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Date of Application, 15th Dec., 1900

Complete Specification Left, 14th Aug., 1901—Accepted, 14th Dec., 1901

PROVISIONAL SPECIFICATION.

"Improvements in Lenses."

I, CARL AUGUST HANS HARTING, of 70, Fasanenstrasse, Brunswick, in the Empire of Germany, Doctor of Philosophy and Director, do hereby declare the nature of this invention to be as follows:—

This invention has for its object a lens system corrected symmetrically and also chromatically spherically, and astigmatically for wide apertures.

If, in an objective formed of similar pairs of lenses the kinds of glass are graded in such a way that they also possess, in combination with a large index of refraction, great colour distribution, it may as is well known be corrected spherically for proportions of aperture, but not astigmatically. If on the other hand such an objective be formed of kinds of glass with the larger indices of refraction having a smaller distribution of colour, a considerable improvement results, as is well known, in the position of the astigmatic picture surfaces, but not sufficient spherical correction for even medium apertures.

The present invention affords however for large apertures a complete spherical correction, both on and outside the axis, and further removes astigmatism and curvature in the field of vision.

The arrangement is as follows:—

Between two symmetrical systems of either one or other kind hereinbefore mentioned, a third system is arranged which is symmetrical in itself, and symmetrically arranged relatively to the two outer ones, and which may consist of one lens. According as this system is required for condensation or distribution, the desired spherical correction may be imparted to the whole system. In order however to remove the astigmatism and curvature of the field of vision left by the outer systems, that is to say to correct the objective into an anastigmatic lens, the kinds of glass to be used are chosen in the following manner:—

The two outer lens systems consist, as already mentioned, at least of two lenses, crown and flint glass, and the crown glass must have in both systems either a larger or a smaller index of refraction than the respective flint glass. The third system inserted between the two must however be so selected that the kinds of glass of which it is composed will correspond in a given manner to the kinds of glass of the outer systems which stand opposite to its faces, and in fact one glass with a large index of refraction and a small distribution of colour must face a similar one, the index of refraction of which is smaller or approximately as great as that of the other, whilst its colour distribution is greater.

By this means it is possible, in consequence of the removal of the faults resulting from spherical aberration, to obtain first in the centre of the picture an extraordinary sharpness the cause of which is in the reduction or removal of the intermediate spherical defects.

As however the spherical aberration of the oblique group of rays is at the same time almost completely removed, and as it is possible to produce anastigmatic levelling over the whole field of vision, which for instance amounts to about 50° for a relative opening of 1:4,5, it follows that the optical picture with a sufficient expansion as an extraordinary sharpness even outside the optical axis. As the whole system is symmetrical in itself the distortion is removed.

[*Price 8d.*]

so that it is practically unnoticeable, so that the picture that is formed is almost perfectly true.

As an example the case of an objective which is typical for the object of the application will be explained.

The outer systems may be formed each of two lenses, of which the two outer lens surfaces are made of flint glass and the two inner lens surfaces of crown glass of higher refractive index and smaller light distribution. The symmetrical central lens must then be made of crown glass, the index of refraction of which is lower or only equally as large, and its colour distribution larger than that of the crown glass of the inner lens glasses of the outer systems.

If the four different radii of curvature of the lenses corresponding to the object sought after are indicated by r^1 r^2 r^3 r^4 and the thicknesses of the lenses are indicated as regards their distance apart by d^1 d^2 d^3 d^4 a calculation yields the following equivalents.

$$r^1 = +\ 41{,}0\ ;\ d^1 = +\ 1{,}6$$
$$r^2 = +\ 25{,}76\ ;\ d^2 = +\ 3{,}6$$
$$r^3 = -583{,}8\ ;\ d^3 = +\ 8{,}1$$
$$r^4 = -\ 44{,}76\ ;\ d^4 = +\ 1{,}6$$

The equivalents of the kinds of glass are here assumed to be the following:

For the outer lens glasses of the two outer systems, and for the central symmetrical lens

$$n_D = 1{,}5638\ ;\ n_G{}^1 = 1{,}5811.$$

For the inner lens glasses of the outer systems

$$n_D = 1{,}6080\ ;\ n_G{}^1 = 1{,}6217.$$

The size of the opening, which may be indicated for this objective with a focal width of 100, amounts to 25, the diameter of the utilisable picture 80. The blind or shutter is placed directly behind the central lens.

If the inner lens glasses of the outer systems consist of flint glass the central lens must consist of crown glass of an approximately equal or higher refractive index and smaller distribution of colour. It is self-evident that in the ordinary manner the half of such a symmetrical system may also be used.

Dated this 14th day of December, 1900.

WM. P. THOMPSON & Co.,
Of 6 Lord Street, Liverpool, Agents for the Applicant.

COMPLETE SPECIFICATION.

"Improvements in Lenses."

I, CARL AUGUST HANS HARTING of 70, Fasanenstrasse, Brunswick in the Empire of Germany, Doctor of Philosophy and Director, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention has for its object a lens system corrected symmetrically and also chromatically, spherically, and astigmatically for wide apertures.

If, in an objective formed of similar pairs of lenses the kinds of glass are graded in such a way that they also possess, in combination with a large index of refraction, great colour dispersion, it may as is well known be corrected spherically for any desired size of aperture, but not astigmatically. If on the other hand such an objective be formed of kinds of glass with the larger indices of refraction having a smaller colour dispersion, a considerable improvement

results, as is well known, in the position of the astigmatic picture surfaces, but not sufficient spherical correction for even medium apertures.

The present invention affords however for large apertures a complete spherical correction, both on and outside the axis, and further removes astigmatism and curvature in the field of vision.

The arrangement is as follows:—

Between two symmetrical systems of either one or other kind hereinbefore mentioned, a third system is arranged which is symmetrical in itself, and symmetrically arranged relatively to the two outer ones, and which may consist of one lens. Whether this system is required to be converging or diverging, the whole system may be spherically corrected. In order however to remove the astigmatism and curvature of the field of vision left by the outer systems, that is to say to correct the objective into an anastigmatic lens, the kinds of glass to be used are chosen in the following manner:—

The two outer lens systems consist, as already mentioned, at least of two lenses, crown and flint glass, and the crown glass must have in both systems either a larger or a smaller index of refraction than the respective flint glass. The third system inserted between the two must however be so selected that the kinds of glass of which it is composed will correspond in a given manner to the kinds of glass of the outer systems which stand opposite to its faces, and in fact one glass with a large index of refraction and a small colour dispersion must face a similar one, the index of refraction of which is smaller or approximately as great as that of the other, whilst its colour dispersion is greater.

By this means it is possible, in consequence of the removal of the faults resulting from spherical aberration, to obtain first in the centre of the picture an extraordinary sharpness, the cause of which is in the reduction or removal of the intermediate spherical defects.

As however the spherical aberration of the oblique group of rays is at the same time almost completely removed, and as it is possible to produce anastigmatic levelling over the whole field of vision, which for instance amounts to about 50° for a relative opening of 1:4,5, it follows that the optical picture with a sufficient expansion has an extraordinary sharpness even outside the optical axis. As the whole system is symmetrical in itself the distortion is removed so that it is practically unnoticeable, so that the picture that is formed is almost perfectly true.

As an example the case of an objective which is typical for the object of the application will be explained.

The accompanying drawing shows such an objective.

The outer systems may be formed each of two lenses *a* and *b*, of which the parts *a* are made of flint glass and the parts *b* of crown glass of higher refractive index and smaller light dispersion. The symmetrical central lens *c* must then be made of crown glass, the index of refraction of which is lower or only equally as large, and its colour dispersion larger than that of the crown glass of the lenses *b*.

If the four different radii of curvature of the lenses corresponding to the object sought after are indicated, as shown in the accompanying drawings, by $r^1, r^2, r^3 r^4$ and the thicknesses of the lenses by $d^1 d^2 d^3 d^4$ a calculation yields the following equivalents.

$$r^1 = +\ 41{,}0\ ;\ d^1 = +\ 1{,}6$$
$$r^2 = +\ 25{,}76\ ;\ d^2 = +\ 3{,}6$$
$$r^3 = -\ 583{,}8\ ;\ d^3 = +\ 8{,}1$$
$$r^4 = -\ 44{,}76\ ;\ d^4 = +\ 1{,}6$$

The equivalents of the kinds of glass are here assumed to be the following:

For *a* and *c*: $n_D = 1{,}5638$; $n_G{}^1 = 1{,}5811$.

For *b*: $n_D = 1{,}6080$; $n_G{}^1 = 1{,}6217$.

The size of aperture, which may be indicated for this objective with a focal length of 100, amounts to 25, the diameter of the utilisable picture 80. The blind or shutter *e* is placed directly behind the central lens.

If the inner lens glasses *b* of the outer system consist of flint glass the central lens *c* must consist of crown glass of an approximately equal or higher refractive index and smaller colour dispersion. It is self-evident that in the ordinary manner the half of such a symmetrical system may also be used.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

In an achromatic, spherically and astigmatically corrected lens system, the arrangement of a third lens between two groups of lenses each of which groups is composed of at least two lenses (of crown and flint glass), symmetrically disposed relatively to one another, and both of which groups contain crown glass of either higher or only slightly lower refractive index than the flint glass, the said third lens being symmetrical in itself, and symmetrically arranged relatively to the outer groups, the central lens forming with the lenses of the two outer groups which are facing it, a lens system in which the one glass with the smaller colour dispersion possesses an index of refraction greater than or approximately equal to that of the other, substantially as hereinbefore described and shown.

Dated this 13th. day of August 1901.

WM. P. THOMPSON & Co.,
Of 6, Lord Street, Liverpool, Agents for the Applicant.

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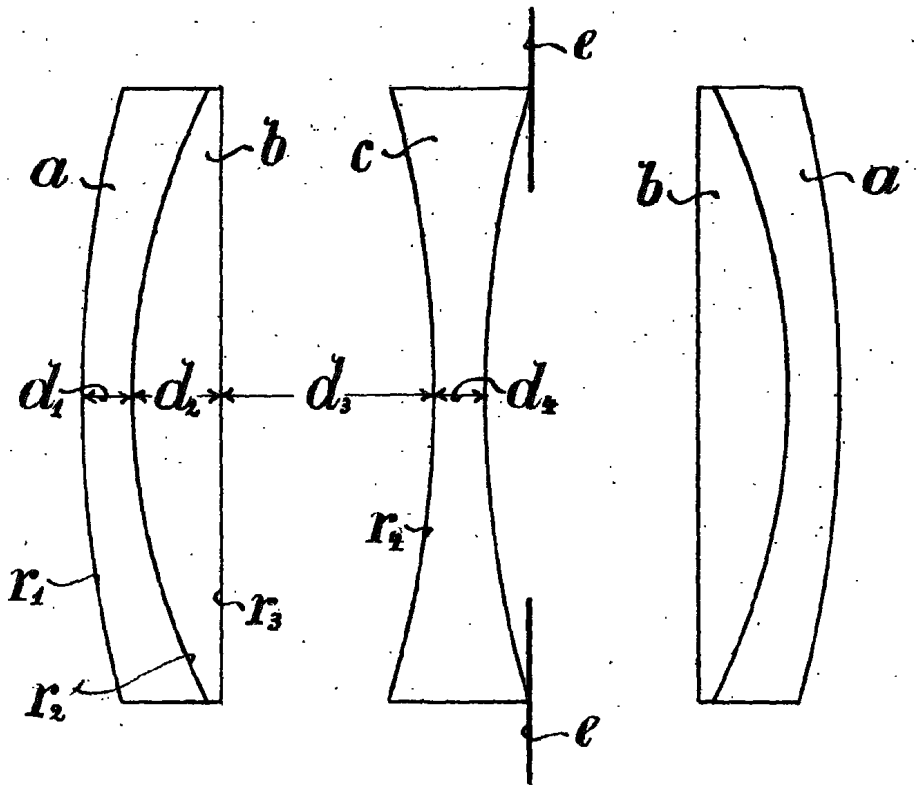

[This Drawing is a reproduction of the Original on a reduced scale.]