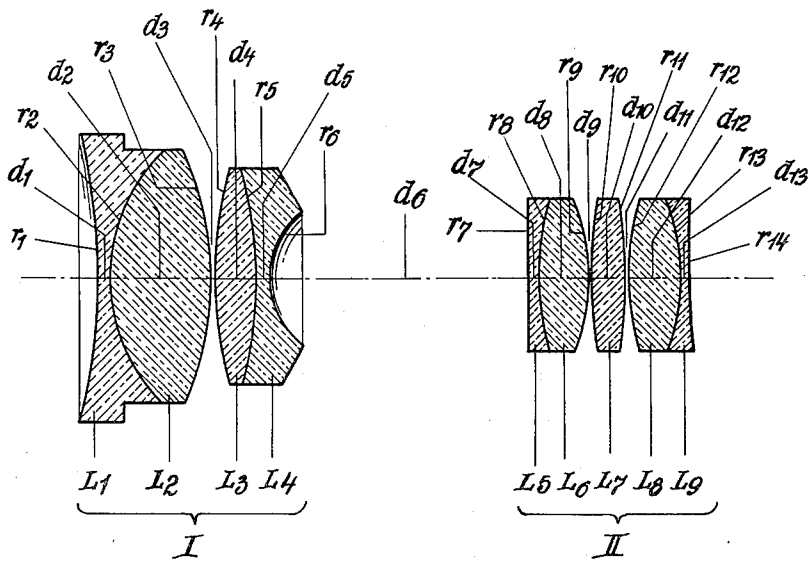


June 12, 1962

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HIGH-SPEED PHOTOGRAPHIC OR CINEMATOGRAPHIC  
OBJECTIVE WITH WIDE IMAGE ANGLE  
Filed Feb. 6, 1959

3,038,379



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1

3,038,379

**HIGH-SPEED PHOTOGRAPHIC OR CINEMATOGRAPHIC OBJECTIVE WITH WIDE IMAGE ANGLE**

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Filed Feb. 6, 1959, Ser. No. 791,730

Claims priority, application Germany Mar. 15, 1958  
2 Claims. (Cl. 88-57)

The present invention relates to a high-speed photographic or cinematographic objective having a wide image angle and a relatively long back-focal distance ranging between 150% and 250% of the overall focal length of the system.

Objectives of this character are of particular value in photographic or cinematographic cameras having additional elements (shutters, deflecting mirrors or the like) located between the last vertex of the objective and the image plane. The invention has for its principal object the provision of an improved objective for such a purpose, adapted to operate with a wide field angle while being of large back-focal length. Other, ancillary objects of the invention are the provision of means in such objectives for correcting chromatic astigmatism and coma as well as other aberrations.

In co-pending U.S. application Serial No. 764,368, filed September 30, 1958, there has been disclosed an objective having a two-member object-side component and a three-member image-side component, the front member of the object-side component being made positively refracting while the associated rear member is negatively refracting, all three members of the image-side component being of positive refractivity. Each of these members is a doublet with the exception of the intermediate member of the image-side component which is advantageously given the form of a biconvex single lens.

In a particularly advantageous embodiment described in the co-pending application, the doublets of each component face each other with their more strongly convex surfaces, their outer surfaces being either concave or substantially plane; also, each doublet turns the concave side of its cemented surface toward the other doublet of the same component.

The present invention has for its object the provision of an optical system of the same general character having an increased field angle and yielding larger images with no increase in dimension, or having smaller proportions for images of a given size, in particular a system in which for equivalent or improved performance the spacing of the vertices is materially reduced.

It has been found, in accordance with this invention, that the above object may be realized by so proportioning the lens thicknesses and air spacings of the elements of the two aforementioned components, including the large diaphragm space between said components, that the total physical length of the system ranges between substantially 5 and 6 times the overall focal length of the objective.

The invention will be described in greater detail with reference to the accompanying drawing the sole FIGURE of which shows, schematically and in axial section, a preferred embodiment.

The objective system shown in the figure of the drawing comprises a first component I on the object side and a second component II on the image side. The front

2

member of component I consists of a negatively refracting first lens  $L_1$ , having radii  $r_1, r_2$  and thickness  $d_1$ , which is cemented onto a positively refracting second lens  $L_2$  (radii  $r_2, r_3$  and thickness  $d_2$ ). The rear member of the same component, spaced from its front member by a distance  $d_3$ , consists of a biconvex third lens  $L_3$  (radii  $r_4, r_5$  and thickness  $d_4$ ) cemented onto a biconcave fourth lens  $L_4$  (radii  $r_5, r_6$  and thickness  $d_5$ ). Members  $L_1, L_2$  and  $L_3, L_4$  are two menisci of respectively positive and negative refractivity, the cemented surfaces  $r_2, r_5$  thereof turning their concave sides toward each other.

The first of the three positively refracting members of component II, which is separated from component I by the diaphragm space  $d_6$ , consists of a dispersive fifth lens  $L_5$  (radii  $r_7, r_8$  and thickness  $d_7$ ) cemented onto a collective sixth lens  $L_6$  (radii  $r_8, r_9$  and thickness  $d_8$ ). It is separated by an air space  $d_9$  from a biconvex seventh lens  $L_7$  of radii  $r_{10}, r_{11}$  and thickness  $d_{10}$ , constituting the intermediate member of this component, which in turn is followed after an air space  $d_{11}$  by a doublet consisting of a positive eighth lens  $L_8$  (radii  $r_{12}, r_{13}$  and thickness  $d_{12}$ ) cemented onto a negative ninth lens  $L_9$  (radii  $r_{13}, r_{14}$  and thickness  $d_{13}$ ).

The following table lists representative values of the radii, thicknesses and air spacings of the lenses  $L_1-L_9$  shown in the drawing, given in terms of an overall focal length of numerical value 1 for an objective having an aperture ratio of 1:1.8, an image angle of  $66^\circ$  and a back-focal length of 1.7, together with the refractive indices  $n_d$  and the Abbé numbers  $\nu$  of these lenses.

Lens	Radii	Thicknesses and Air Spacings	$n_d$	$\nu$	
I	$L_1$ ----- $r_1 = - 12.040$	$d_1 = 0.098$	1.7440	44.9	
	$L_2$ ----- $r_2 = + 1.707$				
	$L_3$ ----- $r_3 = - 3.061$	$d_2 = 0.975$	1.5014	56.5	
					$L_4$ ----- $r_4 = + 3.804$
		$L_4$ ----- $r_5 = - 4.188$	$d_3 = 0.010$	air space	
			$L_4$ ----- $r_5 = - 4.188$	$d_4 = 0.410$	1.7400
II	$L_4$ ----- $r_6 = + 0.791$	$d_5 = 0.146$	1.5128	57.2	
	$L_5$ ----- $r_7 = + 131.700$	$d_6 = 2.511$	diaphragm space		
		$L_5$ ----- $r_8 = + 2.828$	$d_7 = 0.098$	1.6727	32.2
	$L_6$ ----- $r_9 = - 1.950$	$d_8 = 0.488$	1.5687	63.1	
		$L_7$ ----- $r_{10} = + 4.746$	$d_9 = 0.005$	air space	
	$L_7$ ----- $r_{11} = - 5.303$		$d_{10} = 0.341$	1.6425	58.1
$L_8$ ----- $r_{12} = + 2.440$	$d_{11} = 0.005$	air space			
		$L_8$ ----- $r_{12} = + 2.440$	$d_{12} = 0.512$	1.5400	59.7
	$L_9$ ----- $r_{13} = - 2.094$	$d_{13} = 0.088$	1.7282	28.3	
	$L_9$ ----- $r_{14} = + 14.010$	$d_{total} = 5.687$			

It will be noted that the total physical length  $d_{total}$  of the system defined in the foregoing table has a value ranging between 5 and 6, that the back-focal length of this system has a value ranging between 1.5 and 2.5 times the overall focal length, and that the separation  $d_6$  of the two components of the system has a value ranging between 2.5 and 3.5 times the overall focal length. It may also be mentioned that the first doublet  $L_5, L_6$  of component II is very nearly a plano-convex member.

The invention is not limited to the specific numerical

3

values set forth above, nor to the exact lens configurations shown in the drawing, but may be embodied in various modifications without departing from the spirit and scope of the appended claims.

What is claimed is:

1. An optical objective system with a back-focal length ranging between substantially 1.5 and 2.5 times the overall focal length of the system, comprising a first, positively refracting meniscus-shaped doublet composed of a negative first lens and a positive second lens, a second, negatively refracting meniscus-shaped doublet closely air-spaced from said first doublet and composed of a positive third lens and a negative fourth lens, a third, positively refracting, substantially plano-convex doublet separated from said second doublet by a relatively wide diaphragm space and composed of a negative fifth lens and a positive sixth lens, a biconvex seventh lens closely air-spaced from said third doublet, and a meniscus-shaped fourth doublet closely air-spaced from said seventh lens and composed of a positive eighth lens and a negative ninth lens, the separation of the outermost vertices of said components ranging between substantially 5 and 6 times the overall focal length of the system, said first and second doublets having convex sides facing each other and being provided with cemented surfaces turning their concave sides toward each other, the refractive indices of said first and third lenses respectively exceeding those of said second and fourth lenses whereby the refractivity of said cemented surfaces is negative in said first doublet and positive in said second doublet, said third and fourth doublets having convex sides facing said seventh lens and being provided with cemented surfaces turning their concave sides toward said seventh lens, said diaphragm space ranging between substantially 2.5 and 3.5 times the overall focal length of the system.

2. An objective system according to claim 1 wherein the radii  $r_1-r_{14}$  and the thicknesses and air spacings  $d_1-d_{13}$  of said first through ninth lenses  $L_1-L_9$ , based upon a numerical value of unity for the overall focal length of the system, the refractive indices  $n_d$  of said

4

lenses and the Abbé numbers  $\nu$  thereof have numerical values substantially as given in the following table:

Lens	Radii	Thicknesses and Air Spacings	$n_d$	$\nu$	
5 10 15 20 25	I II	$L_1$ ----- $r_1 = - 12.040$	$d_1 = 0.098$ $d_2 = 0.975$ $d_3 = 0.010$ $d_4 = 0.410$ $d_5 = 0.146$ $d_6 = 2.511$ $d_7 = 0.098$ $d_8 = 0.488$ $d_9 = 0.005$ $d_{10} = 0.341$ $d_{11} = 0.005$ $d_{12} = 0.512$ $d_{13} = 0.088$	1.7440 1.5014 air space 1.7400 1.5128 diaphragm space 1.6727 1.5687 air space 1.6425 air space 1.5400 1.7282	44.9 56.5 28.2 57.2 32.2 63.1 58.1 59.7 28.3
		$L_2$ ----- $r_2 = + 1.707$			
		$L_3$ ----- $r_3 = - 3.061$			
		$L_4$ ----- $r_4 = + 3.804$			
		$L_5$ ----- $r_5 = - 4.188$			
		$L_6$ ----- $r_6 = + 0.791$			
		$L_7$ ----- $r_7 = + 131.700$			
		$L_8$ ----- $r_8 = + 2.828$			
		$L_9$ ----- $r_9 = - 1.950$			
		$L_{10}$ ----- $r_{10} = + 4.746$			
		$L_{11}$ ----- $r_{11} = - 5.303$			
		$L_{12}$ ----- $r_{12} = + 2.440$			
		$L_{13}$ ----- $r_{13} = - 2.094$			
		$L_{14}$ ----- $r_{14} = + 14.010$			

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