3. OPHTHALMIC SYSTEM

Torch Light

Description and purpose: A torch light is the first instrument an ophthalmologist uses to examine the eye of a patient. A good torch light should give a circular patch of light of nearly uniform brightness. The light from a torch light that uses two of the regular 1.5V dry cells and a bulb of 1 or 2 watt rating is sufficient for the initial examination. The front glass cover, the bulb, the concave reflector, the switch, the cells and the barrel are the main parts of the torch cell.

Figure 1. An electric torch with front end open and transformer pulled out

Trouble shooting and repair:

❖ No illumination

- bulb 'fused': Remove the bulb, check continuity using a multimeter and change the bulb if there is no continuity.

- If there is continuity in the bulb and the bulb still does not glow, then check the switch and rectify contact problem if any. The switch is usually a press and slide type. When the switch is not functioning, the tip of the copper plate that makes the contact may be tarnished or corroded.

❖ Poor illumination even with fresh cells: This could be due to scratches on the front glass (clear plastic) cover or due to tarnished reflector. Both these items can be changed.

OPHTHALMOSCOPE

Description and Purpose: The Opthalmoscope is by far the most used, and several versions have been designed. It was invented in 1851 by Helmholtz. Bright light is projected into the subject's eye, and the returning light from the subject's retina is positioned so that it can be focused by the examiner. Light is directed into the patient's eye to permit the examiner to view the retina through a correcting lens. Ophthalmoscopes are of two kinds direct and indirect, used to examine the retina around the fundus.

- Light from a bulb is reflected at right angles and projected as a spot through the iris of the patient to illuminate the retina. This reflection is achieved using a front silvered mirror or partially silvered mirror or a total reflecting prism in different scopes. The illuminated retina is seen directly by the doctor through the iris of the patient. A disc with lenses of different powers is provided in the instrument and a lens of required power can be brought in the line of sight to correct any refractive error of the patient or of the doctor himself if he does not look through his spectacles. An image magnified nearly fifteen times is seen.

Description of major subsystems: The Ophthalmoscope has two major subsystems.

1. An electrical system

2. An optical system (also known as the head)

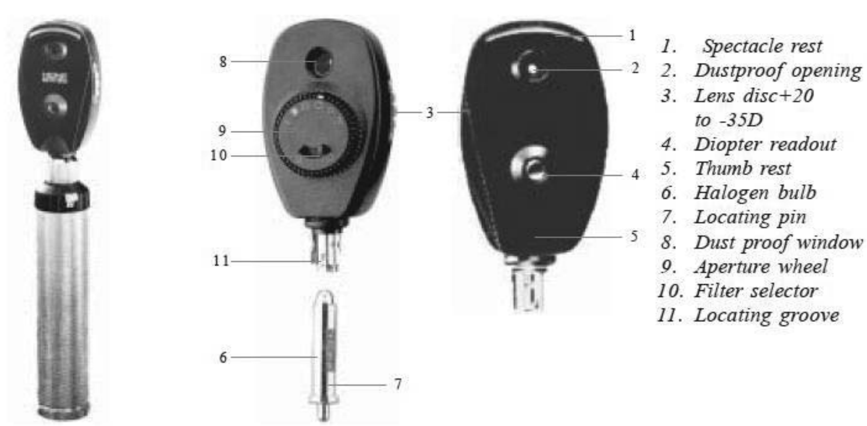

Figure 2 Ophthalmocsope with labeled parts

The electrical system: This consists of either dry cells or a rechargeable battery, used to light a bulb through a switch and a rheostat (a variable resistor) that controls the current through the bulb for changing its brightness. Some ophthalmoscopes run on the main electric supply through a step down transformer. The tube in which the cells (rechargeable battery) are kept also serves as the handle for the instrument. The instrument that works on mains supply is provided with a solid handle. it is possible to convert locally a battery operated ophthalmoscope into an mains voltage operated one using a suitable step down transformer and an associated regulator circuit.

The optical system (the head): This is fitted on the handle with a spring loaded locking or screw mechanism. It consists of:

1. A system of condensing and focusing lenses and a reflector (a front coated mirror or a total reflecting prism) to produce the spot of light.
2. The viewing system consisting of a disc with lenses of different powers usually ranging from -20 to +20D.

In some instruments a high positive or a high negative lens can be brought in by a sliding adjustment. In some instruments that have a much wider range of powers (-40 to +40D), two wheels carrying the lenses are provided and a combination of two lenses give the required power. The power of the lens used for viewing is indicated on the disc and can be seen through a window in the head. The reading is illuminated using a partially reflecting plate held in the path of the main light team. There exist provisions in the head for changing the spot size or for obtaining a semi- circular spot or for reducing it to a streak or to provide concentric circles on the spot using different stops in the path of the light beam. Also there is provision for introducing filters (red free or polarizing) in the path of the light for special applications. The ray diagram of the optical system is shown in **Figure 3-1,3-2**.

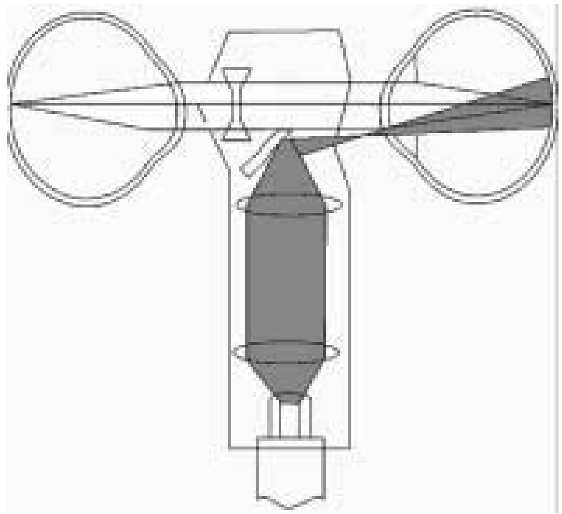

Fig 3.1 The ray diagram of the optical system.

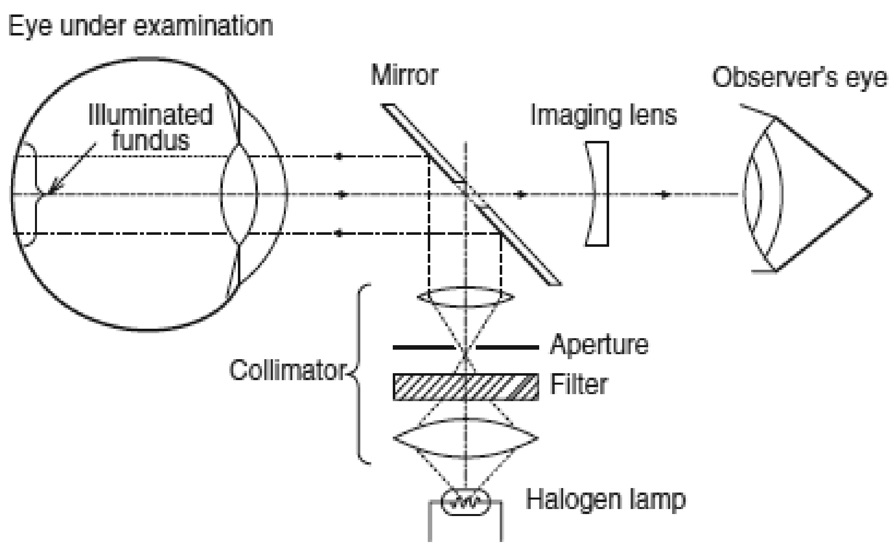

Figure 3.2 Schematic of the optical design of an ophthalmoscope.

Trouble shooting and repair:

Bulb not glowing or the glow is weak:

- Remove the bulb and check for continuity in the bulb using a multimeter.
- If continuity exists, the fault is in the electrical system.

- If there is no discontinuity, replace the bulb. Sometimes there may be continuity but the bulb may be black. Such bulbs do not give out sufficient light and need to be replaced.

Fault in the electrical system:

- Check the operation of switch and rheostat using a multimeter and clean the contact, and replace them if they are defective.
- Check the voltage in the cells / rechargeable battery. Replace the cells or recharge the battery if the voltage is low.
- If the cells runs down very fast it may be because the switch is not functioning properly and the current is drawn from the cell even when the switch is 'off'. In such situations clean the switch mechanism. If found defective replace it. Usually the rheostat and switch come as a unit and are replaced together.
- In the case of instruments running on mains power, check the connecting wires for continuity and replace them if necessary. In these instruments, if the switch and the rheostat fail, external switch and rheostat may be provided at the power supply.
- If there is continuity and the bulb is not glowing, check the switch and the transformer in the power supply and replace them if necessary.

INDIRECT OPHTHALMOSCOPE

Description and Purpose: The modern Indirect Ophthalmoscope functions as the eye piece of a stereomicroscope for which a hand held high positive spheric lens (17D, 20D or 30D) serves as the objective. When viewed properly, a magnified image of the retina is seen.

Some of the advantages of the instrument as compared to the direct ophthalmoscope are: (1) stereoscopic view (2) greater field of view (3) increased illumination (4) reduced distortion (5) An additional advantage is that the doctor is at a distance from the patient. However, the final image seen is inverted and the magnification is much lesser than in a direct ophthalmoscope. Figure (4.1) shows the indirect ophthalmoscope.

Description of major subsystems: An indirect ophthalmoscope has four major subsystems.

1. An illumination system

2. An electric system

3. A stereoscopic viewing system (vision box)

4. A head band that supports the illumination system and the vision box

<u>The Illumination System</u>: This consists of a tungsten filament lamp or a halogen lamp and a front silvered concave reflector suitably positioned behind the lamp. Two condensing lenses are placed in front of the lamp. The lens close to the lamp is fixed while the other lens could be moved forward or backward and fixed in position with the help of a spring loaded screw. There is provision for introducing filters of required characteristics in the path of the light. The light coming through the second lens is reflected using a front silvered mirror to provide the illumination at the eye of the patient. The mirror could be tilted and fixed in any required position for easy examination.

<u>The Electrical System</u>: This consists of a step down transformer provided with a switch, a rheostat, a fuse and a sufficiently long connecting cable. The transformer is either fixed on the wall near the examination table or kept in the box of the instrument.

Figure 4.1. Indirect ophthalmoscope. Top - Head band, Bottom - Spectacle mounted

The Vision Box: This has two eye pieces. They can be moved laterally in the vision box to match with the inter pupillary distance of the doctor. The hand held high power positive aspheric lens gives a real inverted image of the patient's retina in space in front of the lens. The light from this image meets a 90° wedge formed by two mirrors in the vision box. The wedge divides the beam into two beams which are further reflected by two 45° mirrors (or total reflecting prisms) before they reach the eye of the doctor through the eye pieces. The ray diagram indicating the working of vision box is as shown in Figure 4.2. The vision box is rigidly attached to the illumination system. This is usually well sealed so that no dust enters the box. In some instruments, a pair of semi-silvered reflectors can be fixed in the vision box. These are known as teaching attachments. They are useful for assistants (students) to look at what the doctor is looking at. The picture of an indirect ophthalmoscope with this attachment is shown in (Figure 4.3)

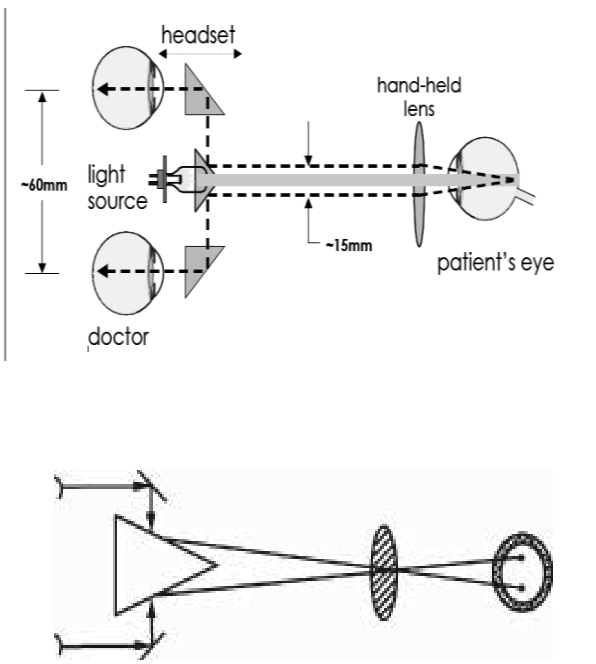

Figure 4.2 The ray diagram indicating the working of vision box

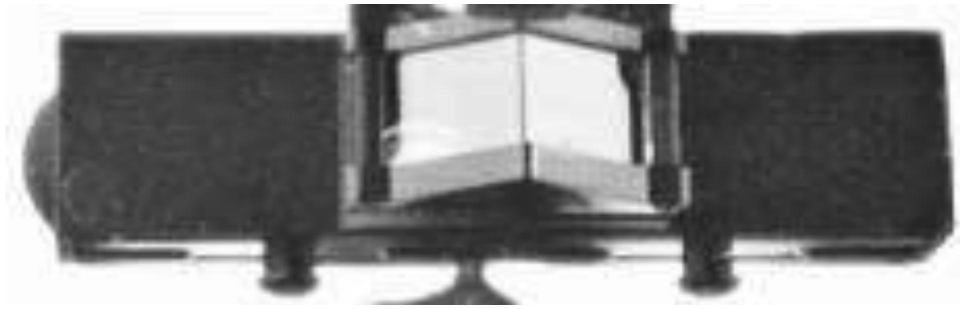

Figure 4.3 The teaching attachment

<u>The Head Band:</u> The illumination system and the attached vision box are attached to a head band that a doctor can wear conveniently. The cable for the lamp is also attached to the head band. The illumination system, vision box combination could be tilted and fixed at the desired position using screws on the head band. While in use, the eye pieces are as close to the doctor's eyes as possible to give a wide field of view.

The illumination system and the vision box are also attached to a spectacle frame. The box provided for the instrument is such that when not in use the instrument together with the head band and the cables could be kept in marked positions in the box.

Trouble shooting and repair:

Bulb not glowing:

- Turn off the power supply and remove the bulb and check for continuity using a multimeter.
- If continuity exists the fault is in the electrical system.
- If not, replace the bulb. Care should be taken not to touch the new bulb with bare fingers.

Fault in the Electrical System:

- Check the continuity in the fuse in the power supply.
- If the fuse has continuity and the bulb does not glow check for continuity in the connecting wires. Replace them if there is any discontinuity.

- If the fuse is having continuity and the connecting wires also have continuity and still the bulb does not glow, check the switch. If it is defective replace it.
- If the fuse is blown only, look for any obvious short circuit in the electrical system.
- If there is no obvious short circuit, replace the fuse with a fresh fuse of the correct rating specified in the instrument.
- Turn the power on. If the bulb glows, the instrument is ready for use.
- If the fuse is blown, once again there is some hidden short circuit that needs more careful investigation.

RETINOSCOPE

The retinoscopy used to determine the prescription of a corrective lens without the patient's active participation (objective examination), although the eye has to be open and in a position suitable for examination.

Principle:

- A streak of light from retinoscope is projected into the patient's unaccommodated diluted eye.
- This light beam is reflected from the retina and acts as a light source for the operator.
- The retina's function in retinoscopy is the reverse of its normal function (**Figure 5-1a**).
- Since an object at the eye's far point would be focused at the retina of a relaxed eye, a light from the retina of a relaxed eye will produce a focused image at the far point.

  The operator views the patient's eye through the retinoscope and adds lens in front of the patient's eye (positive or negative, as needed) to cause the image from the patient's retina to be focused at the operator's own eye (**Figure 5-1b**). Different types of retinoscope are used. One of them, the streak retinoscope described here, is the most common instrument. It is used in the **objective** evaluation of the power of the spectacles needed to correct the refractive error of patients and also in determining the axis and cylindrical power needed for patients with astigmatism. As in direct ophthalmoscope light from a bulb is reflected at right angles and is projected on to the eye of the patient.

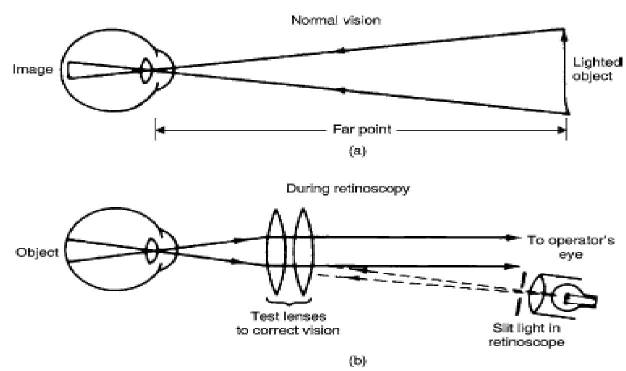

Figure 5.1 Showing (a) The eye during normal vision (b) During retinoscopy, reflected light form the patient's acts as the object. Lenses are added in front of the eye to focus the image from the retina at the operator's eye.

Description of major system: The streak retinoscope has the two major Subsystems:

1. An electrical system

2. An optical system known as the head.

The electrical system: Same as the one of direct ophthalmoscope.

The optical system: The distance between the focusing lens of the instrument and the bulb is movable. This is done by moving a sleeve up or down. This produces either a patch of light or a streak of light of variable width. The bulb is positioned in such a way that it can be turned about the axis of the instrument usually by turning the same sleeve. This results in the rotation of the patch of light or the streak about the line of sight of the user.

The reflector used is always a front silvered mirror and is much wider. In some instruments the reflector has a peep hole at the centre of the reflector. In other instruments the user has to look just above the reflector. The lens disc present in ophthalmoscope is not present in streak retinoscope

Figure 5.2 Retinoscope heads, Two models

Trouble shooting and repair

Fault in optical system (Same as for direct ophthalmoscope)

Fault in the electrical system (Same as for direct ophthalmoscope)

Mechanical faults:

- When the locking mechanism of the head with the handle does not function.
- Sleeve does not rotate and/or it does not move up and down. Loosen the screw holding the sleeve and remove it. Remove all dust, rust if any and gently lubricate it.

SLIT LAMP

Description and purpose: The slit lamp is one of the most commonly used diagnostic instruments of an ophthalmologist of today. It provides illumination and magnification for examining the eye and its various parts. The light is projected as a bright slit, thereby enabling detailed examination of the eye in small segments. It is used in the examination of the anterior segment of the eye, including the crystalline lens. With supplementary lenses the slit lamp is useful in the examination of the posterior region of the eye and the chamber angle, the fundus and good part of the retina. A number of accessories can be added to a slit lamp to convert it into a measuring instrument as well. One can measure intraocular pressure, the curvature of the cornea, the thickness of the cornea, the distance between the cornea and the lens, the anterior chamber volume, the opacity, etc. using different attachments. Some slit lamps can have camera attachment for photographic recording. Slit lamps are also used to deliver laser beam spots at any required place in the eye for treatment.

Description of major subsystems: A modern slit lamp consists of three major components:

1. An illumination system - light source, mirrors & prisms

2. A magnification system - the bio microscope

3. A mechanical system that links the magnification with the illumination system and provides vertical and lateral movements to focus the light on the desired part of the eye.

Figure 6 Slit Lamp

The Illumination System: The illumination system gives a well defined bright streak of light with sharp edges. The slit width is variable. The slit can be tilted as required. It has a source of light, a filament lamp or a halogen lamp used in some models for brighter light. The position and orientation of the filament is very important to avoid the image of the filament in the light projected from the illumination unit on to the eye of the patient. In some models there is a provision for tilting the illumination system forward through an angle of 20 degrees in steps of 5 degrees.

The electrical connection for the lamp is just a series connection through switches and pilot lamp. The voltage supplied to the bulb is adjustable in two or three steps. This is done by turning a knob, designated as brightness control knob (The brightness may have two steps low or high, or three steps low, medium and high). There is a main switch for the slit lamp. The pilot lamp glows when the power is turned on.

The Magnification System: The Biomicroscope is a stereo microscope that provides a stereoscopic view of the object (part of the eye) under focus, which is achieved by moving the microscope towards or away from the object after ensuring that it is at the proper height. The microscope is always focused on the slit image formed by the illumination system.

- (Inclined optics) The most common type has the axis of the two tubes forming the stereo microscopes inclined at 13° to each other, which constitutes essentially two microscopes, each with its own objective. There are usually two sets of objectives available for two different magnifications. The switching from one objective to another can be done with a small handle provided near the objective.

- (Parallel optics) In another type, two beams of light are picked from two diametrically opposite points of objective lens and two parallel beams are taken through two apertures in the instrument. In such instruments, with combinations of two pairs of lenses, forming a Galilean telescope, and a rotating device, five different magnifications can be achieved. The eye pieces generally give a magnification of 10X or 12.5X. A second set of eye pieces with magnification 15X or 16X are usually supplied with the instrument.

Mechanical System: This consists of three major parts.

Part I: This includes the table on which the slit lamp is mounted. The table is provided with castor wheels for ease in moving the equipment from one location to another. The castors also have a locking mechanism to fix the equipment in a location. A manual or motor driven mechanism is provided for the movement of the table top up or down. Motor driver one is activated using a hand or foot switch. The transformer mentioned earlier is fixed to the table. A drawer is provided in the table for storing the extra eyepieces and other accessories.

Part II: A chin rest mounted on a vertical stand is provided for placing the patient's head in the correct position. A head rest with a head band is available for securing the patient's head to the stand if necessary. The height of the chin rest could be adjusted manually to bring the chin rest to the level of patient's chin.

Part III: A joy stick (a lever) is provided to move the illumination system and the microscope together up or down, left or right, forward or backward as needed during observation.

Troubleshooting & Repair:

- Mechanical faults: Any one of the movement listed above may not be smooth. This can be removed by cleaning and lubricating the parts concerned. If the joy stick is not functioning properly, the illumination and magnification systems are to be removed first. The slit lamp should be removed from the table top. The screws holding the slit lamp with the table can be accessed from the bottom of the table. The recess in which the joy stick operates will be seen when the slit lamp is turned upside down. Cleaning and lubricating the recess and tightening the nuts in the assembly will make the joy stick function effectively.
  - **Bulb not glowing:**
  - Turn off the power and remove lamp housing cover.
  - Remove bulb (do not touch with bare fingers).
  - Check continuity of the bulb with a multimeter.

- If bulb is fused, replace it.

- If continuity is present, check the contacts for the bulb in the lamp housing, clean and tighten it, if necessary. Refit the same bulb.

  - Turn on the power and check if the bulb glows.

- If not, check the electrical system.

When the bulb is replaced, care should be taken not to leave any dust or thumb impression on the bulb. Halogen bulbs should not be touched at all with bare fingers. Any oil or grease left on the halogen bulb, which is usually made of quartz, would diffuse through quartz into the bulb reducing its life. As a general rule, bulbs should be handled with tissue paper or with cotton hand gloves. This also applies to removing a bulb for replacement.

Fault in the Electrical System:

- Check the power at the wall plug using a multimeter or a line tester
- Check the fuse for continuity

- If no continuity, replace fuse

- ➢ Check the continuity in the connecting wire from the pins of the plug to the input end of the transformer using multimeter
  - If there is discontinuity, replace the plug and/or the wire
- ➢ Check the switches
  - If they don't function properly, replace them
- ➢ Check the voltage of the output with the power turned on
  - If there is no voltage replace transformer; you may have to ask the supplier for a replacement of transformer
- ➢ Check the continuity in the connecting wires from the transformer to the bulb socket, if there is discontinuity, replace the wire.

LENSOMETER

It is used to measure the focal powers of lenses (spherical, cylindrical and spherocylindrical) It can also determine the decentration in the lens. T

here are two generic models of the instruments. One in which the target seen through the eyepiece of the instrument consists of a number of bright points forming a circle, and another in which the target has a set of three wide lines with wide spacing between them and another set of three narrow lines with smaller spacing between them. These two sets of lines intersect at right angles. The equipment has a clamp for mounting the lens whose power is needed. There is provision for making ink dots on the lens at the desired points. For measuring the power of the lens, a calibrated disc is turned till a clear and sharp image of the target is seen through the eye piece. For measuring the focal power of cylindrical and spherocylindrical lenses that have different powers in different meridians, the optics of the equipment can be rotated around the axis. The angular position can be seen on circular scales on the instrument.

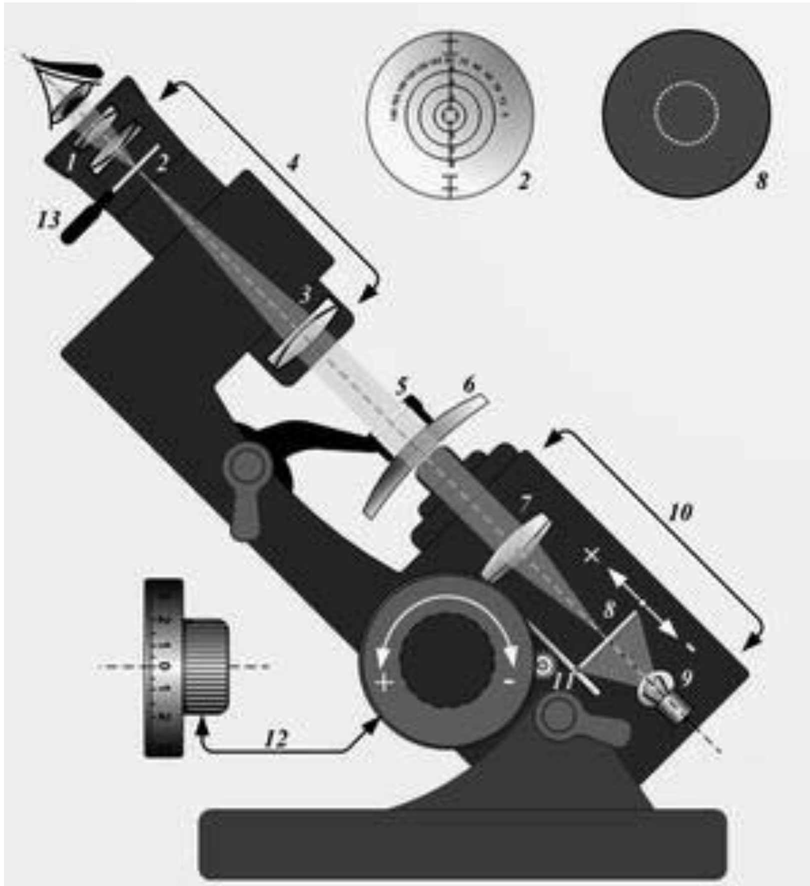

Figure 7: A simple lensmeter cross sectional view.

1. Adjustable eyepiece
2. Reticle
3. Objective lens
4. Keplerian telescope
5. Lens holder
6. Unknown lens
7. Standard lens
8. Illuminated target
9. Light source
10. Collimator
11. Angle adjustment lever
12. Power drum (+20 and -20 Diopters)
13. Prism scale knob

TONOMETER

The eye maintains a fairly constant internal pressure to support its shape. This is known as intraocular pressure (IOP). The normal range of intraocular pressure is between 10 and 20 mmHg. Ophthalmic professionals use tonometers to measure IOP. An elevated IOP may indicate glaucoma. Tonometers come in three main types: Applanation, Non-contact and Schiotz.

Applanation tonometers measure the force that is required to flatten the cornea in mmHg. They require the use of fluorescein dye and the cornea needs to be anesthetized. Most applanation tonometers come mounted on slit lamps.

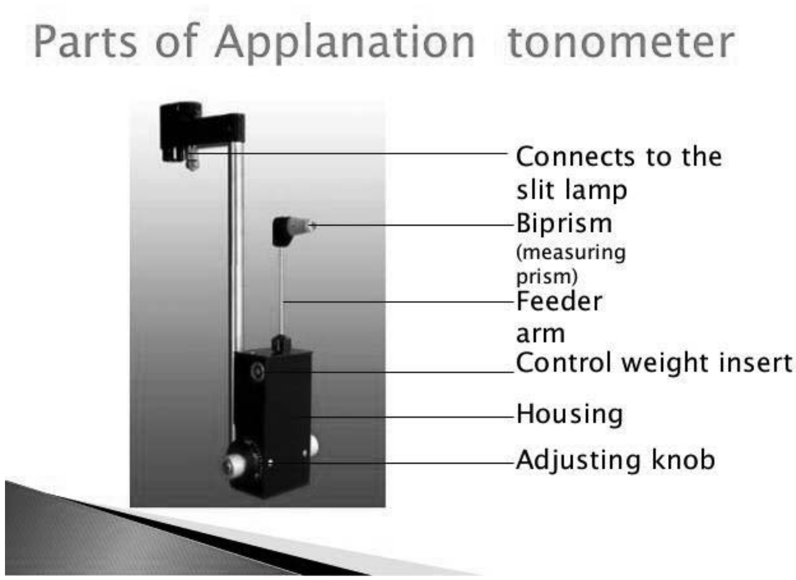

Figure 8: applanation tonometer

Non-contact tonometers obtain IOP without touching the eye and do not require anesthesia. The readings are taken after a soft puff of air is directed at the patient's eye and the resulting corneal deformity is measured and converted to pressure.

Figure 9: non - contact tonometer

<u>*The Schiotz tonometer*</u> is a simple portable metallic device and is generally used in operating rooms. It consists of a footplate that is placed on the cornea and a central movable plunger that is fitted into a barrel. Attached to the plunger is a needle and scale for measurement. The basic technique is to rest the tonometer on the anesthetized cornea with a patient supine (lying face up). The center plunger causes a slight depression in the cornea. The position of the plunger indicates on a scale the internal pressure on the eye. The force on a plunger can be varied by adding various weights. The standard weights have masses of 5.5, 7.5, 10.0 and 15.0 g. The plunger alone has mass of 11.0 g. With the standard 5.5.g mass, there is a 16.5 g resting on a small area of the cornea. The reading on the scale is converted to mmHg by using a conversion card.

Figure (10):The Schiotz tonometer