1.4 PHOTOMETRY

Photometry involves the measurement of candled power or luminous intensity of a given source. The candle power of a given source in a particular direction can be measured by the comparison with a standard or substandard source. Primary Standard is normally defined based on the brightness of a body (i.e. black body) maintained at freezing temperature of platinum. Unit of luminous intensity abbreviated as is candela cd (z). Light Flux hence emanating from a point source in all directions is illuminance - ¼ π lumens and is termed MSLI is the light flux incident on a task surface in lumens per unit area and is called lux.

Comparison with standard

Normally primary standards are kept in standards laboratories. Usually incandent lamp is compared with a primary standard is used as a laboratory standard. The test source / lamp is compared with the laboratory standard. However, incandent lamp is not suitable beyond the range of 50-100 hours. Standardization of lamp is by voltage rating, current rating and wattage. These measurements comprise the photometry. They employ a photometric bench with a photometric head which is an opaque screen. These measurements involve comparing the test lamp with standard lamp.

a. By varying the position of comparison lamp (standard lamp), I_s

b. By varying the position of the test lamp, I_T

c. By varying the position of the screen

Measurement is complete when the bench is balanced. It is balanced when two sides of the screen are equally bright [in a Dark Room] as shown in figure 1.4.1.

Principle of simple photometer

The photometer bench essentially consists of two steel rods with (2-3)m long. This bench carries stands or saddles for holding two sources (test and standard lamps), the carriage for the photometer head and any other apparatus employed in making measurements. The photometer bench should be rigid so that the source being compared may be free from vibration. The photometer head should be capable of moving smoothly and the photometer head acts as screen for the comparison of the illumination of the standard lamp and the test lamp.

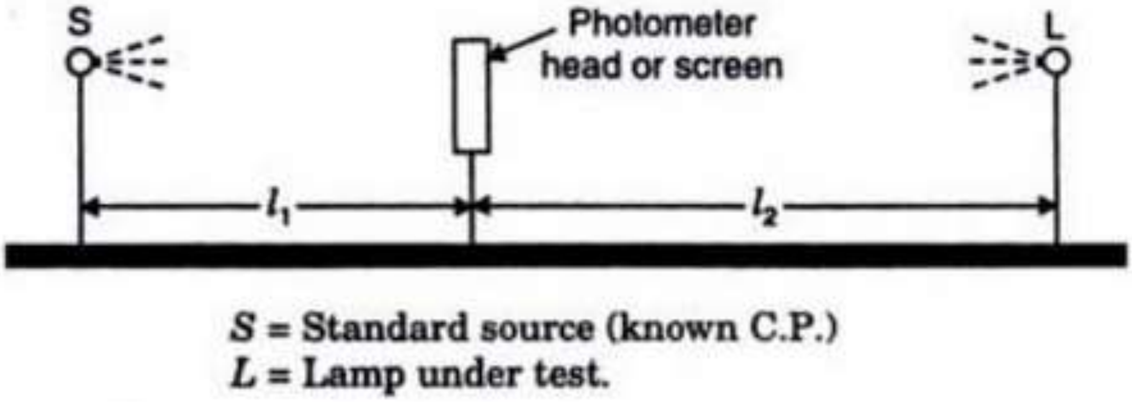

Figure 1.4.1 Photometric bench

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 20]

Measurements may be made on illumination meter or Lux meter. Also, in this method, instead of the screen adjustment, the meter can be adjusted to get the same reading on photometric bench. A method where distance is varied to get the same reading on the meter. Alternatively, the distance on the bench may be kept constant and readings on the meter are noted. Normally, the photometer comprises of a standard point source of light at the centre of an opaque sphere. It has an opening where a photo cell is placed that receives diffused light from the source. The window is shielded by diffusing screen from direct light. Reading on the micrometer is first taken with a standard Lamp and later with the test lamp. In a photocell sensitive element 'S' is selenium coated in the form of a thin layer on a steel plate P. This is in turn covered with a thin layer of metal 'M' on which is a collection ring R.

$$Candle\ power\ of\ standard\ source\ \propto L_1^2$$

$$Candle\ power\ of\ test\ source\ \propto L_2^2$$

$$\frac{Candle\ power\ of\ test\ source}{Candle\ power\ of\ standard\ source} \propto \frac{L_2^2}{L_1^2} = S\,\frac{L_2^2}{L_1^2}$$

In order to obtain the accurate candle power of test source, the distance of the sources from the photometer head should be measured accurately.

PHOTOMETER HEADS

The photometer heads that are most common in use are:

(i) Bunsen grease spot photometer

(ii) Lumer-Brodhun photometer

Bunsen grease photometer

Bunsen photometer consists of a tissue paper, with a spot of grease or wax at its centre. It held vertically in a carrier between the two light sources to be compared. The central spot will appear dark on the side, having illumination in excess when seen from the other side. Then, the observer will adjust the position of photometer head in such a way that until the semitransparent spot and the opaque parts of the paper are equally bright then the grease spot is invisible, i.e., same contrast in brightness is got between the spot and the disc when seen from each sides as shown in figure 1.4.2. The distance of photometer from the two sources is measured. Hence, candle power of test source is then determined by using relation,

$$Candle\ power\ of\ test\ source = Candle\ power\ of\ standard\ source \times \frac{L_2^2}{L_1^2}$$

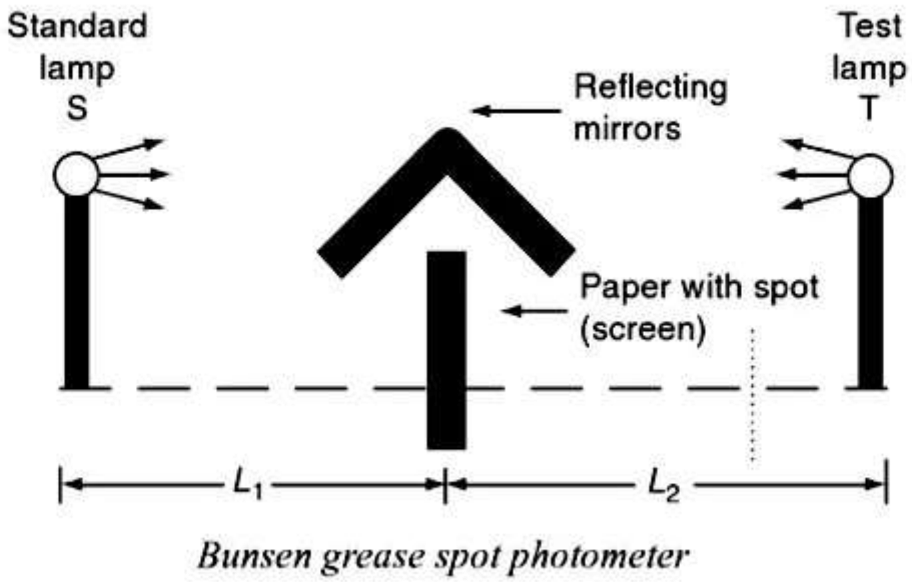

Figure 1.4.2 Bunsen grease spot photometer

[Source: "Generation and Utilization of Electrical Energy" by Sivanagaraju, Balasubba Reddy, Srilatha, Page: 255]

Lumer-Brodhun photometer

The photometer head essentially consists of screen made of plaster of Paris, two mirrors, M_1 and M_2, glass cube or compound prism and telescope. The compound prism is made up of two right angled glass prisms held together, one of which has sand blasted pattern on its face, i.e., principal surface as spherical with small flat portion at the center and the other is perfectly plain. A typical Lumer-Brodhun photometer head is shown in figure 1.4.3.

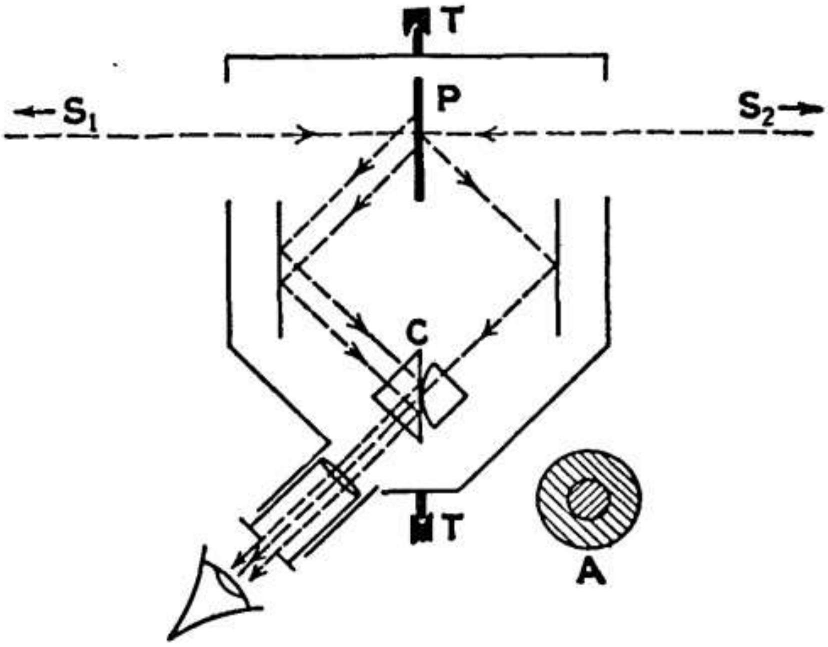

Figure 1.4.3 Lumen-Brodhun photometer

[Source: "Generation and Utilization of Electrical Energy" by Sivanagaraju, Balasubba Reddy, Srilatha, Page: 255]

The two sides of the screen are illuminated by two sources such as the standard and test lamps. The luminous flux lines emitting from the two sources are falling on the screen directly and reflected by it onto the mirrors M_1 and M_2, which in turn reflects the same onto the compound prism. The light ray reflected from M_2 is passing through the plain prism and the light ray reflected by M_1 is falling on the spherical surface of the other prism and is reflected again which pass through the telescope. Thus, the observer views the center portion of the circular area illuminated by the test lamp, S_2 and the outer ring is illuminated by the standard lamp, S_1. The positioning of the photometer head is adjusted in such a way that the dividing line between the center portion and the surrounding disappears. The disappearance of dividing line indicates the same type of colour of the test lamp and the standard lamp. Now, the distance of photometer head from the two sources are measured and the candle power or luminous intensity of test lamp can be calculated by using inverse square law.

PHOTOVOLTAIC CELL

In photometry, the current output of a photocell should be proportional to the illumination which is achieved by keeping the external resistance at a low value. Sensitive element is a semi-conductor that releases electrons upon exposure to light. Selenium and Cuprous oxide are most suitable semi-conductor materials. Steel Plate 'P' coated with thin layer of Selenium at 200°c and annealed at 80°c producing crystalline form. It is in turn coated by a thin transparent film of metal 'M' with a collection ring 'R' of metal. B is the barrier layer upon exposure to light – light enters through 'M' releases electrons from metallic Selenium. They cross barrier 'B' to 'M' and are collected through 'R' and P.

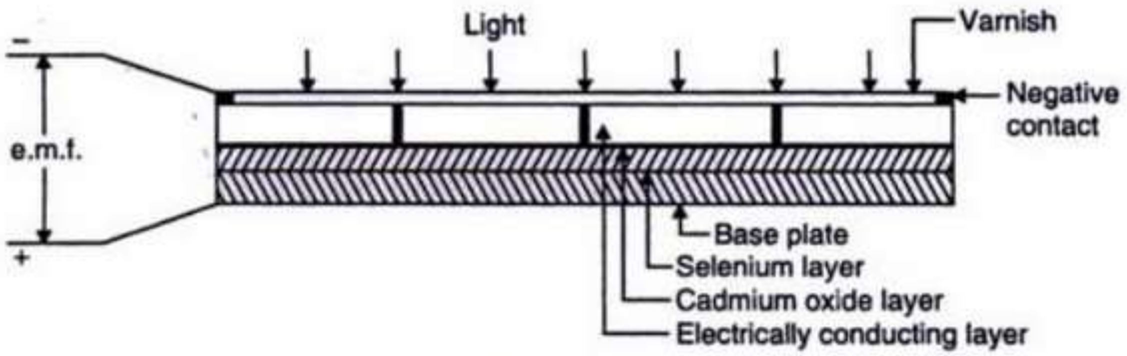

Figure 1.4.4 Photometric bench

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 22]

Current indicated by (A) is proportional to Illuminance. Often (A) is a micro ammeter calibrated in lm.

POLAR CURVES

The luminous flux emitted by a source can be determined using thee intensity distribution curve. The luminous intensity or the distribution of the light can be represented with the help of polar curves. The polar curves can be drawn by taking luminous intensities in various directions at an equal angular displacement in the sphere. A radial ordinate pointing in any particular direction on a polar curve represents the luminous intensity of the source when it is viewed from that direction. Accordingly, there are two different types of polar curves and they are:

a) A curve is plotted between the candle power and the angular position, if the luminous intensity, i.e., candle power is measured in the horizontal plane about the vertical axis, called '*horizontal polar curve.*'
b) A curve is plotted between the candle power, if it is measured in the vertical plane and the angular position is known as '*vertical polar curve.*'

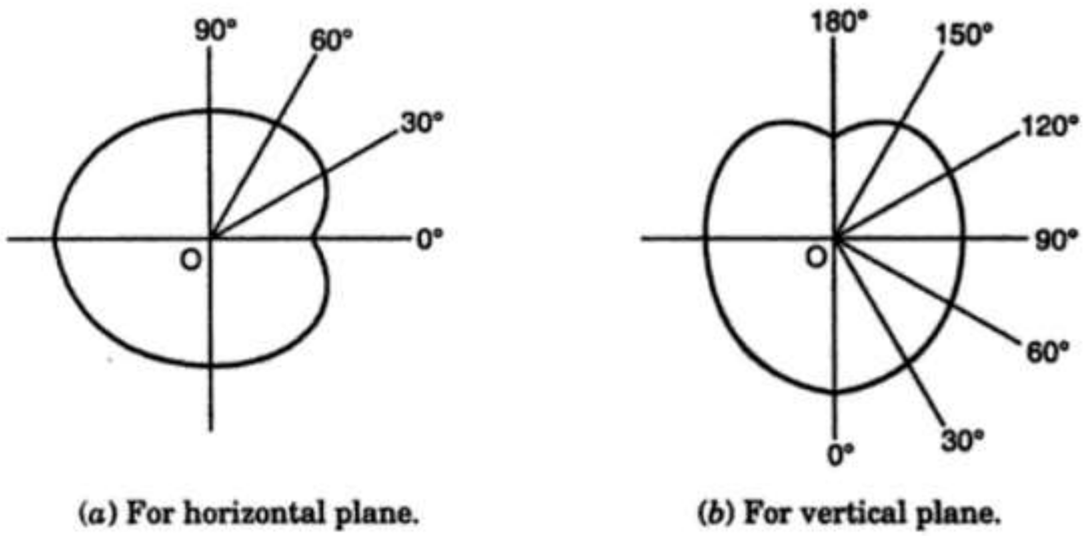

Figure 1.4.5 Polar curves

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 19]

Figure 1.4.5 shows the typical polar curves for an ordinary lamp. Depression at 180° in the vertical polar curve is due to the lamp holder. Slight depression at 0° in horizontal polar curve is because of coiled coil filament. Polar curves are used to determine the actual illumination of a surface by employing the candle power in that particular direction as read from the vertical polar curve. These are also used to determine mean horizontal candle power (MHCP) and mean spherical candle power (MSCP).

MHCP of a lamp can be determined from the horizontal polar curve by considering the mean value of al the candle powers in the horizontal direction.

MSCP of a symmetrical source of a light can be found out from the polar curve by means of a Rousseau's construction.

Rousseau's Construction

Suppose the vertical polar curve is in the form of two lobes symmetrical about YOY's axis. The Rousseau's construction for this polar curve is illustrated in figure 1.4.6.

- Draw a circle with any convenient radius with point O as the centre.
- Draw PQ parallel to YOY' and equal to the vertical diameter of the circle.
- Draw any line OEA meeting the polar curve in E and the circle in A. Let the projection be S.
- At S erect an ordinate ST = OE.
- By similar construction draw other ordinates. The curve PSQUTVP obtained by joining these ordinates is known as Rousseau's curve. The mean ordinate of this curve gives the mean spherical candle power.

$$The\ mean\ ordinate\ of\ the\ curve = \frac{Area\ PSQUTVP}{Length\ of\ PQ}$$

The area under the curve can be either be determined on a graph paper or by Simpson's rule.

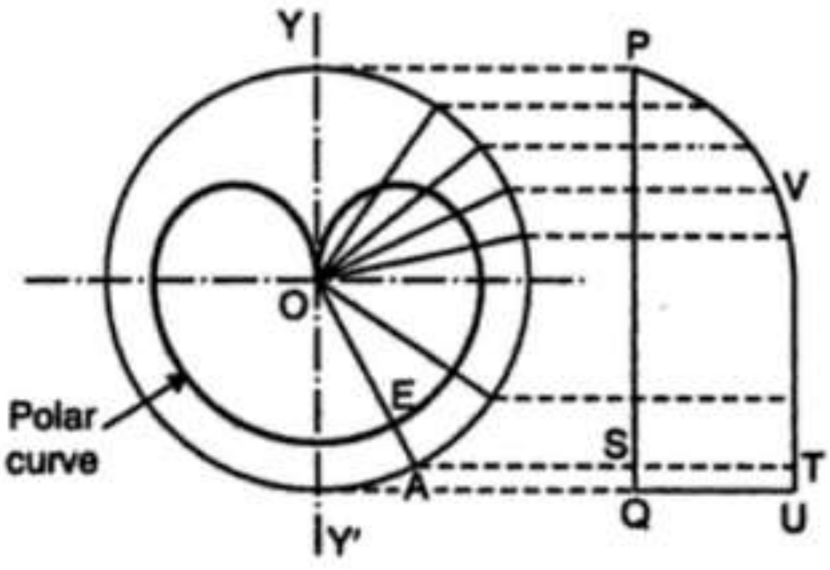

Figure 1.4.6 Rousseau's construction

[Source: "Utilisation of Electrical Power" by R. K. Rajput, Page: 19]