament centered within the pupil of the eye of the patient. This results in a uniform illumination of a large area of ocular fundus. The condensing lens comes in a variety of powers, ranging from +14 D to +33 D. This power directly affects the magnification obtained by the BIO. The following equation demonstrates this: $\frac{\text{power of the eye} = 60\text{ D}}{\text{power of the lens} = X}$ = magnification of the BIO. The lower the power of the condensing lens, the higher the magnification obtained and consequently the smaller the field of view. The condensing lens is held at approximately arms length from the observer and just above the patient's eye. The latter distance is also dependent on the power of the lens.

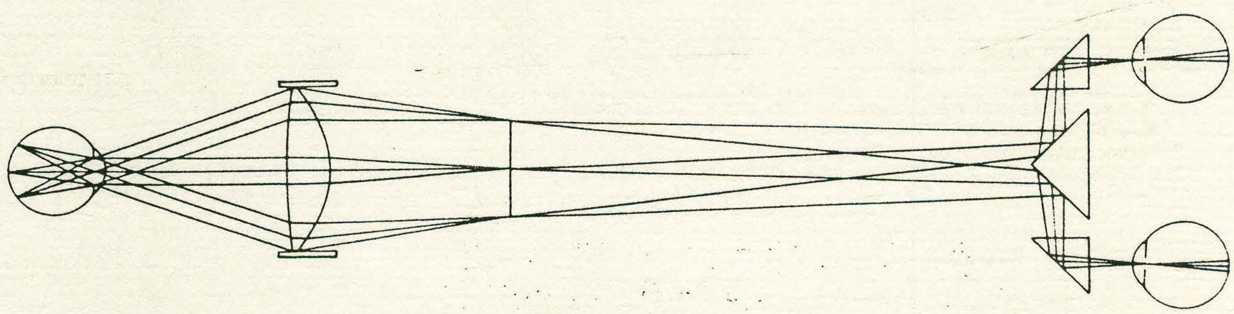

figure 1

The ocular head unit consists of a group of prisms or mirrors that enables the aerial image of the condensing lens to be viewed independently by each eye of the examiner. This provides the stereopsis obtained while using the BIO. A central prism, or two mirrors set at a 90 degree angle to each other and a 45-degree angle to the optical axis of the condensing lens, splits the aerial image in opposite directions. In turn, these two images are again reflected by a second set of prisms, or mirrors, into the corresponding eyes of the observer. (See figures 1 and 2.) In addition to the image-splitting mechanism, each eyepiece of the head unit has an ocular lens ranging in power from a +2.00 D to a +2.50 D. This enables the examiner to view the aerial image at arms length without taxing their accommodation. The eyepieces are also adjustable to compensate for individual inter-pupillary distances.

Attached to the head unit is the light source, which is usually attached above the optical system. The light is reflected by a mirror so that it can be aligned to pass through the condensing lens, along with the optical axis of the head unit. (See figure 2.) The light source provides a great deal of illuminance, which enables the examiner to view the fundus through corneal, lenticular, or vitreal opacities.

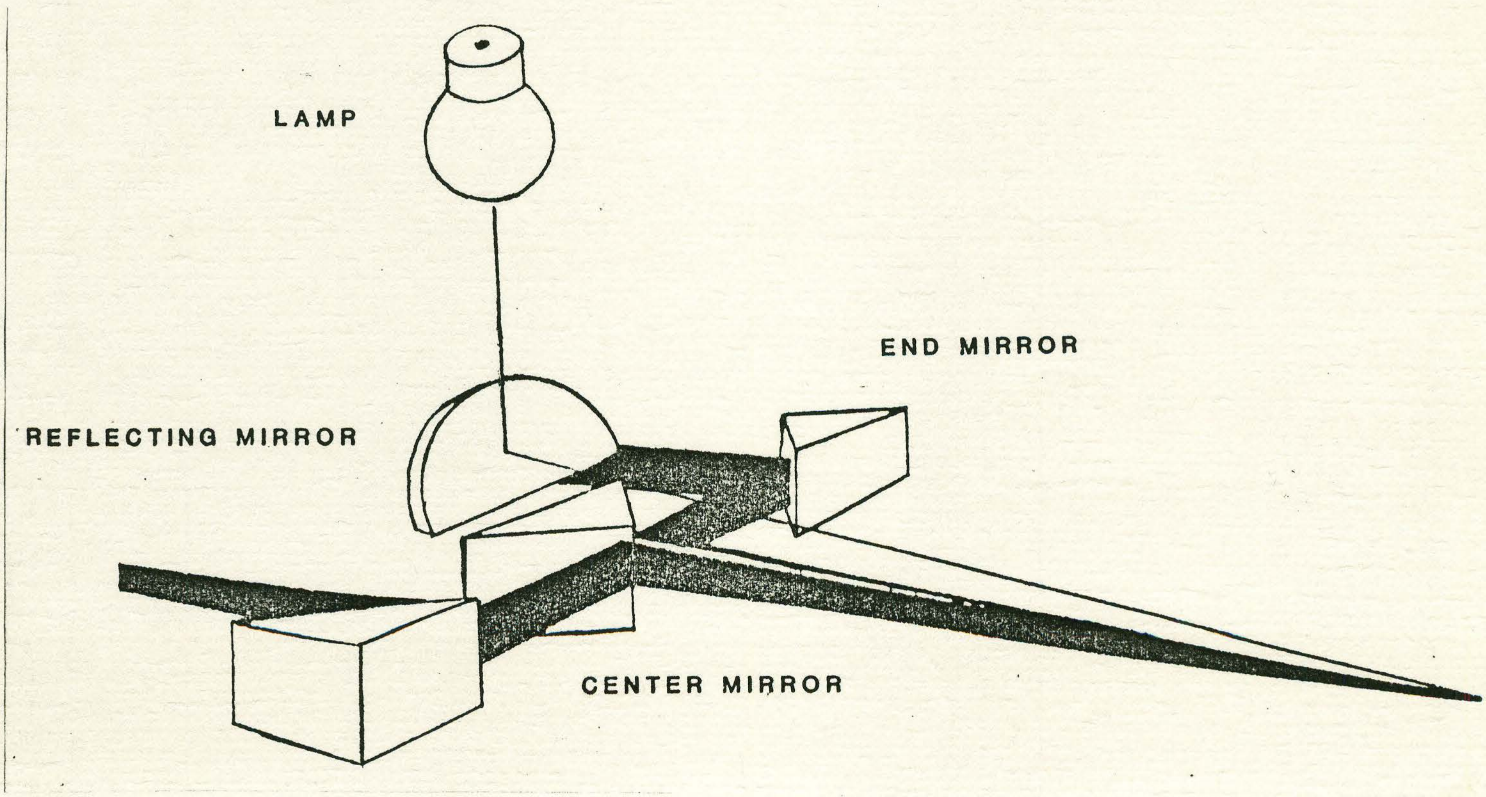

figure 2

DESIGN AND CONSTRUCTION OF A HOMEMADE BIO

With the realization of the importance of the binocular indirect, I decided it would be beneficial to have one. After studying the design of several different models, I decided to try to construct one of my own. To make it as inexpensive as possible, I spent much time searching for the right materials. I started with the optical system of the head unit. For the reflecting surfaces I obtained some scrap front-faced mirrors from the workshop in the FSC optometry building. The mirrors would take the place of the prisms used in commercial models to split the image into two, and direct these two images into the eyes of the examiner.

The next step was to find a material for the housing of the optical system. A material that was lightweight, strong, sturdy, and easy to work with was required. Finding a material with these properties was difficult and was actually found by accident. The material used was from wood paint stirrers. The paint stirrers were cut into sections and glued together to form a rectangular box with dimensions of 100mm x 25mm x 25mm. An area of 40mm x 20mm was cut out of the front panel to allow light to enter the system. In the back panel, two 10mm holes were drilled 64mm apart for the eyepieces. The bottom panel was fit with a 2mm balsam wood border located 2mm from the edge. This enabled the bottom to fit snuggly into place, but it could still be removed to clean the mirrors. The mirrors were cut to the size of 20mm x 25mm. These were then mounted onto blocks of wood already cut with the following designated angles: 90 degrees for the front two mirrors, and 45 degrees for the side two. These were then adjusted until stereopsis was obtained; they then were marked and glued onto the top panel. A thin sheet of glass was then inserted into the front opening to protect the optics from dust; and the bottom panel was secured with a set screw. Ocular lenses were negated due to non-availability.

The edges of the wooden housing were then finely sanded until they were smoothed and rounded. (See figure 3.)

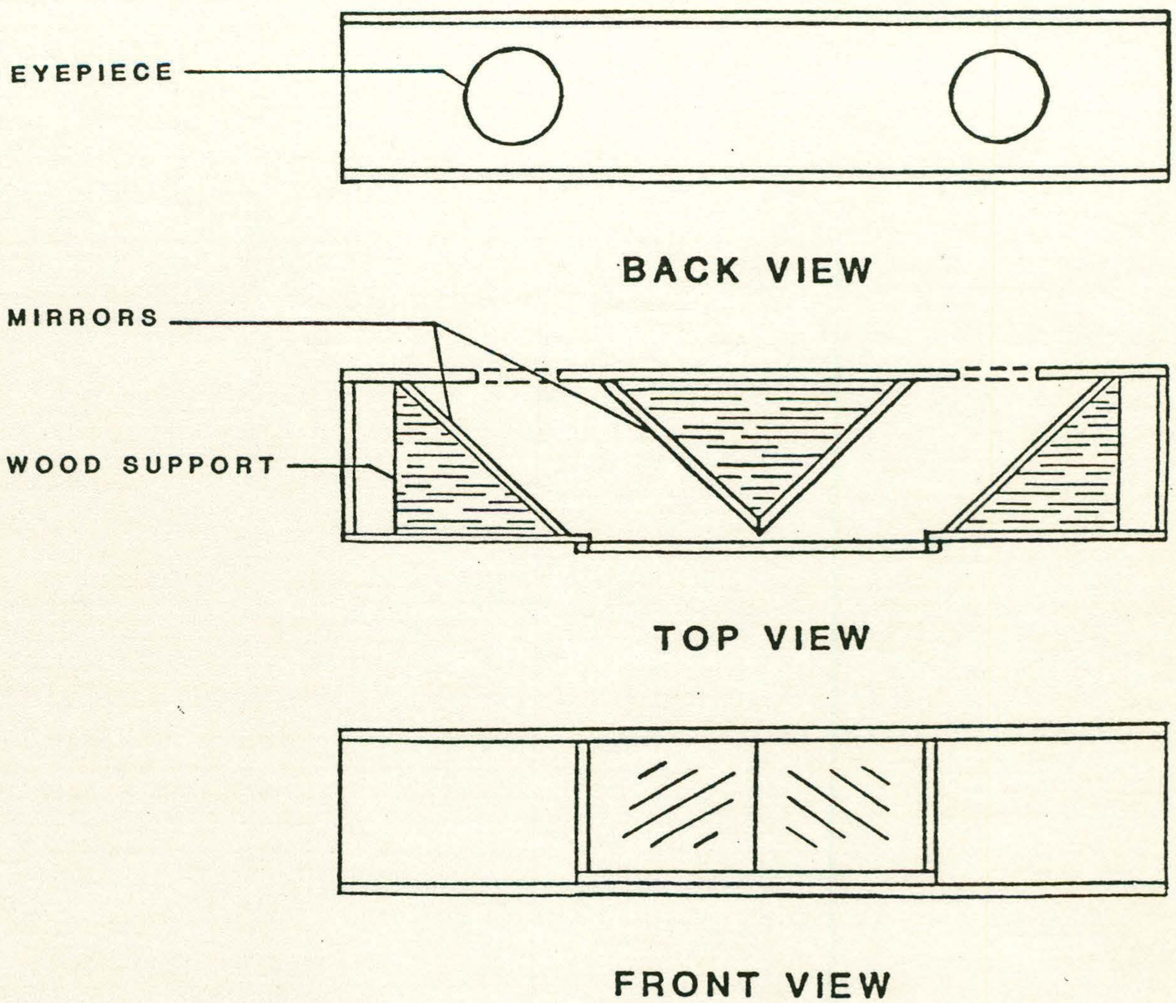

figure 3

The next step was to fabricate a housing for the light source. With the intensity of light a BIO requires, the housing needed to be fairly heat resistant. PVC plumbing pipe was used for the outer portion. Two end pieces were cut to lengths of 40mm and mounted end to end. A +60 D lens was placed between the two ends, which would serve to condense the exiting light. The upper half was drilled with a series of 4mm holes to act as vents, so air would be able to circulate. The front end of the bottom piece was removed to allow an outlet for the light. In this portion a mirror was cut and mounted on a thin metal rod to reflect and align the light source into the hand-held condensing lens. Into the top of the housing a piece of metal plumbing was inserted so that a 1mm gap was left between it and the PVC. A 40 watt bulb, used in some commercial BIO's, was then mounted by two set screws into the metal tubing. The whole unit was then aligned and glued onto the top of the wooden housing. (See figure 4.)

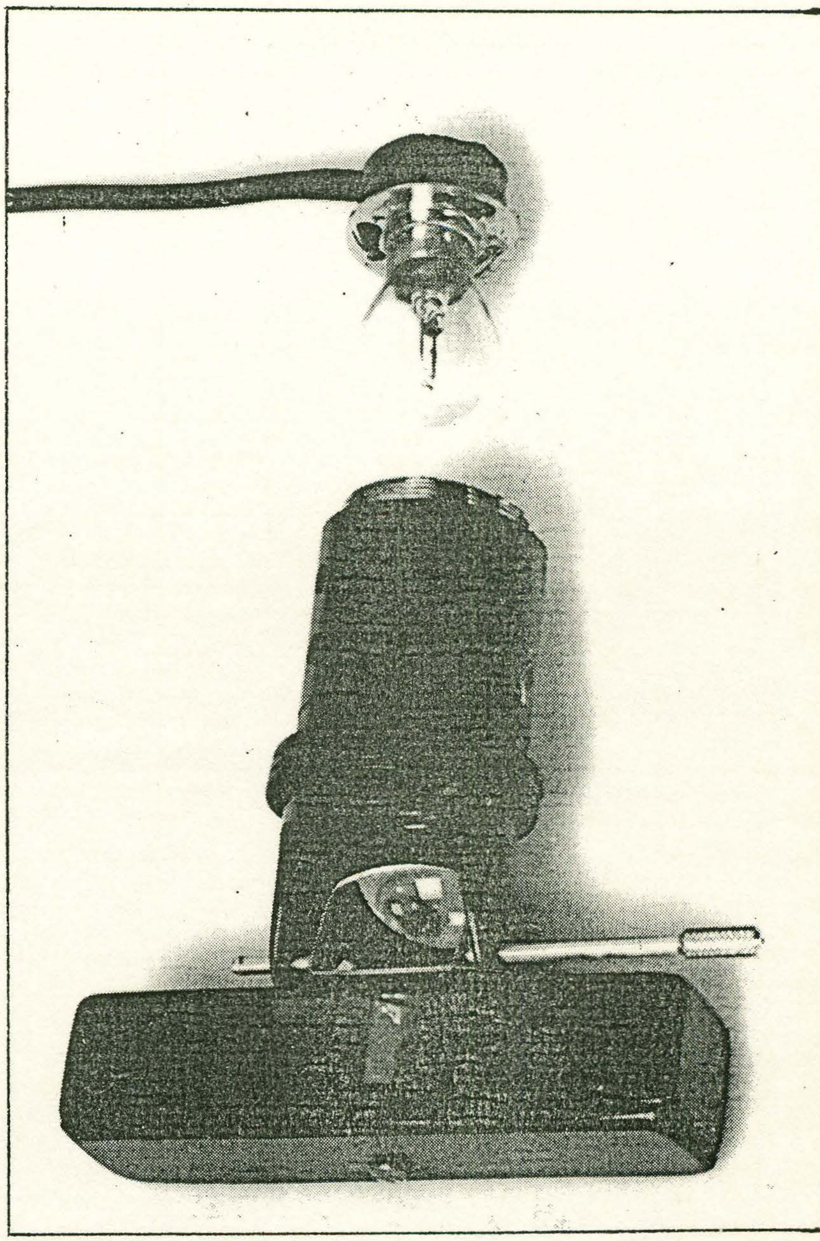

figure 4

An adjustable headband with a flip-up visor was obtained from a welding-supplies store. In the visor a 50mm hole was drilled, so the top of the light unit could fit up into it. A u-bracket was then mounted with two 1 x ¼ inch flat-head bolts onto the upper portion of the PVC housing. The front of the u-bracket was in turn mounted with a third bolt onto the front rim of the visor. This type of setup allows the optical and light unit to be moved back and forth, and up and down for adjustments. (See figure 5.)

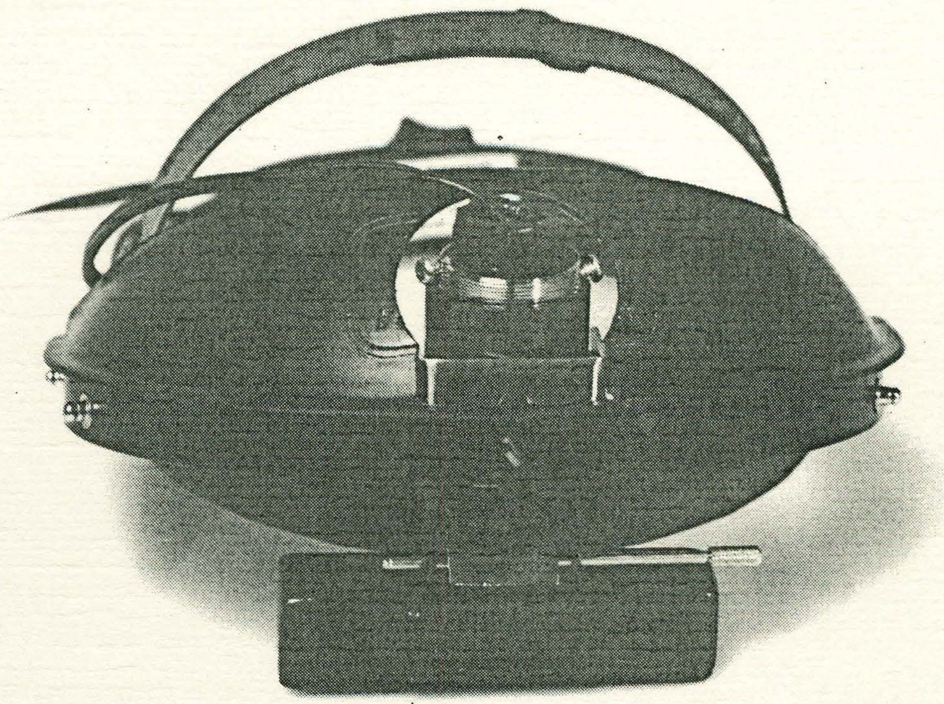

figure 5

The final part to assemble was the transformer. A transformer, a dimmer switch, and an in-line fuse were connected and mounted into a small metal box. All these parts were purchased at a local electrical shop. An eight-foot electrical cord was attached from the bulb to the transformer. The dimmer switch allows the intensity of the light to be adjusted, and the in-line fuse prevents the bulb from being shorted out.

COST AND PERFORMANCE OF THE HOMEMADE BIO

The total cost of the above BIO came out to approximately thirty dollars. Many of the materials used were either scraps or obtained at little or no cost and this helped keep the total cost down. The major components (optical system, light source, headband) were all relatively inexpensive. The major expense was in the transformer and the bulb. Also to be considered when discussing cost is the hand-held condensing lens, which usually runs around $140.00. (See figure 6.)

HEAD UNIT	
Headband	$ 6.25
2 PVC tubes	2.00
8 feet of electrical cord	2.00
Cost to have mirrors cut	2.00
1 metal plumbing	1.00
3 1 x 1/4 inch flat-head bolts and nuts	.30
Mirror handle	.20
	$13.75
TRANSFORMER	
40 watt bulb	$ 6.00
Transformer	5.99
Metal box	3.92
Fuse holder and 3 amp fuse	1.58
	$16.50
TOTAL COST	$30.25

figure 6

The above BIO has been used several times in a clinical situation with no major problems arising. Although the inter-pupillary distance is set at 64mm, several practitioners have demonstrated successful fundus evaluations even though their individual P.D.'s have varied. This is due to the larger than average diameter of the eyepieces, and the ability of the optical unit to be moved toward or away from the observer's face. The eyepiéces are also lacking the ocular lenses found in the commercial models; but this too, has not proven to be a problem due to the ability of accommodation of the observer. This may be shown to be a problem if the examiner is presbyopic. Having used several different models of BIO's, I feel the quality of the view with the homemade BIO is as good as any I've used. It is comfortable and very lightweight. The only foreseeable problem is the inability of the light housing to handle the heat released when the light is used at higher intensity or for an extended period of time.

From the experience of studying the different designs, and constructing the BIO in this paper; I now have a much better understanding of the optics and theory behind indirect ophthalmoscopy. With this increased understanding, I feel I am now much more capable of performing efficiently with this instrument.