



# PATENT SPECIFICATION

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## COMPLETE SPECIFICATION.

### Improvements in Photographic Objectives.

I, CHRISTOPHER GRAF, a citizen of the United States of America, residing at 1118, Lincoln Way West, in the City of South Bend, in the County of St. Joseph, and State of Indiana, United States of America, 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 has reference to improvements in photographic objectives, and it provides an improved compound lens adapted for use in photographic instruments or the like and consisting of a plurality of spaced lenses of substantially the same refractive index for the G-line, and having curvatures of such a character that the inner lenses are symmetrical with respect to each other, and the outer lenses unsymmetrical with respect to each other, thereby forming a compound lens which, as a whole, is unsymmetrical.

This invention, although resembling in a degree the anastigmat objective disclosed in the Specification of my prior Patent No. 22,400 of 1910 in formula and construction, materially differs therefrom in thickness of lenses, radii of curvature, and degree of separation of the lenses, whereby an uncorrected combination is obtained in which a certain amount of spherical aberration remains, thereby pro-

ducing a soft focus lens having a flat field, freedom from astigmatism, and a quality of diffusion not possible in other forms of soft focus lenses.

An object of the invention is to provide a soft focus lens which can be easily manufactured and easily corrected, and which will be devoid of such usual defects of soft focus lenses as chemical focus and halo. This and further objects, together with the construction and combination of parts, will be more fully described hereinafter and particularly set forth in the claims.

The accompanying drawing represents diagrammatically the lenses composing the optical piece and their magnitudes, positions, curvatures and thicknesses.

The line of sight passes from left to right, as indicated by the arrow in the figure. The optical combination is preferably composed of four lenses L<sup>1</sup>, L<sup>2</sup>, L<sup>3</sup>, and L<sup>4</sup>, spaced apart from each other so as to form positive meniscuses between the pairs of lenses. The radii and thickness of the various lenses and their distances apart are particularly set forth in the following table, in which R represents the radii, *d* the thickness of the lenses, and *s* the thickness of the space between the lenses, the successive characteristics being individualised by subscript numerals ascending from left to right.

70	Radius of curvature in millimeters.	Glass constants.	Thicknesses of lenses in millimeters.	85
		Positive		
	L <sup>1</sup> { R <sup>1</sup> — 84.17	{ D—1.6112	{ d <sup>1</sup> —12.5	
	{ R <sup>2</sup> —258.17	{ G—1.6253 }	{ s <sup>1</sup> — 4.6	
		Negative		
	L <sup>2</sup> { R <sup>3</sup> —121.00	{ D—1.6089	{ d <sup>2</sup> — 5.0	
	{ R <sup>4</sup> —188.96	{ G <sup>1</sup> —1.6253	{ s <sup>2</sup> —11.8	
		Negative		
	L <sup>3</sup> { R <sup>5</sup> —188.96	{ D—1.6089	{ d <sup>3</sup> —5.0	
	{ R <sup>6</sup> —121.00	{ G—1.6253	{ s <sup>3</sup> — 6.2	
		Positive		
	L <sup>4</sup> { R <sup>7</sup> —305.16	{ D—1.6112	{ d <sup>4</sup> —12.5	
	{ R <sup>8</sup> — 90.46	{ G—1.6253		

75 Focal length 317 millimeters.

It is to be noted in the above table that the G-line of the two negative lenses has [Price 1/-]

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the same refractive index, and so also the G-line of the two positive lenses. The two outer lenses  $L^1$  and  $L^4$  are not identical and preferably unsymmetrical with respect to each other; and are positive or collecting lenses. The two inner lenses  $L^2$  and  $L^3$  are identical and preferably symmetrical with respect to each other, and are negative or dispersing lenses, having the same index of refraction for the G-line as the positive lenses, which have a D-line index of refraction of greater value than the D-line index of the negative lenses. The radii of curvature of the respective lenses and their degree of separation by air spaces, the positive lenses being spaced a distance from the negative lenses less than the negative lenses are spaced from each other, forming an uncorrected combination in which the spherical aberration remains, but corrected as to astigmatism, and having a flat field and a quality of diffusion capable of producing a soft image with a measurably better definition than is possible with known forms of soft focus lenses.

While I have shown the preferred form of my invention, I do not wish to be limited to specific details thereof, but desire to be protected in various changes and modifications which obviously may be made without departing from the spirit of the invention.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A soft focus objective uncorrected as to spherical aberration, consisting of a pair of positive lenses, and a pair of nega-

tive lenses arranged between the positive lenses and in spaced relation with each other and with the positive lenses, the negative lenses being symmetrical with respect to radii of curvature and index of refraction, and the positive lenses being unsymmetrical with respect to radii of curvature and having an index of refraction greater than that of the negative lenses.

2. A soft focus objective uncorrected as to spherical aberration, consisting of two outer positive and two inner negative lenses separated by air spaces, the negative lenses being symmetrical and spaced from the positive lenses a distance less than the negative lenses are spaced from each other, and the positive lenses being unsymmetrical with respect to radii of curvature, the positive and negative lenses having like indexes of refraction for the G-line, and the negative lenses having indexes of refraction for the D-line of lesser value than those of the positive lenses.

3. A soft focus objective uncorrected as to spherical aberration, consisting of two positive and two negative lenses separated by air spaces, the negative lenses being symmetrical and arranged between the positive lenses, and the positive lenses being of substantially like thicknesses and having different radii of curvature, the positive lenses being spaced from the negative lenses a distance less than the negative lenses are spaced from each other.

Dated this 19th day of June, 1922.

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

