XII. *On the Principle of Construction and general Application of the Negative Achromatic Lens to Telescopes and Eyepieces of every description.* *By* PETER BARLOW, *Esq. F.R.S. &c.*

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THE great advantage which has attended Mr. DOLLOND's ingenious application of the negative achromatic lens to the micrometer eyepiece, seems to make it desirable that the principles on which that lens is constructed, and its general application, should be more fully illustrated than is done in the short extract made from my letter to Mr. DOLLOND, and given by him in his recent paper in the Philosophical Transactions.

In my original fluid telescope, the negative lens was employed for the double purpose of lengthening out the focus and correcting the colour of the front lens; and the great advantage of the lengthening principle was manifested by the high penetrating power of the instrument in the centre of the field. Unfortunately, however, the perfect part of this was very limited, so that when Mr. DOLLOND constructed the second telescope for the Royal Society, I gave up this advantage for the sake of enlarging the field; but I found that by this means much of the penetrating power of the former telescope was lost; for although I had the same aperture, many small stars which were before very perspicuous were in this instrument seen only with difficulty and under advantageous circumstances of weather, absence of moonlight, &c.

This led me to consider whether it would not be possible to retain the advantages I had obtained in the new instrument, and to restore the power of the other principle (that of penetration) by an artificial lengthening of the focus; but as the rays were now as nearly achromatic as I could make them, it was necessary in this case to have the lengthening lens also achromatic. I had no authority from the Royal Society to make any collateral experiment, but having mentioned my idea to Mr. DOLLOND, he very readily undertook to construct the small lens, and it was accordingly made and tried; but owing, as I now imagine, to the imperfect means I had of fixing it, its advantages were not perceived. It was laid aside, was not referred to in my paper, and would most likely have been altogether lost sight of, had it not occurred again to Mr. DOLLOND to try its effect on the micrometer eyepiece for the Rev. Mr. DAWES. It is therefore to Mr. DOLLOND we are indebted for snatching this lens from the oblivion into which I had allowed it to fall.

It must not, however, be understood that it is only applicable to this eyepiece, for it may be applied to any eyepiece, positive or negative, or to the erecting eye-

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piece, or indeed to any telescope of fluid or glass, or to refractors; for it is, in fact, not a part of the eyepiece, but of the telescope itself: and it is for this reason its advantages are so conspicuous in the application Mr. DOLLOND has so ingeniously made of it; for by lengthening the focus before the rays arrive at the eyepiece, the image is magnified, while the wires retain only their original size.

Having thus shown the origin of the negative achromatic lens, I may be allowed to state the motives and reasonings which guided me in the computation of the curves, and what appears to me to constitute the advantages it is found to possess. Notwithstanding the extreme difficulty there is in constructing an achromatic object-glass, yet with perfect materials the difficulty is only in the manipulation; and this being overcome, there is not so great a natural impediment to perfection in this part as in the eyepiece,—for we know that it is impossible to make a perfect positive power*; and if the same absolute impediment does not occur in the negative eyepiece, yet the thicknesses of the lenses render the task very difficult, not only to execute, but to compute the proper curvatures to ensure perfection. If this view of the case be correct, we see at once the advantage of magnifying the object as much as possible before we apply the eyepiece; and this, in fact, is the whole theory of the negative achromatic lens: that is, supposing the rays to be rendered achromatic by the object-glass, they are intercepted by the negative lens before they cross, which, being itself also achromatic, extends them to any length, and thereby produces the effect of lengthening the whole focus in the same proportion, and consequently the power of the telescope, the eyepiece remaining unaltered.

In the conclusion of my letter to Mr. DOLLOND, I have offered a suggestion, whether it would not be possible to retain the same eyepiece for all powers by changing only the negative lens. This must of course, as he has observed, change the scale of the micrometer; but this being changed, by so adapting the lens as to render the powers simple multiples of each other, would not, I conceive, be attended with any disadvantage. In other cases, where a micrometer is not employed, and where the utmost perfection is not looked for, every variety of power may be produced by simply moving the negative lens nearer to or further from the eyepiece; for both the object-glass and lengthening lens being achromatic, the image, wherever the focus is formed, will be achromatic also; and the spherical aberration of the lens is so inconsiderable, as only to be discovered by the most perfect eye, when removed from that point in which it is computed to be perfectly corrected. The negative lens is therefore admirably suited for day telescopes with correcting eyepieces, as also for astronomical telescopes where the micrometer is not applied; for by giving an adjustment to the lengthening lens, the power may be changed in any proportion, even without removing the eye or losing sight of the object. I have no doubt that these and other applications of the lengthening lens will be made, and amongst others, I am willing to hope that

* See Professor AIRY on the Eyepieces of Telescopes, Transactions of the Cambridge Philosophical Society, vol. iii.

it is not impossible the negative secondary spectrum of this lens may, by careful experiment, be so proportioned as in part to counteract the positive secondary spectrum of the object-glass so as to render the image more nearly aplanatic; some experiments, at all events, directed to this inquiry are very desirable.

I have already, in my letter to Mr. DOLLOND, given the formulæ for computing the proper curves according to any distance between the focus and the lengthening lens, and for magnifying the image in any required proportion; but unfortunately the calculation is very laborious, and difficult to be rendered general, or tabulated for general practice. I would therefore recommend opticians to use the same curves as are commonly adopted for short telescopes of six, eight, or ten inches, making those of the plate or crown concave instead of convex, and those of the flint convex instead of concave, turning the plate towards the object-glass and the flint towards the eyepiece, which will in general bring out a close approximation for spherical aberration, and the colour will be sure to be corrected. Starting from this point, practical skill will readily supply the means of making corrections, if any such should be found necessary after all has been done that can be done by changing the position of the lens as regards its distance from the eyepiece. I hope these additional directions for constructing and applying the lengthening lens will not be thought superfluous, nor undeserving the attention of practical opticians.