113,590

PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Improvements in Lenses.

We, ARTHUR WARMISHAM, M.Sc., and TAYLOR, TAYLOR & HOBSON LIMITED, Opticians, all of Stoughton Street Works, Leicester, in the County of Leicester, 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 relates to an improved photographic objective corrected spherically, chromatically, astigmatically and comatically, of the type consisting of four simple lenses separated from one another by air spaces, the two halves being unsymmetrical and each half consisting of a positive lens of crown glass of high refractive index and a negative lens, and the space between the positive and the negative being of the shape of a positive meniscus.

Objectives of this type are constructed on the principles discovered by Mr. H. D. Taylor and described by him in Patent Specifications Nos. 22,607 of 1893 and 15,107 of 1895. A symmetrical four-lens objective was described in Patent Specification No. 12,859 of 1898. The symmetrical type has obvious advantages from the manufacturer's point of view, but calculation shows that it will not yield a first-class objective of large field and wide aperture.

Recent investigators of objectives consisting of four simple lenses have discarded the symmetrical type. Patent Specification No. 22,400 of 1910 describes such an objective depending for its corrections on the use of four lenses of the same refractive index for the principal colour. Rigorous computation shows that a substantial improvement can be obtained by departing from such a limitation of the refractive index. For an objective of aperture F/4.5, for example, the widest anastigmatically flat field is obtained only by making the negative components of glass of the lowest available refractive index consistent with the degree of dispersive power required.

Patent Specification No. 833 of 1913 describes an objective consisting of four simple glasses in which the coma aberration is corrected by making the two surfaces of each negative lens of different curvatures and placing them unsymmetrically with respect to the diaphragm one of them presenting its deeper curve and the other its shallower curve to the diaphragm. Rigid calculation shows that, by a different arrangement, a substantial improvement is obtained in the correction of astigmatism, field curvature and coma.

The method of the present invention is to arrange both negative lenses as well as both positive lenses with their shallow faces turned towards the diaphragm. This arrangement necessitates a shallower curve for the inner surface of the back positive lens, which re-acts very favourably on the field curvature and astigmatic aberrations at the margin of the field and at the same time yields a high degree of coma correction throughout the field.

[*Price* 6*d*.]

We will further describe our invention with reference to the accompanying drawing in which Fig. 1 is a diagrammatic illustration of one form of example of a photographic objective constructed and arranged according to our invention and showing the relative positions, curvatures and thicknesses of the lenses composing the objective, and Fig. 2 is a similar illustration of a second example.

We give below the constructional data for the two objectives illustrated in the drawing. Both are specified in terms of unit focal length. The sign convention used is that + is attached to surfaces convex towards the incident light and − to surfaces concave to the incident light.

In the subjoined specification of the kinds of glass used n_D is used in the usual sense to denote the refractive index of material for sodium D. light, and V in the usual sense as the ratio.

$$\frac{n_D - 1}{\text{Difference of refractive indices for F. and C. light.}}$$

EXAMPLE I. (Fig. I). F/4.5 Equivalent Focal Length 1.00.

Radii.	Thicknesses & Air Spaces.	
r_1 +.2976	t_I	.0455
r_2 − 8152	S_I	.0203
r_3 −.4285	t_{II}	.0100
r_4 +.4464	S_2	.0362
r_5 −.5041	t_{III}	.0100
r_6 +.4330	S_3	.0193
r_7 +.8152	t_{IV}	.0455
r_8 −.2976		

Kinds of Glass.

I	n_D=1.6116	V=56.4	Dense baryta crown
II	n_D=1.5682	V=43.4	Light flint
III	n_D=1.5502	V=45.8	Light flint
IV	n_D=1.6116	V=56.4	Dense baryta crown.

EXAMPLE II. (Fig. II). F/4.5 Equivalent Focal Length 1.00.

Radii.	Thicknesses & Separations.	
r_1 + .3409	t_1	.0257
r_2 − 4.081	S_1	.1089
r_3 − .4143	t_{II}	.0090
r_4 + 1.049	S_2	.0142
r_5 − 14.40	t_{III}	.0090
r_6 + .3698	S_3	.0909
r_7 + 1.336	t_{IV}	.0265
r_8 − .3352		

Kinds of Glass.

I	n_D=1.6116	V=56.4	Dense baryta crown
II	n_D=1.6206	V=36.2	Heavy flint
III	n_D=1.6206	V=36.2	Heavy flint
IV	n_D=1.6116	V=56.4	Dense baryta crown.

Example I attains a wide field highly corrected for the aberrations of coma, astigmatism and curvature at an aperture of F/4.5 by the use of highly refractive baryta crown glass for the positive lenses and of light flints of medium refractive index for the negative glasses.

Example II shows the invention applied to a design intended for objectives of long focal length in which it is necessary to attain a very high degree of correction of the aberrations over a field of moderate extent. In the particular example quoted, the negative lenses are made of material of refractive index higher than that of the positives. This is immaterial to the application of our invention. If one of the negative lenses were made of material of somewhat higher, and the other of material of somewhat lower, refractive index than that of the positive lenses, a compensating effect could be obtained by suitable adjustments of the various curvatures and air spaces. As in Example I, the essential points to secure a high degree of correction of the several aberrations are those embodied in our invention, *viz*:—The employment of highly refractive material for the positive lenses and the favourable distribution of the unsymmetrical curvatures so that all the four glasses turn their surface of least curvature towards the middle air space.

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

1. A spherically, chromatically, astigmatically and comatically corrected objective, consisting of four simple lenses separated from one another by air spaces, whereof the two halves are unsymmetrical, and each of which comprises a positive lens of highly refractive baryta crown and a negative lens, the two lenses being separated by an air space of the shape of a positive meniscus, characterised in that the two less curved surfaces of the two component lenses of each half face inwards to the median plane or diaphragm.

2. A photographic objective as claimed in Claim 1, substantially as described with reference to Figure 1 of the drawings.

3. A photographic objective as claimed in Claim 1, substantially as described with reference to Figure 2 of the drawings.

Dated this 27th day of November, 1917.

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[This Drawing is a full-size reproduction of the Original.]

Fig. 1.

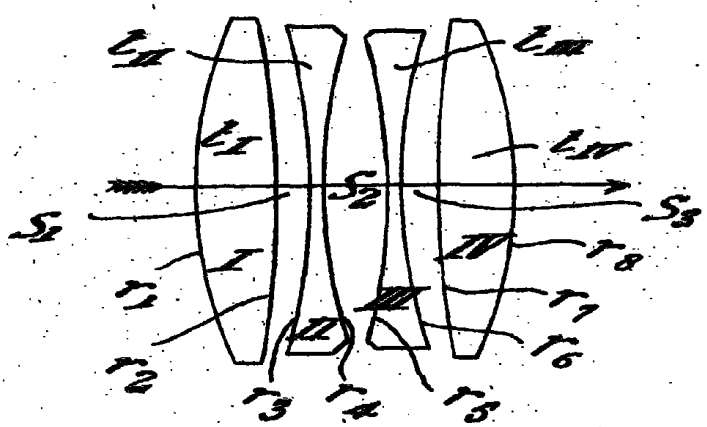
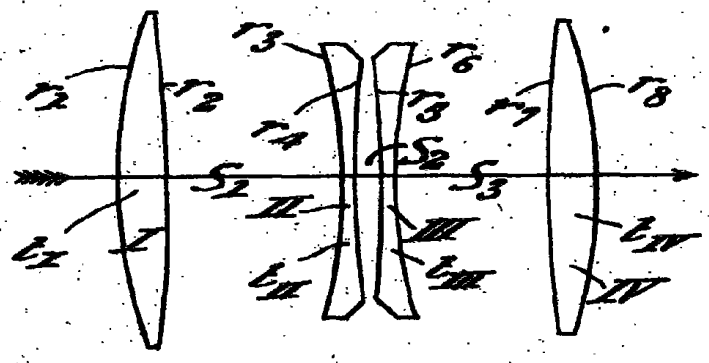


Fig. 2.



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