PATENT SPECIFICATION

Application Date: Dec. 29, 1938. No. 37685/38. **523,218**

Complete Specification Left: Nov. 28, 1939.

Complete Specification Accepted: July 9, 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 optical objective for kinematograph projection or other purposes consisting of a lens system corrected for spherical aberration, coma, astigmatism and distortion, of the kind comprising a double-concave asymmetrical divergent component disposed behind two convergent components and in front of a third convergent component and having its shallow side turned towards the front two components, each of the four components being in the form of a simple element, i.e. consisting of a single piece of glass. It should be made clear that the side of the longer conjugate is herein regarded as the " front " of the objective in accordance with the normal convention.

The present applicants' British Patent Application No. 22153 of 1938 (Serial No. 517,386) relates to an objective of this kind, giving for an aperture of, say, F/2 a much higher degree of correction (more especially for curvature of field and coma) over a semi-field of about ten degrees than had previously been obtained. In such objective the glass of the divergent component has its mean refractive index n_D substantially greater than 1.65 and its Abbé V number substantially less than 33.5 and the air separation on the axis between the shallow side of the divergent component and the convergent component in front of it is not less than 10% of the focal length of the objective, the mean refractive indices of at least two of the three convergent components preferably being greater than 1.6.

The present invention has for its object still further to improve the correction in such an objective.

According to the invention the mean refractive indices of at least two of the three simple convergent components are greater than 1.75, whilst that of the divergent component is greater 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.

Conveniently the sum of the numerical values of the radii of the front surface of the front component and the rear surface of the rear component is greater than 1.25 and less than 2.5 times the equivalent focal length of the whole objective.

The numerical value of the radius of the front surface of the divergent component is preferably greater than that of the rear surface of the rear convergent component, but both surfaces being concave towards the front. The radius of the rear surface of the rear component is preferably less than 1.75 times the equivalent focal length of the whole objective.

Numerical data for two 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.

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EXAMPLE I.

Equivalent focal length 1.000.		Relative Aperture F/1.8.	
Radius	Thickness or Separation	Refractive Index n_D	Abbé V Number
R_1 + .8521			
	D_1 .1124	1.850	42.0
R_2 +1.1628			
	S_1 .0068		
R_3 + .5486			
	D_2 .1124	1.850	42.0
R_4 +1.190			
	S_2 .1514		
R_5 −1.882			
	D_3 .0264	2.022	19.1
R_6 + .4209			
	S_3 .1329		
R_7 +1.028			
	D_4 .0879	1.848	32.5
R_8 − .6288			

EXAMPLE II.

Equivalent focal length 1.000.		Relative Aperture F/2.0.	
Radius	Thickness or Separation	Refractive Index n_D	Abbé V Number
R_1 + .7679			
	D_1 .1011	1.800	38.4
R_2 −20.226			
	S_1 .0030		
R_3 + .4695			
	D_2 .0900	1.800	38.4
R_4 + .6409			
	S_2 .0870		
R_5 −15.807			
	D_3 .0243	2.022	19.1
R_6 + .4103			
	S_3 .3034		
R_7 + 1.686			
	D_4 .0566	1.842	35.5
R_8 − .8015			

Dated this 28th 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 optical objective for kinematograph projection or other purposes consisting of a lens system corrected for spherical aberration, coma, astigmatism and distortion, of the kind comprising a double-concave asymmetrical divergent component disposed behind two convergent components and in front of a third convergent component and having its shallow side turned

towards the front two components, each of the four components being in the form of a simple element, i.e. consisting of a single piece of glass. It should be made clear that the side of the longer conjugate is herein regarded as the " front " of the objective in accordance with the normal convention.

The present applicants' British Patent Application No. 22153 of 1938 (Serial Number 517,386) relates to an objective of this kind, giving for an aperture of, say, F/2 much higher degree of correction (more especially for curvature of field and coma) over a semi-field of about ten degrees than had previously been obtained. In such objective the glass of the divergent component has its mean refractive index n_D substantially greater than 1.65 and its Abbé V number substantially less than 33.5 and the air separation on the axis between the shallow side of the divergent component and the convergent component in front of it is not less than 10% of the focal length of the objective, the mean refractive indices of at least two of the three convergent components preferably being greater than 1.6.

The present invention has for its object still further to improve the correction in such an objective.

According to the invention the mean refractive indices of at least two of the three simple convergent components are greater than 1.75, whilst that of the divergent component is greater 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.

Conveniently the sum of the numerical values of the radii of the front surface of the front component and the rear surface of the rear component is greater than 1.25 and less than 2.5 times the equivalent focal length of the whole objective.

The numerical value of the radius of the front surface of the divergent component is preferably greater than that of the rear surface of the rear convergent component, both such surfaces being concave towards the front. The radius of the rear surface of the rear component is preferably less than 1.75 times the equivalent focal length of the whole objective.

Numerical data for three convenient practical examples 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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	S_2 .1514		
R_5 − 1.882			
	D_3 .0264	2.022	19.1
R_6 + .4209			
	S_3 .1329		
R_7 + 1.028			
	D_4 .0879	1.848	32.5
R_8 − .6288			

EXAMPLE II.

Equivalent focal length 1.000.		Relative Aperture F/2.0.	
Radius	Thickness or Separation	Refractive Index n_D	Abbé V Number
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$R_2 - 20.226$	S_1 .0030		
$R_3 - .4695$	D_2 .0900	1.800	38.4
$R_4 + .6409$	S_2 .0870		
$R_5 - 15.807$	D_3 .0243	2.022	19.1
$R_6 + .4103$	S_3 .3034		
$R_7 + 1.686$	D_4 .0566	1.842	35.5
$R_8 - .8015$			

EXAMPLE III.

Equivalent focal length 1.000.		Relative Aperture F/2.0.	
Radius	Thickness or Separation	Refractive Index n_D	Abbé V Number
$R_1 + .7653$	D_1 .1007	1.800	38.4
$R_2 - 11.35$	S_1 .0029		
$R_3 + .4062$	D_2 .0854	1.613	37.3
$R_4 + .5767$	S_2 .0867		
$R_5 - 8.796$	D_3 .0247	2.022	19.1
$R_6 + .3929$	S_3 .2829		
$R_7 + 1.574$	D_4 .0564	1.842	35.5
$R_8 - .7651$			

It will be noticed that in Examples I and II all three convergent elements are made of glass having a mean refractive index n_D greater than 1.75, whilst in Example III two only of such elements are of the high index glass. The sum of the numerical values of the radii R_1 and R_8 is 1.4809 in Example I, 1.5694 in Example II and 1.5304 in Example III. In each example the fifth and eighth surfaces are both concave to the front and the radius R_5 is much greater than the radius R_8, the radius R_8 being numerically less than 1.75.

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 the mean refractive indices of at least two of the three simple convergent components are greater than 1.75, whilst that of the divergent component is greater than 1.8.

2. An objective as claimed in Claim 1, in which the sum of the numerical values of the radii of the front surface of the front component and the rear surface of the rear component is greater than 1.25 and less than 2.5 times the equivalent focal length of the whole objective.

3. An objective as claimed in Claim 1 or Claim 2, in which the numerical value of the radius of the front surface of the divergent component is greater than that of the rear surface of the rear convergent component, both such surfaces being concave towards the front.

4. An objective as claimed in Claim 1 or Claim 2 or Claim 3, in which the radius of the rear surface of the rear component is less than 1.75 times the equivalent focal length of the whole objective.

5. An 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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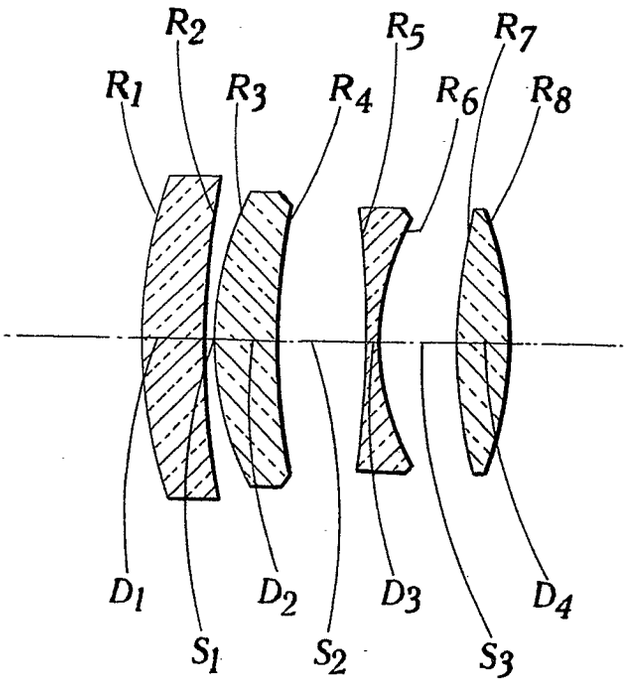

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