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HIGH-SPEED TELEPHOTO OBJECTIVE

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Fig. 1.

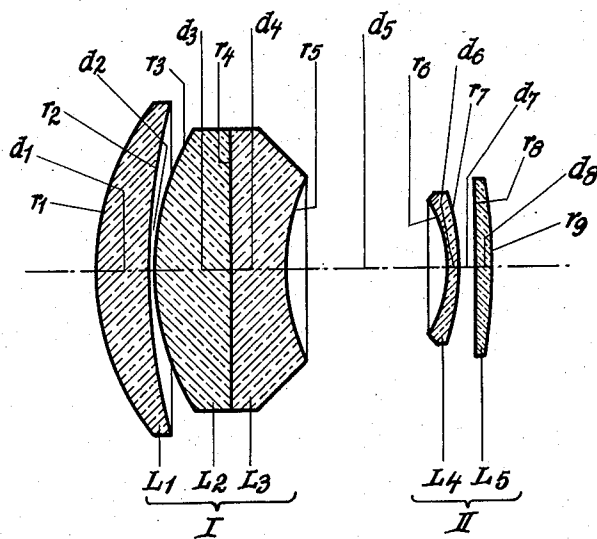
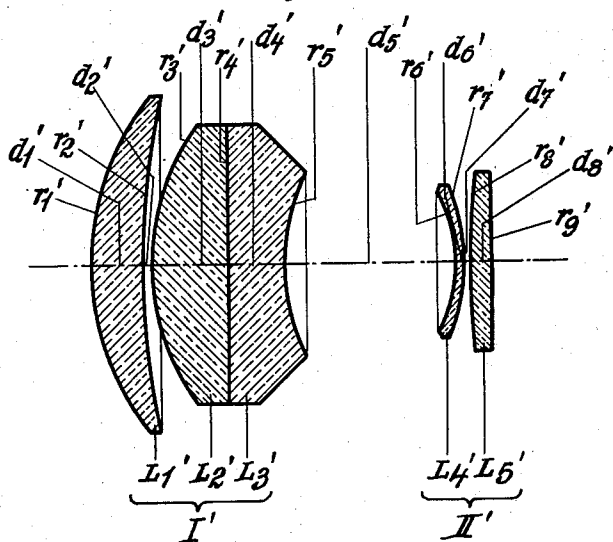


Fig. 2.



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HIGH-SPEED TELEPHOTO OBJECTIVE

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3 Claims. (Cl. 88—57)

Our present invention relates to telephoto objective systems of the type comprising a positively refracting lens group on the object side and a negatively refracting lens group on the image side of the system, the two lens groups being separated from each other by a relatively large air space.

Heretofore, difficulties have been experienced in adapting objective systems of this character for use with certain cameras, especially those of the so-called central-shutter type, while maintaining a large relative aperture. The general object of this invention is to provide a telephoto objective satisfying these desiderata.

A more specific object of our invention is to provide an objective system, of the character set forth, maintaining a good correction for all known types of aberration.

A feature of our invention resides in the provision of a telephoto objective of the construction set forth in which the two lens groups constitute the front and rear halves of a Gaussian dual objective having a front component in the form of a single lens, followed by a compound member cemented from two lenses of opposite refractivity, the rear half of the system consisting of two air-spaced single lenses, the relationships of the refractive powers and of the physical dimensions being such that the focal length of the front half ranges between 85% and 100% of the overall focal length of the system and that the back-focal distance of this front half is less than 65% of the overall focal length.

For the realization of the desired telephoto effect it is furthermore advantageous, according to another feature of the invention, that the air space between the positively refracting front half and the negatively refracting rear half be greater than 0.4 time the total axial length of the system (measured between the outer vertices of its front and rear lenses) but less than 40% of the overall focal length.

A further feature of the invention, designed to eliminate image curvature and astigmatism, resides in such a dimensioning of the cemented component of the front half that the ratio of the radii of curvature of its outer surfaces is less than 1.3, the difference between the refractive indices of the cemented lenses being at the same time greater than 0.15.

The invention will be described in greater detail with reference to the accompanying drawing in which Figs. 1 and 2 diagrammatically illustrate two different embodiments.

In Fig. 1 there has been shown a telephoto objective consisting of a front lens group I and a rear lens group II, the two groups constituting the halves of a Gaussian dual objective. Front group or half I is composed of a positive meniscus L_1 followed by a positively refracting lens L_2 which is cemented onto a negatively refracting lens L_3 to form a compound meniscus. The rear group or half II, separated from front half I by a diaphragm space d_5 , consists of a negative meniscus L_4 and a positive meniscus L_5 , each being in the form of a single lens.

The following Table A lists representative numerical

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values, based upon an overall focal length f of numerical value 100, for the radii r_1 to r_9 and the thicknesses and spacings d_1 to d_8 of lenses L_1 to L_5 , along with their refractive indices n_d and their Abbé numbers ν , all relating to an objective system of aperture ratio 1:4.0 and back-focal distance $s=47.1$.

Table A

10	I-----	L ₁ -----	$r_1=+25.99$	$d_1=5.30$	n_d	ν
			$r_2=+68.52$			
		L ₂ -----	$r_3=+25.99$	$d_2=0.58$	1.5891	61.2
$r_4=-1122.44$	$d_3=7.35$		Air space	70.0		
15	L ₃ -----	$r_5=+20.73$	$d_4=5.29$	1.6477	33.9	
		$r_6=-14.70$	$d_5=16.14$	Diaphragm space		
20	II-----	L ₄ -----	$r_7=-22.99$	$d_6=1.06$	1.6134	57.3
			$r_8=-281.02$			
		L ₅ -----	$r_9=-49.11$	$d_8=2.05$	1.7215	29.3
			$d_{total}=38.96$			

In the system of Table A the focal length f_1 of front lens L_1 has the numerical value of 88.6, being thus between 85% and 100% of the overall focal length $f=100$, while the back-focal distance s_1 of the front group I amounts to 58.1, being thus less than 65% of focal length f . The ratio $r_3:r_5$ of the outer radii of the cemented member L_2-L_3 is less than 1.3 and the difference between the refractive indices n_d of lenses L_2 and L_3 is 0.20.

In Fig. 2 a modified system according to the invention has been shown in which the lenses of the front group I' have been designated L_1' , L_2' and L_3' while the lenses of the rear group II' bear the designations L_4' and L_5' . In the following Table B we have given representative numerical values, based again upon a numerical value of 100 for the overall focal length f' of this system, for the radii r_1' to r_9' and for the thicknesses and spacings d_1' to d_8' of the objective shown in Fig. 2, along with the refractive indices n_d and the Abbé numbers ν thereof, the system having an aperture ratio of 1:4.0 and a back-focal distance $s'=47.0$.

Table B

45	I'-----	L ₁ '-----	$r_1'=+26.37$	$d_1'=5.28$	n_d	ν
			$r_2'=+84.42$			
		L ₂ '-----	$r_3'=+22.81$	$d_2'=0.58$	1.5182	65.2
$r_4'=-1386.32$	$d_3'=7.33$		Air space	65.8		
50	L ₃ '-----	$r_5'=+19.17$	$d_4'=5.65$	1.6645	35.9	
		$r_6'=-14.09$	$d_5'=17.10$	Diaphragm space		
55	II'-----	L ₄ '-----	$r_7'=-18.45$	$d_6'=1.05$	1.6204	60.3
			$r_8'=+84.09$			
		L ₅ '-----	$r_9'=-758.16$	$d_8'=2.04$	1.7215	29.3
			$d_{total}=39.27$			

The focal length f_1' of the front lens L_1' is 98.6, being thus again between 85% and 100% of the overall focal length. The back-focal distance s_1' amounts to 64.0, hence is again less than 65% of the overall focal length. In this system, too, the ratio $r_3':r_5'$ of the outer radii of the cemented component $L_2'-L_3'$ is again less than 1.3 and the difference of the refractive indices of the cemented lenses is once more greater than 0.15, being 0.16 in the case of lenses L_2' and L_3' .

We claim:

1. A telephoto objective system comprising a positively refracting front lens group and a negatively refracting

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rear lens group separated by a large air space, said lens groups constituting respective halves of a Gaussian dual objective, said front group consisting of a single meniscus-shaped positive front lens followed by a cemented negative meniscus composed of lenses of opposite refractivity, said rear group consisting of two air-spaced single lenses, said front group having a focal length ranging between 85% and 100% of the overall focal length of the system and having a back-focal distance less than 65% of said overall focal length, said objective system having an overall focal length of numerical value 100 and an aperture ratio of 1:4.0, the radii r_1 — r_9 , the thicknesses and spacings d_1 — d_8 , the refractive indices n_d and the Abbé numbers ν of said front lens L_1 , said lenses L_2 — L_3 of said cemented meniscus, and said air-spaced single lenses L_4 , L_5 having numerical values substantially as given in the following table:

L_1 -----	$+24.6 < r_1 < +27.6$ $+65.1 < r_2 < +88.6$	$5.0 < d_1 < 5.6$ $.55 < d_2 < .61$	$1.51 < n_d < 1.59$ Air space	$61.0 < \nu < 65.4$
L_2 -----	$+21.7 < r_3 < +27.3$	$7.0 < d_3 < 7.7$	$1.46 < n_d < 1.49$	$65.6 < \nu < 70.2$
L_3 -----	$-1456.0 < r_4 < -1178.0$ $+18.1 < r_5 < +21.7$	$5.0 < d_4 < 5.9$ $15.3 < d_5 < 18.0$	$1.64 < n_d < 1.67$ Diaphragm space	$33.8 < \nu < 36.0$
L_4 -----	$-15.5 < r_6 < -13.2$ $-24.1 < r_7 < -17.5$	$1.0 < d_6 < 1.2$ $.23 < d_7 < 1.3$	$1.61 < n_d < 1.63$ Air space	$57.1 < \nu < 60.5$
L_5 -----	$-295.0 < r_8 < +88.0$ $-798.0 < r_9 < -46.6$	$1.9 < d_8 < 2.2$	$1.72 < n_d < 1.73$	$29.2 < \nu < 29.4$

2. An objective system according to claim 1, having numerical values substantially as given in the following table:

L_1 -----	$r_1 = +25.99$ $r_2 = +68.52$	$d_1 = 5.30$ $d_2 = 0.58$	n_d 1.5891 Air space	ν 61.2	35
L_2 -----	$r_3 = +25.99$	$d_3 = 7.35$	1.4875	70.0	40
L_3 -----	$r_4 = -1122.44$ $r_5 = +20.73$	$d_4 = 5.29$ $d_5 = 16.14$	1.6477 Diaphragm space	33.9	
L_4 -----	$r_6 = -14.70$ $r_7 = -22.99$	$d_6 = 1.06$ $d_7 = 1.19$	1.6134 Air space	57.3	45
L_5 -----	$r_8 = -281.02$ $r_9 = -49.11$	$d_8 = 2.05$	1.7215	29.3	

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3. An objective system according to claim 1, having numerical values substantially as given in the following table:

L_1' -----	$r_1' = +26.37$ $r_2' = +84.42$	$d_1' = 5.28$ $d_2' = 0.58$	n_d 1.5182 Air space	ν 65.2
L_2' -----	$r_3' = +22.81$	$d_3' = 7.33$	1.4645	65.8
L_3' -----	$r_4' = -1386.32$ $r_5' = +19.17$	$d_4' = 5.65$ $d_5' = 17.10$	1.6645 Diaphragm space	35.9
L_4' -----	$r_6' = -14.09$ $r_7' = -18.45$	$d_6' = 1.05$ $d_7' = 0.24$	1.6204 Air space	60.3
L_5' -----	$r_8' = +84.09$ $r_9' = -758.16$	$d_8' = 2.04$	1.7215	29.3

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