THE SCIENCE OF LIGHT

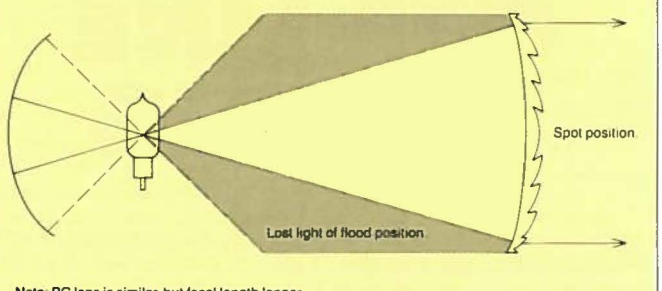
Luminaires can use both reflection and refraction to control the luminous flux emitted by a light source, so that light is directed or focused in particular ways. Popular spotlights are classified by their lens arrangements, and by implication, the type of performance they give.

Fresnel spotlights (Fig.1) utilise a type of lens which fundamentally consists of a series of concentric prisms and a small central convex lens. To simplify the description, we can assume that the lamp is a point source; in practice, of course, it has a finite dimension. Today's lamps, however, are more compact than those of earlier times when a simple plano-convex lens was used. The fresnel lens led to important improvements: firstly, it created a similar optical performance to a plano-convex lens by dividing the lens curvature into a series of separate prisms thus using considerably less glass and reducing weight. Secondly, a better distribution was achieved without the projected image of the lamp itself.

Although the fresnel lens is designed to have optimum performance at one particular beam angle, adjustments can be made. Used in conjunction with a spherical reflector, light is collected from the lamp and directed through the fresnel lens, which when close to the lamp gives the wide angle (flood) position. Moved further away, the beam reduces into a soft-edged narrow-angle spot. The spot position is the least efficient in light utilisation, although the intensity is still greater than flood. Light also spills a little from the 'risers' of the lens. The soft-edged feature enables overlapping of beams side by side and layer upon layer using several fresnel spotlights, to build up the lighting coverage on stage.

In recent years, the plano-convex lens has enjoyed something of a renaissance due to improvements resulting from the development of compact-filament tungsten-halogen lamps and an improved lens design, which by stippling the rear of the lens diffused the image pattern of the filament. Originally, this was achieved by small engraved prisms, hence the reference to 'prism-convex' or PC to distinguish it from the simpler plano convex type. Optically, the PC is similar to a fresnel, but it produces a tighter spot with less spill light and a soft edge. Some designers have found this an economic alternative to using a profile with the focus softened. Barndoors are usually added to control the degree of spill light and to give an approximate shaping of the beam on both PC and Fresnel.

Fig.1 Fresnel spotlight in spot position.

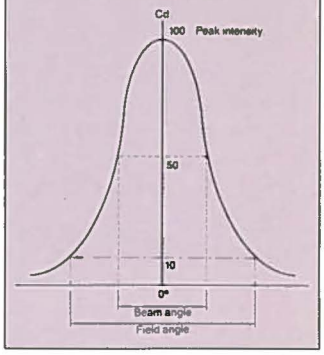


Note: PC lens is similar, but focal length longer.

For even greater beam control the projection capabilities of a profile spotlight are required (Fig.2). An ellipsoidal reflector is used to collect as much light as possible to illuminate an aperture which is called the 'gate'. This illumination is related to the required distribution which may be either 'peaky', as in the American Leko, or 'flat' as traditionally favoured in British designs. The light leaving the gate has to be collected by the lenses efficiently to avoid waste, and so the converging main flux is focused by the reflector through the gate to a 'cross-over' point beyond. However, there is also a diverging beam of light from the front of the lamp. The two lenses form a compound single lens, the focal length of which is dependent on their separation. The compound lens projects an image of the gate on the stage, and the magnification is governed by the focal length of the lens. Thus by altering the relative positions of the lenses, both the size of the image and its focus can be adjusted.

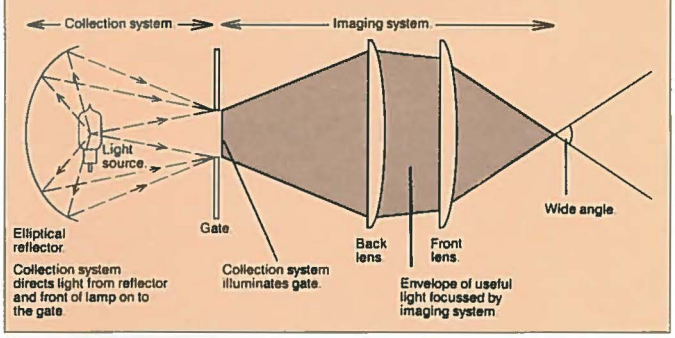
At the usual projection distances, the beam angle is determined by the focal length of the lens system, and it is this angle which frequently appears in the name of the spotlight: a Cantata 18/32 for example, describes a luminaire suitable for a range of medium beam angle applications between 18° and 32°. Four externally operated shutters enable the beam to be shaped and this image focused.

Fig.3 Photometric diagram of beam data.



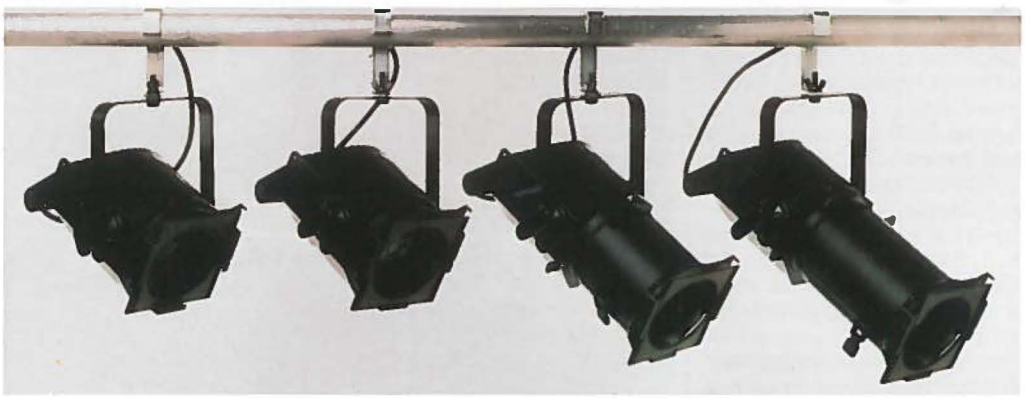
To illustrate the luminaire performance, a photometric diagram (Fig.3) will describe the variation in intensity across the beam from a central peak intensity in candelas, diminishing with the angular separation from the central axis, 1/2 peak indicates the brightest area of the beam and 1/10th peak represents the maximum beam angle for useful light from the luminaire.

Fig.2 Variable beam angle profile spotlight — wide angle.



Whilst these are the popularly used optical arrangements, reflector-only systems are widely used in flood, studio equipment and with a parabolic reflector in the very narrow beam projectors such as Beamlite.

Finally, we should not forget the integral reflector lamps such as the PAR 64 as deployed in Punchlite, or the small MR16 dichroic reflector lamps now popularly used in architectural Minispots.



Luminaire latest — the Quartet range from Strand Lighting.