PATENT SPECIFICATION

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COMPLETE SPECIFICATION

Improvements in or relating to Optical Lens Systems

We, ERNST LEITZ G.M.B.H., of Wetzlar, Germany, a German Company, 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:—

The present invention relates to a specific variety of the so-called triplet type of lens system, which, in its simplest form, consists of two collecting members enclosing a biconcave dispersing member.

Many varieties of this type are known which have been obtained by inserting cemented surfaces in the members and/or by subdividing one or more members each into two. The present invention relates to that variety in which a dispersing meniscus member, the outer surfaces of which are convex towards the object side, is arranged between the first collecting member (the numbering being reckoned from the object side) and the biconcave dispersing member. The first two members of such an optical system form a partial system after the fashion of a Gauss optical system, whereas the following members still clearly indicate a triplet origin. Optical systems of this type are known having in the dispersing meniscus member a highly-dispersive cemented surface which is required not only for the chromatic correction of the optical system, but very essentially also for its spherical correction.

It is an object of the present invention to remove or at least diminish the considerable spherical zone which such systems show at great rapidity, and also the astigmatic zone which arises at a large image angle in such systems, as well as the distortion errors. The "spherical zone" and "astigmatic zone" of a corrected system are those zones at which the spherical or astigmatic corrections respectively are substantially worse than they are in the centre and margin of the image field.

Our investigations have shown that in optical systems of this type, which in themselves allow of combining the properties of a Gauss optical system with those of a triplet in an advantageous manner, substantial improvements in the direction indicated are obtained if the cemented surface in the dispersing meniscus member no longer contributes to a great extent to the spherical correction, but for this correction, chiefly the opposed air-exposed concave surfaces of the meniscus member and the biconcave dispersing member are used. The cemented surface of the meniscus member is relieved of the spherical correction so far that the absolute effect of this cemented surface on the spherical aberration becomes the smallest of those of all the three surfaces of the meniscus member. Furthermore, the surface of the biconcave member on the image side has such a curvature that this surface contributes not more than numerically about 20% to the total refractive power of the system. Under these conditions, and if a collecting cemented surface which is concave towards the object side is inserted in the biconcave member, the spherical zone errors can be kept small to a great extent, while distortion and appreciable astigmatic intermediate errors are substantially avoided and the Petzval sum is small.

Preferably in both the meniscus and biconcave members, the lens of the glass with a higher Abbé V number, seen from the object side, stands in front of the lens of the glass with a smaller Abbé V number.

Whether in a particular case the biconcave dispersing member is followed by only one or two converging members depends upon the specific requirements which are made with regard to the rapidity and to the image angle, and is a matter familiar to any person skilled in the art. Likewise, besides the cemented surfaces in the meniscus and biconcave members, already mentioned, additional cemented surfaces may be provided in the collecting members.

An embodiment of the invention is illustrated diagrammatically, by way of example, in the accompanying drawing. L_1 indicates the first collecting member of thickness d_1, having two air-exposed surfaces r_1, r_2, L_2 and L_3 indicate two lenses cemented together along the surface

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r_4 and forming the meniscus member which has the air-exposed surfaces r_3 and r_5, the thicknesses of the lenses L_2 and L_3 are d_2 and d_3 respectively. The distance of the meniscus member from the collecting member L_1 is A_1. L_4 and L_5 indicate two lenses cemented together along the surface r_7 and forming the biconcave dispersing member which has the air-exposed surfaces r_6 and r_8. The thicknesses of the lenses L_4 and L_5 are d_4 and d_5 respectively. The distance of the biconcave dispersing member from the meniscus member is A_2. L_6 indicates a collecting lens having the air-exposed surfaces r_9 and r_{10}. The thickness of the lens L_6 is d_6, its distance from the biconcave dispersing member being A_3. L_7 indicates a further collecting lens having the air-exposed surfaces r_{11} and r_{12}. The thickness of the lens L_7 is d_7 and its distance from the lens L_6 is A_4.

The specification of this lens system is given in the following table which is believed to be self-explanatory. A, B, C, P and □ are the Seidel partial coefficients according to the textbook of M. Berek, Grundlagen der praktischen Optik, Berlin, 1930, pages 61—71, their totals being indicated by S_I, S_{II}, S_{III}, S_{IV}, S_V respectively. In column 4 the material is defined by its mean refractive index, denoted by n. The Abbé V number is also given.

TABLE

Surface.	Curvature.	Thicknesses and distances.	Medium n	Medium V	Proportion of the refractive power.
r_1	+1.731				+0.63
		$d_1=0.108$	1.564	61	
r_2	+0.191				+0.25
		$A_1=0.003$	Air		
r_3	+3.221				+0.81
		$d_2=0.108$	1.620	60	
r_4	+1.442				−0.02
		$d_3=0.042$	1.673	32	
r_5	+4.587				−0.97
		$A_2=0.193$	Air		
r_6	−3.033				−0.87
		$d_4=0.069$	1.592	58	
r_7	−4.401				+0.09
		$d_5=0.031$	1.533	49	
r_8	+0.175				−0.10
		$A_3=0.008$	Air		
r_9	−0.081				+0.05
		$d_6=0.058$	1.620	60	
r_{10}	−1.855				+0.57
		$A_4=0.003$	Air		
r_{11}	+0.908				+0.03
		$d_7=0.081$	1.620	60	
r_{12}	−0.742				+0.53
				Total:	+1.00

	A	B	Γ	P	□
	+1.19	+0.69	+ 0.40	+0.62	+0.59
	+0.22	−0.32	+ 0.46	−0.07	−0.58
	+0.69	+0.41	+ 0.24	+1.23	+0.86
	−0.03	+0.04	− 0.05	+0.03	+0.02
	−1.17	−0.98	− 0.82	−1.85	−2.23
	−2.41	+0.09	− 0.00	−1.13	+0.04
	+0.38	+0.15	+ 0.06	+0.11	+0.06
	−0.01	−0.04	− 0.30	−0.06	−2.67
	+0.00	+0.02	+ 0.21	−0.03	+2.53
	+0.65	−0.06	+ 0.01	+0.71	−0.07
	−0.00	−0.01	− 0.29	+0.35	+1.41
	+0.73	−0.07	+ 0.01	+0.28	−0.03
	S_I	S_{II}	S_{III}	S_{IV}	S_V
Totals	+0.24	−0.08	− 0.07	+0.19	−0.07

The lens system in the example given can easily be finely corrected to furnish a system of great rapidity and having a comparatively large image angle.

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 rapid optical lens system, the first three members of which are respectively a collecting member, a dispersing meniscus member the air-exposed surfaces of which are convex towards the object side, and a biconcave dispersing member, these members being followed by one or two converging members, and a cemented surface being provided at least in each of the meniscus and biconcave members, characterised in that the absolute effect of the cemented surface in the meniscus member on the spherical aberrations, is the smallest of those of all the three surfaces of the meniscus member; the surface of the biconcave member on the image side has such a curvature that this surface contributes not more than numerically about 20% to the total refractive power of the system and the cemented surface in the biconcave member is collecting and concave towards the object side.

2. A rapid optical lens system as claimed in claim 1, wherein in both the meniscus and biconcave members, the lens of the glass with a higher Abbé V number, seen from the object side, stands in front of the lens of the glass with a smaller Abbé V number.

3. A rapid optical lens system substantially as herein described with reference to the example illustrated in the accompanying drawing.

Dated this 11th day of June, 1937.

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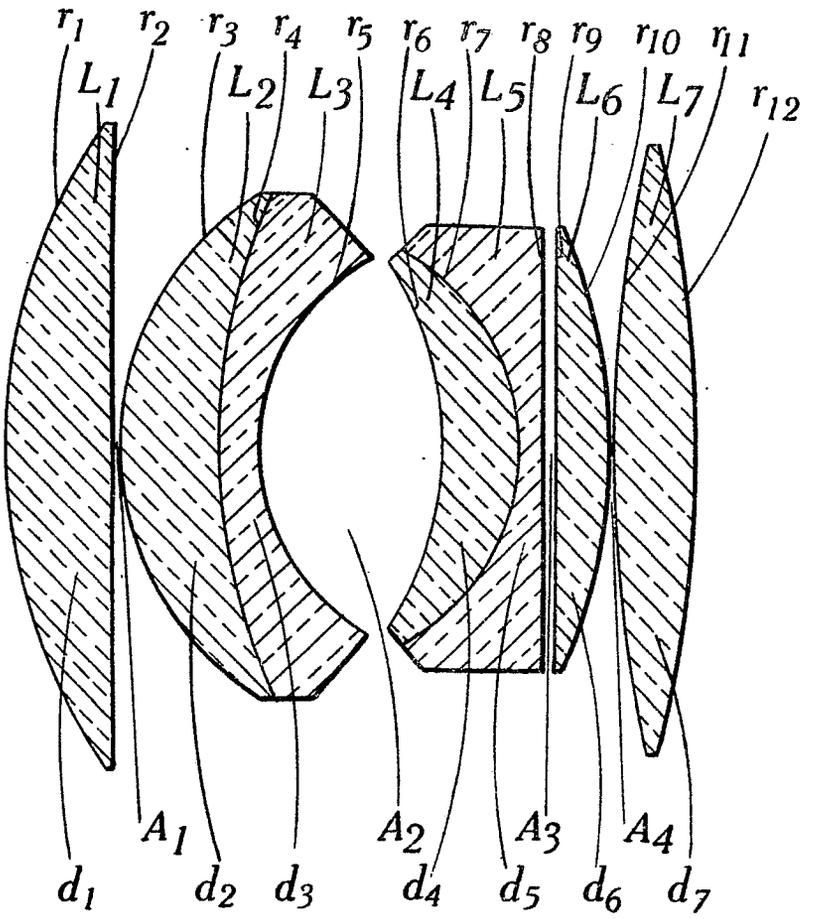

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