PATENT SPECIFICATION

Application Date: Dec. 23, 1938. No. 37410/38. **523,062**

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 an anastigmatically corrected objective for photographic or projection or like purposes, of the kind comprising three axially aligned components, each consisting of a simple element, the middle component being dispersive and the two outer components collective.

Attempts to design an objective of this kind with a high aperture, say F/2.5, have hitherto resulted in an objective having rather heavy residual zonal spherical aberration, thereby restricting their use to short focal lengths of $1\frac{1}{2}$ inches or less.

The present invention has for its object to provide an objective of this kind in which the same high aperture can be obtained with considerably improved zonal spherical aberration correction, or alternatively in which a still higher aperture can be obtained with the same degree of residual zonal spherical aberration.

In the objective according to the invention each of the three 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, lanthanum, thorium, yttrium, zirconium, hafnium and columbium.

The sum of the numerical values of the radii of curvature of the front surface of the front component and the rear surface of the rear component is preferably greater than the equivalent focal length of the objective and less than 1.33 times such focal length. The total axial length of the objective between such two surfaces preferably lies betwen 55% and 85% 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 three 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 D_3 and the axial air spaces between the components by S_1 S_2. The tables also give the mean refractive indices and the Abbé V numbers of the glasses used for the individual elements.

EXAMPLE I.

Equivalent focal length 1.000.		Relative aperture F/2.5.	
Radius	Thickness or Separation	Refractive Index n_D	Abbé V Number.
R_1 + .4543			
	D_1 .200	1.812	41.1
R_2 − 5.000			
	S_1 .050		
R_3 − .9259			
	D_2 .061	1.995	26.6
R_4 + .4292			
	S_2 .100		
R_5 + 1.176			
	D_3 .200	1.812	41.1
R_6 − .6254			

EXAMPLE II.

Equivalent focal length 1.000.		Relative aperture F/2.5.	
Radius	Thickness or Separation	Refractive Index n_D	Abbé V Number.
R_1 + .4470			
	D_1 .1979	1.893	30.8
R_2 ∞			
	S_1 .0495		
R_3 − 1.164			
	D_2 .0604	2.022	19.1
R_4 + .3965			
	S_2 .0990		
R_5 + 1.414			
	D_3 .1979	1.893	30.8
R_6 − .6909			

EXAMPLE III.

Equivalent focal length 1.000.		Relative aperture F/2.25.	
Radius	Thickness or Separation	Refractive Index n_D	Abbé V Number.
R_1 + .6143			
	D_1 .200	1.893	30.8
R_2 ∞			
	S_1 .100		
R_3 − .6579			
	D_2 .061	2.022	19.1
R_4 + .5429			
	S_2 .050		
R_5 + 1.429			
	D_3 .200	1.893	30.8
R_6 − .4782			

As will be seen, all three examples employ high index glass throughout, the glass used for the middle component in each case having higher refractive index and lower Abbé V number than that used for each of the two outer components. The sum of the numerical value of the two outermost radii is in Example I 1.0797, in Example II 1.1379 and in Example III 1.0925. The total axial length of the

objective is in Examples I and III .611 and in Example II .5647.

The first two examples give good zonal spherical abberration correction for aperture F/2.5, whilst in the third example a higher aperture F/2.25 is obtained at the expense of leaving a residual zonal spherical aberration which restricts practical use of the objective to short focal lengths of $1\frac{1}{2}$ inches or less.

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 an anastigmatically corrected objective for photographic or projection or like purposes, of the kind comprising three axially aligned components, each consisting of a simple element, the middle component being dispersive and the two outer components collective.

Attempts to design an objective of this kind with a high aperture, say F/2.5, have hitherto resulted in an objective having rather heavy residual zonal spherical aberration, thereby restricting their use to short focal lengths of $1\frac{1}{2}$ inches or less.

The present invention has for its object to provide an objective of this kind in which the same high aperture can be obtained with considerably improved zonal spherical aberration correction, or alternatively in which a still higher aperture can be obtained with the same degree of residual zonal spherical aberration.

In the objective according to the invention each of the three 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, lanthanum, thorium, yttrium, zirconium, hafnium and columbium.

The sum of the numerical values of the radii of curvature of the front surface of the front component and the rear surface of the rear component is preferably greater than the equivalent focal length of the object and less than 1.33 times such focal length. The total axial length of the objective between such two surfaces preferably lies between 55% and 85% of the equvalent 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 three 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 D_3 and the axial air spaces between the components by S_1 S_2. The tables also give the mean refractive indices and the Abbé V numbers of the glasses used for the individual elements.

EXAMPLE I.

Equivalent focal length 1.000.		Relative aperture F/2.5.	
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R_2−5.000			
	S_1 .050		
R_3− .9259			
	D_2 .061	1.995	26.6
R_4+ .4292			
	S_2 .100		
R_5+1.176			
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EXAMPLE II.

Equivalent focal length 1.000.		Relative aperture F/2.5.	
Radius	Thickness or Separation	Refractive Index n_D	Abbé V Number.
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	S_2 .0990		
R_5+1.414			
	D_3 .1979	1.893	30.8
R_6− .6909			

EXAMPLE III.

Equivalent focal length 1.000.		Relative aperture F/2.25.	
Radius	Thickness or Separation	Refractive Index n_D	Abbé V Number.
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	D_1 .200	1.893	30.8
R_2 ∞			
	S_1 .100		
R_3− .6579			
	D_2 .061	2.022	19.1
R_4+ .5429			
	S_2 .050		
R_5+1.429			
	D_3 .200	1.893	30.8
R_6− .4782			

As will be seen, all three examples employ high index glass throughout, the glass used for the middle component in each case having higher refractive index and lower Abbé V number than that used for each of the two outer components. The sum of the numerical values of the two outermost radii is in Example I 1.0797, in Example II 1.1379 and in Example III 1.0925. The total axial

length of the objective is in Examples I and III .611 and in Example II .6047.

The first two examples give good zonal spherical aberration correction for aperture F/2:5, whilst in the third example a higher aperture F/2.25 is obtained at the expense of leaving a residual zonal spherical aberration which restricts practical use of the objective to short focal lengths of 1½ inches or less.

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 each of the three components is made of a glass having a mean refractive index higher than 1.75 and preferably higher than 1.8.

2. An optical objective as claimed in Claim 1, in which the sum of the numerical values of the radii of curvature of the front surface of the front component and the rear surface of the rear component is greater than the equivalent focal length of the objective and less than 1.33 times such focal length.

3. An optical objective as claimed in Claim 1 or Claim 2, in which the total axial length of the objective lies between 55% and 85% of the equivalent focal length of the objective.

4. 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.

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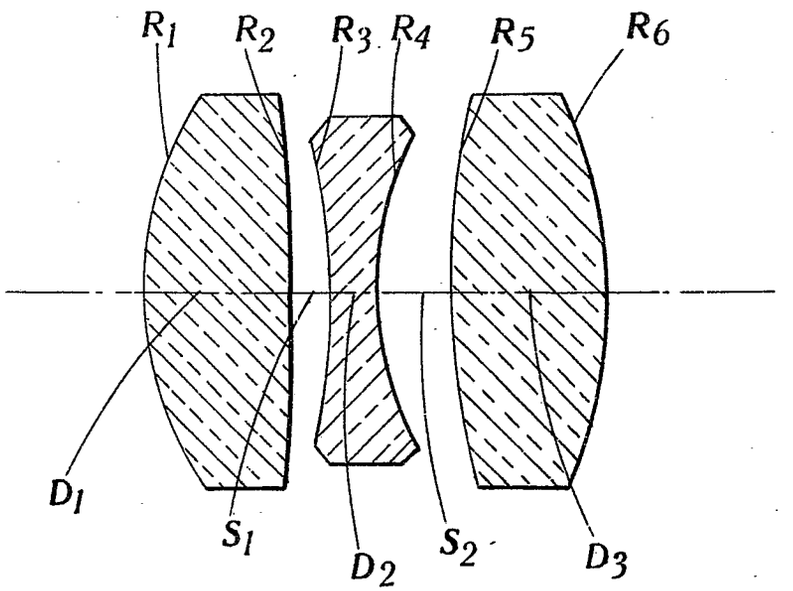

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