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(54) **Three group zoom lens system**

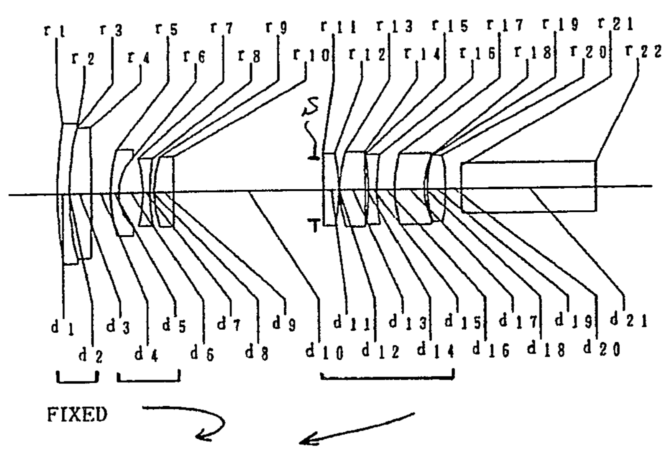
(57) A zoom lens system comprises in order from the object side, a first positive lens group r_1 - r_4, a second negative lens group r_5 - r_{10} and a third positive lens group r_{11} - r_{20}. The second lens group and the third lens group are moved along an optical axis for changing magnification and the second lens system group is moved for focusing. The system preferably satisfies the condition (h):

(h) $0.0 < \log z2/\log z < 0.3$

where

z2 is the magnification ratio (z2=m2L/m2S) of the second lens group,
m2L is a lateral magnification of the second lens group at the telescopic end,
m2S is a lateral magnification of the second lens group at the wide angle end,
z is the change ratio (z=ft/fw) of the magnification of the overall system,
ft is the focal length of the overall system at the telescopic end,
fw is the focal length of the overall system at the wide angle end.

FIG.5



GB 2 281 409 A

FIG.1

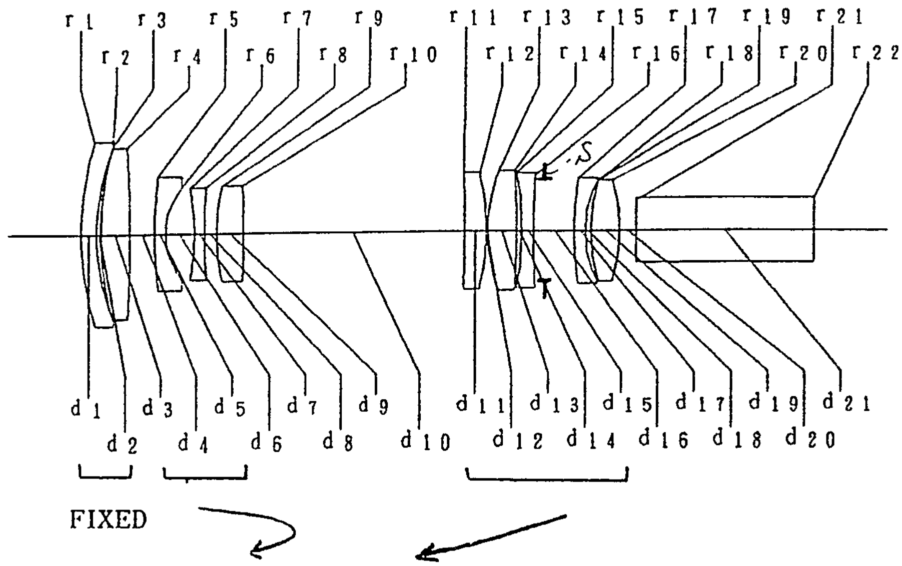

r1
r2
r3
r4
r5
r6
r7
r8
r9
r10
r11
r12
r13
r14
r15
r16
r17
r18
r19
r20
r21
r22
S
d1
d2
d3
d4
d5
d6
d7
d8
d9
d10
d11
d12
d13
d14
d15
d16
d17
d18
d19
d20
d21
FIXED

FIG.2

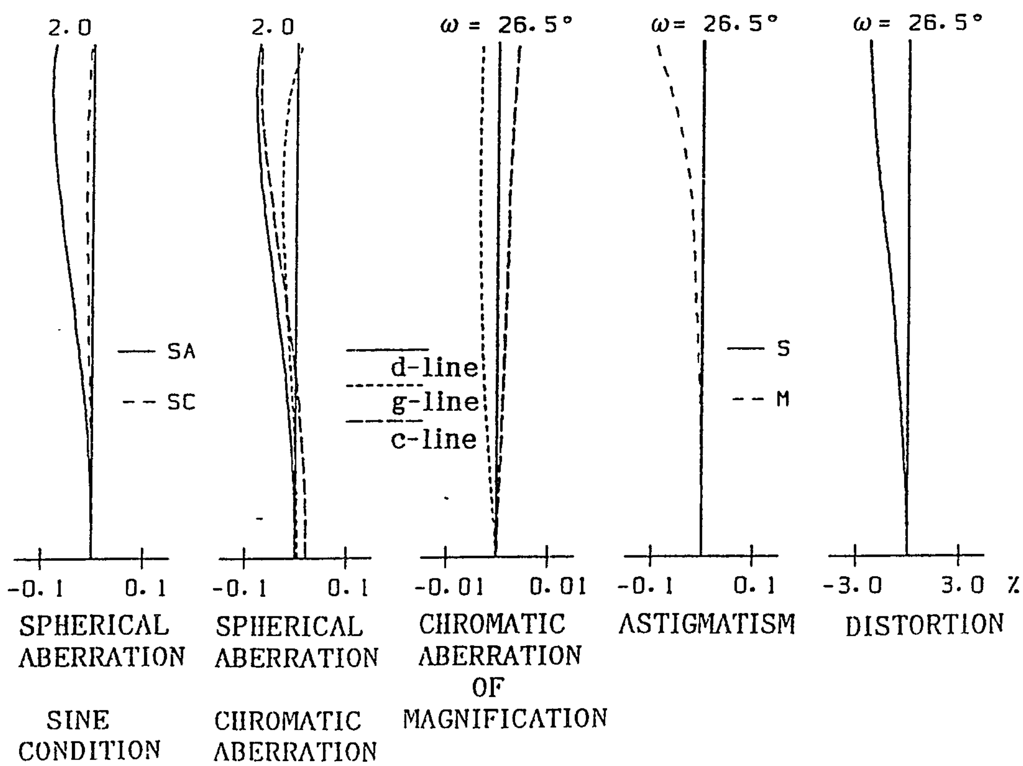

2.0
2.0
ω = 26.5°
ω= 26.5°
ω = 26.5°
SA
SC
d-line
g-line
c-line
S
M
-0.1
0.1
-0.1
0.1
-0.01
0.01
-0.1
0.1
-3.0
3.0 %
SPHERICAL ABERRATION
SPHERICAL ABERRATION
CHROMATIC ABERRATION OF MAGNIFICATION
ASTIGMATISM
DISTORTION
SINE CONDITION
CHROMATIC ABERRATION

FIG. 3

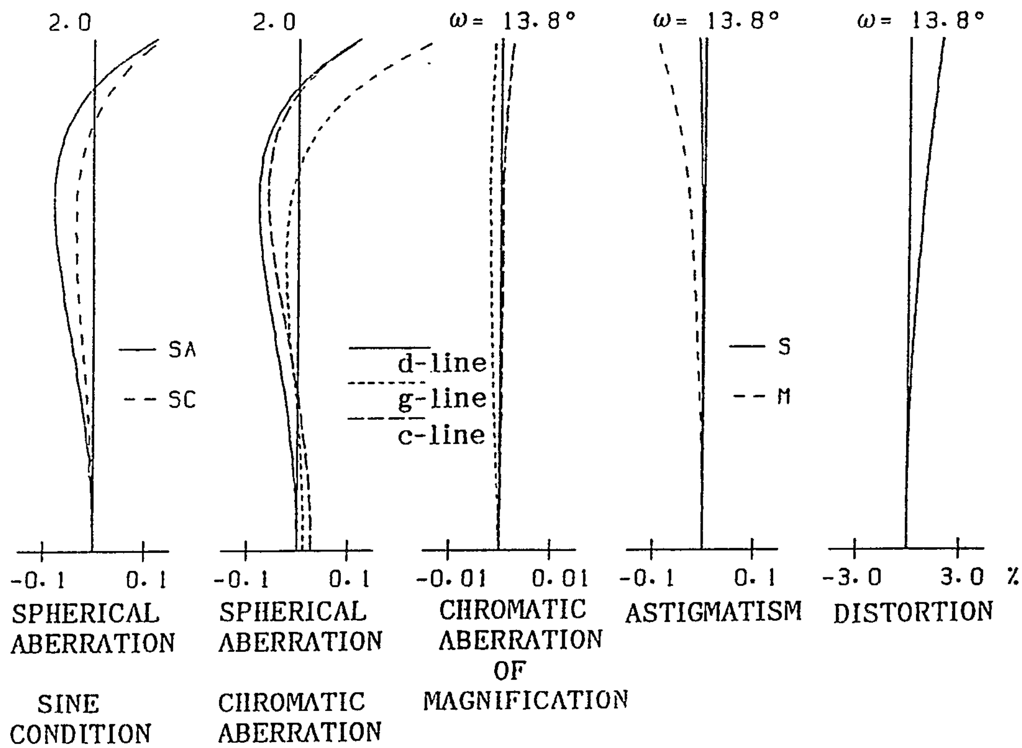

2.0
2.0
ω= 13.8°
ω= 13.8°
ω= 13.8°
SA
SC
d-line
g-line
c-line
S
M
-0.1
0.1
-0.1
0.1
-0.01
0.01
-0.1
0.1
-3.0
3.0 %
SPHERICAL ABERRATION
SINE CONDITION
SPHERICAL ABERRATION
CHROMATIC ABERRATION
CHROMATIC ABERRATION OF MAGNIFICATION
ASTIGMATISM
DISTORTION

FIG. 4

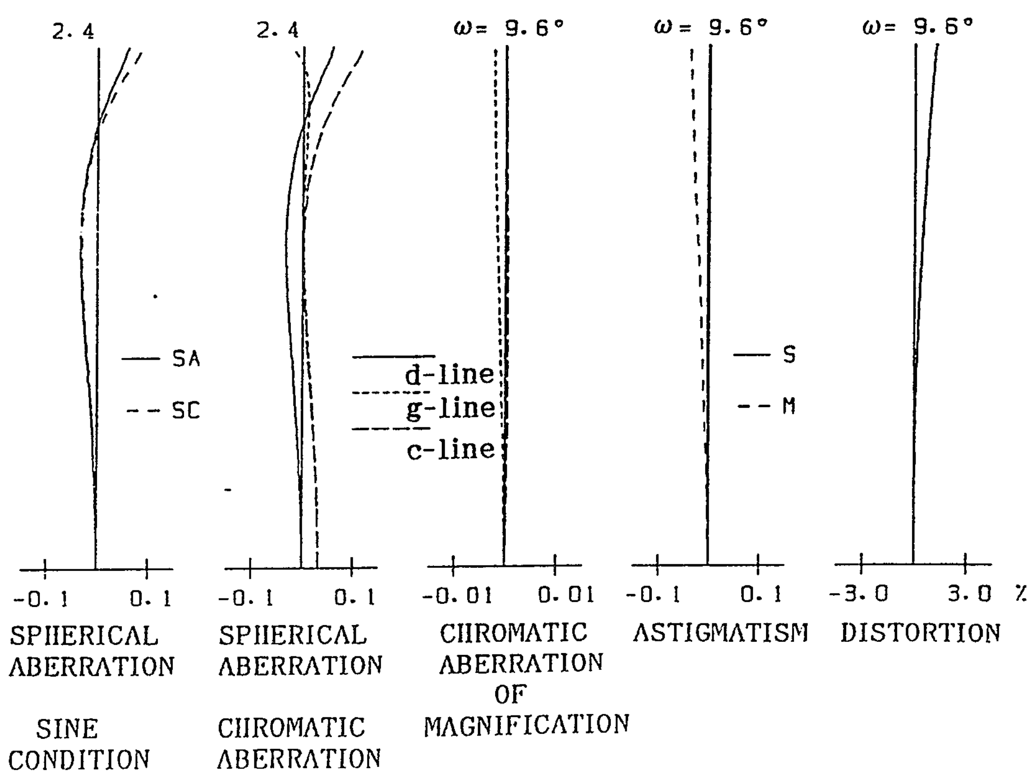

2.4
2.4
ω= 9.6°
ω= 9.6°
ω= 9.6°
SA
SC
d-line
g-line
c-line
S
M
-0.1
0.1
-0.1
0.1
-0.01
0.01
-0.1
0.1
-3.0
3.0 %
SPHERICAL ABERRATION
SINE CONDITION
SPHERICAL ABERRATION
CHROMATIC ABERRATION
CHROMATIC ABERRATION OF MAGNIFICATION
ASTIGMATISM
DISTORTION

FIG.5

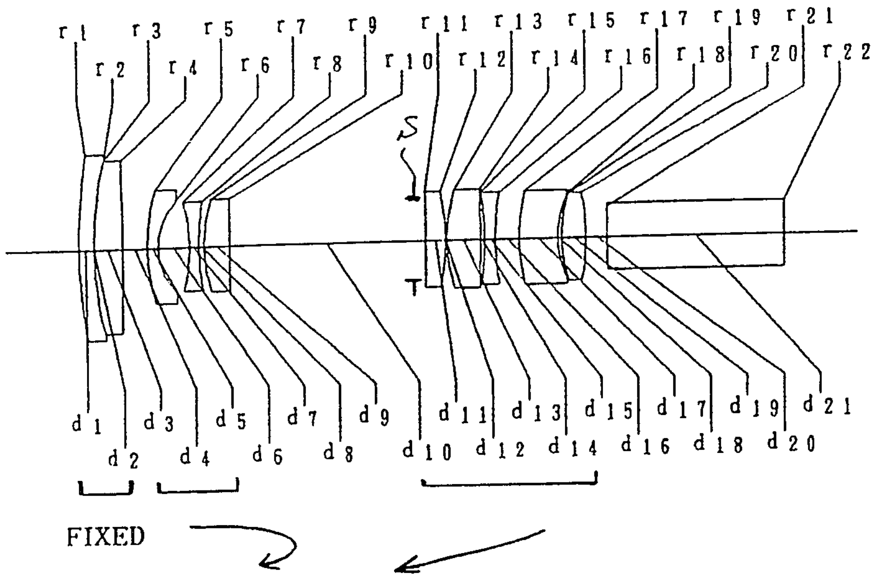

r1
r2
r3
r4
r5
r6
r7
r8
r9
r10
r11
r12
r13
r14
r15
r16
r17
r18
r19
r20
r21
r22
S
d1
d2
d3
d4
d5
d6
d7
d8
d9
d10
d11
d12
d13
d14
d15
d16
d17
d18
d19
d20
d21
FIXED

FIG.6

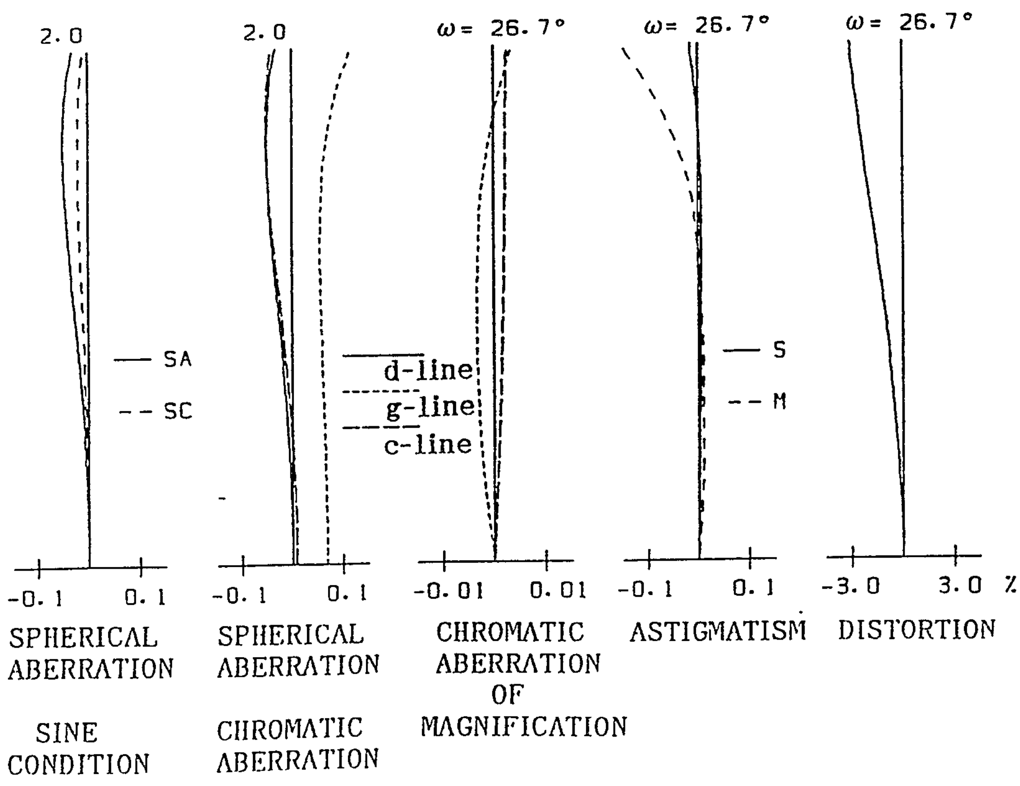

2.0
2.0
ω= 26.7°
ω= 26.7°
ω= 26.7°
SA
SC
d-line
g-line
c-line
S
M
-0.1
0.1
-0.1
0.1
-0.01
0.01
-0.1
0.1
-3.0
3.0 %
SPHERICAL ABERRATION
SINE CONDITION
SPHERICAL ABERRATION
CHROMATIC ABERRATION
CHROMATIC ABERRATION OF MAGNIFICATION
ASTIGMATISM
DISTORTION

FIG.7

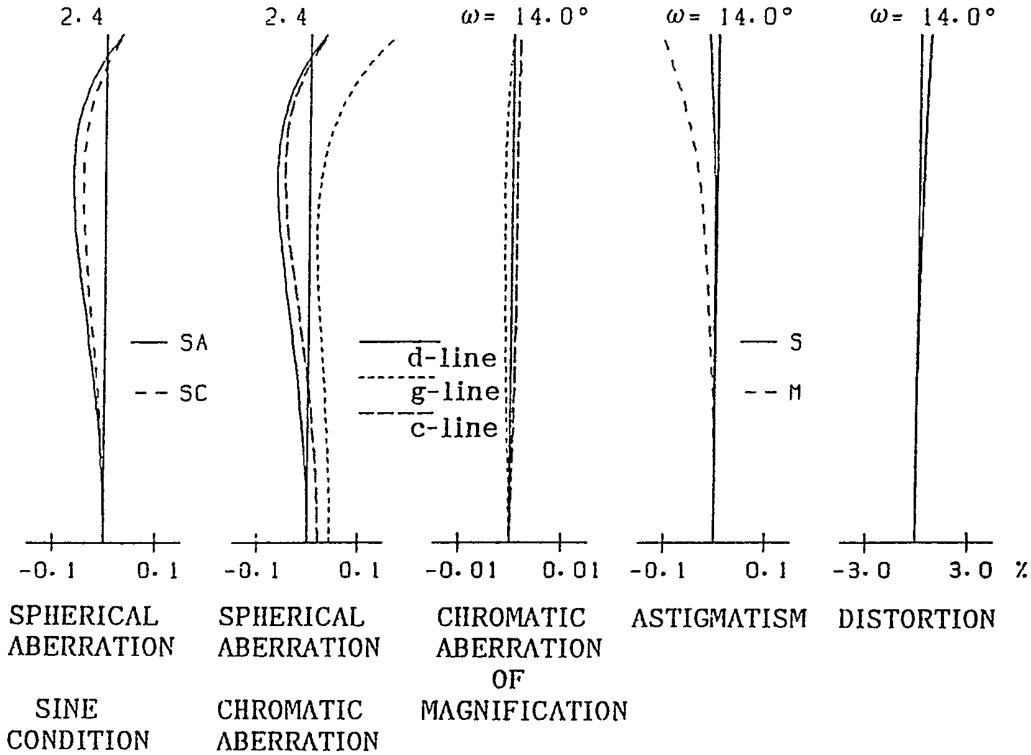

2.4
2.4
ω= 14.0°
ω= 14.0°
ω= 14.0°
— SA
-- SC
d-line
g-line
c-line
— S
-- M
-0.1 0.1
-0.1 0.1
-0.01 0.01
-0.1 0.1
-3.0 3.0 %
SPHERICAL ABERRATION
SINE CONDITION
SPHERICAL ABERRATION
CHROMATIC ABERRATION
CHROMATIC ABERRATION OF MAGNIFICATION
ASTIGMATISM
DISTORTION

FIG.8

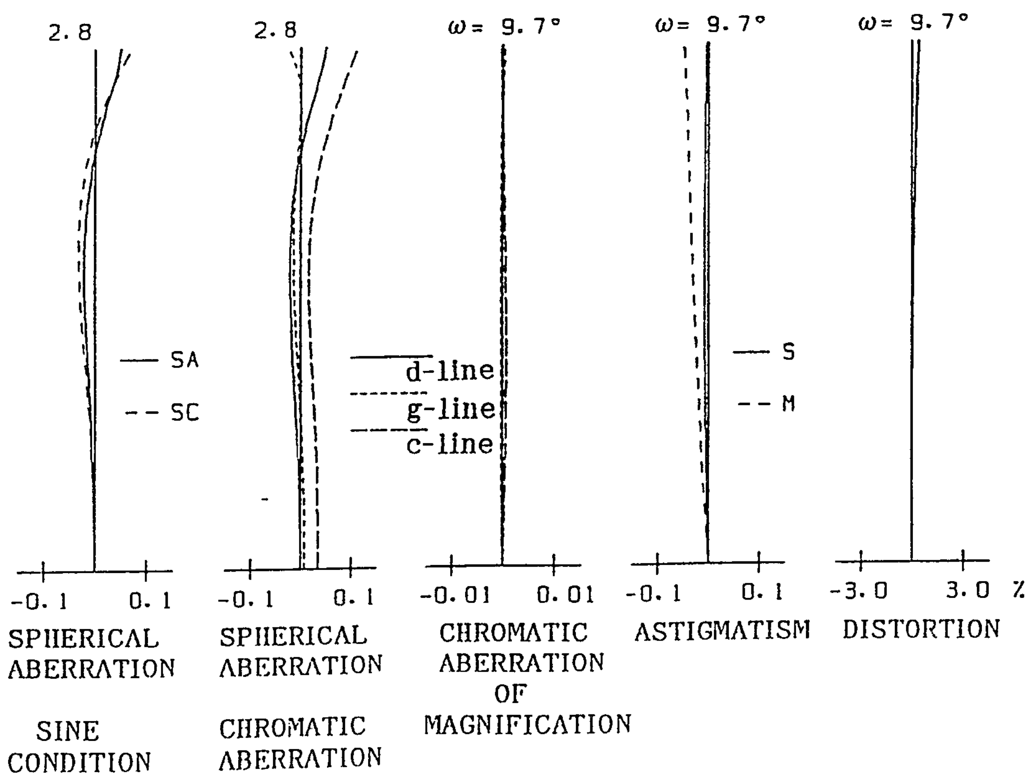

2.8
2.8
ω= 9.7°
ω= 9.7°
ω= 9.7°
— SA
-- SC
d-line
g-line
c-line
— S
-- M
-0.1 0.1
-0.1 0.1
-0.01 0.01
-0.1 0.1
-3.0 3.0 %
SPHERICAL ABERRATION
SINE CONDITION
SPHERICAL ABERRATION
CHROMATIC ABERRATION
CHROMATIC ABERRATION OF MAGNIFICATION
ASTIGMATISM
DISTORTION

FIG. 9

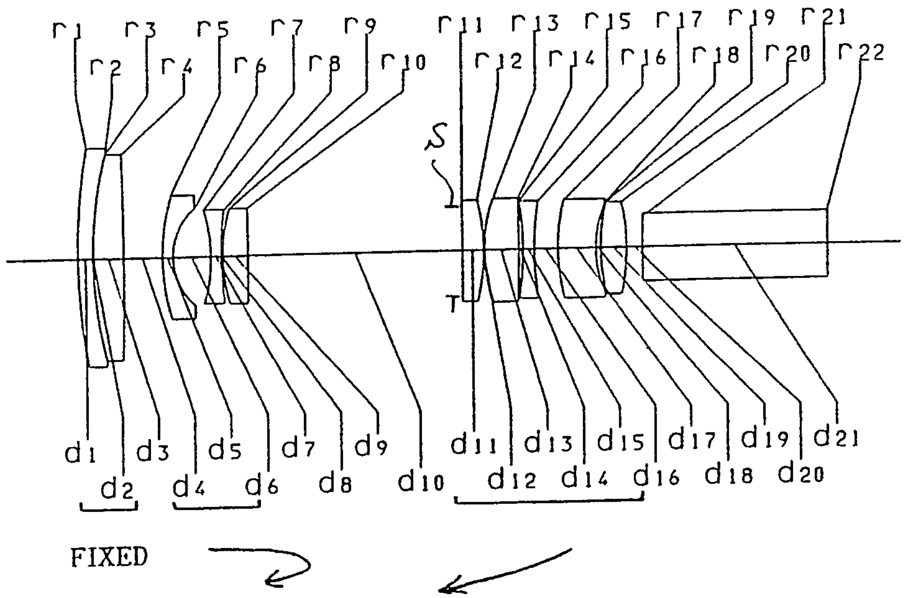

r1
r2
r3
r4
r5
r6
r7
r8
r9
r10
r11
r12
r13
r14
r15
r16
r17
r18
r19
r20
r21
r22
S
T
d1
d2
d3
d4
d5
d6
d7
d8
d9
d10
d11
d12
d13
d14
d15
d16
d17
d18
d19
d20
d21
FIXED

FIG. 10

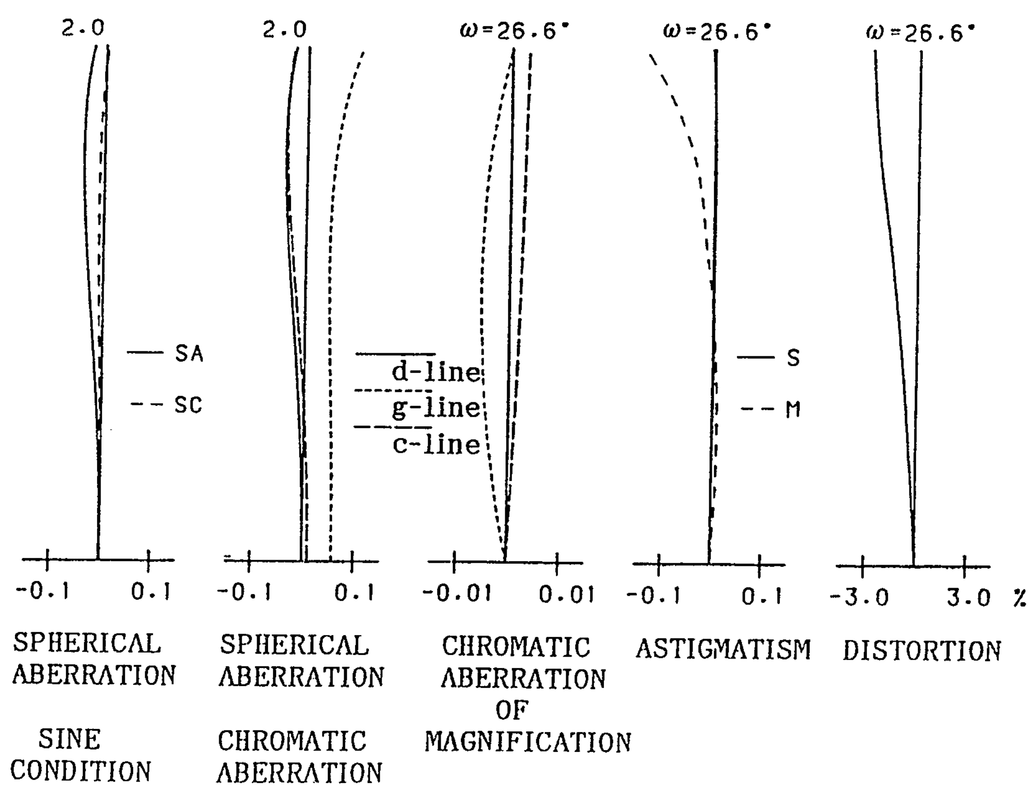

2.0
SA
SC
-0.1
0.1
SPHERICAL ABERRATION
SINE CONDITION
2.0
d-line
g-line
c-line
-0.1
0.1
SPHERICAL ABERRATION
CHROMATIC ABERRATION
ω=26.6°
-0.01
0.01
CHROMATIC ABERRATION OF MAGNIFICATION
ω=26.6°
S
M
-0.1
0.1
ASTIGMATISM
ω=26.6°
-3.0
3.0 %
DISTORTION

FIG.11

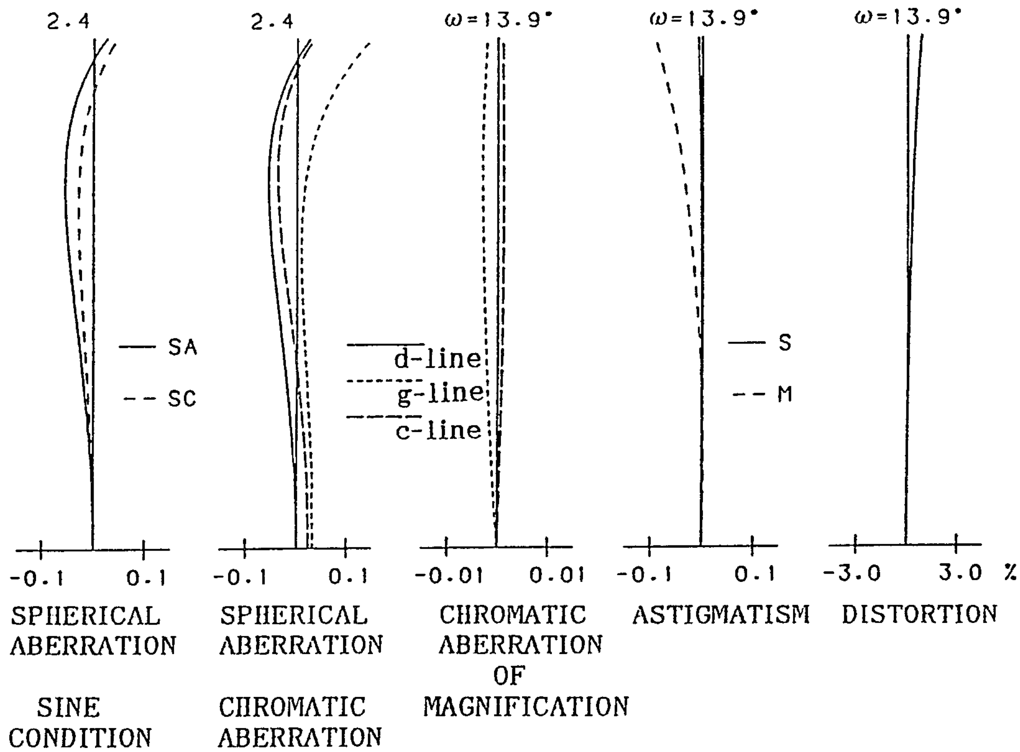

2.4
2.4
ω=13.9°
ω=13.9°
ω=13.9°
— SA
-- SC
d-line
g-line
c-line
— S
-- M
-0.1
0.1
-0.1
0.1
-0.01
0.01
-0.1
0.1
-3.0
3.0 %
SPHERICAL ABERRATION
SINE CONDITION
SPHERICAL ABERRATION
CHROMATIC ABERRATION
CHROMATIC ABERRATION OF MAGNIFICATION
ASTIGMATISM
DISTORTION

FIG.12

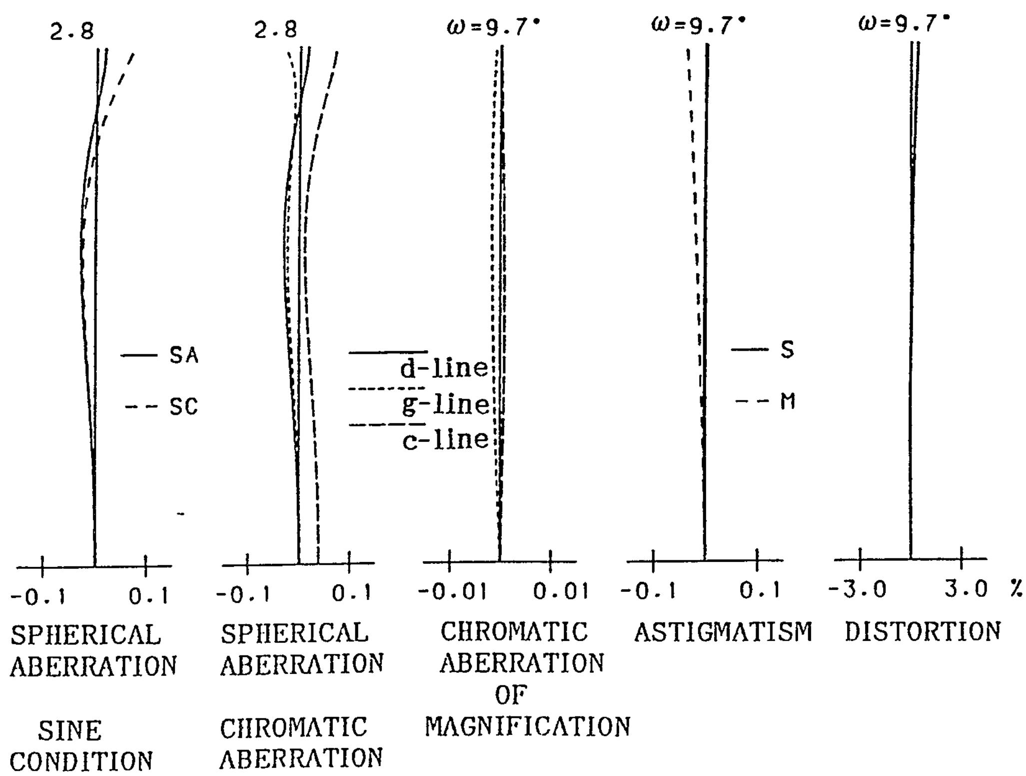

2.8
2.8
ω=9.7°
ω=9.7°
ω=9.7°
— SA
-- SC
d-line
g-line
c-line
— S
-- M
-0.1
0.1
-0.1
0.1
-0.01
0.01
-0.1
0.1
-3.0
3.0 %
SPHERICAL ABERRATION
SINE CONDITION
SPHERICAL ABERRATION
CHROMATIC ABERRATION
CHROMATIC ABERRATION OF MAGNIFICATION
ASTIGMATISM
DISTORTION

FIG. 13

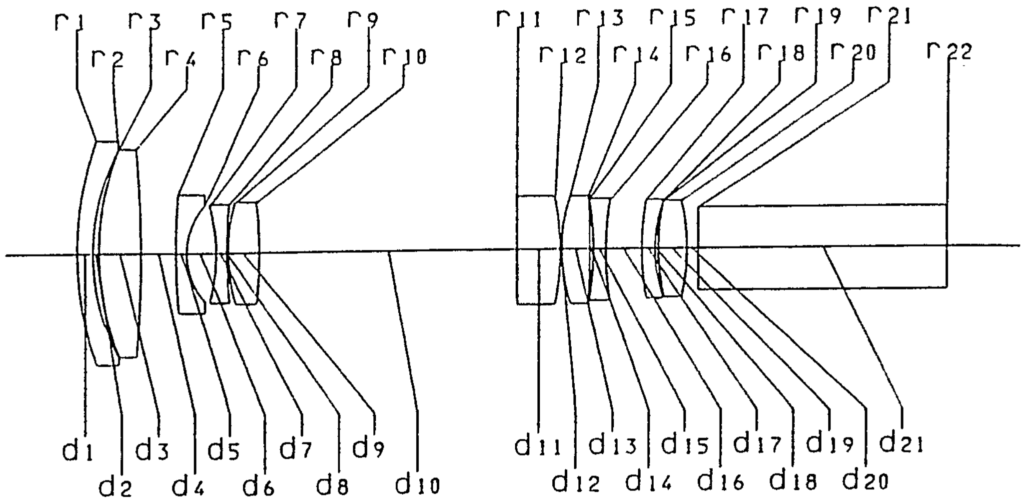

r1
r2
r3
r4
r5
r6
r7
r8
r9
r10
r11
r12
r13
r14
r15
r16
r17
r18
r19
r20
r21
r22
d1
d2
d3
d4
d5
d6
d7
d8
d9
d10
d11
d12
d13
d14
d15
d16
d17
d18
d19
d20
d21

FIG. 14

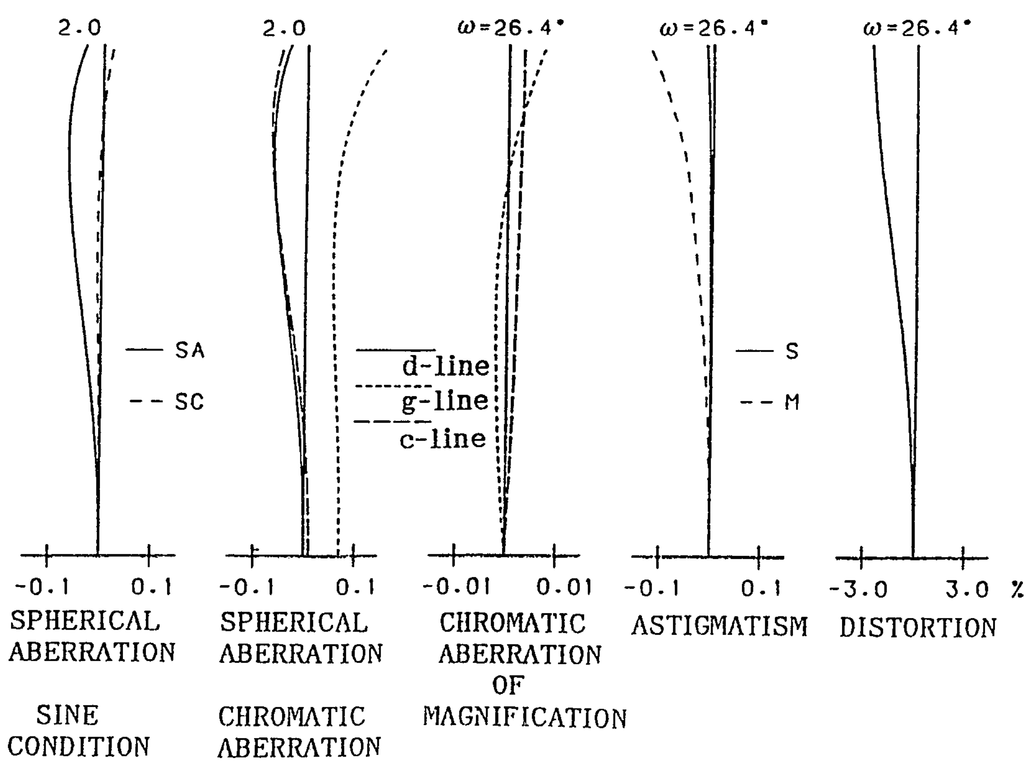

2.0
2.0
ω=26.4°
ω=26.4°
ω=26.4°
SA
SC
d-line
g-line
c-line
S
M
-0.1
0.1
-0.1
0.1
-0.01
0.01
-0.1
0.1
-3.0
3.0 %
SPHERICAL ABERRATION
SINE CONDITION
SPHERICAL ABERRATION
CHROMATIC ABERRATION
CHROMATIC ABERRATION OF MAGNIFICATION
ASTIGMATISM
DISTORTION

FIG.15

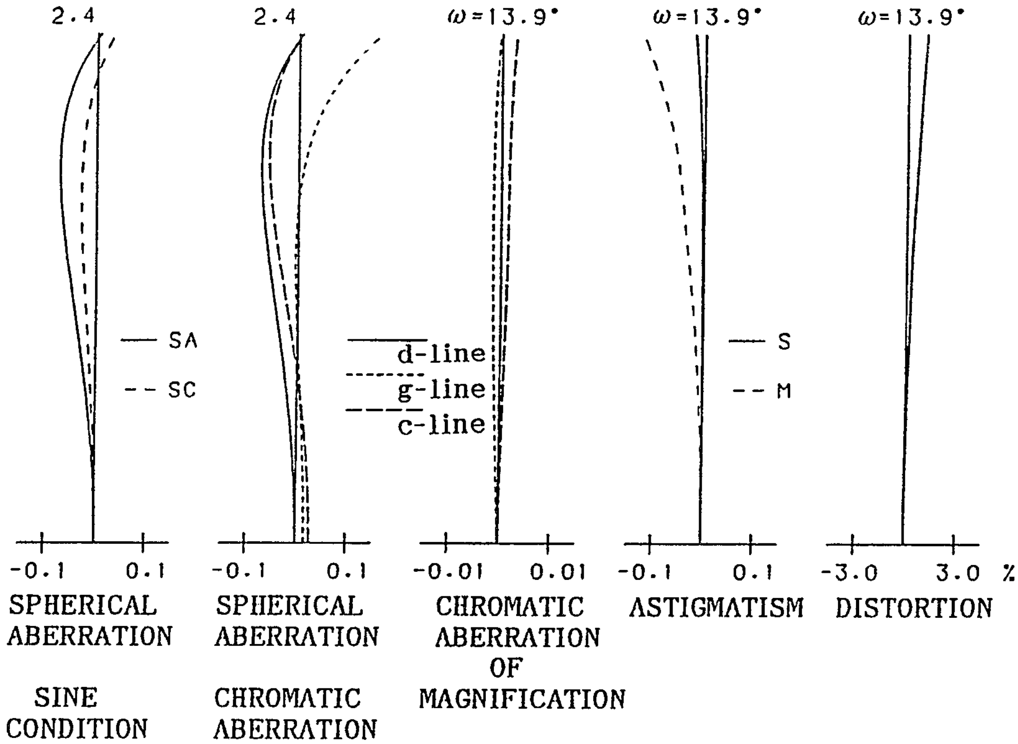

2.4
2.4
ω=13.9°
ω=13.9°
ω=13.9°
SA
SC
d-line
g-line
c-line
S
M
-0.1 0.1
-0.1 0.1
-0.01 0.01
-0.1 0.1
-3.0 3.0 %
SPHERICAL ABERRATION
SINE CONDITION
SPHERICAL ABERRATION
CHROMATIC ABERRATION
CHROMATIC ABERRATION OF MAGNIFICATION
ASTIGMATISM
DISTORTION

FIG.16

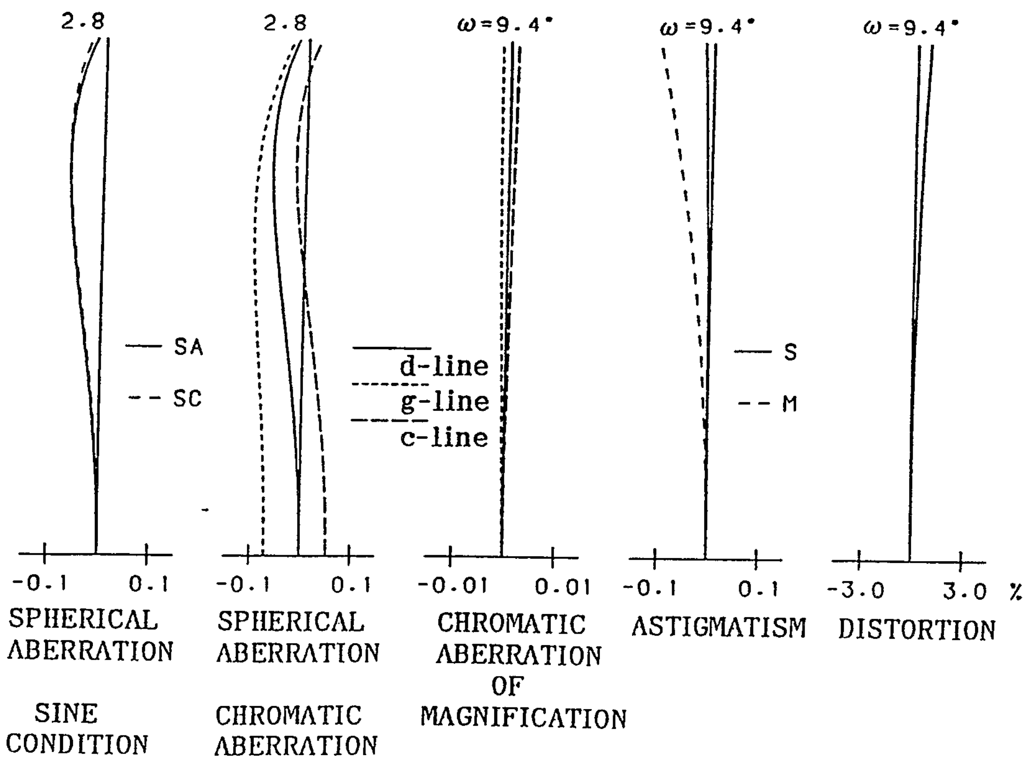

2.8
2.8
ω=9.4°
ω=9.4°
ω=9.4°
SA
SC
d-line
g-line
c-line
S
M
-0.1 0.1
-0.1 0.1
-0.01 0.01
-0.1 0.1
-3.0 3.0 %
SPHERICAL ABERRATION
SINE CONDITION
SPHERICAL ABERRATION
CHROMATIC ABERRATION
CHROMATIC ABERRATION OF MAGNIFICATION
ASTIGMATISM
DISTORTION

FIG.17

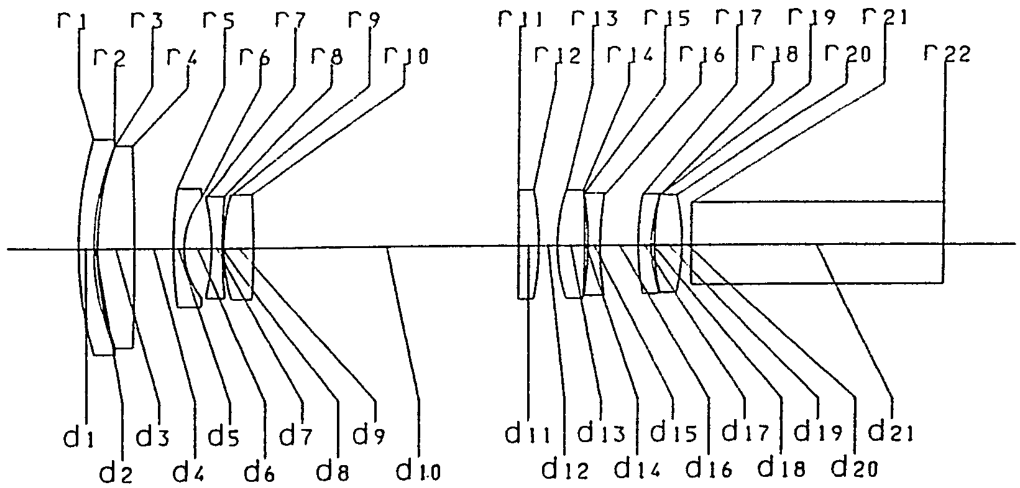

r1 r2 r3 r4 r5 r6 r7 r8 r9 r10 r11 r12 r13 r14 r15 r16 r17 r18 r19 r20 r21 r22
d1 d2 d3 d4 d5 d6 d7 d8 d9 d10 d11 d12 d13 d14 d15 d16 d17 d18 d19 d20 d21

FIG.18

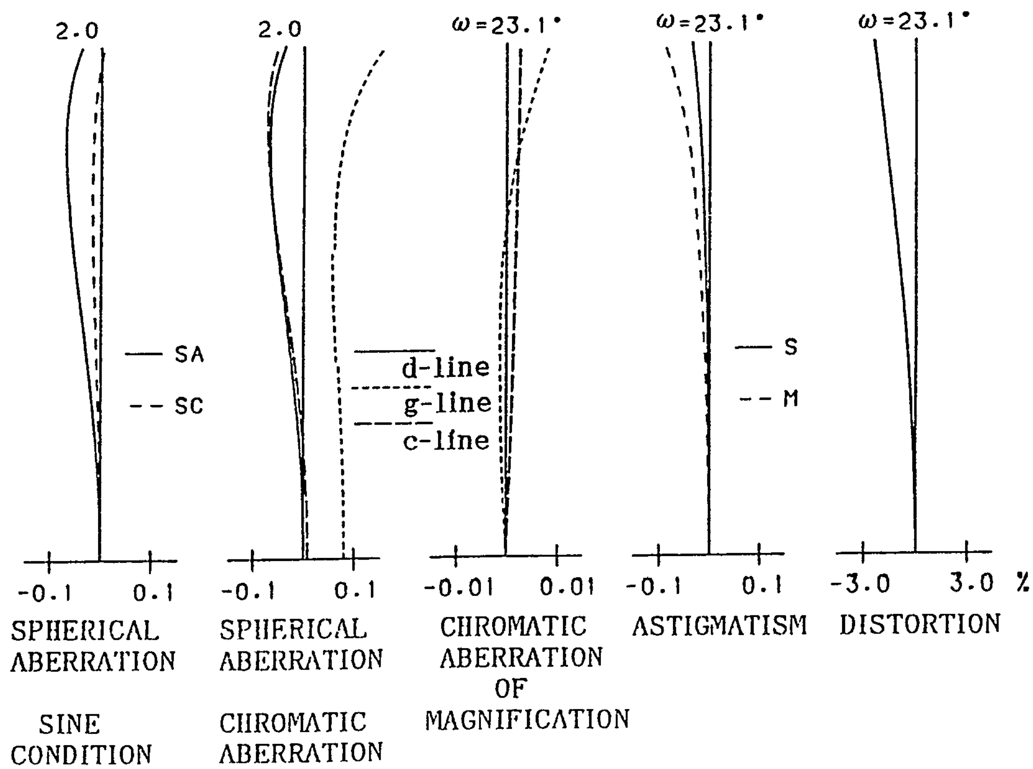

2.0
SA
SC
-0.1
0.1
SPHERICAL ABERRATION
SINE CONDITION
2.0
d-line
g-line
c-line
-0.1
0.1
SPHERICAL ABERRATION
CHROMATIC ABERRATION
ω=23.1°
-0.01
0.01
CHROMATIC ABERRATION OF MAGNIFICATION
ω=23.1°
S
M
-0.1
0.1
ASTIGMATISM
ω=23.1°
-3.0
3.0 %
DISTORTION

FIG. 19

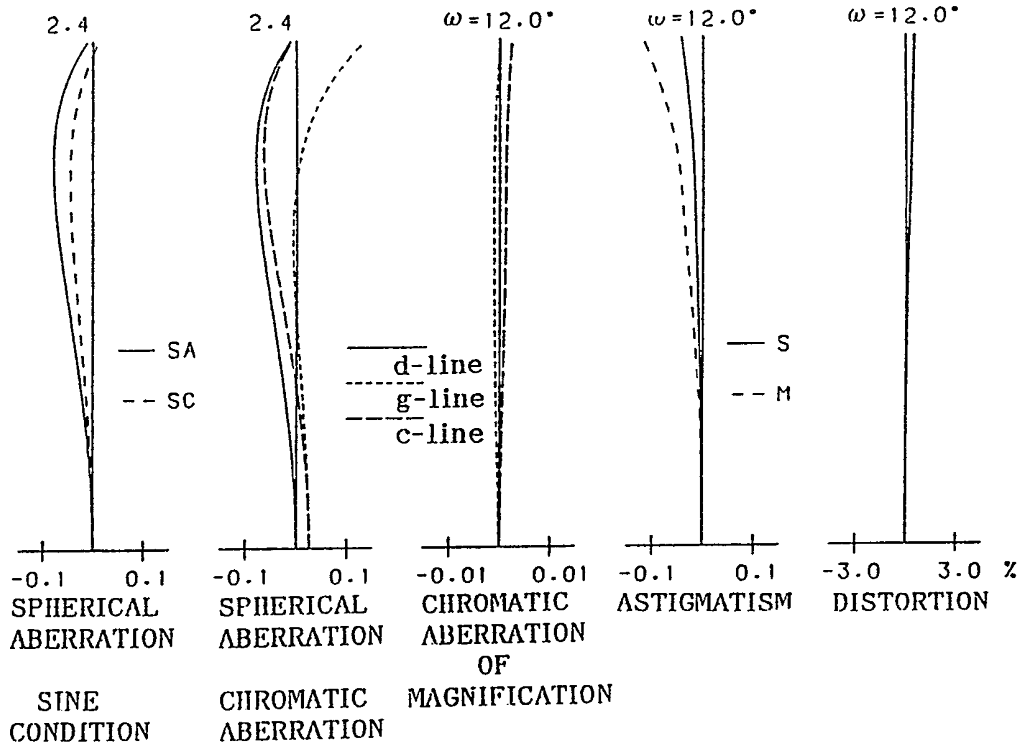
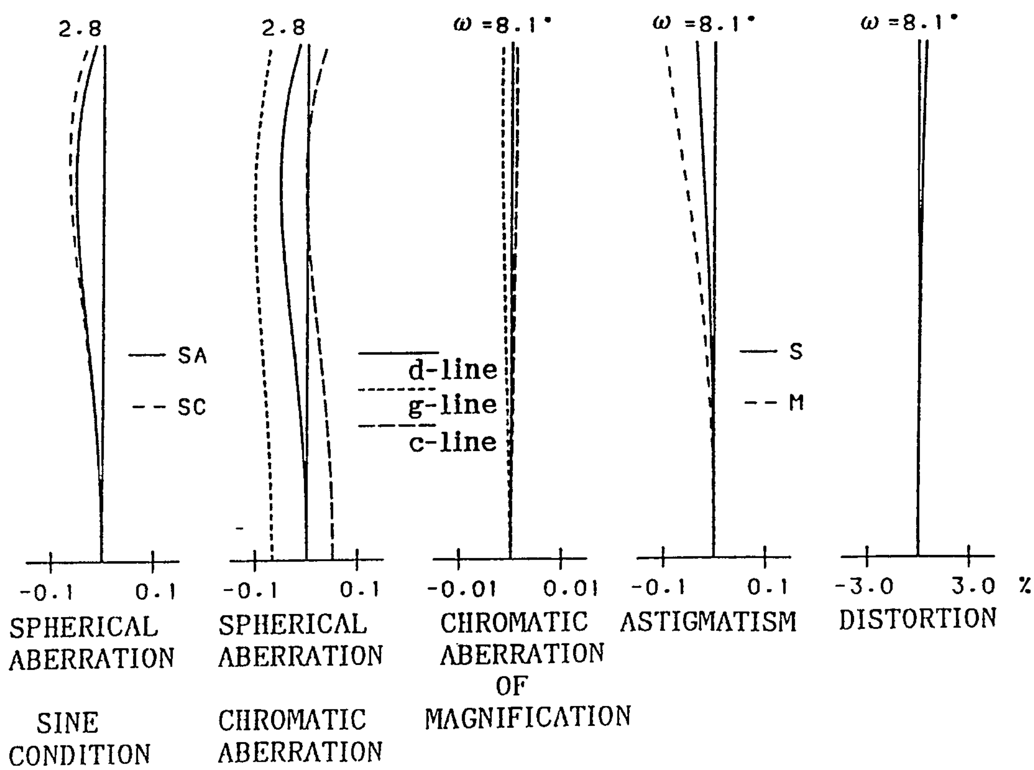

2.4
SA
SC
-0.1
0.1
SPHERICAL ABERRATION
SINE CONDITION
2.4
d-line
g-line
c-line
-0.1
0.1
SPHERICAL ABERRATION
CHROMATIC ABERRATION
ω = 12.0°
-0.01
0.01
CHROMATIC ABERRATION OF MAGNIFICATION
ω = 12.0°
S
M
-0.1
0.1
ASTIGMATISM
ω = 12.0°
-3.0
3.0 %
DISTORTION

FIG. 20


2.8
SA
SC
-0.1
0.1
SPHERICAL ABERRATION
SINE CONDITION
2.8
d-line
g-line
c-line
-0.1
0.1
SPHERICAL ABERRATION
CHROMATIC ABERRATION
ω = 8.1°
-0.01
0.01
CHROMATIC ABERRATION OF MAGNIFICATION
ω = 8.1°
S
M
-0.1
0.1
ASTIGMATISM
ω = 8.1°
-3.0
3.0 %
DISTORTION

2281409

ZOOM LENS SYSTEM

The present invention relates to a zoom lens system used for a compact video camera, an electronic still camera, or the like.

Recently, there has been developed a compact video camera and an electronic still camera which have a 1/2 inch or a 1/3 inch screen and a CCD as a light receiving element.

A taking lens used for these kinds of camera is a compact zoom lens system which has a small F-number (it is bright). A retro-focus type 2 group zoom lens system has a negative first lens group and is known as a conventional compact zoom lens system. However if the retro-focus type 2 group zoom lens system has an F number of about 1:2, the diameter of a lens of a back group becomes large. Moreover, high order spherical aberration occurs.

A 4 group zoom lens system is also known for a small F number zoom lens system. The 4 group type lens has a positive first lens group, a negative second lens group as a variable power lens, a negative third lens group as a compensator, and a positive fourth lens group as a master lens.

However, the 4 group type zoom lens system has a long overall length, and the diameter of a front side lens becomes especially large.

In a conventional three group lens system, a first lens group of a part of a third lens group (master lens group) is moved along an optical axis in order to adjust a focus.

However, when the first lens group is moved, if the minimum photography distance is to be shortened, the moving amount of the first lens and the diameter of the lens system becomes large. Moreover, when the third lens is moved, there is a large change of an aberration by focusing.

An object of the present invention is to provide a zoom lens system which is able to shorten the minimum photography distance without enlarging the diameter of the lens and to reduce the change of the aberration at the time of a focusing.

According to the present invention there is provided a zoom lens system comprising, in order from the object side, a first positive lens group, a second negative lens group and a third positive lens group, wherein said second lens group and said third lens group are moved along an optical axis for changing magnification, and wherein said second lens group is moved for focusing.

Preferably, said zoom lens system satisfies the following condition (h):

(h) $0.0 < \log z2/\log z < 0.3$

where

$z2$ is the magnification ratio ($z2=m2L/m2S$) of the second lens group,

$m2L$ is a lateral magnification of the second lens group at the telescopic end,

$m2S$ is a lateral magnification of the second lens group at the wide angle end,

z is the change ratio ($z = ft/fw$) of the magnification of the overall system,

ft is the focal length of the overall system at the telescopic end,

fw is the focal length of the overall system at the wide angle end.

Conveniently, said first lens group is fixed at the time of focusing or zooming.

Reference is made to co-pending patent application GB-A-2-262 816, from which the present application has been divided, and which concerns a zoom lens system comprising, in order from the object side, a first positive lens group, a second negative lens group and a third positive lens group, wherein at least said second lens group and said third lens group are moved along an optical axis for changing magnification, said zoom lens system satisfying the following conditions (a) - (d):

(a) $0 < fw/f1 < 0.25$

(b) $-0.9 < fw/f2 < -0.4$

(c) $0.3 < fw/f3 < 0.8$

(d) $0.7 < \log z3/\log z < 1.0$

where

fw is the focal length of the overall system at the wide angle end,

fi is the focal length (i=1, 2, 3) of the i-th lens group,

z is the change ratio (z=ft/fw) of the magnification of the overall system,

ft is the focal length of the overall system at the telescopic end,

z3 is the change ratio (z3=m3t/m3w) of the magnification of the third lens group,

m3t is a lateral magnification of the third lens group at the wide angle end,

m3w is a lateral magnification of the third lens group at the telescopic end.

Examples of the present invention will now be described with reference to the accompanying drawings, in which:-

Fig. 1 is a section through a first example of a lens embodying the present invention.

Fig. 2 is a diagram of aberrations at the wide angle end of Example 1.

Fig. 3 is a diagram of aberrations at the intermediate focal length of Example 1.

Fig. 4 is a diagram of aberrations at the telescopic end of Example 1.

Fig. 5 is a section through a second example of a lens embodying the present invention.

Fig. 6 is a diagram of aberrations at the wide angle end of Example 2.

Fig. 7 is a diagram of aberrations at the intermediate focal length of Example 2.

Fig. 8 is a diagram of aberrations at the telescopic end of Example 2.

Fig. 9 is a section through a third example of a lens embodying the present invention.

Fig. 10 is a diagram of aberrations at the wide angle end of Example 3.

Fig. 11 is a diagram of aberrations at the intermediate focal length of Example 3.

Fig. 12 is a diagram of aberrations at the telescopic end of Example 3.

Fig. 13 is a section through a fourth example of a lens embodying the present invention.

Fig. 14 is a diagram of aberrations at the wide angle end of Example 4.

Fig. 15 is a diagram of aberrations at the intermediate focal length of Example 4.

Fig. 16 is a diagram of aberrations at the telescopic end of Example 4.

Fig. 17 is a section through a fifth example of a lens embodying the present invention.

Fig. 18 is a diagram of aberrations at the wide angle end of Example 5.

Fig. 19 is a diagram of aberrations at the intermediate focal length of Example 5.

Fig. 20 is a diagram of aberrations at the telescopic end of Example 5.

The present disclosure relates to subject matter contained in Japanese patent application Nos. H3-361412 (filed on December 25, 1991) and H4-239125 (filed on September 8, 1992) which are expressly incorporated herein by reference in their entireties.

A zoom lens system of the present invention uses a new zooming method and focusing method which is like a combination of the conventional retro-focus type 2 group zoom lens system and a 4 group type zoom lens system.

The zooming methods of the present invention and the conventional 4 group type zoom system are compared below. The second and the third lens groups move in both systems. However, with the conventional system the function which mainly changes magnification is given to the second lens group, and the function which compensates focus error caused by changing of magnification is given to the third lens group.

On the other hand, in the system of the present invention, the third lens group is given the function of changing magnification and the function as a master lens. The second lens group has the auxiliary function of changing magnification, and has the function to compensate for focus error caused by changes of magnification.

The zoom lens system of the present invention is provided with, in order from the object side, a first positive lens group, a second negative lens group and a third positive lens group, wherein said second lens group and said third lens group are moved along an optical axis for changing magnification, and wherein said second lens group is moved for focusing.

It is desirable to give focusing function to the second lens group which has larger power than the first lens since if the focusing function is given to the first lens group, the light flux at the periphery of the field is insufficient.

In this case, it is desirable to satisfy the following condition (h).

(h) $0.0 < \log z2/\log z < 0.3$

where

z2 is the magnification ratio (z2=m2L/m2S) of the second lens group,

m2L is a lateral magnification of the second lens group at the telescopic end, and

m2S is a lateral magnification of the second lens group at the wide angle end.

Condition (h) specifies a magnification change function of the second lens group. By satisfying this condition, it is possible to reduce the dispersion of the lens moving amount for the focusing at each focal length.

For example, when the distance from an object to the image surface is 0.2m, the relationships between the focal length (f) and the lens moving amounts (X) of Examples 1 and 2 are shown in the following table.

f	X (Example 1)	X (Example 2)
6.15	1.14	1.01
12.0	1.51	1.22
17.5	1.57	1.21

Furthermore, in the Example 3, when the distance from an object to the image surface is 0.1m, the range of the lens moving amount X is 2.95 - 3.06, and therefore, the dispersion of the amount X can be reduced to under 0.1mm.

Another zoom lens system is provided with, in order from the object side, a first positive lens group, a second negative lens group and a third positive lens group. At least the second lens group and the third lens group are moved along an optical axis for changing magnification. This system further satisfies the following conditions:

(a) $0<fw/f1<0.25$

(b) $-0.9<fw/f2<-0.4$

(c) $0.3<fw/f3<0.8$

(d) $0.7<\log z3/\log z<1.0$.

where

fw is the focal length of the overall system at the wide angle end,

fi is the focal length (i=1, 2, 3) of the i-th lens group,

z is the change ratio (z=ft/fw) of the magnification of the overall system,

ft is the focal length of the overall system at the telescopic end,

z3 is the change ratio (z3=m3t/m3w) of the magnification of the third lens group,

m3t is a lateral magnification of the third lens group at the wide angle end, m3w is a lateral magnification of the third lens groups at the telescopic end.

Condition (a) is for determining the power of the first lens group. If the lower limit of condition (a) is exceeded, since the power of the first lens group becomes negative, the diameter of a lens of a back group becomes large and a bright zoom lens system of which the F number is about 1:2 can not be obtained. On the other hand, if the upper limit is exceeded, the positive power of the first lens group becomes large, the magnification change function of the second lens group grows, and the change of the aberration at the time of changing the magnification becomes large.

Condition (b) specifies the power of the second lens group. If the lower limit of condition (b) is exceeded, the negative power becomes large and the aberration at the time of changing the magnification is changed. On the other hand, the lens becomes large if the upper limit is exceeded.

Condition (c) specifies the power of the third lens group. If the lower limit of condition (c) is exceeded, since the power of the third lens group becomes small, the amount of movement of the third lens group for changing the magnification becomes large and the overall length of the lens becomes large. On the other hand, if the upper limit of condition (c) is exceeded, since the power becomes large, the change of the aberration at the time of changing the magnification becomes large.

Condition (d) specifies enlarging a magnification change function of the third lens group compared with the same of the second lens group. If the lower limit of the condition (d) is exceeded, the magnification change function of the second lens group grows, and correction of an aberration becomes hard. On the other hand, if the upper limit is exceeded, since only the third lens group comes to have a magnification change function, the ratio of magnification change cannot be made high.

When the zoom lens system satisfies these conditions at the same time, a compact zoom lens system of which the change ratio of magnification is about 3 times can be obtained.

In order to obtain a more compact zoom lens system, it is desirable to satisfy the following conditions (e) and (f).

(e) $-1 < m2 < 0$

(f) $m3t < -1 < m3w$

where

m2 is a lateral magnification of the second lens group from the wide angle side to a telescopic side.

Conditions (e) and (f) specify the lateral magnification of the second lens group and the third lens group. By satisfying these conditions, the direction of movement of the second lens group is changed at an intermediate focal length. Moreover, since the third lens group is moved to the side of an object corresponding to the increase in focal length, a more compact zoom lens system can be obtained.

Furthermore, in order to provide a beam splitter between the image surface and the lens, it is desirable to satisfy the following condition (g).

(g) $1.5 < fBw/fw$

where

fBw is the back focus at the end of the wide angle.

The back focus is defined as the interval between a last surface of the lens system and the image surface.

Condition (g) specifies the back focus. By satisfying this condition, two or more beam splitters can be provided between the lens and the image side.

In addition, an aperture may be disposed in front of the third lens group, or inside the third lens group. When the aperture is disposed in front of the third lens group, the diameter of the lens at the front side can be made small. Moreover, when the aperture is disposed inside the third lens group, ghosting by the image surface or a surface of the master lens can be effectively prevented.

It is also desirable to satisfy the conditions (i) and (j) in order to obtain a long back focus.

(i) $1.0 < dS/ft < 2.0$

(j) $2.1 < fBw/fw < 3.5$

where

dS is the distance between the second lens group and the third lens group.

The condition (i) specifies the distance between the second and the third lens groups. If the lower limit of the condition (i) is exceeded, the change of the aberration at the time of changing the magnification becomes large when obtaining long back focus.

If the upper limit of the condition (i) is exceeded, the overall length of the zoom lens system and the diameter of a lens of the front group becomes large.

The condition (j) specifies the back focus in a narrower range than the condition (g).

Next, some numerical examples of the invention will be described.

Example 1

Fig. 1 shows a first example illustrating the invention. Specific numerical values are shown in Tables 1 and 2.

In the tables, r is radius of curvature, d is inter-surface distance, N is refractive index, ν is Abbe number, f is focal length, fB is back focus, FNo is f-number and ω is half view angle. In the following embodiments, back focus fB is defined as the following equation.

$$fB = d20 + d21/n21$$

A plane parallel plate shown by surface numbers 21 and 22 indicates a beam splitter, which is shown in expanded form, mounted between the zoom lens system and the image surface.

Fig. 2, 3 and 4 show spherical aberration SA, sine condition SC, chromatic aberration shown by spherical aberrations in d-line (588nm), g-line (436nm) and C-line (656nm), chromatic aberration of magnification, astigmatism (S: sagittal, M: meridional) which are produced by this arrangement at the wide angle end, intermediate position and telescopic end respectively.

Table 1

Surface number	r	d	n	ν
1	28.795	1.40	1.80518	25.4
2	20.910	0.45		
3	31.730	2.69	1.69680	55.5
4	-135.229	variable		
5	45.427	1.00	1.83481	42.7
6	6.656	2.72		
7	-20.299	0.90	1.77250	49.6
8	44.075	1.11		
9	17.912	2.40	1.84666	23.8
10	-357.973	variable		
11	-311.568	2.02	1.80400	46.6
12	-23.121	0.10		
13	15.462	2.63	1.77250	49.6
14	-77.216	0.49		
15	-25.865	1.10	1.80518	25.4
16	127.915	3.67		
17	33.345	1.00	1.84666	23.8
18	10.550	0.55		
19	18.179	2.60	1.69680	55.5
20	-15.998	variable		
21	∞	16.20	1.49782	66.8
22	∞			

Table 2

FNo.	2.1	2.0	2.4
f	6.15	12.00	17.50
fB	0.00	0.00	0.00
ω	26.5	13.8	9.6
d4	2.30	10.12	11.22
d10	20.47	8.58	3.02
d20	2.01	6.09	10.54

Example 2

Fig. 5 shows a second example illustrating the invention. Specific numerical values are shown in Tables 3 and 4. Figs. 6, 7 and 8 show the aberrations produced by this arrangement at the wide angle end, intermediate position and telescopic end respectively.

Table 3

Surface number	r	d	n	ν
1	48.543	1.40	1.80518	25.4
2	32.536	0.00		
3	32.536	2.59	1.69680	55.5
4	-520.912	variable		
5	17.833	1.00	1.77250	49.6
6	5.742	2.89		
7	-15.626	0.90	1.77250	49.6
8	24.610	0.54		
9	14.675	2.30	1.84666	23.8
10	-238.854	variable		
11	-187.185	1.84	1.69680	55.5
12	-20.008	0.10		
13	13.745	3.10	1.77250	49.6
14	-145.272	0.36		
15	-26.752	1.00	1.84666	23.8
16	28.172	2.20		
17	19.509	3.50	1.80518	25.4
18	9.719	0.37		
19	14.255	2.20	1.77250	49.6
20	-17.484	variable		
21	∞	16.20	1.49782	66.8
22	∞			

Table 4

FNo.	2.0	2.4	2.8
f	6.15	12.00	17.50
fB	0.00	0.00	0.00
ω	26.7	-14.0	9.7
d4	2.30	9.00	8.78
d10	18.09	6.77	1.80
d20	1.93	6.55	11.74

Example 3

Fig. 9 shows a third example illustrating the invention. Specific numerical values are shown in Tables 5 and 6. Figs. 10, 11 and 12 show the aberrations produced by this arrangement at the wide angle end, intermediate position and telescopic end respectively.

Table 5

Surface number	r	d	n	ν
1	53.595	1.40	1.80518	25.4
2	36.114	0.00		
3	36.114	2.85	1.69680	55.5
4	-346.993	variable		
5	18.487	1.00	1.77250	49.6
6	5.744	3.46		
7	-14.666	1.00	1.77250	49.6
8	31.999	0.10		
9	14.503	2.30	1.84666	23.8
10	-319.236	variable		
11	-309.023	1.92	1.69680	55.5
12	-19.418	0.10		
13	14.518	3.10	1.77250	49.6
14	-106.483	0.36		
15	-26.562	1.00	1.84666	23.8
16	26.562	2.16		
17	17.284	3.50	1.80518	25.4
18	10.313	0.46		
19	18.044	2.40	1.77250	49.6
20	-18.044	variable		
21	∞	17.00	1.49782	66.8
22	∞			

Table 6

FNo.	2.0	2.4	2.8
f	6.15	12.00	17.50
fB	0.00	0.00	0.00
ω	26.6	13.9	9.7
d4	3.60	10.34	9.99
d10	19.58	8.05	3.00
d20	1.50	6.29	11.71

Example 4

Fig. 13 shows a fourth example illustrating the invention. Specific numerical values are shown in Tables 7 and 8. Figs. 14, 15 and 16 show the aberrations produced by this arrangement at the wide angle end, intermediate position and telescopic end respectively.

Table 7

Surface number	r	d	n	ν
1	30.068	1.40	1.80518	25.4
2	19.874	0.59		
3	25.140	3.78	1.58267	46.4
4	-107.221	variable		
5	60.319	1.00	1.83481	42.7
6	6.573	2.71		
7	-16.257	1.00	1.80400	46.6
8	45.243	0.10		
9	16.256	2.90	1.84666	23.8
10	-41.887	variable		
11	-388.257	3.90	1.74950	35.3
12	-25.427	0.10		
13	16.085	2.54	1.77250	49.6
14	-74.583	0.32		
15	-28.012	1.10	1.84666	23.8
16	28.012	3.31		
17	25.756	1.20	1.80518	25.4
18	13.011	0.34		
19	19.623	2.63	1.77250	49.6
20	-19.623	variable		
21	∞	23.00	1.49782	66.8
22	∞			

Table 8

FNo.	2.0	2.4	2.8
f	6.20	12.00	18.00
fB	0.00	0.00	0.00
ω	26.4	-13.9	9.4
d4	3.20	12.39	14.45
d10	23.88	10.72	4.06
d20	1.00	4.97	9.57

Example 5

Fig. 17 shows a fifth example illustrating the invention. Specific numerical values are shown in Tables 9 and 10. Figs. 18, 19 and 20 show the aberrations produced by this arrangement at the wide angle end, intermediate position and telescopic end respectively.

Table 9

Surface number	r	d	n	ν
1	35.284	1.39	1.80518	25.4
2	23.039	0.37		
3	27.427	3.34	1.62374	47.1
4	-248.837	variable		
5	39.943	0.99	1.83481	42.7
6	7.067	2.58		
7	-18.771	0.99	1.77250	49.6
8	49.642	0.12		
9	16.139	2.77	1.84666	23.8
10	-73.668	variable		
11	-315.129	1.87	1.69680	55.5
12	-26.062	1.71		
13	15.927	2.49	1.80610	40.9
14	-79.506	0.32		
15	-28.702	1.09	1.84666	23.8
16	28.702	3.47		
17	25.490	1.19	1.80518	25.4
18	12.854	0.33		
19	19.777	2.57	1.77250	49.6
20	-19.777	variable		
21	∞	23.00	1.49782	66.8
22	∞			

Table 10

FNo.	2.0	2.4	2.8
f	7.20	14.00	21.00
fB	0.00	0.00	0.00
ω	23.1	12.0	8.1
d4	3.57	13.77	16.15
d10	24.43	10.12	3.08
d20	0.88	4.98	9.65

The following Table 11 shows the relationship between the conditions and respective examples described hereinbefore.

Table 11

Condition	Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5
fw/f1	0.104	0.090	0.086	0.094	0.096
fw/f2	-0.62	-0.63	-0.65	-0.59	-0.58
fw/f3	0.43	0.47	0.45	0.40	0.45
logz3/logz	0.79	0.88	0.88	0.76	0.765
m2	-0.22～	-0.18～	-0.17～	-0.21～	-0.22～
	-0.28	-0.21	-0.20	-0.27	-0.29
m3w	-0.47	-0.49	-0.50	-0.45	-0.43
m3t	-1.07	-1.24	-1.25	-1.00	-0.98
fBw	12.83	12.75	12.85	16.36	16.23
fBw/fw	2.09	2.07	2.09	2.64	2.25
logz2/logz	0.21	0.12	0.12	0.24	0.235
dS/ft	1.17	0.97	1.12	1.33	1.16

CLAIMS:

1. A zoom lens system comprising, in order from the object side, a first positive lens group, a second negative lens group and a third positive lens group, wherein said second lens group and said third lens group are moved along an optical axis for changing magnification, and wherein said second lens group is moved for focusing.

2. A zoom lens system according to claim 1 wherein said zoom lens system satisfies the following condition (h):

(h) $0.0 < \log z2/\log z < 0.3$

where

z2 is the magnification ratio (z2=m2L/m2S) of the second lens group,

m2L is a lateral magnification of the second lens group at the telescopic end,

m2S is a lateral magnification of the second lens group at the wide angle end,

z is the change ratio (z = ft/fw) of the magnification of the overall system,

ft is the focal length of the overall system at the telescopic end,

fw is the focal length of the overall system at the wide angle end.

3. A zoom lens system according to claim 1 or 2 wherein said first lens group is fixed at the time of focusing or zooming.

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Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii)

Documents considered relevant following a search in respect of Claims :-
1-3

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Category	Identity of document and relevant passages		Relevant to claim(s)
X	US 4452513	(NIPPON)	1 at least
X	US 4230397	(BELL & HOWELL) see especially column 2 lines 18-20	1 at least

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