

the condensers of the common order, as it acts in condensing the scattered rays from those of this class, enabling also the light to be approached nearer to the condenser. The lens tube should be longer than in the case of its application to photography, for, unlike this, all it is required to cover is the very limited area comprised in a plate three and a-quarter inches square, minus the portion occupied by the mat. For the highest class of objective, it suffices that it be achromatic in the sense different from actinic, for, so long as the visual image is perfect, it matters not what becomes of the violet or chemical rays, or what relation they have to the luminous ones.

It is in the construction of a lantern objective of short focus that the skill of the optician is taxed, as it has to cover sharply to the margin with its full aperture, and under circumstances in which the slightest inequality in the definition is instantly detected. To a cultivated eye it is extremely unpleasant to see an image quite sharp in the centre of the disc, and falling off rapidly towards the margin, or by racking in securing marginal sharpness at the expense of the centre. Of the various forms of objective to be met with in commerce, at any rate for those of medium short focus, I incline to give preference to that introduced ten or eleven years ago by J. H. Dallmeyer, judging by the performance of one of this class in my possession, made by Newton and Co. In it the elements of the back lens are separated to an extent which would prove hostile to sharpness in the case of one employed in producing a photographic image in the camera. If photographic lenses are to be employed in the lantern, those of the *carte-de-visite* (Petzval form), that is, those corrected for flatness of field, even to the extent of there being slight astigmatism, are advantageous. One of the most satisfactory *short-focus* objectives I ever used had a back lens $2\frac{1}{4}$ in. in diameter, the front lens being $1\frac{3}{4}$ in. It gave a very great excess of negative spherical aberration to the back lens, and the front was a nearly plano-convex achromatic of short focus. This gave a field which was singularly flat, the definition at the margin quite equalling that in the centre; but, owing to the excess of aberration spoken of, the image did not quite equal in sharpness that obtained by the ordinary *carte-de-visite* lens with rounder field. Still, spectators seated at a distance of five yards from the screen were unable readily to appreciate that the definition was imperfect, for, as you know, even the crude brush-work of the scene-painter seems sharp when viewed from a distance.

In objectives of long focus there does not appear to be the same tax on the skill of the optician. Poor, indeed, must be the lens of 10, 12, or 14 in. focus that will not cover sharply and uniformly a plate 3 in. in dimensions.

DISCUSSION.

Commander GLADSTONE: Mr. Taylor said that in the ordinary commercial lanterns the whole of the back lens is not used. I found, in using the ordinary green glass condensers, that even taking the lime 3 in. away, you might cut off half an inch of the condenser all round, so that a 4 in. condenser becomes practically a 3 in. I think the principal point in the condenser is the glass of which it is made. We don't quite realise the amount of light which is lost in passing through the green glass condenser in the ordinary lantern; there is also degradation of tone, for the colour of the glass considerably interferes with the colour of the slide, especially if it has anything of a brown or mauve colour. Mr. Taylor says that the condenser he described takes in an angle of 95 deg.; if the back lens were $4\frac{1}{2}$ in., and the lime 2 in. away,

that would be so. But I also understood him to say that the front lens was 5 in. in diameter, and if so, it seems to me that the effective angle is not 95 deg., because, taking the opening of the slide to be 3 in., the whole of the light collected by the back lens does not pass through it, it being in close contact with the condenser. I have no doubt that the system he has described is the proper one; you want first a collecting system to get parallel rays, and then to place in front of it a lens that you can adjust the focus of, and so adjust the cone for whatever lens you want to use.

Mr. ELDER: I might just point out one or two things. First, a method used by Professor Boys for saving his condensers from damage by heat. He places a sheet of plain glass against the condenser at a slight angle. Everyone knows how sensitive the ear is to the crack of glass under heat. When the lime gets pitted, or anything else goes wrong, this piece of glass cracks, he hears it, attends to the lantern, and so saves the condenser. The disadvantage of the plan is that it gives another reflection, and so wastes light. It can be used, unless very large work is being done, ample light passing through the glass for ordinary purposes. I was very much interested in what Mr. Taylor said about the position of the focus of the cone of rays coming from the condenser. But it seems to me there is a difference in practice in using the lantern and using the microscope; the same laws must apply, and yet there does seem to be a difference. My friends who use the microscope habitually say that to get the best effect they find it necessary to focus the radiant with the condenser on the object. One would therefore presume that, to get the best effect on the screen, it would be necessary to focus it on the slide, and not in the centre of the projecting system. It struck me whether it might not be possible to alter the whole system of projection by using a moderately large radiant brought to a focus on the slide. No doubt, if it were possible, the best system would be to use no condenser at all, but to put a large radiant—in fact, a sheet of light—close to the slide. Light is always lost in using condensers, and it is only because it is impossible to do this that we are compelled to use them. The next best thing seems to me to be to focus the radiant on the slide, thus making the slide the luminous object or origin of light as far as the projecting system is concerned.

Commander GLADSTONE: I have cracked a good many condensers, and I tried to see if I could not get something to interpose between them and the light. I tried all kinds of glass, but never found a piece that would stand the heat for ten minutes. I was using a blow-through jet, which I turned on until it was hissing, and left it there. If you attend to your jet, and don't let the lime get pitted, there is no danger at all. I tried chemical glass, Bohemian flask bottoms, unsuccessfully. At last I got a Sugg's lamp chimney, 16 in. long and 5 in. diameter, used for 500 candle-power light; I had it cut into four, and put one piece over the whole jet, and I have never cracked it yet.

Mr. ELDER: Professor Boys told me he found that his plan acted well, though he often cracked the piece of glass.

Mr. KAPTEYN: There is a rule that you must not let the sun shine on the lens. Is the principal reason of this because the glass of the lens is affected by the sunlight coming right into it? There are, of course, other reasons why, when taking a photograph, the direct sunlight should not be admitted.

Mr. TRAILL TAYLOR: If the 3-in. slide is close to a 5-in. condenser, there is a loss of light; but I have always taught that the slide ought to be movable, so that it can be brought to the point where the cone of rays is of the same diameter as the slide. The slide-holder ought to be really the moveable part of the lantern, in conjunction with the condensing lens, and if it were so, even the whole power of the light could be made to pass even through a 1-in. picture. The degradation of tone by green glass is more than anyone has any conception of. But there is another degradation of tone, and that is due to the printing of transparencies upon strongly coloured green glass, and covering them with another piece of the same colour. Most of them are exceedingly offensive in that way. Lay one on white paper and you will see the degradation. Many years ago I had some transparencies made on French crystal glass,