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DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Ultra-Achromatic Lens System

We, ASAHI KOGAKU KOGYO KABUSHIKI KAISHA, a corporation under the Japanese Law, of 36, 2-chome, Maeno-cho, Itabashi-Ku, Tokyo-to, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a photographic lens system in which an improved correction of chromatic aberration is made.

Generally, hitherto employed photographic lens systems have been of poor transmittance with respect to light rays of shorter wave length range. Especially, in recently produced lens systems having an increased number of lenses for obtaining larger relative aperture or made of optical glasses containing rare elements such as lanthanum or tellurium, light rays in the shorter wave length range are absorbed and do not reach the photosensitive film. Thus, although the film has the character of being sensitive to light rays in the shorter wave length range, because of the above mentioned tendency of the lens system, improvement of lens system brightness due to increase in relative aperture is actually checked. Therefore, such improvement would be increased appreciably by a lens system which absorbs a smaller amount of shorter wave length range light rays and illuminates the film with the corresponding shorter wave length range light rays. Such a lens systems, however, presents difficulties in making corrections for chromatic aberration with respect to light rays ranging from very short to very long wave lengths.

Ultra-achromatic lens systems that have been hitherto provided or in use have been unable to have a large photographic image angle because their Petzval sums have been relatively large. Therefore, only those with very narrow image angle have been in practical use.

It is therefore a principal object of the present invention to provide a photographic lens system which is sufficiently corrected for chromatic aberration with respect to light rays ranging from very short to very long wave lengths.

Another object of the present invention is to provide a photographic lens system which is very effectively corrected for chromatic aberration with respect to light rays of such wide wave length range as from 200 to 800 mμ.

Still another object of the present invention is to provide an improved lens system which enables the hitherto absorbed light to reach the film and to excite same, thus improving the film exciting efficiency.

A further object of the present invention is to provide an ultra-achromatic lens system having ordinary photographing image angle, the defect of narrow image angle of the conventional ultr-achromatic lens systems being eliminated.

The invention will now be described in more detail by way of example with reference to the accompanying drawing, in which:—

Fig. 1 is a longitudinal sectional view of a lens system embodying the present invention; and

Fig. 2 is a group of curves illustrating the aberration characteristics of a lens system of the present invention, (a) indicating spherical aberration (solid line) and sine condition (dotted line), (b) chromatic differences of spherical aberrations, (c) distortion and (d) astigmatism.

In order to attain the above mentioned objects, in the present invention new materials are employed for the lenses, and the optical design of the lens system has been carried out with due consideration to the characteristics of such new materials as fluorite and fused silica, which have come into use recently due to development in their artificial production.

Referring now to Fig. 1, the lens system shown consists of five lenses forming five groups, comprising the first lens L_1 which is negative, the second lens L_2 which is positive, the third lens L_3 which is positive, the fourth lens L_4 which is negative, and the fifth lens L_5 which is positive, the lenses being separated one from another. The positive lenses are made of fluorite while the negative lenses are made of fused silica. The lens system satisfies the following condition:

(I) $-2/F \leqq \varphi_1 \leqq -1/F$

(II) $2.8/F \geqq \varphi_{1.2.3.} \geqq 1.5/F$

(III) $-1.2/F \leqq \varphi_{1.2.3.4} \leqq 0$

(IV) $r_9 \leqq F$

wherein $\varphi_{1.2.\ldots i}$ is the resultant power of the lenes L_1 to L_i, that is, from the first to the i-th lenses; F is the resultant focal length; and r_i is the radius of curvature of the i-th face.

The condition (I) $-2/F \leqq \varphi_1 \leqq -1/F$ and the condition (II) $2.8/F \geqq \varphi_{1.2.3} \geqq 1.5/F$ satisfy the condition of correcting chromatic aberration and contribute to decreasing the Petzval sum value. The condition (III) $-1.2/F \leqq \varphi_{1.2.3.4} \leqq 0$, in co-operation with said conditions (I) and (II), further contributes to correcting chromatic aberration and decreasing the Petzval sum value, and further, with the condition (IV) $r_9 \leqq F$ included contributes to establishing a well-balanced relationship among the aberrations. On the other hand, the condition (IV) serves to prevent excessive correction of astigmatism due to the conditions (I) and (III).

One example of the present invention as illustrated in Fig. 1 is as follows:

Focal length F = 100 mm. Maximum aperture = F/4.5

r_1	− 38.500	d_1	1.50	L_1	1.45854/69.6
r_2	113.490	d_2	1.00		
r_3	55.500	d_3	5.00	L_2	1.43387/94.9
r_4	− 52.896	d_4	0.20		
r_5	24.500	d_5	6.00	L_3	1.43387/94.9
r_6	−136.347	d_6	8.50		
r_7	− 38.000	d_7	2.00	L_4	1.45854/69.6
r_8	20.007	d_8	7.00		
r_9	39.000	d_9	4.00	L_5	1.43387/94.9
r_{10}	− 60.456				

The table of Seidel's aberration co-efficient in connection with the above example is as follows:

	S_1	S_2	S_3	P	S_5
1	− 3.777	1.454	−0.559	−0.816	0.529
2	− 6.538	−2.658	−1.080	−0.277	−0.552
3	14.865	4.481	1.350	0.545	0.571
4	2.061	−0.837	0.340	0.572	−0.370
5	16.578	4.593	1.272	1.235	0.694
6	11.194	−2.817	0.709	0.221	0.234
7	−23.838	2.154	−0.194	−0.827	0.092
8	−14.886	−7.948	−4.244	−1.571	−3.105
9	3.283	2.778	2.351	0.775	2.647
10	3.265	−0.543	0.090	0.500	−0.098
Sum	2.207	0.655	0.035	0.358	0.174

The lens system shown in Fig. 1 also has

$$-1.2/F \leq \varphi_{1,2,3,4} \leq 0$$