

# PATENT SPECIFICATION

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## PROVISIONAL SPECIFICATION.

### Large Aperture Lenses with Improved Colour Correction.

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 to be as follows:—

5 In the Specification of Letters Patent No. 157,040 we described a form of lens system suitable for the construction of large aperture lenses. The system described was achromatic, i.e., the foci for 10 two rays from different parts of the spectrum could be made identical, and the images formed at the common focus of equal size. For example, in the case of 15 a photographic lens, it is usual to combine in a common focus the rays D and G<sup>1</sup> of the spectrum. Rays from the red end of the spectrum will then be brought to a focus more distant from the lens, and 20 rays from intermediate parts of the spectrum, viz. green and blue, to a focus nearer the lens. In order to avoid this secondary spectrum, as it is called, it is necessary to use in the construction of the lens system glasses whose partial disper- 25 sions are proportional throughout the spectrum. Such glasses do not exist, but a limited number approximately fulfil this condition, such as, for example, the 30 glasses designated Telescope Flint (No. 4277 in the Catalogue of Chance Bros. & Co. Ltd., Birmingham; and T.F. 1, 2 and 3 in that of the Parsons Optical Glass Company) when used with ordinary or 35 dense barium crown glasses.

Our present invention consists, as did our earlier one mentioned above, of a system of lenses comprising two dispersive

menisci enclosed between two collective lenses, the convex surfaces of the menisci, and the deeper convex surfaces of the collective lenses, being turned outwards, i.e., away from the diaphragm. Each dispersive meniscus consists of two lenses cemented together, and for the purpose of reducing the secondary spectrum, we use a double concave lens of the said Telescope Flint and a double convex lens of Crown. On account of the small dispersive power of the Telescope Flint compared with ordinary flint glasses, it is not possible to produce complete achromatism without employing very deep curves. Now according to the present invention, we avoid this by constructing each of our collective lenses of two or three glasses, each preferably of high refractive index, of different dispersive powers and approximately equal partial dispersions. Such glasses at present available are Chance's Dense Barium Crown No. 8894, used as the flint component, in combination with Chance's Dense Barium Crown No. 3465, or similar glass.

Dated the 20th day of November, 1928.

HORACE WILLIAM LEE,  
KAPELLA LIMITED,

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

A. WARMISHAM,  
G. STAFFORD,

Directors,

T. E. HUDSON,

Secretary.

## COMPLETE SPECIFICATION.

### Large Aperture Lenses with Improved Colour Correction.

65 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 70 same is to be performed, to be particularly described and ascertained in and by the following statement:—

75 In the Specification of Letters Patent No. 157,040 we described a form of lens system suitable for the construction of large aperture lenses having an anastigmatic flat field free from spherical aberration, coma and distortion. The system

described was achromatic, i.e. the foci for two rays from different parts of the spectrum could be made identical, and the images formed at the common focus of equal size. For example, in the case of a photographic lens, it is usual to combine in a common focus the rays D and G<sup>1</sup> of the spectrum. Rays from the red end of the spectrum will then be brought to a focus more distant from the lens, and rays from intermediate parts of the spectrum, viz. green and blue, to a focus nearer the lens. In order to avoid this secondary spectrum, as it is called, it is necessary

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to use in the construction of the lens system glasses whose partial dispersions are proportional throughout the spectrum. Such glasses do not exist, but a limited number approximately fulfil this condition, such as, for example, the glasses designated Telescope Flint (No. 4277 in the Catalogue of Chance Bros. & Co. Ltd., Birmingham; and T.F. 1, 2 and 3 in that of the Parsons Optical Glass Company) when used with ordinary or dense barium crown glasses.

Our present invention consists, as did our earlier one mentioned above, of a system of lenses having an anastigmatic flat field free from spherical aberration, coma and distortion, comprising two dispersive menisci enclosed between two collective lenses, the convex surfaces of the menisci, and the deeper convex surfaces of the collective lenses, being turned outwards, i.e., away from the diaphragm. Each dispersive meniscus consists of two lenses cemented together, and for the purpose of reducing the secondary spectrum, we use in the present invention a double concave lens of the said Telescope Flint and a double convex lens of Crown. On account of the small dispersive power of the Telescope Flint compared with ordinary flint glasses, it is not possible to produce complete achromatism without employing very deep curves. Now according to the present invention, we avoid this by constructing each of our collective lenses of two or three glasses, each pre-

ferably of high refractive index, of different dispersive powers and approximately equal partial dispersions. Such glasses at present available are Chance's Dense Barium Crown No. 8894, used as the flint component, in combination with Chance's Dense Barium Crown No. 3465, or similar glass.

A system having shallower curves, and therefore less overall length, can be constructed if a less rigorous fulfilment of the condition for the abolition of the secondary spectrum can be tolerated, by using a flint glass of lower V value but somewhat higher partial dispersion  $F - G^1$ , such as No. 4676 in the Catalogue of Messrs. Parra-Mantois & Cie., of Paris. In order to obtain substantial improvement over systems made with ordinary glasses, the ratio of the partial dispersion of the flint glass for the rays F and G<sup>1</sup> of the solar spectrum to that for the rays C and F must not differ by more than three per cent. from the corresponding ratio for the crown glasses. With such a glass a system can be constructed which will give substantial improvement over a system constructed with e.g. the glasses described in the Specification of Letters Patent No. 157,040.

As an example of our method of construction, data are given for a lens of one inch focal length and aperture  $f/2$  giving a flat field of about 40°, which is illustrated by a sectional diagram.

	Radii.	Thicknesses and Separations.	$n_D$	V	$\frac{n_G^1 - n_F}{n_F - n_C}$	Glass No.
75	$R_1 + .915$	$T_1 .118$	1.6160	59.5	.568	3465
	$R_2 - .495$	$T_2 .015$	1.6100	53.3	.579	8894
	$R_3 + .495$	$T_3 .083$	1.6160	59.5	.568	3465
80	$R_4 \infty$	$D_1 .003$	1			
	$R_5 + .455$	$T_4 .15$	1.5186	60.3	.569	9322
85	$R_6 - .375$	$T_5 .015$	1.5237	52.2	.575	4277
	$R_7 + .32$	$D_2 .15$	1			
	$R_8 - .2975$	$T_6 .013$	1.5237	52.2	.575	4277
90	$R_9 + .391$	$T_7 .12$	1.5186	60.3	.569	9322
	$R_{10} - .38$	$D_3 .003$	1			
95	$R_{11} \infty$	$T_8 .065$	1.6160	59.5	.568	3465
	$R_{12} - .391$	$T_9 .013$	1.6100	53.3	.579	8894
	$R_{13} + .391$	$T_{10} .095$	1.6160	59.5	.568	3465
100	$R_{14} - .725$					

The Glass No. refers to the Catalogue of Chance Bros. & Co. Ltd., of Birmingham. The + sign indicates that the curve is convex to the incident light.

5 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:—

- 10 1. A flat-field lens system for photography and the like, corrected for spherical aberration, coma, astigmatism and distortion, having substantially the same focus and focal length for all the  
15 colours of the visible spectrum, comprising two dispersive menisci enclosed between two collective lenses, the menisci each consisting of two elements, a double concave flint glass cemented to a double  
20 convex crown glass, and the collective lenses each consisting of two or three elements, a dispersive flint glass cemented to a collective crown glass or, alternatively, between two such crown glasses,  
25 in which all the glasses are chosen to give a reduced secondary spectrum, that is to

say the ratio of partial dispersion of the flint glasses for the rays F and G<sup>1</sup> of the solar spectrum to that for the rays C and F does not differ by more than 3 per cent. 30 from the corresponding ratio for the crown glasses.

2. Lens system constructed according to Claim 1 in which the refractive indices of the components of the two collective 35 elements are greater than those of the components of the two dispersive menisci.

3. Lens system constructed according to Claims 1 and 2, substantially as described in the example with reference to the 40 diagram.

Dated the 17th day of July, 1929.

HORACE WILLIAM LEE,  
KAPELLA LIMITED,

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

A. WARMISHAM,

G. STAFFORD,

Directors,

T. E. HUDSON,

Secretary.

*[This Drawing is a reproduction of the Original on a reduced scale.]*

