975,160

PATENT SPECIFICATION

DRAWINGS ATTACHED

975,160

Date of Application and filing Complete Specification: March 29, 1963.
No. 12499/63.
Application made in France (No. 901,732) on June 23, 1962.
Application made in France (No. 916,120) on Nov. 22, 1962.
Complete Specification Published: Nov. 11, 1964.

Index at acceptance:—G2 J(B7C7, B7C8)

International Classification:—G 02 b

COMPLETE SPECIFICATION

Improvements in or relating to Variable Focal Length Lens Systems

I, PIERRE ANGENIEUX, a citizen of the French Republic, residing: 27, rue du Cherche-Midi, Paris (Seine), France, do hereby declare the invention for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to variable focal length lens systems having at the front a convergent front member. It is known that lens systems of this character are focused by causing the axial displacement of this front member if it is desired to maintain in a fixed position the image given by the complete system, during focal length variations. Now, since in lens systems of this character the leading iris diaphragm is placed rather far behind the front member, an abnormal diametral dimension would be required for this front member, if it were intended that the axial movement of this front member be sufficient to afford focusing on very near objects.

It is the object of the present invention to provide an improvement, in such a lens system, serving to eliminate this drawback.

According to the present invention, a variable focal length lens system having at the front a convergent front member is characterised in that said front member consists of the combination of two components, viz. a divergent front component and a fixed convergent rear component, said front divergent component being axially movable and adapted to effect alone the focusing of the lens system by an axial displacement.

According to another feature of the lens system of this invention, the rear convergent component of the front member comprises at least four elements of which at least one is a divergent element, the front divergent component comprising on the other hand at least three elements of which at least one is a convergent meniscus element having its convexity facing forwards and of which at least two are divergent elements.

In order to afford a clearer understanding of this invention and of the manner in which the same may be carried out in practice, reference will now be made to the accompanying drawing, in which:

Figs. 1, 2 and 3 are diagrams showing a variable focal length lens system of conventional design, comprising thin elements and wherein the focusing is effected by moving axially the front member;

Figs. 4 and 5 are similar diagrams but wherein the front member is in accordance with the teachings of this invention, and

Figs. 6, 7 and 8 are specific embodiments of the lens system of this invention.

Referring firstly to fig. 1, the diagram illustrates in the wide-angle position a variable focal length lens system of known type comprising at the front end a convergent front member 1 moved only for focusing followed by an axially movable divergent member 2 and an axially movable convergent member 3 both moved to alter the focal length. An iris diaphragm 4 is placed behind the last - named component 3 and the image given by this assembly is formed in the focal plane 5.

In the selected example it is assumed that the lens system comprises a front member 1 having an 80-millimeter focal length, an intermediate member 2 having a 20-mm focal length, and a rear member 3 having a 22-mm focal length.

In figure 1 these three members are so disposed that member 2 produces a .4 magnification while member 3 gives a .44 magnification, the resultant magnification being therefore .4 x .44 = .176, the focal length of the lens system being therefore 80 x .176 = 14.08 mm.

Figure 3 shows the same arrangement except that members 2 and 3 are in a different position. With respect to fig. 1, these members are axially shifted whereby member 2 produces a .91-mm magnification and member 3 a .92-mm magnification, giving a resultant magnification of .837, the focal length of the system becoming thus 80 x .837 = 66.96. The relative positions of member 1, diaphragm 4 and of the focal plane remain unchanged and are therefore as shown in fig. 1.

All these numerical characteristics are given with a view to emphasizing in a practical example, the advantage obtained by the present invention. However, this invention refers only to the front member 1 and is applicable to any variable focal length lens system comprising at the front a convergent member, whether the latter is fixed after focusing on an object located at a given distance, or whether it is axially movable in order to participate in the variation in the focal length of the system or in maintaining the resultant image in a fixed position.

The device described hereinabove is of conventional design. The light rays passing through the centre of the diaphragm and limiting the field are shown in thick lines in fig. 1 and fig. 3. In the same figures, the broken lines show also light rays bounding the axial beam of which the aperture corresponds to the diameter of the diaphragm 4.

In these two figures 1 and 3, member 1 is located in a position corresponding to focusing on infinity and it will be seen that in the object space the rays 6,7 in Fig. 1, and 8,9 in fig. 3, which in each case correspond to the field limits, determine the diameter of member 1 which is necessary for covering this field completely, assuming that said member 1 has a fixed position constantly maintaining the focus on infinity.

If it desired to shift this front member forwards, for focusing the system on a near object, the diameter of the front member suitable for focusing on infinity is no longer sufficient and the purpose of fig. 2 is to show the proportion in which this diameter should be increased. Therefore, fig. 2 shows the same system as fig. 1, the members 2 and 3, diaphragm 4 and focal plane 5 being in the same order along the optical axis as in the case of fig. 1, but with member 1 shifted axially forwards. Since this shift is 20 millimeters, the focusing is effected on an object located 400 millimeters ahead of this member. It will be seen that due to the strong inclination of the light rays 10 and 11 which, as in fig. 1, correspond to the field edge, the diameter of member 1 should be increased considerably.

This effect is particularly perceptible in the wide-angle position of fig. 2. In fact, from fig. 3 it will be seen that the moderate inclination of rays 16 and 17 does not cause the same disturbance as in fig. 2 and corresponds to a relatively great length of the complete lens system.

According to this invention, this drawback which, as already stated, is felt more particularly in the wide-angle position, is avoided by decomposing the convergent front member into two components: a divergent front component and a convergent rear component, thus focusing being effected in this case by axially shifting the front divergent component alone.

Figures 4 and 5 illustrate in the same diagrammatic fashion a lens system of this character. In fig. 4, the members 2 and 3, diaphragm 4 and focal plane 5 are the same as in fig. 1, and their relative arrangement is also the same as in this figure. However, member 1 of fig. 1 is replaced here by a novel front member consisting two components: a front divergent component *1a* having an 80 - mm focal length and a rear convergent component *1b* having a 42.5 focal length. If these two components shown in fig. 4 in the form of thin elements are spaced 5 mm apart, the equivalent focal length of the member constituted by these two components is 80 millimeters.

In this example, this focal length was selected to be 80 mm for the front member for it corresponds to that of the front member of the example shown in figs. 1, 2 and 3, so that the arrangement of fig. 4 covers the same field as that of fig. 1.

Figure 5 shows the same lens system as in fig. 1, except that the divergent component *1a* has been shifted axially forwards so that the focusing will correspond to an object located 400 mm ahead of this component. From this figure it will be seen that the rear component *1b* (having the same axial position as in fig. 4) causes the rays 14 and 15 to converge, thereby limiting the useful diameter of the front component *1a*.

It may also be noted that in the example illustrated in figs. 4 and 5 the choice, for the front component *1a* of an 80-mm focal length equal in absolute value to that of member 1 in the example of figs. 1 and 2, requires a movement of about 13.3 mm only instead of 20 mm (owing to the fact that this front component is divergent) for focusing the system on an object disposed 400 mm ahead of said component. As a result, the higher the power (in absolute value) of components *1a* and *1b*, the better the desired effect.

Finally, a secondary advantage characterising this invention lies in the fact that, in contradistinction with what is observed then—as in the conventional system of figs. 1 and 2—the field decreases when focusing on near objects, the use of a divergent component for focusing the image increases the field when said divergent component is shifted axially forwards.

Of course, the device illustrated in figs. 4 and 5, as just described, constitutes but an example and should not be construed as limiting the scope of the invention as defined in the claims following this description.

As a consequence of investigations made by the Inventor with a view to providing a front member of this character which afforded a proper correction of the various aberrations, it appeared that it is preferably to constitute this complete member of at least seven elements, the rear component comprising at least four elements of which at least one element is divergent whereas the front divergent component comprises at least three elements of which at least one is a convergent meniscus element having its convexity facing forwards, and at least two are divergent elements.

Moreover, it may be noted that it is advantageous to select, for said convergent meniscus element of said front component, a convex front face having a radius of curvature smaller than the focal length of said front component and preferably greater than 40% of said focal length.

Figures 6 to 8 illustrate three typical embodiments of a lens system incorporating a front member of this character.

Figure 6 illustrates a lens system comprising at the front a front member C_1 arranged according to this invention and two axially movable members C_2 and C_3, the first axially movable member C_2 having a =48.38 mm focal length and being divergent, the second axially movable member C_3 having a +63.23 focal length and being convergent, and their axial movements are so related that when member C_2 moves backwards member C_3 moves forwards. This lens system is completed by a fourth fixed member C_4 (the focal length of which is −327.4 mm) disposed behind the diaphragm. The focal lengths of this lens system range from +40.0 mm to +370.0 mm.

Figure 7 refers to a lens system comprising similarly at the front a front member C_5 according to this invention and two axially movable members, the first movable member C_6 having a −48.78 focal length and being divergent, the second movable member C_7 having a +48.79 focal length and being convergent. The axial movements of these last-named two members are so related that when member C_6 moves backwards member C_7 moves firstly forwards and then completes its stroke in the backward direction. This lens system is completed by a last member C_8 (the focal length of which is +154.7 mm) disposed behind the diaphragm. The focal lengths of this lens system range from +35.0 mm to +133.5 mm.

Figure 8 refers to another lens system comprising at the front a front member C_9 according to this invention, and two axially movable members of which the first member C_{10} has a −48.38 mm focal length and is divergent, the second member C_{11} having a +63.23 focal length and being convergent, and the axial movements of these last - named two members are so related that when member C_{10} moves forwards, member C_{11} moves backwards. This lens is completed by a fourth fixed member C_{12} (the focal length of which is −327.4 mm) disposed behind the diaphragm. The focal lengths of this lens system range from +35.7 mm to +330.4 mm.

In each one of figures 6 to 8 the reference numerals 2, 22, 23......designate the various elements; t1, t2, t3......designate the thicknesses of the elements; s1, s2, s3......designate the air gaps, and R1, R2, R3......designate the radii of curvature of the surfaces of the elements.

In each example front member consists of two components as consistent with the basic principle of this invention and in figs. 6 and 7 the divergent front component consists of elements 21, 22 and 23, whereas the convergent rear component consists of elements 24, 25, 26 and 27; in fig. 8 the divergent front component consists of elements 21, 22, 23 and 24 whereas the convergent rear component consists of elements 25, 26, 27 and 28. Of course, the focusing is effected in each case by shifting the front component along the optical axis. In the example illustrated in fig. 6 the focal length of the front component is −218.2 mm, that of the rear component being +115.7 mm, so that the focal length of the front member consisting of these two components is +196.8 mm when the front component is in the position corresponding to focusing on infinity. The distance between these two components is in this case S_3=3.97 mm. In the example illustrated in fig. 7 the focal length of the front component is −162.0 mm, that of the rear component being +97.6 mm, and the focal length of the front member consisting of these two components is +116.4 mm when the front component is in the position corresponding to focusing on infinity. The distance between these two components is in this case S_3=32.89 mm. In the example shown in fig. 8, the focal length of the front component is −200.6 mm, that of the rear component is +115.9 mm and the focal length of the complete front member consisting of these two components is +175.7 mm when the front component is in the position corresponding to focusing on infinity. The distance between these two components is in this case S_4=3.97 mm.

The numerical characteristics of these three practical embodiments shown in figs. 6, 7 and 8 are given in the following tables. Table 1 corresponds to fig. 6, Table 2 to fig. 7 and Table 3 to fig 8, respectively. In these tables the elements are designated in the front to rear direction in column I, the indices of refraction *n* for the spectrum line D and the dispersion indices (Abbe number) are given in columns II and III; the radii of curvature of the surfaces of the elements, affected by the sign + or − according as the convexity of said surfaces is directed forwards or backwards, are given in column IV; the thicknesses *t* of the elements and the air gaps *s* are given in column V. In each table the numerical value of the air gap s3 in Table I and II, and s4 in Table

III which separate the two components constituting the front member corresponds to the focusing of the lens system on infinity.

In the example illustrated in fig. 6 the front divergent component of the front member comprises a convergent meniscus element disposed between two divergent elements. In a member of this character it is advantageous to select, for the foremost divergent element, a rear face which is concave to the rear and has a radius of curvature greater than 40% of the focal length of said divergent front component and preferably smaller than 150% of this focal length.

In the example illustrated in fig. 7 the convergent meniscus element is placed behind the front divergent component comprising two divergent elements at the front. In this member it is advantageous to select, for the divergent element placed ahead of this front component, a rear face which is concave to the rear and has a radius of curvature greater than 30% of the focal length of said divergent front component and, preferably, smaller than 70% of this focal length.

In the example shown in fig. 8, the divergent front component of the front member comprises in the front-to-rear direction two divergent elements, a convergent meniscus element and a divergent element. In this member, it is advantageous to select for the divergent element disposed at the front end a rear face which is concave to the rear and has a radius of curvature greater than 35% of the focal length of said divergent front component and, preferably, smaller than said focal length.

In each example shown in figs. 6 to 8 the convergent rear component of the front member comprises four elements, two of which are divergent and the other two convergent. In a member of this character it is not essential that the divergent element be disposed at the front, as shown in fig. 7, but it is advantageous to select for this divergent element a rear surface which is concave to the rear and has a radius of curvature greater than 60% of the focal length of said convergent rear component and smaller than 125% of said focal length.

In the example shown in fig. 7 the rear component comprises four elements of which two are convergent and two divergent. These four elements are arranged in the form of two doublets each consisting of a convergent element and a divergent element. In a member of this character it is advantageous to use divergent meniscus elements having their rear surfaces concave to the rear, and to dispose these divergent elements each in the forward position of its respective doublet.

TABLE I

I	II	III	IV	V
Lens element	N	ν	Radii in mm.	Thicknesses of the lens elements or air spaces in mm.
			R 1 = ∞	
1	1.6202	60.2		t 1 = 3.97
			R 2 = + 159	
				s 1 = 0.20
			R 3 = + 139.12	
2	1.7313	28.4		t 2 = 9.94
			R 4 = + 212.98	
				s 2 = 11.92
			R 5 = − 695.60	
3	1.6202	60.2		t 3 = 3.97
			R 6 = + 390.43	
				s 3 = 3.97
			R 7 = ∞	
4	1.7313	28.4		t 4 = 3.97
			R 8 = + 119.25	
5	1.6202	60.2		t 5 = 15.90
			R 9 = − 344.16	
				s 4 = 0.20
			R 10 = + 233.66	
6	1.6202	60.2		t 6 = 9.94
			R 11 = − 369.17	
				s 5 = 0.20
			R 12 = + 156.71	
7	1.6202	60.2		t 7 = 9.94
			R 13 = +1188.84	
				s 6 from 1.887 to 110.906
			R 14 = + 398.80	
8	1.6903	54.0		t 8 = 1.40
			R 15 = + 43.00	
				s 7 = 12.64
			R 16 = − 81.35	
9	1.5894	61.5		t 9 = 1.05
			R 17 = + 40.85	
10	1.6973	30.2	R 18 = + 954.06	t 10 = 12.52
				s 8 from 150.446 to 0.441
			R 19 = + 208.96	
11	1.6973	30.2		t 11 = 6.16
			R 20 = − 410.52	
				s 9 = 1.03
			R 21 = − 615.79	
12	1.6973	30.2		t 12 = 2.05
			R 22 = + 44.58	
13	1.6566	57.2		t 13 = 16.11
			R 23 = − 97.11	
				s 10 = 0.12
			R 24 = + 80.46	
14	1.6213	60.2		t 14 = 6.57
			R 25 = + 589.64	
				s 11 from 11.954 to 52.940

TABLE I Continued

I	II	III	IV	V
Lens element	N	ν	Radii in mm.	Thicknesses of the lens elements or air spaces in mm.
			R 26 = − 69.89	
15	1.6202	60.2	R 27 = + 21.51	t 15 = 2.05
16	1.6201	36.2	R 28 = + 55.22	t 16 = 28.74
				s 12 = 10.26
			R 29 = + 619.58	
17	1.5164	64.0	R 30 = − 40.88	t 17 = 10.26
				s 13 = 1.03
			R 31 = + 836.24	
18	1.6985	30.2	R 32 = + 33.56	t 18 = 10.26
				s 14 = 0.10
			R 33 = + 34.20	
19	1.6244	46.9	R 34 = − 1005.78	t 19 = 14.37

The focal length varies from + 40.0 to + 370.0

TABLE II

I	II	III	IV	V
Lens element	N	ν	Radii in mm.	Thicknesses of the lens elements or air spaces in mm.
			R 1 = + 199.28	
1	1.6202	60.2	R 2 = + 72.07	t 1 = 3.64
				s 1 = 18.21
			R 3 = −3797.42	
2	1.6202	60.2	R 4 = + 118.20	t 2 = 3.64
				s 2 = 3.64
			R 5 = + 92.51	
3	1.6985	30.2	R 6 = + 237.59	t 3 = 10.93
				s 3 = 32.89
			R 7 = + 189.23	
4	1.6531	33.5	R 8 = + 73.07	t 4 = 3.64
				s 4 = 0.81
			R 9 = + 75.34	
5	1.6202	60.2	R 10 = − 372.79	t 5 = 14.57
				s 5 = 2.73

TABLE II Continued

I	II	III	IV	V
Lens element	N	ν	Radii in mm.	Thicknesses of the lens elements or air spaces in mm.
			R 11 = + 100.85	
6	1.6673	33.2		t 6 = 1.97
			R 12 = + 46.26	
7	1.6087	56.6		t 7 = 15.74
			R 13 = − 745.46	
				s 6 from 1.978 to 52.655 and to 66.667
			R 14 = − 385.75	
8	1.6202	60.2		t 8 = 1.40
			15 = + 49.18	
				s 7 = 8.21
			R 16 = − 113.66	
9	1.6574	57.2		t 9 = 1.06
			R 17 = + 34.66	
10	1.6985	30.2		t 10 = 7.18
			R 18 = + 742.36	
				s 8 from 73.912 to 12.291 and to 1.995
			R 19 = + 180.81	
11	1.6576	51.1		t 11 = 4.03
			R 20 = − 92.51	
				s 9 = 0.25
			R 21 = + 55.53	
12	1.6779	55.5		t 12 = 7.87
			R 22 = − 38.38	
13	1.6751	32.3		t 13 = 1.06
			R 23 = + 252.52	
				s 10 from 6.092 to 17.036 and to 13.320
			R 24 = − 94.52	
14	1.6202	60.2		t 14 = 15.79
			R 25 = + 41.92	
				s 11 = 25.50
			R 26 = − 169.24	
15	1.5179	64.5		t 15 = 9.11
			R 27 = − 53.64	
				s 12 = 0.18
			R 28 = + 202.26	
16	1.6574	57.2		t 16 = 14.57
			R 29 = − 31.18	
17	1.6284	35.5		t 17 = 3.64
			R 30 = − 132.07	

The focal length varies from + 35.00 to + 107.4 and + 133.5

TABLE III

I Lens element	II N	III ν	IV Radii in mm.	V Thicknesses of the lens elements or air spaces in mm.
			R 1 = + 500.32	
1	1.6202	60.2		t 1 = 3.97
			R 2 = + 139.13	
				s 1 = 19.87
			R 3 = + 993.49	
2	1.6202	60.2		t 2 = 3.97
			R 4 = + 257.91	
				s 2 = 0.20
			R 5 = + 148.53	
3	1.7313	28.4		t 3 = 9.93
			R 6 = + 238.08	
				s 3 = 12.92
			R 7 = − 696.93	
4	1.6202	60.2		t 4 = 3.97
			R 8 = + 794.02	
				s 4 = 3.97
			R 9 = − 993.49	
5	1.7313	28.4		t 5 = 3.97
			R 10 = + 115.62	
6	1.6202	60.2		t 6 = 17.88
			R 11 = − 292.32	
				s 5 = 0.20
			R 12 = + 234.23	
7	1.6202	60.2		t 7 = 11.92
			R 13 = − 369.26	
				s 6 = 0.20
			R 14 = + 156.40	
8	1.6202	60.2		t 8 = 7.95
			R 15 = +3555.68	
				s 7 from 1.887 to 110.906
			R 16 = + 398.80	
9	1.6903	54.0		t 9 = 1.40
			R 17 = + 43	
				s 8 = 12.64
			R 18 = − 81.35	
10	1.5894	61.5		t 10 = 1.05
			R 19 = + 40.85	
11	1.6973	30.2		t 11 = 12.52
			R 20 = + 954.06	
				s 9 from 150.446 to 0.441
			R 21 = + 208.96	
12	1.6973	30.2		t 12 = 6.16
			R 22 = − 410.52	
				s 10 = 1.03
			R 23 = − 615.79	
13	1.6973	30.3		t 13 = 2.05
			R 24 = + 44.58	
14	1.6566	57.2		t 14 = 16.11
			R 25 = − 97.11	
				s 11 = 0.12

TABLE III Continued

I	II	III	IV	V
Lens element	N	ν	Radii in mm.	Thicknesses of the lens elements or air spaces in mm.
			R 26 = + 80.46	
15	1.6213	60.2		t 15 = 6.57
			R 27 = + 589.64	
				s 12 from 11.954 to 52.940
			R 28 = − 69.89	
16	1.6202	60.2		t 16 = 2.05
			R 29 = + 21.51	
17	1.6201	36.2		t 17 = 28.74
			R 30 = + 55.22	
				s 13 = 10.26
			R 31 = + 619.58	
18	1.5164	64.0		t 18 = 10.26
			R 32 = − 40.88	
				s 14 = 1.03
			R 33 = + 836.24	
19	1.6985	30.2		t 19 = 10.26
			R 34 = + 33.56	
				s 15 = 0.10
			R 35 = + 34.20	
20	1.6244	46.9		t 20 = 14.37
			R 36 = −1005.78	

The focal length varies from + 35.7 to + 330.4

WHAT I CLAIM IS:—

1. A variable focal length lens system of the type comprising at the front a convergent front member, characterised in that said front member consists of the combination of two components, viz. a divergent front component and a fixed convergent rear component, said divergent front component being axially movable and adapted to effect alone the focusing of the lens sytem by an axial displacement.

2. A variable focal length lens system, according to claim 1, characterised in that the convergent rear component of said front member comprises at least four elements of which at least one is divergent whereas said divergent front component comprises at least three elements of which at least one is a convergent meniscus element which has its convex face to the front and of which at least two are divergent elements.

3. A variable focal length lens system, according to claim 2, characterised in that the front surface of said convergent meniscus element has a radius of curvature smaller than the focal length of said front component.

4. A variable focal length lens system according to claim 2, characterised in that the front surface of said convergent meniscus element has a radius of curvature smaller than the focal length of said front component and greater than 40% of said focal length.

5. A variable focal length lens system, according to any of claims 2, 3 and 4, characterised in that said divergent front component of said front member consists of a convergent meniscus element disposed between two divergent elements, the divergent element placed at the front of said divergent front component having a concave rear face of which the radius of curvature is greater than 40% of the focal length of said divergent front component and smaller than 150% of said focal length.

6. A variable focal length lens system, according to any of claims 2, 3 and 4, characterised in that said divergent front component of said front member consists of a convergent meniscus element placed behind said two divergent elements, the divergent element disposed at the front of said divergent front component having a concave rear face of which the radius of curvature is greater than 30% of the focal length of said divergent front component and smaller than 70% of said focal length.

7. A variable focal length lens system, according to any of claims 2, 3 and 4, characterised in that said divergent front component

of said front member comprises a convergent meniscus element preceded by two divergent elements and followed by a third divergent element, the divergent element placed at the front of said divergent front component having a concave rear face of which the radius of curvature is greater than 35% of the focal length of said front component.

8. A variable focal length lens system, according to any of claims 2, 3 and 4, characterised in that said divergent front component of said front member comprises a convergent meniscus element preceded by two divergent elements and followed by a third divergent element, the divergent element placed at the front of said divergent front component having a concave rear face of which the radius of curvature is greater than 35% of the focal length of said front component and smaller than said focal length.

9. A variable focal length lens system, according to any of claims 2, 3 and 4, characterised in that said convergent rear component of said front member comprises four elements, one of said four elements being divergent and having a concave rear face of which the radius of curvature is greater than 60% of the focal length of said convergent rear component and smaller than 150% of said focal length.

10. A variable focal length lens system, according to any of claims 2, 3 and 4, characterised in that the convergent rear component of said front member comprises four elements, said four elements being arranged to form two doublets consisting each of a convergent element and of a divergent element, in each of said doublets the divergent element being placed at the front of the respective doublet and consisting of a meniscus element having its convex face directed forwards.

11. A variable focal length lens system substantially as described hereinabove with reference to figs. 4 to 8 of the accompanying drawings.

For the Applicant:
CHATWIN & COMPANY,
Chartered Patent Agents,
253, Gray's Inn Road, London, W.C.1.

Leamington Spa: Printed for Her Majesty's Stationery Office, by the Courier Press (Leamington) Ltd.—1964. Published by The Patent Office, 25 Southampton Buildings London, W.C.2, from which copies may be obtained.

Fig.1

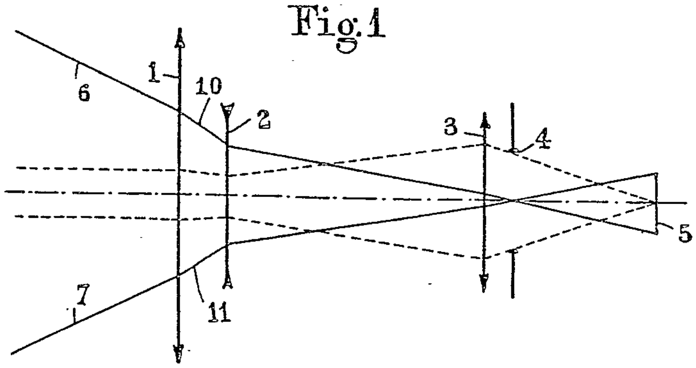


Fig. 2

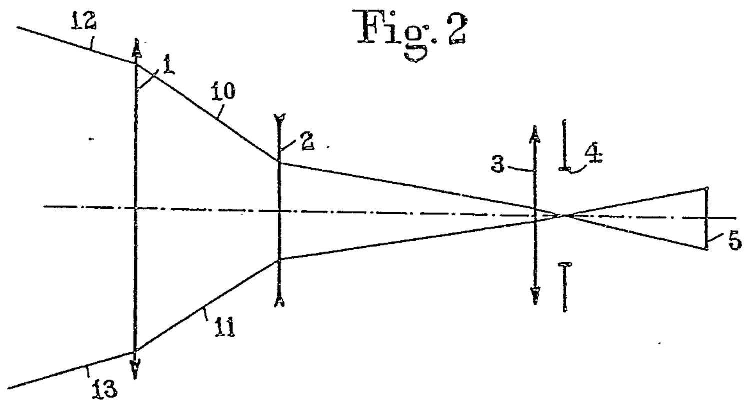
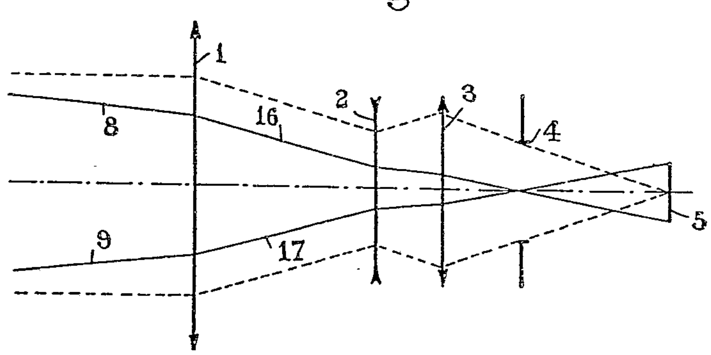


Fig.3



975160 COMPLETE SPECIFICATION

4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 1 & 2

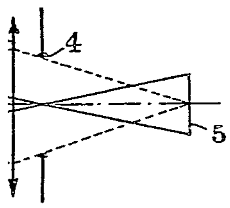
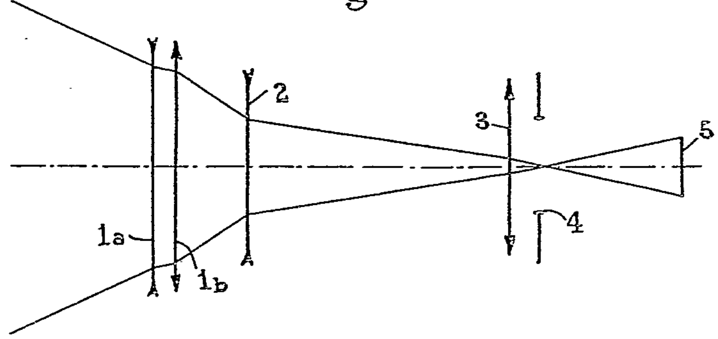


Fig.4



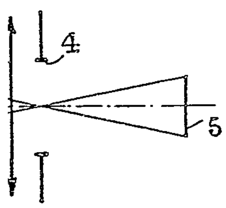
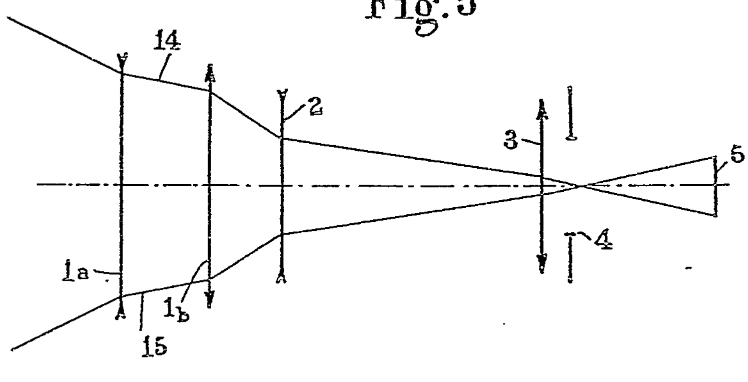
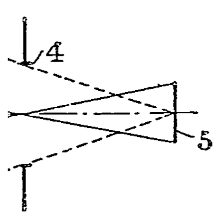


Fig.5





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4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheets 1 & 2

Fig.1

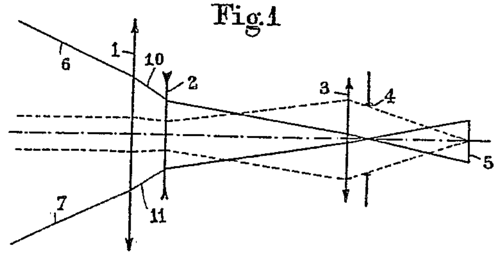


Fig.2

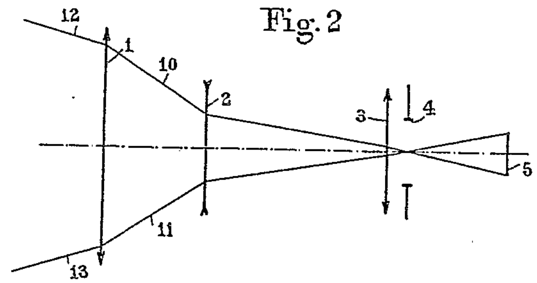


Fig.3

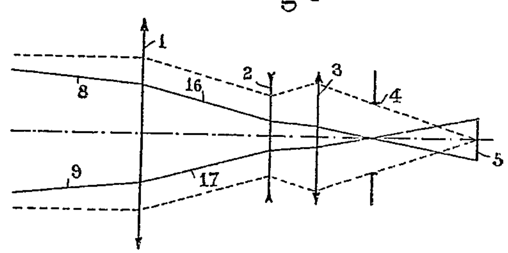


Fig.4

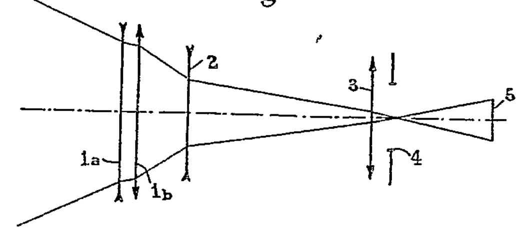
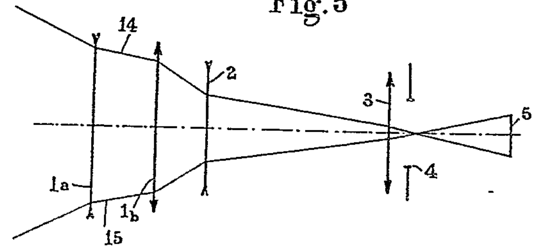
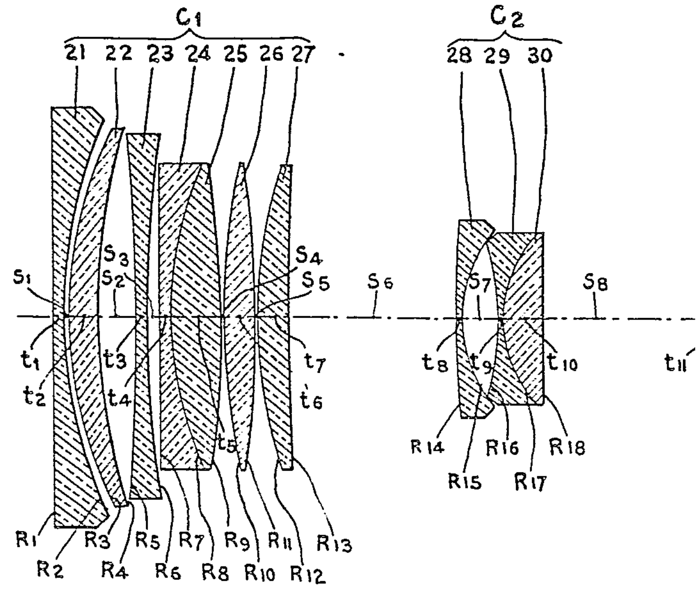
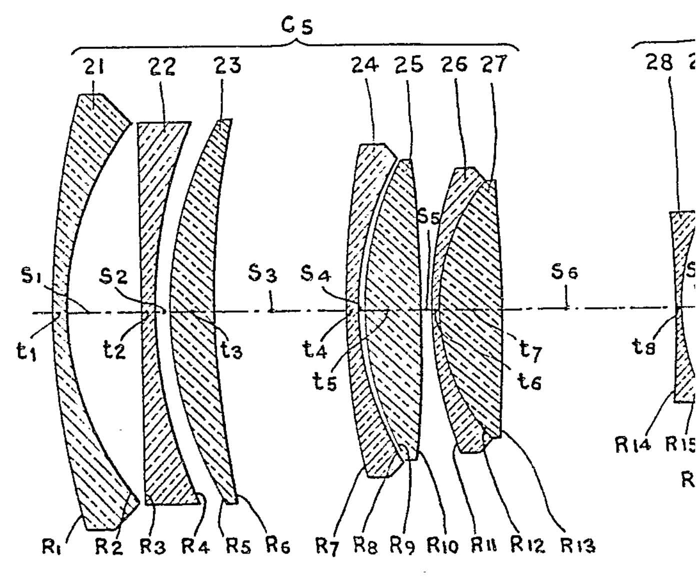


Fig.5




C1
C2
21 22 23 24 25 26 27
28 29 30
S1 S2 S3 S4 S5 S6 S7 S8
t1 t2 t3 t4 t5 t6 t7 t8 t9 t10 t11
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13
R14 R15 R16 R17 R18


C5
21 22 23 24 25 26 27
28
S1 S2 S3 S4 S5 S6
t1 t2 t3 t4 t5 t6 t7 t8
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13
R14

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4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 3

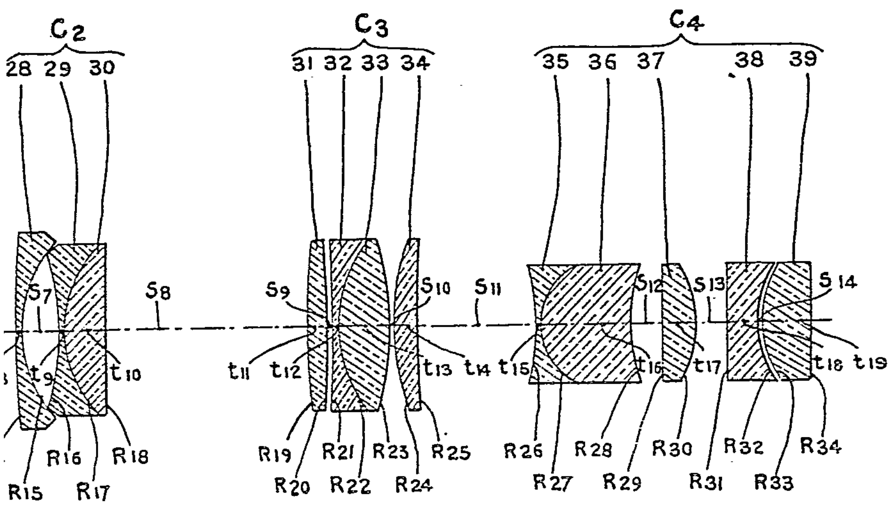


Fig. 6

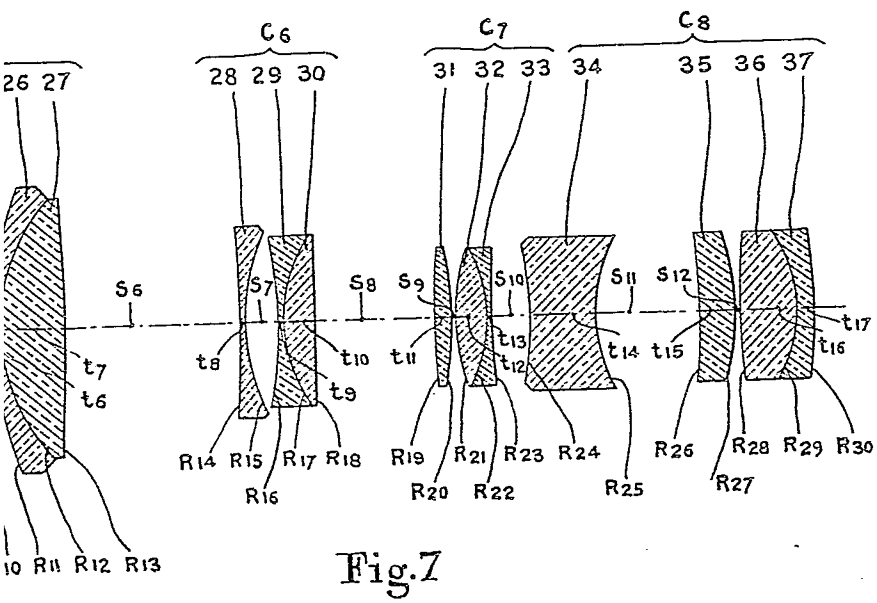


Fig. 7

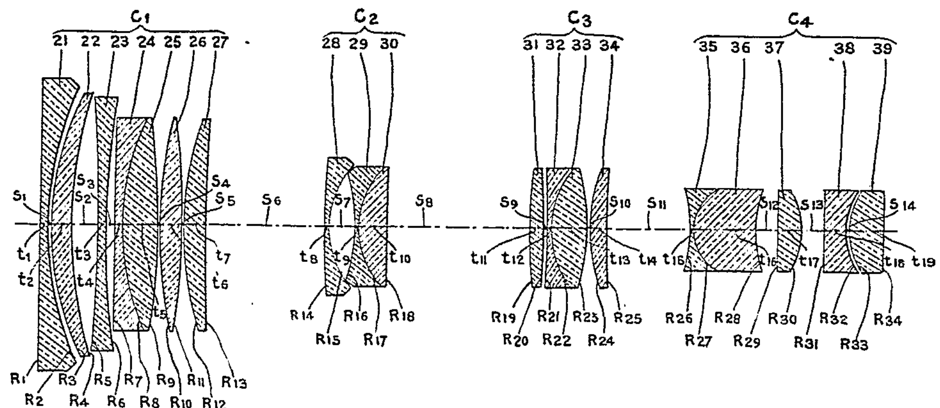


Fig. 6

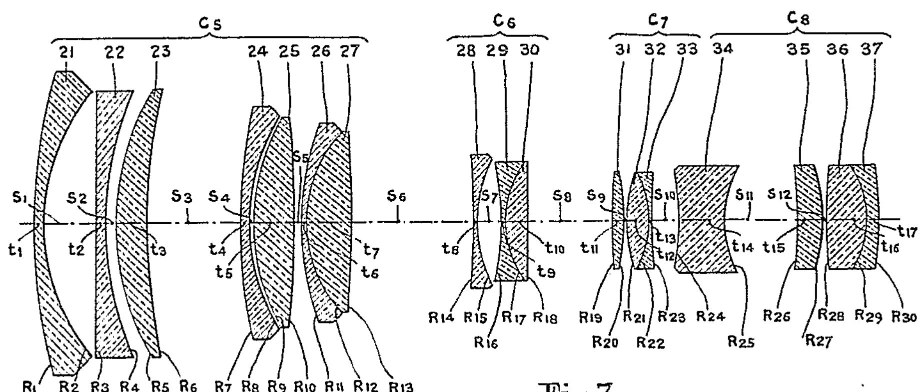
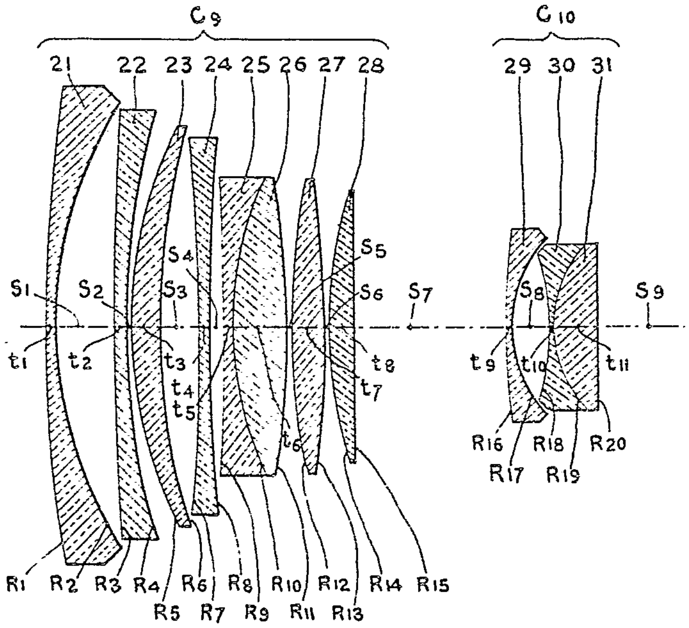


Fig. 7


C9
C10
21 22 23 24 25 26 27 28
29 30 31
S1 S2 S3 S4 S5 S6 S7 S8 S9
t1 t2 t3 t4 t5 t6 t7 t8 t9 t10 t11
R1 R2 R3 R4 R5 R6 R7 R8 R9 R10 R11 R12 R13 R14 R15
R16 R17 R18 R19 R20

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4 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 4

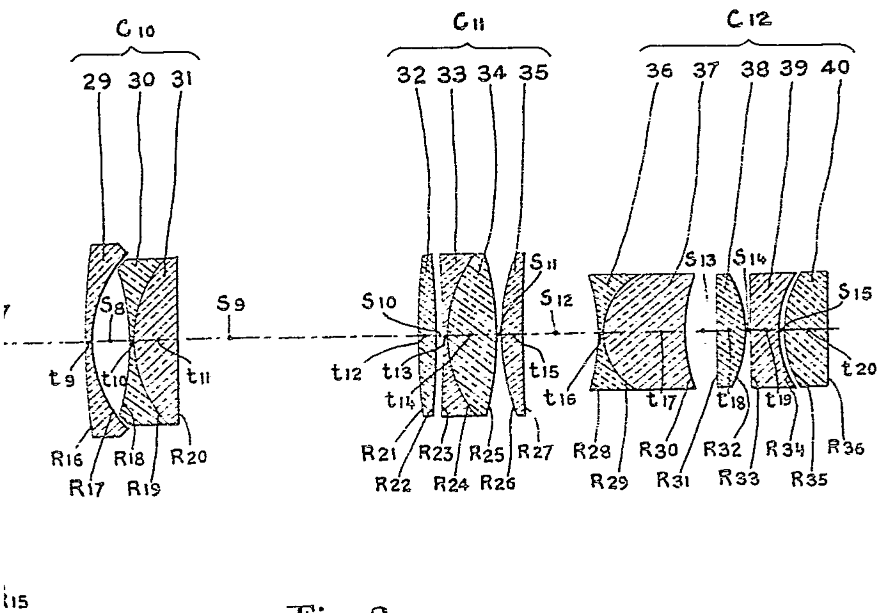

Fig.8

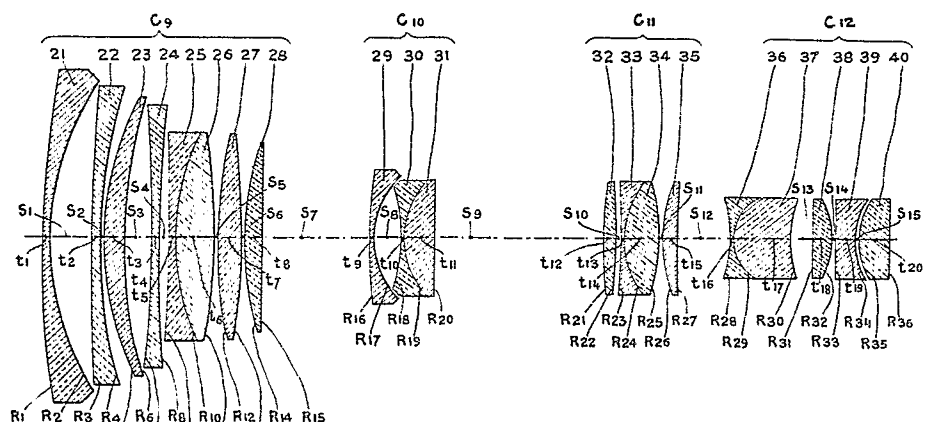

Fig. 8