PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Improvements in or relating to Optical Objectives

We, TAYLOR, TAYLOR & HOBSON LIMITED, a Company registered under the Laws of Great Britain, ARTHUR WARMISHAM, British Subject, and CHARLES GORRIE WYNNE, British Subject, all of 104, Stoughton Street, Leicester, do hereby declare the nature of this invention to be as follows:—

This invention relates to an optical objective for photographic or other purposes of the kind corrected for spherical and chromatic aberrations, coma, astigmatism, field curvature and distortion, and comprising two divergent components located between two simple convergent components, each divergent component consisting of a divergent element compounded with a convergent element.

It is well-known that a simple doublet can be corrected paraxially for chromatic aberration in respect of two colours by a suitable combination of flint and crown glass, but such correction does not extend throughout the spectrum and there is a residual colour aberration known as secondary spectrum.

The present invention has for its object to provide in an objective of the above kind a much higher degree of correction for secondary spectrum than hitherto without sacrificing the corrections for astigmatism, field curvature and distortion.

In the objective according to the invention the two divergent elements are each made of an alkaline halide crystal, and the materials of which all the elements are made have substantially the same relative partial dispersion. The relative partial dispersion, usually represented by the symbol θ, may be defined by the mathematical expression $\frac{n_g - n_e}{n_F - n_C}$, where n_C, n_e, n_F and n_g are respectively the refractive indices for the spectrum lines C, e, F and g.

Preferably, the materials used for the divergent elements have mean refractive index between 1.53 and 1.58 and Abbé V number between 30.0 and 33.0, whilst those used for the convergent elements have mean refractive index between 1.59 and 1.63 and Abbé V number between 52.0 and 62.0. Thus potassium bromide crystal may be used for the divergent elements, and a dense barium crown glass or glasses for the convergent elements. Conveniently the mean refractive index of each divergent element is greater than that of the convergent element cemented to it by at least .05.

The cemented surfaces in the two divergent components are preferably such that (regarding a cemented surface as having positive curvature if concave to the diaphragm and as having negative curvature if convex thereto) the algebraic sum of the curvatures of the two cemented surfaces is positive. When the overall axial length of the objective lies between .55 and .65 times the equivalent focal length of the objective, such algebraic sum preferably lies between 3.0 and 1.5 times the reciprocal of such equivalent focal length, whilst when the overall length is between .65 and .80 times the equivalent focal length, the algebraic sum preferably lies between 2.0 and 1.0 times the reciprocal of the equivalent focal length.

Numerical data for two convenient practical examples of objective according to the invention are given in the following tables, in which R_1 R_2 . . . represent the radii of curvature of the individual lens surfaces counting from the front (that is from the side of the longer conjugate) the positive sign indicating that the surface is convex to the front and the negative sign that it is concave thereto, D_1 D_2 . . . represent the axial thicknesses of the various elements, and S_1 S_2 S_3 the axial air separations between the components. The tables also give the mean refractive indices n_D and the Abbé V numbers of the materials of which the individual elements are made.

EXAMPLE I.

Equivalent focal length 1.000		Relative aperture F/2.0		
Radius	Thickness or Air Separation	Refractive Index N_D	Abbé V Number	Relative Partial Dispersion
R_1 + .7923				
	D_1 .0665	1.6154	59.4	.999
R_2 +4.926				
	S_1 .0044			
R_3 + .4022				
	D_2 .0985	1.6154	56.3	1.008
R_4 + .6569				
	D_3 .0985	1.558	31.5	1.000
R_5 + .2485				
	S_2 .1970			
R_6 − .3397				
	D_4 .0493	1.558	31.5	1.000
R_7 +3.284				
	D_5 .1478	1.6154	59.4	.999
R_8 − .5260				
	S_3 .0032			
R_9 +2.526				
	D_6 .0985	1.6154	56.3	1.008
R_{10} − .7084				

In this example potassium bromide crystal is used for the third and fourth elements, which are divergent, whilst the two convergent elements respectively cemented thereto are made of a dense barium crown glass, and the front and rear convergent elements are made of a slightly different dense barium crown glass. The relative partial dispersions of the potassium bromide crystal and the two dense barium crown glasses are all approximately 1.00.

The second example also employs potassium bromide crystal for the divergent elements, but in conjunction with three other dense barium crown glasses all having relative partial dispersions approximately 1.00.

EXAMPLE II.

Equivalent focal length 1.000		Relative aperture F/2.0		
Radius	Thickness or Air Separation	Refractive Index N_D	Abbé V Number	Relative Partial Dispersion
R_1 + .6610				
	D_1 .0782	1.6105	53.3	1.016
R_2 +2.875				
	S_1 .0090			
R_3 + .4207				
	D_2 .1081	1.6128	59.3	.999
R_4 + .6185				
	D_3 .0297	1.558	31.5	1.000
R_5 + .2698				
	S_2 .1591			
R_6 − .2787				
	D_4 .0267	1.558	31.5	1.000
R_7 − .9505				
	D_5 .0972	1.6216	60.2	.998
R_8 − .3958				
	S_3 .0054			
R_9 −8.990				
	D_6 .0742	1.6128	59.3	.999
R_{10} − .5589				

In Example I, the overall axial length of the objective is .7637, the curvature of the front cemented surface R_4 which is concave to the diaphragm is about 1.52 and that of the rear cemented surface R_7 which is convex to the diaphragm is about 0.30.

In Example II, the overall axial length is .5876, the curvature of R_4 which is again concave to the diaphragm is about 1.61 and that of R_7 which is also concave to the diaphragm is about 1.05.

It will be appreciated that the foregoing arrangements have been described by way of example only and that the invention may be carried into practice in other ways.

Dated this 5th day of October, 1942.

PULLINGER & MALET,
Agents for the Applicants.

COMPLETE SPECIFICATION

Improvements in or relating to Optical Objectives

We, TAYLOR, TAYLOR & HOBSON LIMITED, a Company registered under the Laws of Great Britain, ARTHUR WARMISHAM, British Subject, and CHARLES GORRIE WYNNE, British Subject, all of 104, Stoughton Street, 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 optical objective for photographic or other purposes of the kind corrected for spherical and chromatic aberrations, coma, astigmatism, field curvature and distortion, and comprising two divergent components located between two simple convergent components, each divergent component consisting of a divergent element compounded with a convergent element.

It is well-known that a simple doublet can be corrected paraxially for chromatic aberration in respect of two colours by a suitable combination of flint and crown glass, but such correction does not extend through the spectrum and there is a residual colour aberration known as secondary spectrum.

The present invention has for its object to provide in an objective of the above kind a much higher degree of correction for secondary spectrum than hitherto without sacrificing the corrections for astigmatism, field curvature and distortion.

In the objective according to the invention the two divergent elements are each made of an alkaline halide crystal, and the materials of which all the elements are made have substantially the same relative partial dispersion. The relative partial dispersion, usually represented by the symbol θ, may be defined by the mathematical expression $\frac{n_g - n_e}{n_F - n_C}$, where n_C, n_e, n_F and n_g are respectively the refractive indices for the spectrum lines C, e, F and g.

Preferably, the materials used for the divergent elements have mean refractive index between 1.53 and 1.58 and Abbé V number between 30.0 and 33.0, whilst those used for the convergent elements have mean refractive index between 1.59 and 1.63 and Abbé V number between 52.0 and 62.0. Thus potassium bromide crystal may be used for the divergent elements, and a dense barium crown glass or glasses for the convergent elements. Conveniently the mean refractive index of the material used for each divergent element is greater than that of the material used for the convergent element cemented to it by at least .05.

The cemented surfaces in the two divergent components are preferably such that (regarding a cemented surface as having positive curvature if concave to the diaphragm and as having negative curvature if convex thereto) the algebraic sum of the curvatures of the two cemented surfaces is positive. When the overall axial length of the objective lies between .55 and .65 times the equivalent focal length of the objective, such algebraic sum preferably lies between 3.0 and 1.5 times the reciprocal of such equivalent focal length, whilst when the overall length is between .65 and .80 times the equivalent focal length, the algebraic sum preferably lies between 2.0 and 1.0 times the reciprocal of the equivalent focal length.

Numerical data for two convenient practical examples of objective according to the invention, respectively illustrated in the two figures of the accompanying drawings, are given in the following tables in which R_1 R_2 . . . represent the radii of curvature of the individual lens surfaces counting from the front (that is from the side of the longer conjugate) the positive sign indicating that the surface is convex to the front and the negative sign that it is concave thereto, D_1 D_2 . . . represent the axial thicknesses of the various elements, and S_1 S_2 S_3 the axial air separations between the components. The tables also give the mean refractive indices n_D and the Abbé V numbers of the materials of which the individual elements are made.

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	D_6 .0985	1.6154	56.3	1.008
R_{10} − .7084				

In this example potassium bromide crystal is used for the third and fourth elements, which are divergent, whilst the two convergent elements respectively cemented thereto are made of two slightly different dense barium crown glasses, which are also used respectively for the rear and front simple convergent components. The relative partial dispersions of the potassium bromide crystal and the two dense barium crown glasses are all approximately 1.00.

The second example also employs potassium bromide crystal for the divergent elements, but in conjunction with three other dense barium crown glasses all having relative partial dispersions approximately 1.00.

EXAMPLE II.

Equivalent focal length 1.000 · Relative aperture F/2.0

Radius	Thickness or Air Separation	Refractive Index N_D	Abbé V Number	Relative Partial Dispersion
R_1 + .6610				
	D_1 .0782	1.6105	53.3	1.016
R_2 +2.875				
	S_1 .0090			
R_3 + .4207				
	D_2 .1081	1.6128	59.3	.999
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It will be appreciated that the foregoing arrangements have been described by way of example only and that the invention may be carried into practice in other ways.

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. An optical objective, corrected for spherical and chromatic aberrations, coma, astigmatism field curvature and distortion, and comprising two divergent components located between two simple convergent components and each consisting of a divergent element compounded with a convergent element, wherein the materials of which all the elements are made have substantially the same relative partial dispersion, the two divergent elements each being made of an alkaline halide crystal.

2. An optical objective as claimed in Claim 1, in which the materials used for the divergent elements have mean refractive index lying between 1.53 and 1.58 and Abbé V number lying between 30.0 and 33.0, whilst those used for the convergent elements have mean refractive index lying between 1.59 and 1.63 and Abbé V number lying between 52.0 and 62.0.

3. An optical objective as claimed in Claim 1 or Claim 2, in which the material used for each divergent element has mean refractive index at least .05 less than that of the material used for the convergent element cemented to it.

4. An optical objective as claimed in Claim 2 or Claim 3 in which potassium bromide crystal is used for the divergent elements, whilst the convergent elements are made of a dense barium crown glass or glasses.

5. An optical objective as claimed in any one of Claims 1 to 4, in which the algebraic sum of the curvatures of the cemented surfaces in the two divergent components (regarding such curvature as positive, if the surface is concave to the diaphragm and negative if the surface is convex thereto) is positive.

6. An optical objective as claimed in

Claim 5, in which the overall axial length of the objective lies between .55 and .65 times the equivalent focal length of the objective, and the algebraic sum of the curvatures (as defined in Claim 5) of the cemented surfaces lies between 3.0 and 1.5 times the reciprocal of the equivalent focal length of the objective.

7. An optical objective as claimed in Claim 5, in which the overall axial length of the objective lies between .65 and .80 times the equivalent focal length of the objective and the algebraic sum of the curvatures (as defined in Claim 5) of the cemented surfaces lies between 2.0 and 1.0 times the reciprocal of the equivalent focal length of the objective.

8. An optical objective having numerical data substantially in accordance with one or other of the tables herein set forth.

Dated this 5th day of October, 1943.

PULLINGER & MALET,
Agents for the Applicants.

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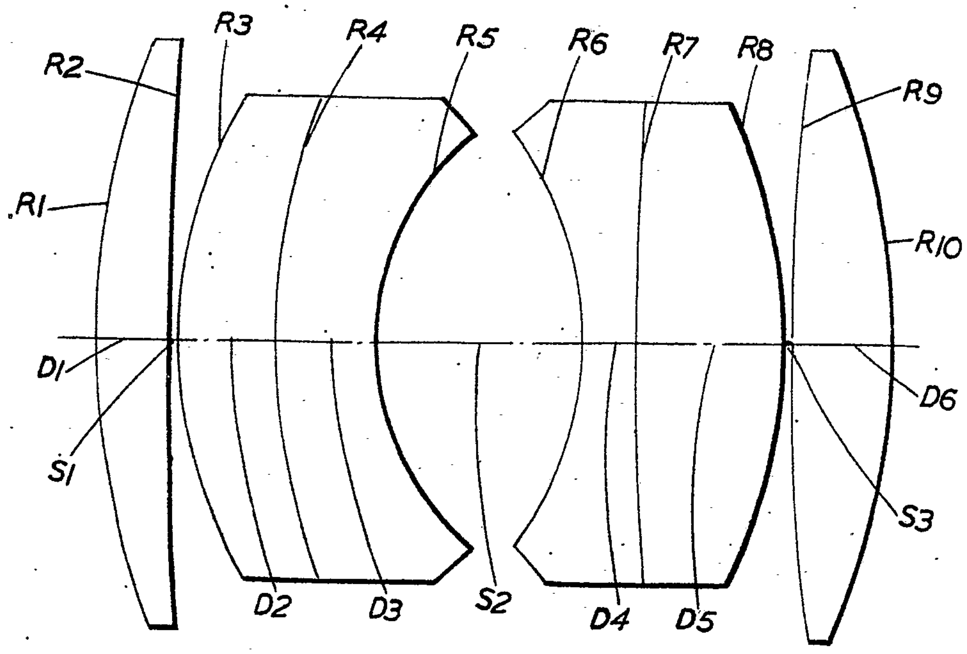

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