

## PATENT SPECIFICATION



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377,537

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## COMPLETE SPECIFICATION.

## Improvements in Lenses for Photography and the like.

We, HORACE WILLIAM LEE, a British Subject, and KAPELLA LIMITED, a British Company, 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 wide aperture lenses corrected for spherical and chromatic aberrations, coma, astigmatism, and distortion, of the type comprising two compound meniscus dispersive components, with their concave surfaces facing one another, said components being between two collective components having surfaces of different curvatures and having their more strongly curved surfaces turned outwards: and its object is to provide an improved form of such lenses, yielding better definition.

Lenses of the kind referred to herein, if corrected for distortion, must comply with the following conditions:—

(1) The spherical aberration on the concave surface of the rear meniscus dispersive component (that on the shorter conjugate side of the system) is at least 75% greater than that on the concave surface of the front meniscus dispersive component. This we ensure by making the ratio between the radius of curvature of the concave surface of the rear dispersive component and that of the concave surface of the front dispersive component not greater than 1.25.

(2) The point midway between the images of the front and rear surfaces of the entire system, in the space on the long conjugate side of the system, divides the space between the images of the concave surfaces of the dispersive components in a ratio not exceeding 3:1, counting such spaces in order from the long conjugate side of the system.

Lenses of the kind referred to are described in our Patent Specification No. 157,040. Such lenses yield good definition over a field of  $50^\circ$  or more, at an aperture of  $F/2$ . For some purposes, e.g. cinematography, such a large field is not required, and as the image has subsequently to be very greatly enlarged, it is

advisable to improve the definition over a narrower field, say up to  $35^\circ$  or  $40^\circ$ . This is the object of the present invention, and we attain it:—

a) by constructing the exterior surfaces of the rear dispersive component with curves such that the radius of the concave surface is greater than 0.3, and the radius of the convex surface is greater than 0.4 the focal length of the system.

(b) by making the thickness of each of the dispersive components more than 0.14 the focal length of the system.

By these means we reduce the zonal spherical aberration and the oblique spherical aberration of high order.

We prefer to construct the collective elements of the rear component (i.e. the collective elements of the two components on the shorter conjugate side of the system) of glasses each having a refractive index greater than 1.62. By this means we reduce the Petzval sum to less than 0.3, and thereby obtain a field free from zonal astigmatism.

In certain cases, e.g. for the improvement of the secondary spectrum, we may make the collective components compound. Where the front collective component, however, is a simple element, we may make it of glass having a lower refractive index than 1.61, this being possible without raising the Petzval sum, since we use, in the collective elements of the rear components, glass having a higher refractive index than 1.62. This is of special utility, as such a lens system is always used with this element most exposed, and glasses having a refractive index less than 1.61 are more stable than those having a higher refractive index.

Preferably the refractive index of each of the dispersive elements should not exceed that of the collective element to which it is cemented, by more than 0.02.

Preferably the front collective component is meniscus in form with its exterior surfaces having radii of curvature in ratio exceeding 9:2. Preferably the rear collective component is double convex and its exterior surfaces have radii of curvature in a ratio not exceeding 7:1.

The constructional data vary slightly

according to the angular field the lens is to embrace, but in all cases the above conditions obtain.

We now give data for the construction of an example illustrated in section in the accompanying drawing. The notation is that the successive radii of curvature, counting from the front, are called  $R_1$ ,  $R_2$ , etc., the sign + denoting that the curve is convex toward the incident light,

and - that it is concave toward the same. The axial thicknesses of the elements are denoted by  $D_1$ ,  $D_2$ , etc., and the separations of the members by  $S_1$ ,  $S_2$ , etc.

The material is defined in terms of the main refractive index  ${}^nD$ , as conventionally employed, followed by the Abbe V number and by the type number in Messrs. Chance Brothers' optical glass catalogue.

	EQUIVALENT FOCAL LENGTH 1"		APERTURE F/2 ${}^nD$	V	FLAT FIELD 35° No.
20	$R_1 + .766$	$D_1 = .08$	1.6100	53.3	8894
	$R_2 + 3.948$	$S_1 = .005$			
25	$R_3 + .401$	$D_2 = .15$	1.6150	56.1	3265
	$R_4 - 1.035$	$D_3 = .044$	1.6134	36.9	4743
30	$R_5 + .257$	$S_2 = .22$			
	$R_6 - .31$	$D_4 = .045$	1.6469	33.7	337
35	$R_7 + .50$	$D_5 = .157$	1.6437	48.3	-*
	$R_8 - .416$	$S_3 = .005$			
	$R_9 + 1.4$	$D_6 = .081$	1.6234	56.3	6665
40	$R_{10} - 1.01$				

\*(This glass has been introduced since the publication of Chance's Catalogue).

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 lens system of the kind referred to, corrected for spherical and chromatic aberrations, coma, astigmatism and distortion, in which:—

(a) the concave exterior surface of the rear dispersive component has a radius greater than 0.3 the focal length of the system and its convex exterior surface has a radius greater than 0.4 such focal length; and

(b) the thickness of each of the dispersive components is more than .14 the focal length of the system.

2. A lens system as claimed in claim 1, in which the collective elements of the rear components are constructed of glass having a refractive index greater than 1.62.

3. A lens system as claimed in claim 1 or claim 2, in which the ratio of the

curvatures of the exterior surfaces of the front collective component is greater than 9:2.

4. A lens system as claimed in any of the preceding claims, in which the rear collective component is double convex and the ratio of the curvatures of its exterior surfaces does not exceed 7:1.

5. A lens system as claimed in any of the preceding claims, in which the front collective component is a single element and its refractive index is not greater than 1.61.

Dated the Thirteenth day of November, 1931.

HORACE WILLIAM LEE,  
KAPELLA LIMITED,

The Common Seal of Kapella Limited was hereunto affixed in the presence of:—

J. RONALD TAYLOR,  
Director.

G. STAFFORD,  
Secretary.

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

