PATENT SPECIFICATION

Application Date: Dec. 23, 1938. No. 37409/38.

523,061

Complete Specification Left: Nov. 28, 1939.

Complete Specification Accepted: July 4, 1940.

PROVISIONAL SPECIFICATION

Improvements in or relating to Optical Objectives

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

This invention relates to optical objectives for photographic or projection or like purposes, corrected for spherical and chromatic aberrations and for coma, astigmatism, distortion and curvature of field, and comprising four axially aligned components separated by air gaps, the two inner components consisting of compound dispersive meniscus components, with their concave surfaces facing one another, whilst the two outer components consist of simple collective elements.

The invention has for its primary object to secure improved zonal spherical aberration correction or to reduce the higher order overcorrected spherical aberration in such an objective, and thereby to obtain in comparison with known objectives of this kind either a higher aperture with generally the same degree of correction or considerably improved correction at the usual apertures.

In the objective according to the present invention one or each of the outer collective components is made of a glass having a mean refractive index higher than 1.75 and preferably higher than 1.8. Various examples of glass having such high refractive index are given in British Patent Specification No. 462,304, such glass having as its main constituents oxides of elements such as tungsten, tantalum, lanthalum, thorium, yttrium, zirconium, hafnium and columbium.

The sum of the numerical values of the curvatures of the front surface of the front dispersive component and the rear surface of the rear dispersive component conveniently lies between 4.25 and 4.85 times the reciprocal of the equivalent focal length of the objective.

When the relative aperture is not less than F/1.5, the sum of the numerical values of the curvatures of the front and rear surfaces of the rear collective component should preferably be less than 1.6 times the reciprocal of the equivalent focal length of the objective.

It is to be understood that the term "front" as herein used refers to the side of the objective nearer to the longer conjugate and the term "rear" to that nearer the shorter conjugate.

Numerical data of four convenient practical examples of objective according to the invention are given in the following tables, in which the radii of curvature of the individual surfaces are designated by R_1 R_2 . . . . . . counting from the front, the positive sign indicating that the surface is convex towards the front and the negative sign that it is concave thereto, whilst the thicknesses of the individual elements along the axis are designated by D_1 D_2 . . . . . . , and the axial air spaces between the various components by S_1 S_2 S_3. The tables also give the mean refractive indices and the Abbé V numbers of the glasses used for the individual elements.

[Price 1/-]

Price 4s 6d. Price 3s. 6d.

EXAMPLE I.

Equivalent focal length 1.000.		Relative aperture F/2.	
Radius	Thickness or Separation	Refractive Index n_D	Abbé V Number
R_1 + .8106			
	D_1 .084	1.6130	59.3
R_2 +5.336			
	S_1 .0359		
R_3 + .4226			
	D_2 .1332	1.6130	59.3
R_4 + .8628			
	D_3 .0594	1.6130	37.4
R_5 + .2784			
	S_2 .2244		
R_6 − .3243			
	D_4 .0820	1.6446	33.5
R_7 + .3955			
	D_5 .1127	1.6441	48.3
R_8 − .4394			
	S_3 .0061		
R_9 +1.934			
	D_6 .1332	1.8040	42.4
R_{10} −1.168			

EXAMPLE II.

Equivalent focal length 1.000.		Relative aperture F/1.5.	
Radius	Thickness or Separation	Refractive Index n_D	Abbé V Number
R_1 + .9289			
	D_1 .0943	1.804	42.4
R_2 +3.418			
	S_1 .0359		
R_3 + .4474			
	D_2 .1332	1.613	59.3
R_4 −5.102			
	D_3 .0594	1.613	37.4
R_5 + .2930			
	S_2 .2246		
R_6 − .3464			
	D_4 .0820	1.6446	33.5
R_7 + .4611			
	D_5 .1128	1.6441	48.3
R_8 − .4588			
	S_3 .0062		
R_9 +1.935			
	D_6 .1332	1.804	42.4
R_{10} −1.186			

EXAMPLE III.

Equivalent focal length 1.000.		Relative aperture F/1.4.	
Radius	Thickness or Separation	Refractive Index n_D	Abbé V Number
R_1 + .8369			
	D_1 .0862	1.613	59.4
R_2 +7.008			
	S_1 .0021		
R_3 + .4204			
	D_2 .1524	1.613	59.4
R_4 +1.752			
	D_3 .0368	1.621	36.1
R_5 + .2920			
	S_2 .2102		
R_6 − .3581			
	D_4 .0368	1.6457	33.9
R_7 + .7508			
	D_5 .1682	1.644	48.3
R_8 − .5053			
	S_3 .0021		
R_9 +3.003			
	D_6 .1209	1.850	42.0
R_{10} −1.067			

EXAMPLE IV.

Equivalent focal length 1.000.		Relative aperture F/2.	
Radius	Thickness or Separation	Refractive Index n_D	Abbé V Number
R_1 + .9237			
	D_1 .1066	1.850	42.0
R_2 +3.083			
	S_1 .0345		
R_2 + .4068			
	D_2 .1283	1.613	59.3
R_4 +3.026			
	D_3 .0572	1.613	37.4
R_5 + .2681			
	S_2 .2160		
R_6 − .3122			
	D_4 .0789	1.644	33.5
R_7 + .6348			
	D_5 .1085	1.644	48.3
R_8 − .4234			
	S_3 .0059		
R_9 +1.644			
	D_6 .0839	1.613	59.3
R_{10} − .8468			

It will be noticed that the high index glass is employed in Examples I and III for the rear component alone, in Example IV for the front component alone, and in Example II for both front and rear components. The sum of the numerical values of the curvatures of the third and eighth surfaces is in Example I 4.64, in Example II 4.41, in Example III 4.36, and in Example IV 4.82. The sum of the numerical values of the curvatures of the two surfaces of the rear component is in Example I 1.373, in Example II 1.395, in Example III 1.335, and in Example IV 1.789.

All four examples show good zonal spherical aberration correction, the first two being almost perfectly corrected in this respect. Thus the maximum departure from paraxial focus in Example I is only .08%, and in Example II .14%, whilst in Example III, although greater than in Examples I and II, it is still only .50% and in Example IV it is .40%. All the examples also maintain the good correction for the other aberrations which is characteristic of well-designed objectives of the kind to which the invention relates.

Dated this 23rd day of December, 1938.

A. F. PULLINGER,
Agent 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, and ARTHUR WARMISHAM, British Subject, both 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 optical objectives for photographic or projection or like purposes, corrected for spherical and chromatic aberrations and for coma, astigmatism, distortion and curvature of field, and comprising four axially aligned components separated by air gaps, the two inner components consisting of compound dispersive meniscus components, with their concave surfaces facing one another, whilst the two outer components consist of simple collective elements.

The invention has for its primary object to secure improved zonal spherical aberration correction or to reduce the higher order overcorrected spherical aberration in such an objective, and thereby to obtain in comparison with known objectives of this kind either a higher aperture with generally the same degree of correction or considerably improved correction at the usual apertures.

In the objective according to the present invention one or each of the outer collective components is made of a glass having a mean refractive index higher than 1.75 and preferably higher than 1.8, and the sum of the numerical values of the curvatures of the front surface of the front dispersive component and the rear surface of the rear dispersive component lies between 4.25 and 4.85 times the reciprocal of the equivalent focal length of the objective.

Various examples of glass having the desired high refractive index are given in British Patent Specification No. 462,304, such glass having as its main constituents oxides of elements such as tungsten, tantalum, lanthalum, thorium, yttrium, zirconium, hafnium and colombium.

When the relative aperture is not less than F/1.5, the sum of the numerical values of the curvatures of the front and rear surfaces of the rear collective component should preferably be less than 1.6 times the reciprocal of the equivalent focal length of the objective.

It is to be understood that the term "front" as herein used refers to the side of the objective nearer to the longer conjugate and the term "rear" to that nearer the shorter conjugate.

Numerical data of four convenient practical examples of objective according to the invention (of which the first is illustrated in the accompanying drawing) are given in the following tables, in which the radii of curvature of the individual surfaces are designated by R_1 R_2 . . . . . counting from the front, the positive sign indicating that the surface is convex towards the front and the negative sign that it is concave thereto, whilst the thicknesses of the individual elements along the axis are designated by D_1 D_2 . . . . . and the axial air spaces between the various components by S_1 S_2 S_3. The tables also give the mean refractive indices and the Abbé V numbers of the glasses used for the individual elements.

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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 of the kind described, in which one or each of the outer collective components is made of glass having a mean refractive index higher than 1.75 and preferably higher than 1.8, and the sum of the numerical values of the curvatures of the front surface of the front dispersive component and of the rear surface of the rear dispersive component lies between 4.25 and 4.85 times the reciprocal of the equivalent focal length of the objective.

2. An optical objective as claimed in Claim 1, having a relative aperture not less than F/1.5 in which the sum of the numerical values of the curvatures of the front and rear surfaces of the rear collective component is less than 1.6 times the reciprocal of the equivalent focal length of the objective.

3. An optical objective having numerical data substantially as set forth in any one of the tables herein.

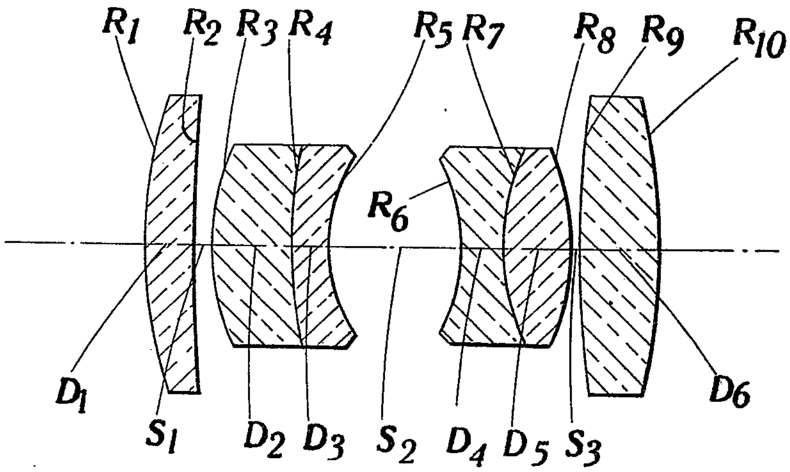
Dated this 28th day of November, 1939.

PULLINGER & MALET-VEALE,

Agents for the Applicants.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1940.

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



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