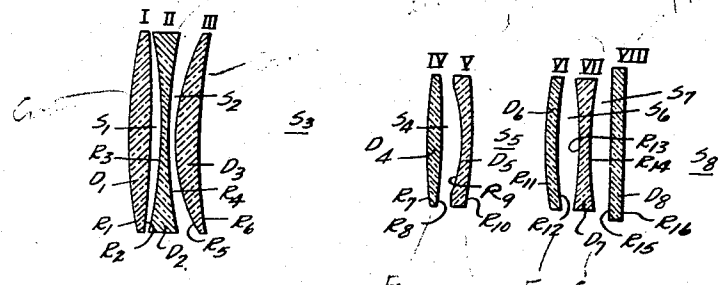
350-438 SR OR 2,685,230 SEARCH ROOM

Aug. 3, 1954 J. G. BAKER 2,685,230

LARGE APERTURE TELEPHOTO OBJECTIVE

Filed Nov. 6, 1947 3 Sheets-Sheet 1

Fig 1



EXAMPLE: 1 40 IN. f/5

EL.	RADII (INCHES)	THICKNESS (INCHES)	SPACE (INCHES)	No	ABBE-V NUMBER
I	R1 = 14.058 R2 = -115.80	D1 = .882		1.5168	64.5
			S1 = .264		
II	R3 = -33.942 R4 = 36.880	D2 = .405		1.7195	29.3
			S2 = .051		
III	R5 = 7.664 R6 = 19.722	D3 = .941		1.517	64.5
			S3 = 9.454		
IV	R7 = 40.066 R8 = -59.907	D4 = .395		1.6164	36.6
			S4 = .819		
V	R9 = -5.724 R10 = -14.164	D5 = .356		1.6102	58.8
			S5 = 3.002		
VI	R11 = 11.254 R12 = 37.075	D6 = .499		1.6164	36.6
			S6 = .850		
VII	R13 = -17.347 R14 = 42.692	D7 = .401		1.6102	58.8
			S7 = .916		
VIII	R15 = PLANO R16 = PLANO	D8 = .523		1.517	V-7 R-2
			S8 = 11.631		

EXAMPLE: 2 60 IN. f/5

RADII (INCHES)	THICKNESS (INCHES)	SPACE (INCHES)
R1 = 21.525 R2 = -161.48	D1 = 1.351	
		S1 = .401
R3 = -51.436 R4 = 55.888	D2 = .614	
		S2 = .077
R5 = 11.649 R6 = 30.121	D3 = 1.144	
		S3 = 14.677
R7 = 60.72 R8 = -90.78	D4 = .599	
		S4 = 1.241
R9 = -8.670 R10 = -21.442	D5 = .542	
		S5 = 4.550
R11 = 17.704 R12 = 44.977	D6 = .732	
		S6 = 1.288
R13 = -32.374 R14 = 75.40	D7 = 1.573	
		S7 = 1.418
R15 = PLANO R16 = PLANO	D8 = .541	
		S8 = 17.166

ORANGE FILTER

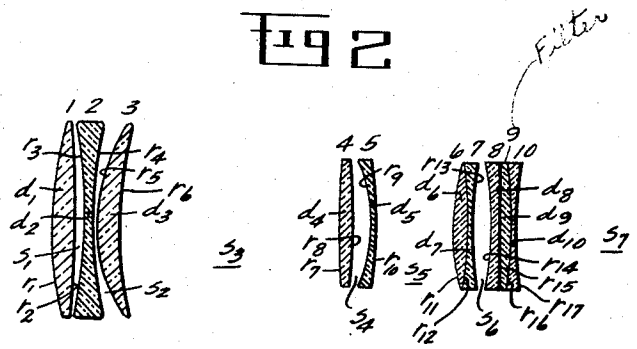
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Aug. 3, 1954 J. G. BAKER 2,685,230

LARGE APERTURE TELEPHOTO OBJECTIVE

Filed Nov. 6, 1947 3 Sheets-Sheet 2

Fig 2



40 IN. f/5

EL.	RADII (INCHES)	THICKNESS (INCHES)	SPACE (INCHES)	No	ABBE-V NUMBER
1	r_1 = 13.387 r_2 = -141.63	d_1 = .866	s_1 = .261	1.5168	64.5
2	r_3 = -34.003 r_4 = 34.274	d_2 = .396	s_2 = .050	1.7195	29.3
3	r_5 = 7.54 r_6 = 19.699	d_3 = .924	s_3 = 9.317	1.5164	64.5
4	r_7 = 38.84 r_8 = -58.074	d_4 = .387	s_4 = .810	1.6102	58.8
5	r_9 = -5.580 r_{10} = -13.809	d_5 = .149	s_5 = 3.162	1.6164	36.6
6	r_{11} = 10.91	d_6 = .513		1.6164	36.6
7	r_{12} = -23.227 r_{13} = 35.941	d_7 = .150	s_6 = .513	1.6102	58.8
8	r_{14} = -17.772	d_8 = .150		1.6102	58.8
9	r_{15} = PLANO r_{16} = -43.873	d_9 = .513 d_{10} = .150		1.6164	36.6
10	r_{17} = 37.189		s_7 = 12.746	1.61908	60.2

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Aug. 3, 1954 J. G. BAKER 2,685,230

LARGE APERTURE TELEPHOTO OBJECTIVE

Filed Nov. 6, 1947 3 Sheets-Sheet 3

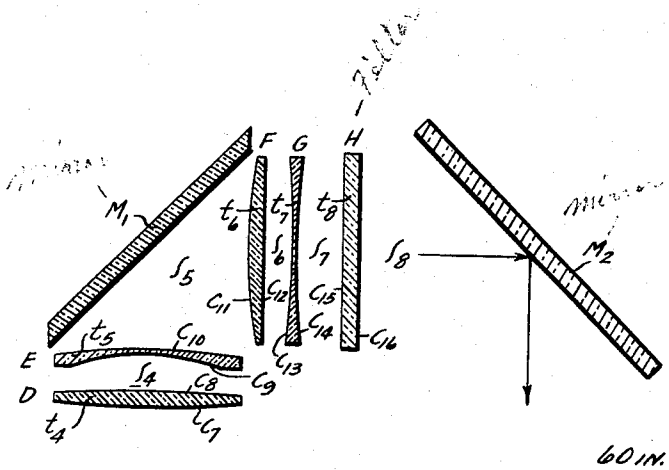
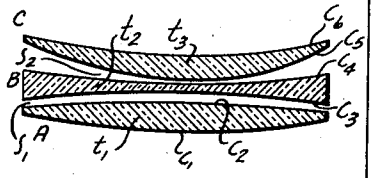


FIG 3

60 IN. f/6



EL.	RADII (INCHES)	THICKNESS (INCHES)	DISTANCE (INCHES)	No	ABBE-V NUMBER
A	$C_1 = 24.521$ $C_2 = -77.22$	$t_1 = 1.055$	$s_1 = .261$	1.517	64.5
B	$C_3 = -47.038$ $C_4 = 65.076$	$t_2 = .744$	$s_2 = .061$	1.72	29.3
C	$C_5 = 11.456$ $C_6 = 27.984$	$t_3 = .954$	$s_3 = 14.451$	1.517	64.5
D	$C_7 = 59.524$ $C_8 = -89.002$	$t_4 = .695$	$s_4 = 1.122$	1.617	36.6
E	$C_9 = -9.196$ $C_{10} = -25.859$	$t_5 = .595$	$s_5 = 6.977$	1.61088	57.2
F	$C_{11} = 18.572$ $C_{12} = 138.26$	$t_6 = .695$	$s_6 = .726$	1.617	36.6
G	$C_{13} = -25.819$ $C_{14} = 63.227$	$t_7 = .601$	$s_7 = .595$	1.61088	57.2
H	$C_{15} =$ PLANO $C_{16} =$ PLANO	$t_8 = .496$	$s_8 = 18.037$	1.517	R_2 OR ORANGE FILTER

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Patented Aug. 3, 1954

2,685,230

UNITED STATES PATENT OFFICE

2,685,230

LARGE APERTURE TELEPHOTO OBJECTIVE

James G. Baker, Waban, Mass., assignor to the United States of America as represented by the Secretary of War

Application November 6, 1947, Serial No. 784,478

8 Claims. (Cl. 88—57)

1

This invention relates to large aperture photographic objectives and particularly to telephoto objective lens systems.

It is a primary object of this invention to provide a telephoto objective having a large aperture and long equivalent focal length.

It is another important object of this invention to provide a lens system for telephoto objectives having an air spaced triplet using a high index flint negative element between two low index positive crown elements in the objective component and having air spaced flint positive elements preceding negative crown elements in the rear component to eliminate distortion without impairing definition at maximum telephoto effect on a flat field.

It is a further object of this invention to provide a compact lens system for telephoto objectives of large aperture and long equivalent focal length by reflecting the light beam on mirrored surfaces.

There has been an expressed need for long equivalent focal length telephoto objectives with a low telephoto ratio. The telephoto ratio as used in this disclosure refers to the ratio of the camera length as measured between the focal plane and the vertex of the front lens surface, and the equivalent focal length. Such telephoto objectives have innumerable uses and are particularly desirable for aerial photography where a high degree of resolution and contrast are necessary for precision reconnaissance, and the like. In usual practice, lens forms that have been found to perform satisfactorily in small focal lengths have been scaled up and modified for use in aerial photography at large focal lengths. However, this practice has been found to lead to photographs of lowered linear resolution and lowered contrast that in part defeat the purpose of using large focal lengths. Lenses of large focal length must therefore employ improvements in design beyond the requirements of scaling if satisfactory results are to be achieved. At the same time in order to avoid cumbersome and weighty construction of large lens systems it has proved advisable to make use of the telephoto type of optical system, a choice that makes the burden on the optical design doubly difficult. In the present invention a type of telephoto system has been devised that obviates all the above-mentioned difficulties and provides satisfactory results at large focal lengths.

The present invention provides a lens system for large aperture telephoto objectives which produce good resolution and definition at maximum telephoto effect on a flat field that is distortionless and is substantially free of undesirable aberrations. This is accomplished by using an air-

2

spaced triplet consisting of a high index flint negative element between two low index crown positive elements for the forward objective component and air spacing one or both of two doublets in the rear component in which a positive flint element may precede a negative crown element in each doublet. The use of the low index crown and a high index flint in the forward objective component, contrary to the usual practice in standard lenses, favors the telephoto effect, permits distortion correction and provides the elimination of zonal terms in the sine condition. However, the above elements tend to increase lateral color which is restricted by the filter and by the restricted angular coverage of these large lenses.

In the construction of the lens system, placing a filter in the converging beam behind the last element is contemplated. The aberrations of the filter are small and can be taken into account in the lens design. Positioning the filter behind the lens system has several advantages in that the surface figure need be only a fraction as good as a filter in front of the lens system; the filter diameter need be only about half as large which simplifies manufacture; and the filter thickness can be used to adjust the best focus in any color that goes with the filter, that is, an infra-red filter should be thinner than the yellow filter in order that the infra-red focus lie on the focal plane determined for yellow light.

Referring to the drawings:

Fig. 1 shows a telephoto objective lens system in accordance with the invention;

Fig. 2 shows another embodiment of the invention; and

Fig. 3 shows a modification of the lens system shown in Fig. 1 with the ray path reflected on mirrored surfaces.

Referring to Fig. 1, which illustrates the invention, there is shown by way of example a telephoto objective lens system that consists of lenses I to VII, inclusive, having radii of curvature represented by R_1 to R_{16}, inclusive; lens thicknesses represented by D_1 to D_8, inclusive; and air spaces represented by S_1 to S_8, inclusive. The lenses I, II, and III are on the side of the longer conjugate and will be referred to as the forward objective component; while the lenses IV to VII, inclusive, are on the side of the shorter conjugate and will be referred to as the rear component.

The element VIII is a filter of plano-plano construction that is placed in the converging beam of the last element with respect to the direction of light travel through the system. The index of refraction and thickness of this filter must be considered in the lens system and is

given in the examples of Fig. 1 although the filter may be changed for different light.

Two examples of specifications are given below in accordance with the invention. Example 1 provides a lens system of 40-inch equivalent focal length and a relative aperture of f/5. The notation R_1, R_2 . . . etc. refers to the successive radii of curvature, counting from the front, which will be denoted as convex toward the longer conjugate in the absence of any sign, and will be denoted by a minus (—) sign when the radii of curvature is concave toward the same, as is conventional. N_D is used in the examples to denote the refractive indices of the lens elements for the D-line and the Abbe-V number is used to denote the dispersion value. The radii, thicknesses and spacing of the lens elements for these two examples, and all other examples in this disclosure, are given in inches. The refractive indices and Abbe-V numbers of Example 2 are the same as for Example 1. As may be noted in Example 2 the lens thicknesses and radii of curvature as well as the air spaces of Example 1 have been modified both by scaling and alteration to provide a 60-inch f/5 telephoto objective lens system for producing a larger scale picture of even greater angular coverage than produced in practicing the invention of Example 1. By scaling up or down the lens thicknesses, radii of curvature, and air spaces, and by altering these quantities by small amounts according to the requirements of optical design, one can produce telephoto objective lens systems of various focal lengths, relative apertures, and angular coverages without departing from the spirit and scope of this invention.

Example 1

[F=40 inches f/5]

El.	Radii (inches)	Thickness (inches)	Space (inches)	N_d	Abbe-V Number
I	R_1 = 14.058 R_2 = −115.80	D_1=.882	S_1= .264	1.5168	64.5
II	R_3 = −33.942 R_4 = 36.880	D_2=.405	S_2= .051	1.7195	29.3
III	R_5 = 7.664 R_6 = 19.722	D_3=.941	S_3= 9.454	1.517	64.5
IV	R_7 = 40.066 R_8 = −59.907	D_4=.395	S_4= .819	1.6164	36.6
V	R_9 = −5.724 R_{10} = −14.164	D_5=.356	S_5= 3.002	1.6102	58.8
VI	R_{11} = 11.254 R_{12} = 37.075	D_6=.499	S_6= .850	1.6164	36.6
VII	R_{13} = −17.347 R_{14} = 42.692	D_7=.407	S_7= .916	1.6102	58.8
VIII	R_{15}=Plano R_{16}=Plano	D_8=.523	S_8=11.631	1.517	Y-7,R-2

Example 2

[F=60 inches f/5]

El.	Radii (inches)	Thickness (inches)	Space (inches)	N_d	Abbe-V Number
I	R_1 = 21.525 R_2 = −161.48	D_1=1.351	S_1= .401	1.5168	64.5.
II	R_3 = −51.436 R_4 = 55.888	D_2= .614	S_2= .077	1.7195	29.3.
III	R_5 = 11.649 R_6 = 30.121	D_3=1.144	S_3=14.677	1.517	64.5.
IV	R_7 = 60.72 R_8 = −90.78	D_4= .599	S_4= 1.241	1.6164	36.6.
V	R_9 = −8.670 R_{10} = −21.442	D_5= .542	S_5= 4.550	1.6102	58.8.
VI	R_{11} = 17.704 R_{12} = 44.977	D_6= .732	S_6= 1.288	1.6164	36.6.
VII	R_{13} = −32.374 R_{14} = 75.40	D_7=1.573	S_7= 1.418	1.6102	58.8.
VIII	R_{15}=Plano R_{16}=Plano	D_8= .541	S_8=17.166	1.517	Orange Filter.

It may be noted that the element D_7 in Example 2 has a large central thickness that is not ordinarily necessary for the optical requirements of the 60-inch, f/5 telephoto objective. This great thickness is introduced into the design of this telephoto objective for the purpose of particularly adapting this optical system for high altitude flying in which the optical system is evacuated. The element D_7 forms one boundary of the evacuated lens system and is subjected to great pressure which pressure depends on altitude. The other boundary of the vacuum space containing the optical system is formed, in actual practice, by a plane-parallel window of considerable thickness but of no optical effects and therefore has not been shown in the optical system.

Referring to Fig. 2 there is shown a modification of the lens system of Fig. 1 which is adaptable for infra-red telephoto use. Reference is directed to the descriptive chart below in which the various characteristics are denoted in the same manner as explained for the examples in Fig. 1. Where necessary a lens, or lenses as 8 and 10, may be cemented to the filter to obtain proper focus on the focal plane. The specific example given produces a 40-inch, f/5 telephoto objective lens system but the lens thicknesses, radii of curvature, and air spaces may be scaled up or down for producing other focal lengths and relative apertures without departing from the spirit and scope of this invention.

[F=40 inches f/5]

El.	Radii (Inches)	Thickness (Inches)	Space (Inches)	N_d	Abbe-V Number
1	$r_1 = 13.387$ $r_2 = -141.63$	$d_1 = .866$	$S_1 = .261$	1.5168	64.5
2	$r_3 = -34.003$ $r_4 = 34.274$	$d_2 = .396$	$S_2 = .050$	1.7195	29.3
3	$r_5 = 7.54$ $r_6 = 19.699$	$d_3 = .924$	$S_3 = 9.317$	1.5164	64.5
4	$r_7 = 38.84$ $r_8 = -58.074$ $r_9 = -5.580$	$d_4 = .387$	$S_4 = .810$	1.6102	58.8

[F=40 inches f/5] (continued)

El.	Radii (Inches)	Thickness (Inches)	Space (Inches)	N_d	Abbe-V Number
5	$r_{10} = -13.809$ $r_{11} = 10.91$	$d_5 = .149$	$S_5 = 3.162$	1.6164	36.6
6	$r_{12} = -23.227$	$d_6 = .513$		1.6164	36.6
7	$r_{13} = 35.941$ $r_{14} = -17.772$	$d_7 = .150$	$S_6 = .513$	1.6102	58.8
8	$r_{15} =$ Plano	$d_8 = .150$		1.6102	58.8
9	$r_{16} = -43.873$	$d_9 = .513$		1.6164	36.6
10	$r_{17} = 37.189$	$d_{10} = .150$	$S_7 = 12.746$	1.61908	60.2

Referring to Fig. 3 there is shown a modification of the lens system of Fig. 1 in which two front surface mirrors M_1 and M_2 are used to direct the light rays in a U-shaped path. In this manner the camera in which this lens system may be used can be made more compact. A full description of this lens system is given below. The descriptive example given in this chart will provide a 60-inch f/6 telephoto objective but the specifications of lens thicknesses, radii of curvature, and air spaces may be scaled up or down for other focal lengths and relative apertures, if desired, without departing from the spirit and scope of this invention.

[F=60 inches f/6]

El.	Radii (Inches)	Thickness (Inches)	Distance (Inches)	N_d	Abbe-V Number
A	$C_1 = 24.521$ $C_2 = -77.22$	$t_1 = 1.055$	$S_1 = .261$	1.517	64.5.
B	$C_3 = -47.038$ $C_4 = 65.076$	$t_2 = .744$	$S_2 = .061$	1.72	29.3.
C	$C_5 = 11.456$ $C_6 = 27.984$	$t_3 = .954$	$S_3 = 14.451$	1.517	64.5.
D	$C_7 = 59.524$ $C_8 = -89.002$	$t_4 = .695$	$S_4 = 1.122$	1.617	36.6
E	$C_9 = -9.196$ $C_{10} = -25.859$	$t_5 = .595$	$S_5 = 6.977$	1.61088	57.2
F	$C_{11} = 18.572$ $C_{12} = 138.26$	$t_6 = .695$	$S_6 = .726$	1.617	36.6.
G	$C_{13} = -25.819$ $C_{14} = 63.227$	$t_7 = .601$	$S_7 = .595$	1.61088	57.2.
H	$C_{15} =$ Plano $C_{16} =$ Plano	$t_8 = .496$	$S_8 = 18.037$	1.517	R_2 or Orange Filter.

The rear element of the rear component of the modifications shown in Figs. 2 and 3 could be increased in thickness to adapt these optical systems for evacuated high altitude systems by altering the rear component in accordance with optical design, if desirable.

Many advantages have been attained by the above described telephoto objectives over other known systems. The low optical power and form of the rear component make these telephoto objective systems suitable for incorporating temperature and air density compensation and the rear elements of each is particularly suitable for acting as one boundary of an evacuated lens system, illustrated in Fig. 1, Example 2. The choice of glass types and lens forms brought about the fact that the negative rear component of

four lenses lies at an unusually low height in the converging beam making possible the use of a relatively small iris diaphragm and a between-the-lens shutter of useful size for camera operation. These telephoto objective systems each provide very good resolving power and permit faster shutter speeds which make them extremely useful for aerial photography.

The 60-inch f/6 telephoto objective lens system, using mirrors to direct the rays in a reverse direction, has the advantage of providing a compact camera, particularly for aircraft where space is usually at a premium, without sacrificing any of the advantages of the systems of Fig. 1 and 2.

While preferred forms of the invention have been shown and described, it is to be understood that modifications and changes may be made without departing from the spirit and scope of this invention and I desire to be limited only by the scope of the appended claims.

I claim:

1. A telephoto objective having numerical data as set forth in the following chart where R_1, R_2, . . . represent the radii of curvature of the surfaces, D_1, D_2, . . . represent the axial thicknesses of the elements, S_1, S_2, . . . represent the axial air separations, N_d represents the indices of refraction, the Abbe-V number represents the dispersion values of the elements, and F is the equivalent focal length:

[F=40 inches. f/5]

El.	Radii (Inches)	Thickness (Inches)	Space (Inches)	N_d	Abbe-V Number
I	R_1 = 14.058 R_2 = −115.80	D_1=.882		1.5168	64.5
			S_1= .264		
II	R_3 = −33.942 R_4 = 36.880	D_2=.405		1.7195	29.3
			S_2= .051		
III	R_5 = 7.664 R_6 = 19.722	D_3=.941		1.517	64.5
			S_3=9.454		
IV	R_7 = 40.066 R_8 = −59.907	D_4=.395		1.6164	36.6
			S_4= .819		
V	R_9 = −5.724 R_{10}= −14.164	D_5=.356		1.6102	58.8
			S_5=3.002		
VI	R_{11}= 11.254 R_{12}= 37.075	D_6=.499		1.6164	36.6
			S_6= .850		
VII	R_{13}= −17.347 R_{14}= 42.692	D_7=.407		1.6102	58.8
			S_7= .916		
VIII	R_{15}=Plano R_{16}=Plano	D_8=.523		1.517	Y-7, R-2
			S_8=11.631		

2. A telephoto objective having numerical data as set forth in the following chart where R_1, R_2, . . . represent the radii of curvature of the surfaces, D_1, D_2, . . . represent the axial thicknesses of the elements, S_1, S_2, . . . represent the axial air separations, N_d represents the indices of refraction, the Abbe-V number represents the dispersion values, and F represents the equivalent focal length:

[F=60 inches. f/5]

El.	Radii (Inches)	Thickness (Inches)	Space (Inches)	N_d	Abbe-V Number
I	R_1 = 21.525 R_2 = −161.48	D_1=1.351		1.5168	64.5.
			S_1= .401		
II	R_3 = −51.436 R_4 = 55.888	D_2= .614		1.7195	29.3.
			S_2= .077		
III	R_5 = 11.649 R_6 = 30.121	D_3=1.144		1.517	64.5.
			S_3=14.677		
IV	R_7 = 60.72 R_8 = −90.78	D_4= .599		1.6164	36.6.
			S_4= 1.241		
V	R_9 = −8.670 R_{10}= −21.442	D_5= .542		1.6102	58.8.
			S_5= 4.550		
VI	R_{11}= 17.704 R_{12}= 44.977	D_6= .732		1.6164	36.6.
			S_6= 1.288		
VII	R_{13}= −32.374 R_{14}= 75.40	D_7=1.573		1.6102	58.8.
			S_7= 1.418		
VIII	R_{15}=Plano R_{16}=Plano	D_8= .541		1.517	Orange Filter.
			S_8=17.166		

3. A telephoto objective having numerical data as set forth in the following chart where r_1, r_2, . . . represent the radii of curvature of the surfaces, d_1, d_2, . . . represent the axial thicknesses of the elements, s_1, s_2, . . . represent the axial air separations, N_d represents the indices of refraction, the Abbe-V number represents the dispersion values, and F represents the equivalent focal length:

[F=40 inches f/5]

El.	Radii (Inches)	Thickness (Inches)	Space (Inches)	N_d	Abbe-V Number
1	r_1 = 13.387	d_1 = .866		1.5168	64.5
	r_2 = −141.63		S_1 = .261		
2	r_3 = −34.003	d_2 = .396		1.7195	29.3
	r_4 = 34.274		S_2 = .050		
3	r_5 = 7.54	d_3 = .924		1.5164	64.5
	r_6 = 19.699		S_3 = 9.317		
4	r_7 = 38.84	d_4 = .387		1.6102	58.8
	r_8 = −58.074		S_4 = .810		
5	r_9 = −5.580	d_5 = .149		1.6164	36.6
	r_{10} = −13.809		S_5 = 3.162		
6	r_{11} = 10.91	d_6 = .513		1.6164	36.6
7	r_{12} = −23.227	d_7 = .150		1.6102	58.8
	r_{13} = 35.941		S_6 = .513		
8	r_{14} = −17.772	d_8 = .150		1.6102	58.8
9	r_{15} = Plano	d_9 = .513		1.6164	36.6
	r_{16} = −43.873	d_{10} = .150		1.61908	60.2
10	r_{17} = 37.189		S_7 = 12.746		

4. A telephoto objective having numerical data as set forth in the following chart where C_1, C_2, . . . represent the radii of curvature of the surfaces, t_1, t_2, . . . represent the axial thicknesses of the elements, l_1, l_2, . . . represent the axial air separations, N_d represents the indices of refraction, the Abbe-V number represents the dispersion values, and F represents the equivalent focal length:

[F=60 inches f/5]

El.	Radii (Inches)	Thickness (Inches)	Distance (Inches)	N_d	Abbe-V Number
A	C_1 = 24.521	t_1 = 1.055		1.517	64.5.
	C_2 = −77.22		S_1 = .261		
B	C_3 = −47.038	t_2 = .744		1.72	29.3.
	C_4 = 65.076		S_2 = .061		
C	C_5 = 11.456	t_3 = .954		1.517	64.5.
	C_6 = 27.984		S_3 = 14.451		
D	C_7 = 59.524	t_4 = .695		1.617	36.6.
	C_8 = −89.002		S_4 = 1.122		
E	C_9 = −9.196	t_5 = .595		1.61088	57.2.
	C_{10} = −25.859		S_5 = 6.977		
F	C_{11} = 18.572	t_6 = .695		1.617	36.6.
	C_{12} = 138.26		S_6 = .726		
G	C_{13} = −25.819	t_7 = .601		1.61088	57.2.
	C_{14} = 63.227		S_7 = .595		
H	C_{15} = Plano	t_8 = .496		1.517	R_1 or Orange Filter.
	C_{16} = Plano		S_8 = 18.037		

5. A large aperture telephoto objective lens system comprising; a convergent front objective component having a focal point on the side of the shorter conjugate and having the front and rear surfaces thereof convex toward the longer conjugate to produce a second principal plane forwardly of the center of said objective component; and a rear divergent component spaced on the side of the shorter conjugate of said front objective component not less than ⅓ or more than ¾ the front objective component focal length and having a focal point on the side of the longer conjugate in front of said front objective component a distance not more than 4 or less than 2 times the axial distance along the optical axis between the two components, said rear divergent component including at least two doublets on the side of the front convergent component each having a positive element preceding a negative element in the order named from said front objective component and being spaced apart a distance not less than ¼ or more than ½ the axial distance along the optical axis between the two said components, one element of each doublet being flint and the other element of each doublet being crown, the crown elements having the same index of refraction and the same dispersive value and the flint elements having the same index of refraction and the same dispersive value, the index of refraction of the last-mentioned flint elements being greater than 1.61 with a dispersion value of less than 40 and the index of refraction of the crown elements being less than 1.61 with a dispersion value greater than 55, the front surface of each doublet and the rear surface of the rearmost doublet being convex toward the longer conjugate to establish in said rear divergent component together with said front objective component a second principal plane for the lens system forward of said front objective component and a focal plane for the lens system rearwardly of the rear divergent component such that the axial distance along the optical axis from the front vertex of the objective component to said focal plane of the lens system is less than 82% of the distance from said second principal plane of the lens system to said focal plane of said lens system, and the distance

from the front vertex of said front objective component to the focal plane of the lens system is not more than 3 or less than 2 times the distance from the rearmost vertex of the rear divergent component to the focal plane of the lens system to provide a large aperture telephoto objective of relative long equivalent focal length that is distortionless and substantially free from undesirable aberrations to produce good resolution and definition on a flat field.

6. A large aperture telephoto objective lens system as set forth in claim 5 wherein the forward doublet of said rear divergent component has the positive and negative elements thereof air spaced an axial distance along the optical axis not less than 1/15 or greater than 1/6 the axial distance along the optical axis between said two components and forming a centrally thick air lens therebetween.

7. A large aperture telephoto objective lens system comprising; a convergent front objective triple component consisting of a negative high index flint element coaxially air spaced between two positive low index crown elements, the foremost air space characterizing a centrally thick meniscus air lens concave toward the longer conjugate and the rearmost air space characterizing a centrally thin meniscus air lens convex toward the longer conjugate, said two low index crown elements having the same index of refraction and the same dispersion value, the index of refraction thereof being lower than 1.52 with the dispersion value thereof being greater than 60 and the index of refraction of said high index flint element being greater than 1.71 with a dispersion value less than 30, the powers of said positive crown elements being greater than the power of said negative flint element to produce its focus on the optical axis thereof on the side of the shorter conjugate, and the front and rear surfaces of said triplet component being convex toward the longer conjugate to establish a second principal plane forwardly of the center of said triplet component; and a divergent rear component spaced along the optical axis on the side of the shorter conjugate of said triplet component not more than 3/4 or less than 1/3 of the focal length of said triplet component, said divergent rear component including at least two doublet members on the side of the triplet component the doublet members of the divergent rear components each having a positive element preceding a negative element in the order named from the longer conjugate with one element of each doublet being flint and one element of each doublet being crown, the crown elements having the same index of refraction and the same dispersion value and the flint elements having the same index of refraction and the same dispersion value, the index of refraction of the last mentioned flint elements being greater than 1.61 with a dispersion value less than 40 and the index of refraction of the crown elements being less than 1.61 with a dispersive value greater than 55, said doublets being separated by more than 1/4 and less than 1/2 the axial distance along the optical axis between the said triplet component and said rear divergent component, the front surface of the forward doublet and the front and rear surface of the rearward doublet being convex toward the longer conjugate to produce in combination in said rear divergent component a second principal plane therefor forward of the center of said rear divergent component and to produce a focal point on the side of the longer conjugate forward of said triplet component not more than 4 or less than 2 times the distance of said triplet component from said rear divergent component to establish in the combination of said rear divergent component and said triplet component a second principal plane forward of said triplet component and a focal plane rearwardly of said rear divergent component, the axial distance along the optical axis from the front vertex of said triplet component to said focal plane of said lens system being not less than 2 or more than 3 times the axial distance along the optical axis from the rear vertex of said rear divergent component to said focal plane of the lens system which constitutes the telephoto effect of the lens system, and the axial distance along the optical axis from the front vertex of said objective triplet component to said focal plane of said lens system being not more than 82% of the distance from said second principal plane of the lens system to said focal plane of the lens system constituting the telephoto ratio of the lens system whereby to provide a large aperture telephoto objective of long equivalent focal length.

8. A large aperture telephoto objective lens system as set forth in claim 7 wherein the foremost doublet of said rear divergent component has the positive and negative elements thereof air spaced an axial distance along the optical axis not less than 1/15 or greater than 1/6 the axial distance along the optical axis between said two components, said air space forming a centrally thick air lens.

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