Condensers

By C. Francis Jenkins

In optical projection, the lantern slide, or the single frame of the motion picture film, is simply a stencil to let directed light therethrough to a receiving screen upon which the enlarged stencil is imaged. This stencil may be opaque with transparent portions, in definite arrangement, as in titles, or it may also contain half tones as in pictures. If light filtered by this stencil were projected from a point source, a projection lens would be unnecessary.

Sharpness of image on the screen depends, therefore, on those rays of light which meet most nearly in a point at or near the shutter position, and in the exact axis of the projection system. All other rays tend to blur the image on the screen though adding to the illumination.

For proof of the first proposition one has but to shift the position of the light source considerably to one side of the axis of projection, while still keeping the aperture fully illuminated, a position which gets no picture at all on the screen; and in proof of the second proposition, to observe that a light source of large area will not, even with the best lens, put as sharp a motion picture on the screen as a point source.

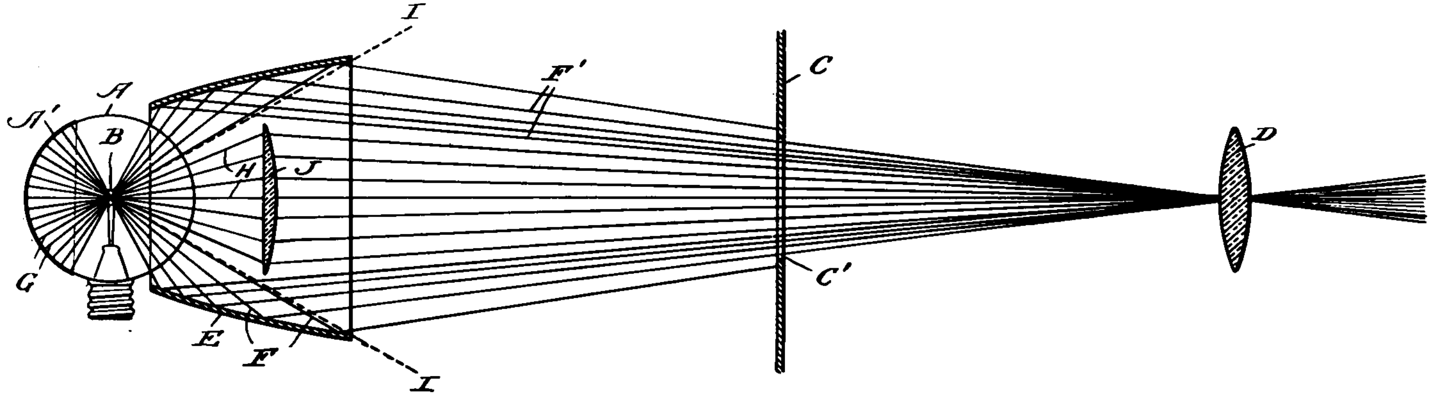
If one had a large stencil to work with, as a lantern slide, a fairly good screen picture could be had with a rather large light source, but as the motion picture frame has less than one-eighth the area of the slide, the most concentrated and intense source of light is required and the highest possible corrected lens.

Given, therefore, a well-corrected lens which will make a picture in spite of defects in the light, further improvement in the system must be in an effort to gather the greatest amount of light and direct it through the stencil of the frame, in the most right lines to a common point, and with the least possible loss.

Designers of early motion picture projectors had the misfortune to begin by using the two thick, light-wasteful, glass condensers employed in magic lanterns. In the lantern the condensers must have a diameter greater than the diagonal of the slide, hence the selection of the 4½-inch diameter in lanterns.

But as the diagonal of the motion picture frame is less than 1¼ inches, a thin, 2-inch condenser would have been quite ample, and we would have avoided the great light loss in the use of 4½-inch condensers, and which has been variously estimated by different authorities to be 75 to 80 percent. Which simply means that if we could effectively employ it, 10 amperes of electric current would do our work where 40 amperes is now required.

Any conservation of light lost between the source and the aperture frame is, therefore, well worth our best efforts, and to determine how we shall proceed, we should analyze the losses and seek the sources. Certainly one of the most glaring is the light reflection and absorption loss and chromatic fringing of the glass of the present system of condensers.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The obvious method would be to avoid the light absorption loss by using only thin lenses, and to usefully employ light now lost by reflection. Not only would thin lenses avoid absorption loss, but also the prismatic fringes at the blunt-angled edge of the lens.

Keeping well in mind the single fundamental requirement laid down initially, namely, that all rays from the light source should meet at a common point, we find that the most divergent rays, plus those lost by prismatic refraction, can readily be reflected, while those of smaller angle with the axial ray are easily concentrated by a small, thin lens, the total forming an almost ideal cone illuminating the aperture stencil of the frame, and with surprising and gratifying conservation of light.

I think few of us have ever considered the loss resulting from the differences in areas of the rectangular aperture and the circular light spot thereon. The light spot on the aperture plate is often 3 inches in diameter, more frequently 2½ inches, and never less than 2 inches in diameter, including in each case the color fringe. The areas of these spots are 6.75, 4.65 and 3 square inches; and because the area of the aperture is but three-fourths of a square inch, the actual light loss from this cause is 89, 84 and 75 per cent respectively. In other words, we waste from three to six times as much light as we usefully employ. This is not a very creditable showing.

Immense advantages would accrue from any considerable saving of this loss, and while I do not say that this is attainable, neither will I say that it is impossible, for my observation has been that the man who says a thing can't be done has his heels tread upon by the man who does it.

Believing that improvement is worth striving for, my own plan for attacking the problem of light conservation in motion picture projecting machines has been along the lines of eliminating the reflection, chromatic and absorption losses.

A considerable part of the absorption loss is avoided by using a single, thin lens; the chromatic loss by avoiding the prismatic edge of the usual blunt-edged condenser lenses, and reflecting this as white light toward the aperture together with the usual lens reflection loss.

The sketch herewith illustrates how this may be attained, though it may not be the best possible means that can be devised.

The lens converges those rays of light which would be lost in the angle bounded by the dotted lines; the light which would be lost rearwardly is reflected into effective position by the spherical mirror, and all others are directed in the right channels by a single reflection. The whole of the spot is white light and can, therefore, be much more concentrated because there is no colored fringe.

As a general observation I might add that considerable confusion seems to exist regarding the optical system of the motion picture machine, whereas it is not at all complex, consisting as it does of two distinct elements, a reversed camera, and a concentrating illuminating system, and which combined are scarcely less simple than either alone. The first motion picture machine, both my own in 1892-94 and Prof. Lumiere's, of France, practically coincident, were combination camera-projectors, the camera part remaining integral, with a lighting system added thereto when projection was desired.