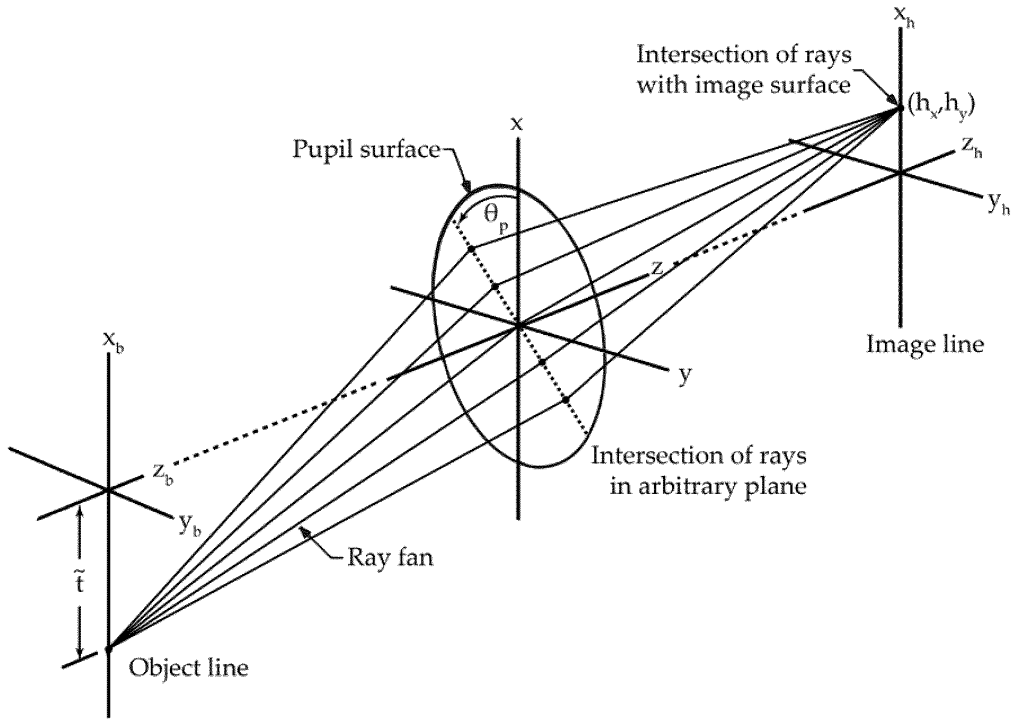
Intersection of rays
with image surface
(h_x,h_y)
x_h
z_h
y_h
Pupil surface
x
θ_p
z
y
Image line
x_b
z_b
y_b
$\tilde{t}$
Intersection of rays
in arbitrary plane
Ray fan
Object line

Fig. 1

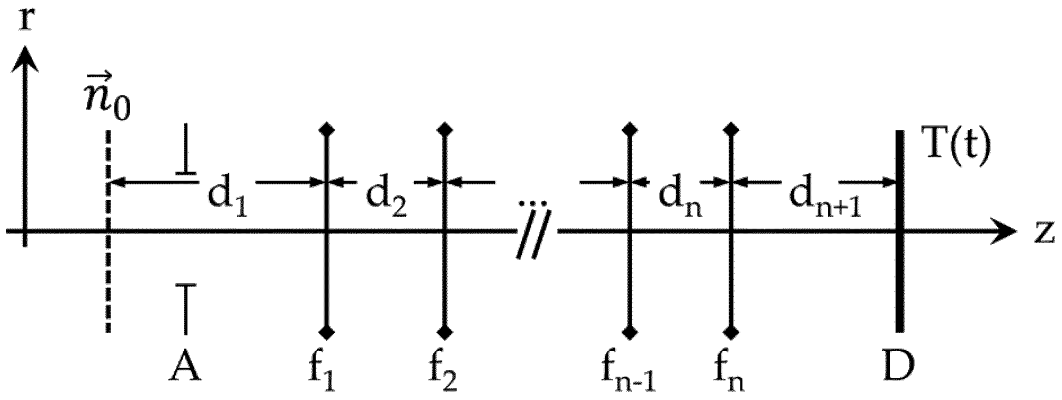
r
$\vec{n}_0$
d_1
d_2
d_n
d_{n+1}
T(t)
z
A
f_1
f_2
f_{n-1}
f_n
D

Fig. 2

$\varepsilon_{x,1}$	a	b	c	d	e	f	g	h
1		∂x		∂x^3		∂x^5		∂x^7
2	∂t		$\partial x^2 \partial t$		$\partial x^4 \partial t$		$\partial x^6 \partial t$	
3		$\partial x \partial t^2$		$\partial x^3 \partial t^2$		$\partial x^5 \partial t^2$		...
4	∂t^3		$\partial x^2 \partial t^3$		$\partial x^4 \partial t^3$		...	
5		$\partial x \partial t^4$		$\partial x^3 \partial t^4$		...		
6	∂t^5		$\partial x^2 \partial t^5$		...			
7		$\partial x \partial t^6$		...				
8	∂t^7		...					

Fig. 3

$\varepsilon_{x,2}$	a	b	c	d	e	f	g	h
1		~~∂y~~		~~∂y^3~~		~~∂y^5~~		~~∂y^7~~
2	∂t		$\partial y^2 \partial t$		$\partial y^4 \partial t$		$\partial y^6 \partial t$	
3		~~$\partial y \partial t^2$~~		~~$\partial y^3 \partial t^2$~~		~~$\partial y^5 \partial t^2$~~		...
4	∂t^3		$\partial y^2 \partial t^3$		$\partial y^4 \partial t^3$		...	
5		~~$\partial y \partial t^4$~~		~~$\partial y^3 \partial t^4$~~		...		
6	∂t^5		$\partial y^2 \partial t^5$		...			
7		~~$\partial y \partial t^6$~~		...				
8	∂t^7		...					

Fig. 4

$\varepsilon_{y,2}$	a	b	c	d	e	f	g	h
1		∂y		∂y^3		∂y^5		∂y^7
2	~~∂t~~		~~$\partial y^2 \partial t$~~		~~$\partial y^4 \partial t$~~		~~$\partial y^6 \partial t$~~	
3		$\partial y \partial t^2$		$\partial y^3 \partial t^2$		$\partial y^5 \partial t^2$		...
4	~~∂t^3~~		~~$\partial y^2 \partial t^3$~~		~~$\partial y^4 \partial t^3$~~		...	
5		$\partial y \partial t^4$		$\partial y^3 \partial t^4$		...		
6	~~∂t^5~~		~~$\partial y^2 \partial t^5$~~		...			
7		$\partial y \partial t^6$		...				
8	~~∂t^7~~		...					

Fig. 5

$\varepsilon_{x,3}$	a	b	c	d	e	f	g	h
1		∂q_3		∂q_3^3		∂q_3^5		∂q_3^7
2	∂t		$\partial q_3^2 \partial t$		$\partial q_3^4 \partial t$		$\partial q_3^6 \partial t$	
3		$\partial q_3 \partial t^2$		$\partial q_3^3 \partial t^2$		$\partial q_3^5 \partial t^2$		$\partial q_3^7 \partial t^2$
4	∂t^3		$\partial q_3^2 \partial t^3$		$\partial q_3^4 \partial t^3$		$\partial q_3^6 \partial t^3$	
5		$\partial q_3 \partial t^4$		$\partial q_3^3 \partial t^4$		$\partial q_3^5 \partial t^4$		...
6	∂t^5		$\partial q_3^2 \partial t^5$		$\partial q_3^4 \partial t^5$		...	
7		$\partial q_3 \partial t^6$		$\partial q_3^3 \partial t^6$		...		
8	∂t^7		$\partial q_3^3 \partial t^4$		...			

Fig. 6

$\varepsilon_{y,3}$	a	b	c	d	e	f	g	h
1		∂q_3		∂q_3^3		∂q_3^5		∂q_3^7
2	~~∂t~~		$\partial q_3^2 \partial t$		$\partial q_3^4 \partial t$		$\partial q_3^6 \partial t$	
3		$\partial q_3 \partial t^2$		$\partial q_3^3 \partial t^2$		$\partial q_3^5 \partial t^2$		$\partial q_3^7 \partial t^2$
4	~~∂t^3~~		$\partial q_3^2 \partial t^3$		$\partial q_3^4 \partial t^3$		$\partial q_3^6 \partial t^3$	
5		$\partial q_3 \partial t^4$		$\partial q_3^3 \partial t^4$		$\partial q_3^5 \partial t^4$		$\partial q_3^7 \partial t^4$
6	~~∂t^5~~		$\partial q_3^2 \partial t^5$		$\partial q_3^4 \partial t^5$		$\partial q_3^6 \partial t^5$	
7		$\partial q_3 \partial t^6$		$\partial q_3^3 \partial t^6$		$\partial q_3^5 \partial t^6$		...
8	~~∂t^7~~		$\partial q_3^3 \partial t^4$		$\partial q_3^4 \partial t^7$		...	

Fig. 7

$\varepsilon_{x,y,2}$	a	b	c	d	e	f	g	h
1		∂y		∂y^3		∂y^5		∂y^7
2	∂t		$\partial y^2 \partial t$		$\partial y^4 \partial t$		$\partial y^6 \partial t$	
3		$\partial y \partial t^2$		$\partial y^3 \partial t^2$		$\partial y^5 \partial t^2$		...
4	∂t^3		$\partial y^2 \partial t^3$		$\partial y^4 \partial t^3$		...	
5		$\partial y \partial t^4$		$\partial y^3 \partial t^4$		...		
6	∂t^5		$\partial y^2 \partial t^5$		...			
7		$\partial y \partial t^6$		...				
8	∂t^7		...					

Fig. 8

$\varepsilon_{x,y,p}$	a	b	c	d	e	f	g	h	
1		∂q_p		∂q_p^3		∂q_p^5		∂q_p^7	$\epsilon_{x,1}$
2	∂t		$\partial q_p^2 \partial t$		$\partial q_p^4 \partial t$		$\partial q_p^6 \partial t$		
3		$\partial q_p \partial t^2$		$\partial q_p^3 \partial t^2$		$\partial q_p^5 \partial t^2$		$\partial q_p^7 \partial t^2$	$\epsilon_{x,y,2}$
4	∂t^3		$\partial q_p^2 \partial t^3$		$\partial q_p^4 \partial t^3$		$\partial q_p^6 \partial t^3$		
5		$\partial q_p \partial t^4$		$\partial q_p^3 \partial t^4$		$\partial q_p^5 \partial t^4$		$\partial q_p^7 \partial t^4$	$\epsilon_{x,3}$
6	∂t^5		$\partial q_p^2 \partial t^5$		$\partial q_p^4 \partial t^5$		$\partial q_p^6 \partial t^5$		
7		$\partial q_p \partial t^6$		$\partial q_p^3 \partial t^6$		$\partial q_p^5 \partial t^6$		$\partial q_p^7 \partial t^6$	$\epsilon_{y,3}$
8	∂t^7		$\partial q_p^2 \partial t^7$		$\partial q_p^4 \partial t^7$		$\partial q_p^6 \partial t^7$		

Fig. 9

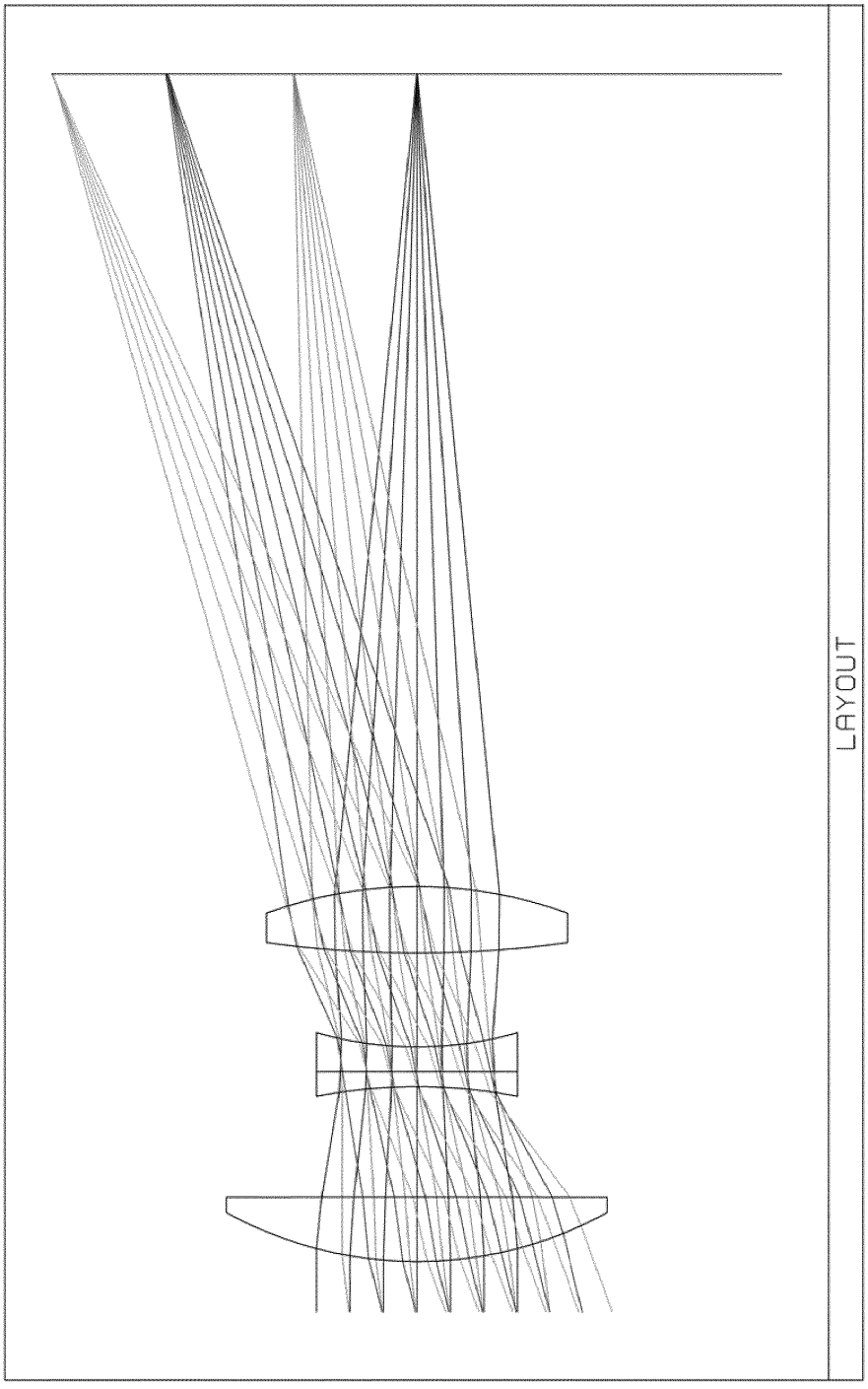

Fig. 10

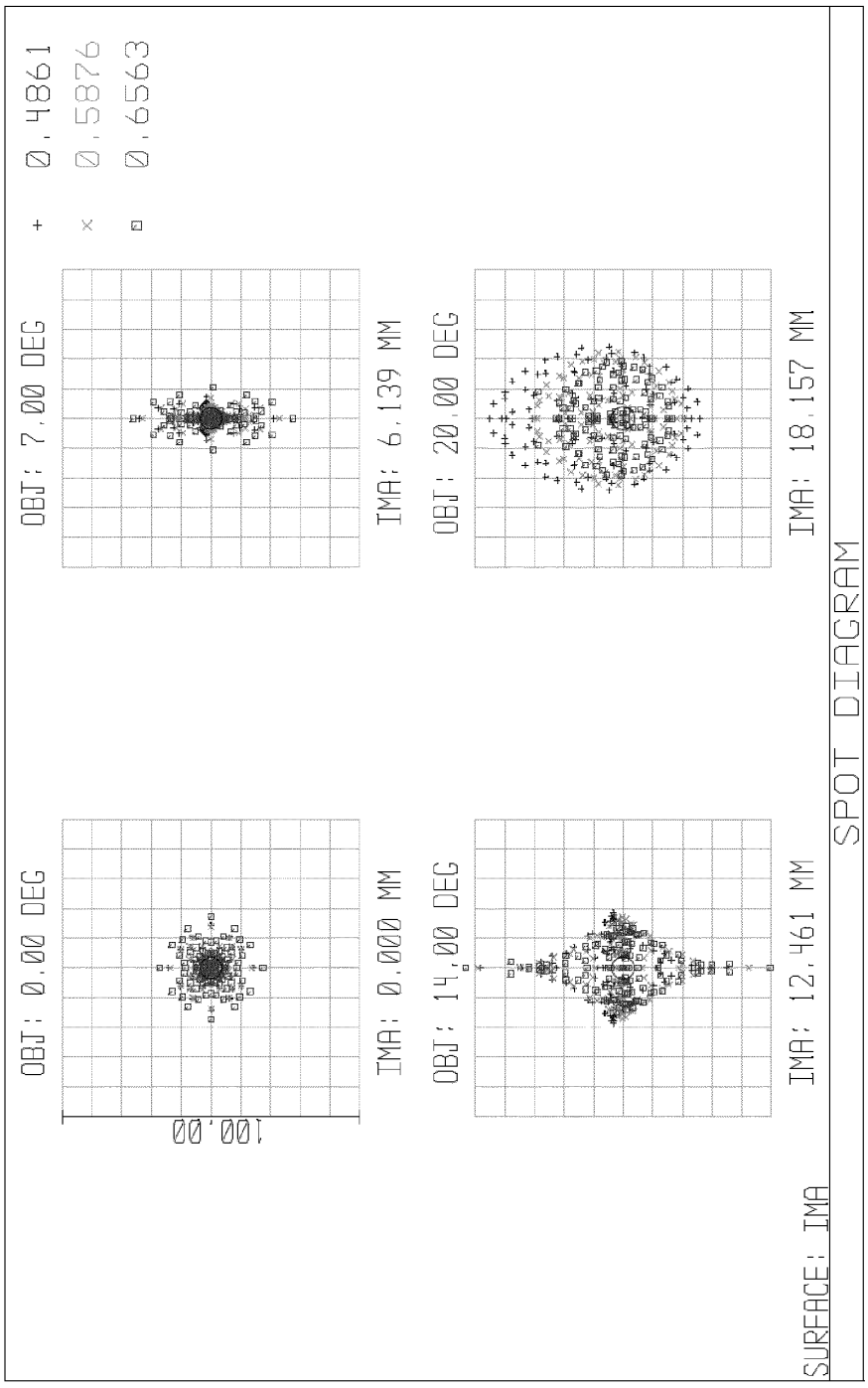
SPOT DIAGRAM
SURFACE: IMA
OBJ: 0.00 DEG
IMA: 0.000 MM
OBJ: 7.00 DEG
IMA: 6.139 MM
OBJ: 14.00 DEG
IMA: 12.461 MM
OBJ: 20.00 DEG
IMA: 18.157 MM
100.00
+ 0.4861
× 0.5876
□ 0.6563

Fig. 11

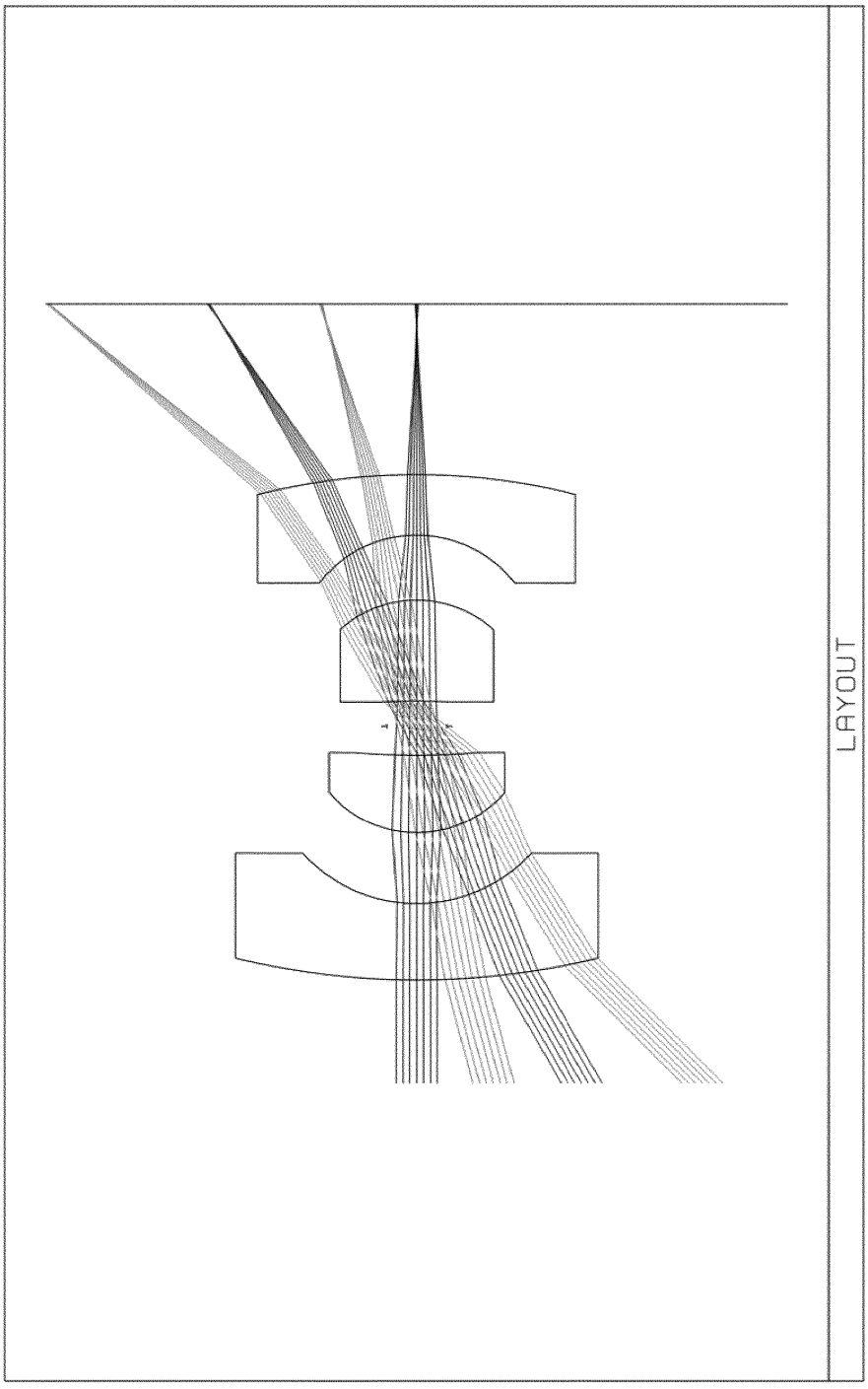

Fig. 12

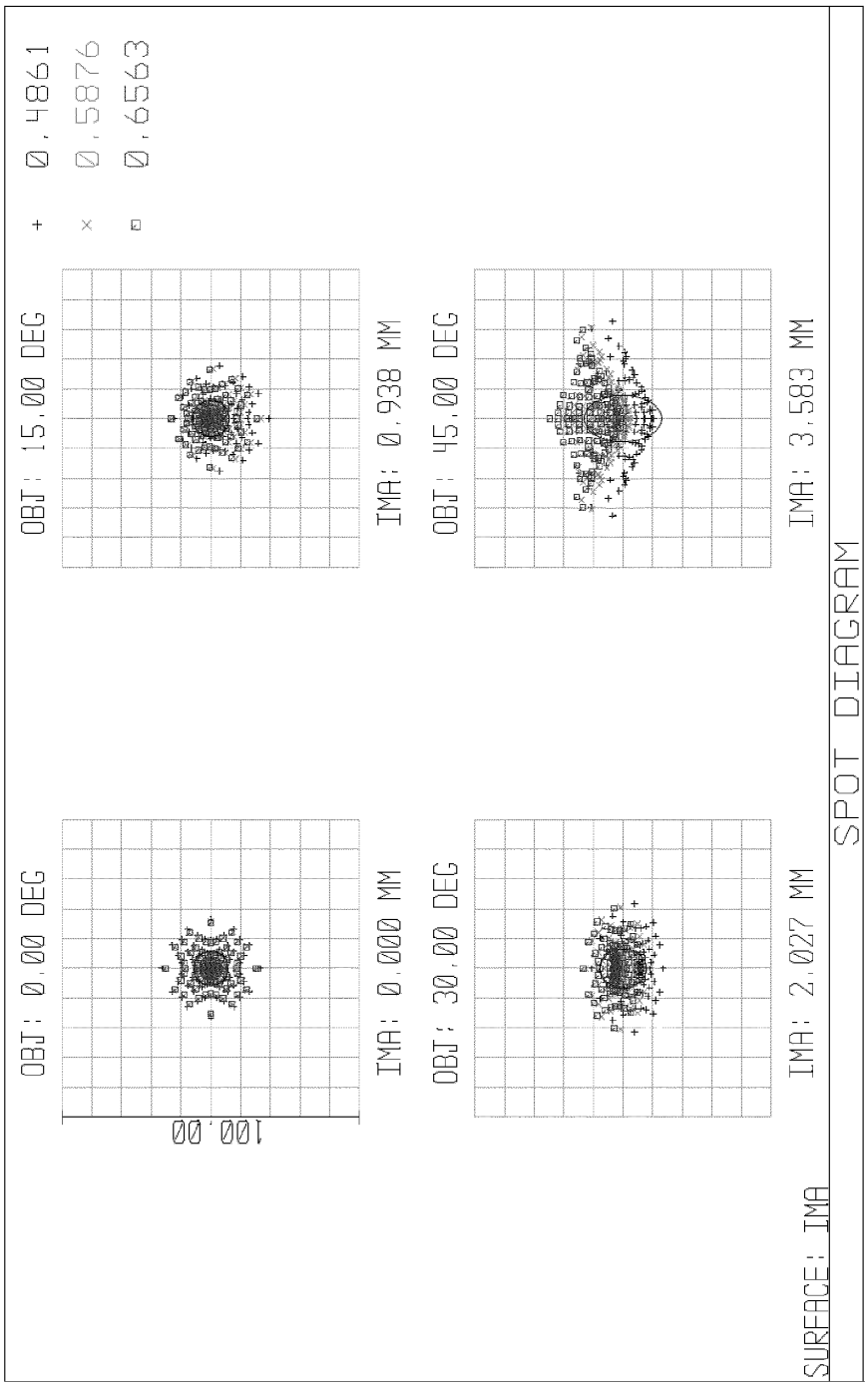
SPOT DIAGRAM
SURFACE: IMA
OBJ: 0.00 DEG
IMA: 0.000 MM
OBJ: 15.00 DEG
IMA: 0.938 MM
OBJ: 30.00 DEG
IMA: 2.027 MM
OBJ: 45.00 DEG
IMA: 3.583 MM
100.00
+ 0.4861
× 0.5876
□ 0.6563

Fig. 13

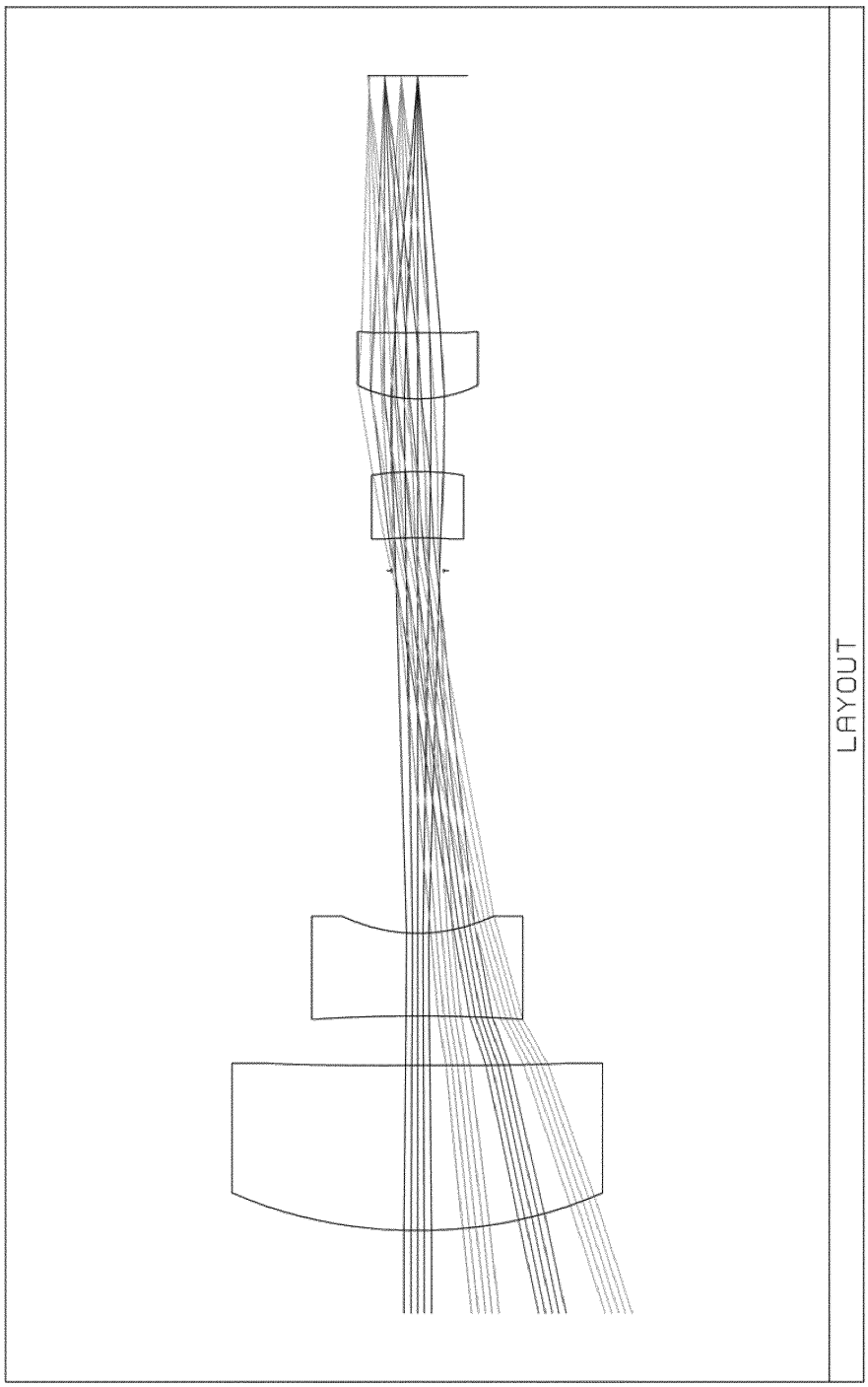

Fig. 14

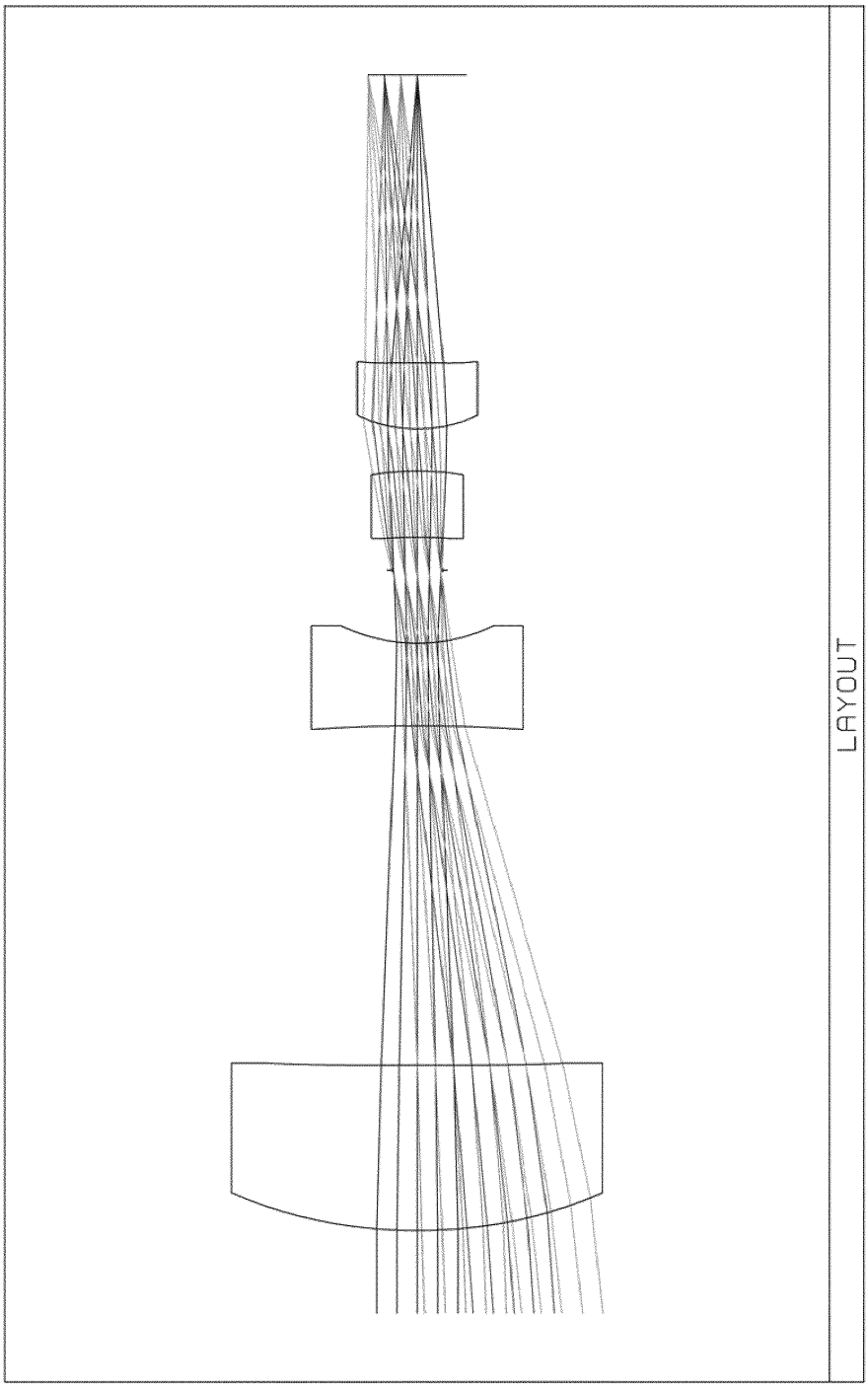

Fig. 15

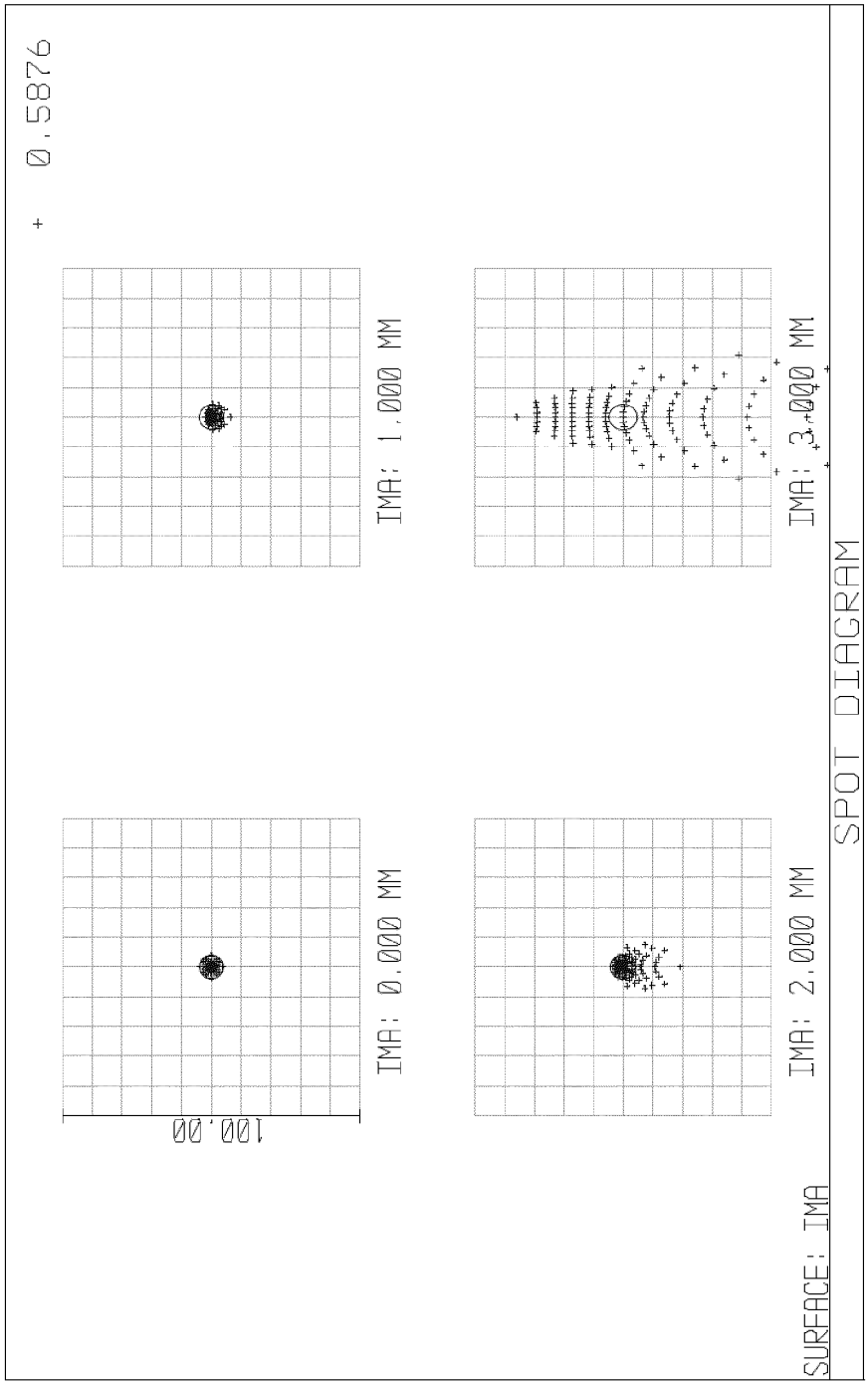
+ 0.5876
IMA: 1.000 MM
IMA: 3.000 MM
IMA: 0.000 MM
IMA: 2.000 MM
100.00
SURFACE: IMA
SPOT DIAGRAM

Fig. 16

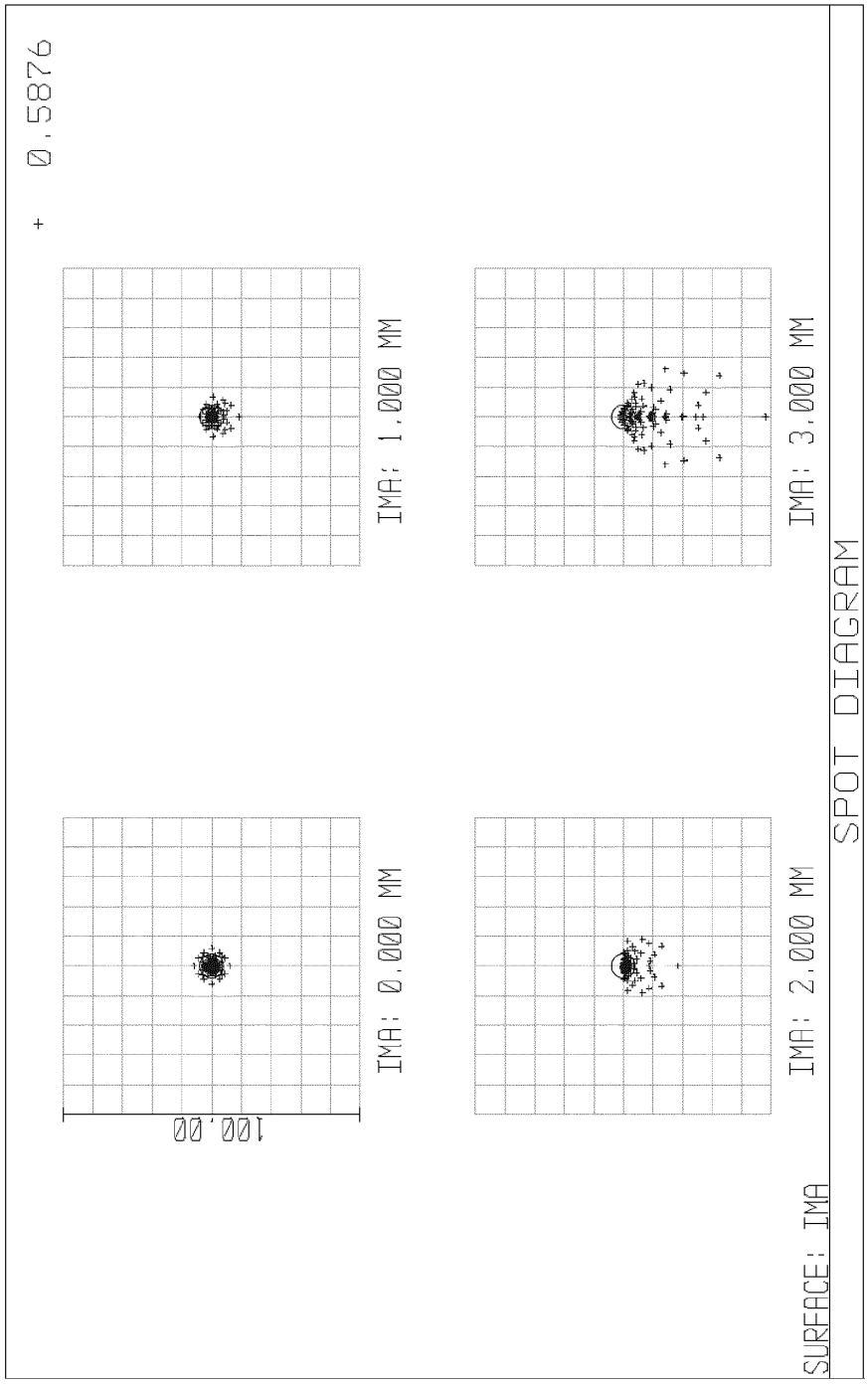
+ 0.5876
IMA: 1.000 MM
IMA: 3.000 MM
IMA: 0.000 MM
IMA: 2.000 MM
100.00
SURFACE: IMA
SPOT DIAGRAM

Fig. 17

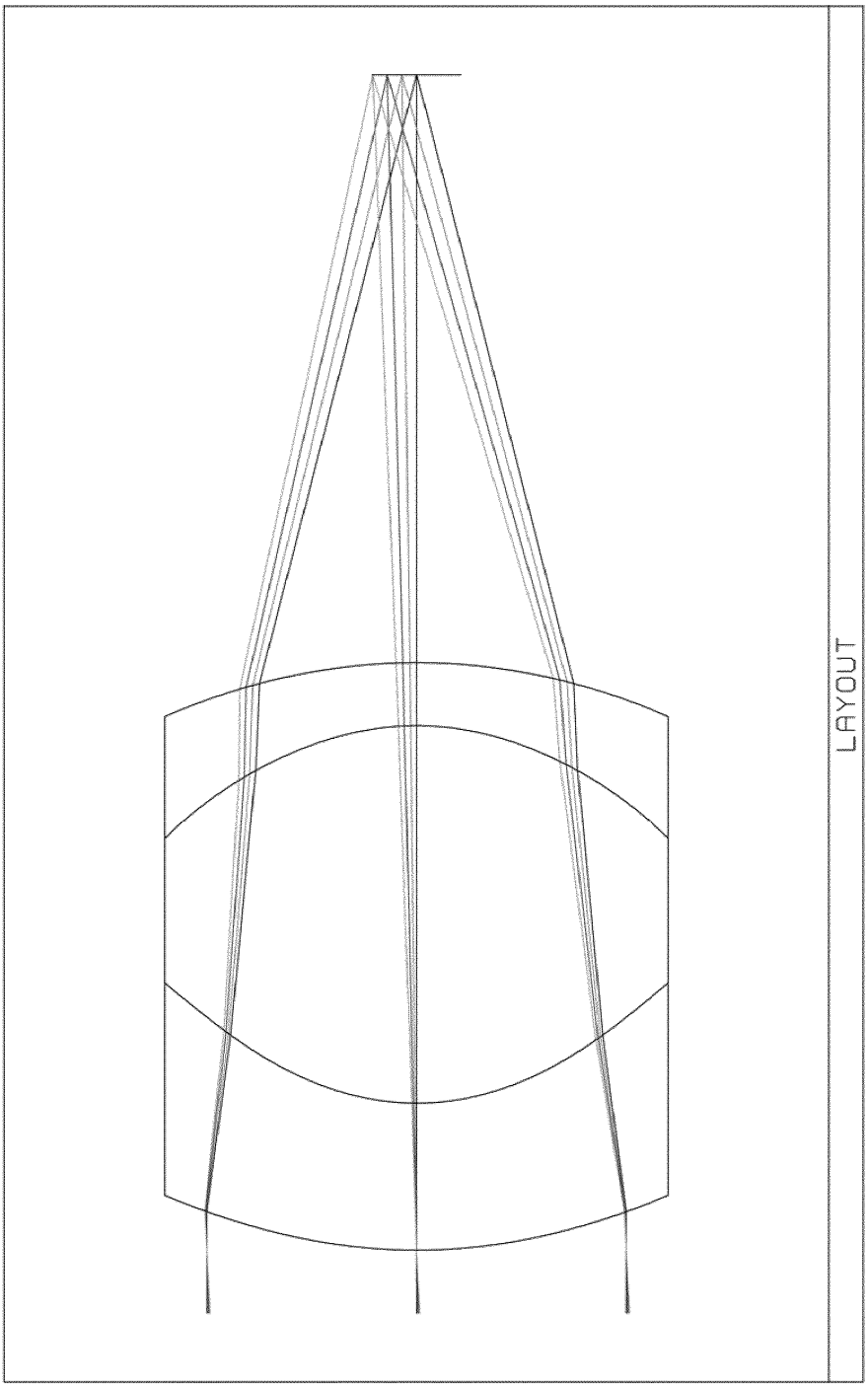

Fig. 18

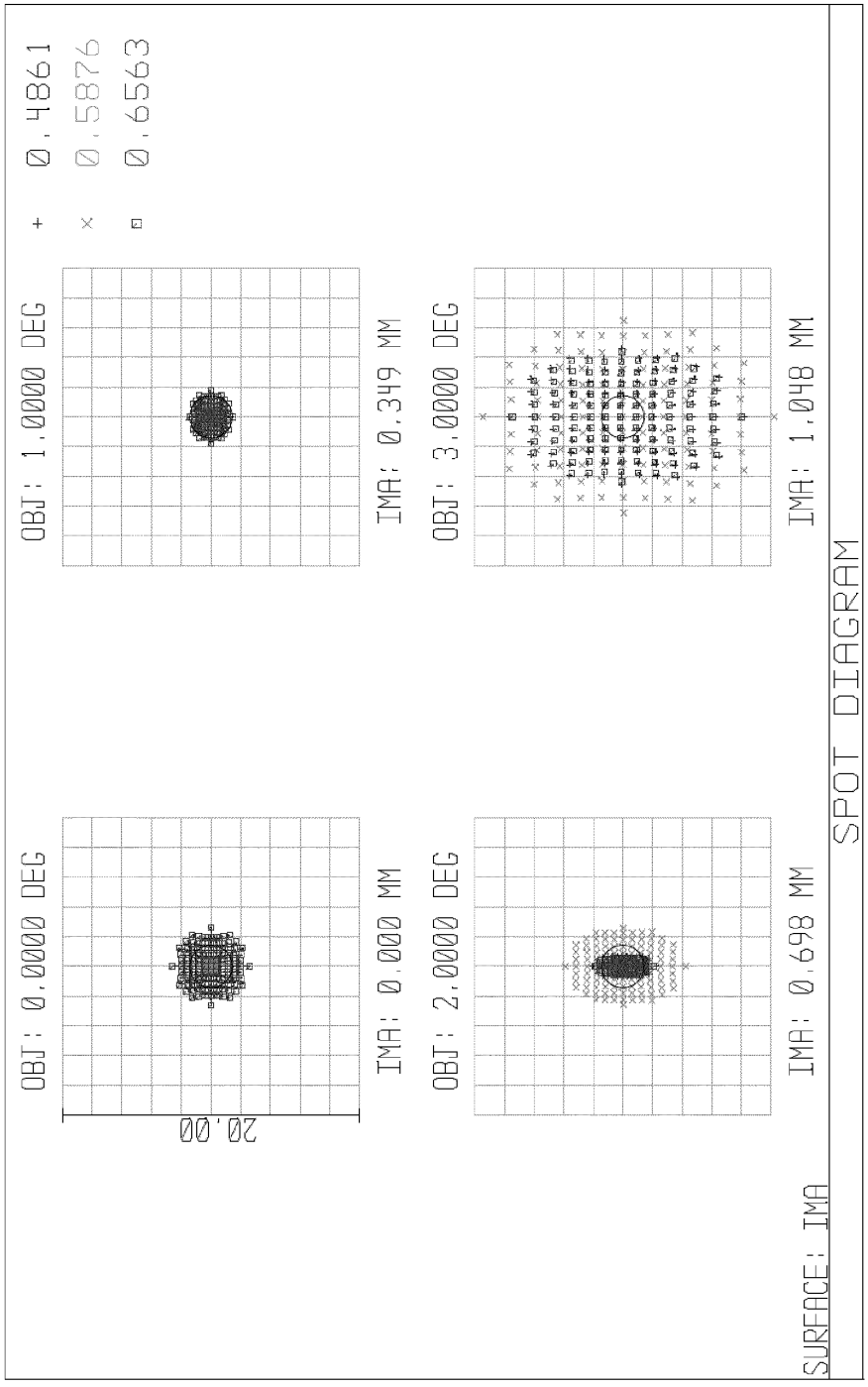
SPOT DIAGRAM
SURFACE: IMA
OBJ: 0.0000 DEG
IMA: 0.000 MM
OBJ: 1.0000 DEG
IMA: 0.349 MM
OBJ: 2.0000 DEG
IMA: 0.698 MM
OBJ: 3.0000 DEG
IMA: 1.048 MM
+ 0.4861
× 0.5876
□ 0.6563
20.00

Fig. 19

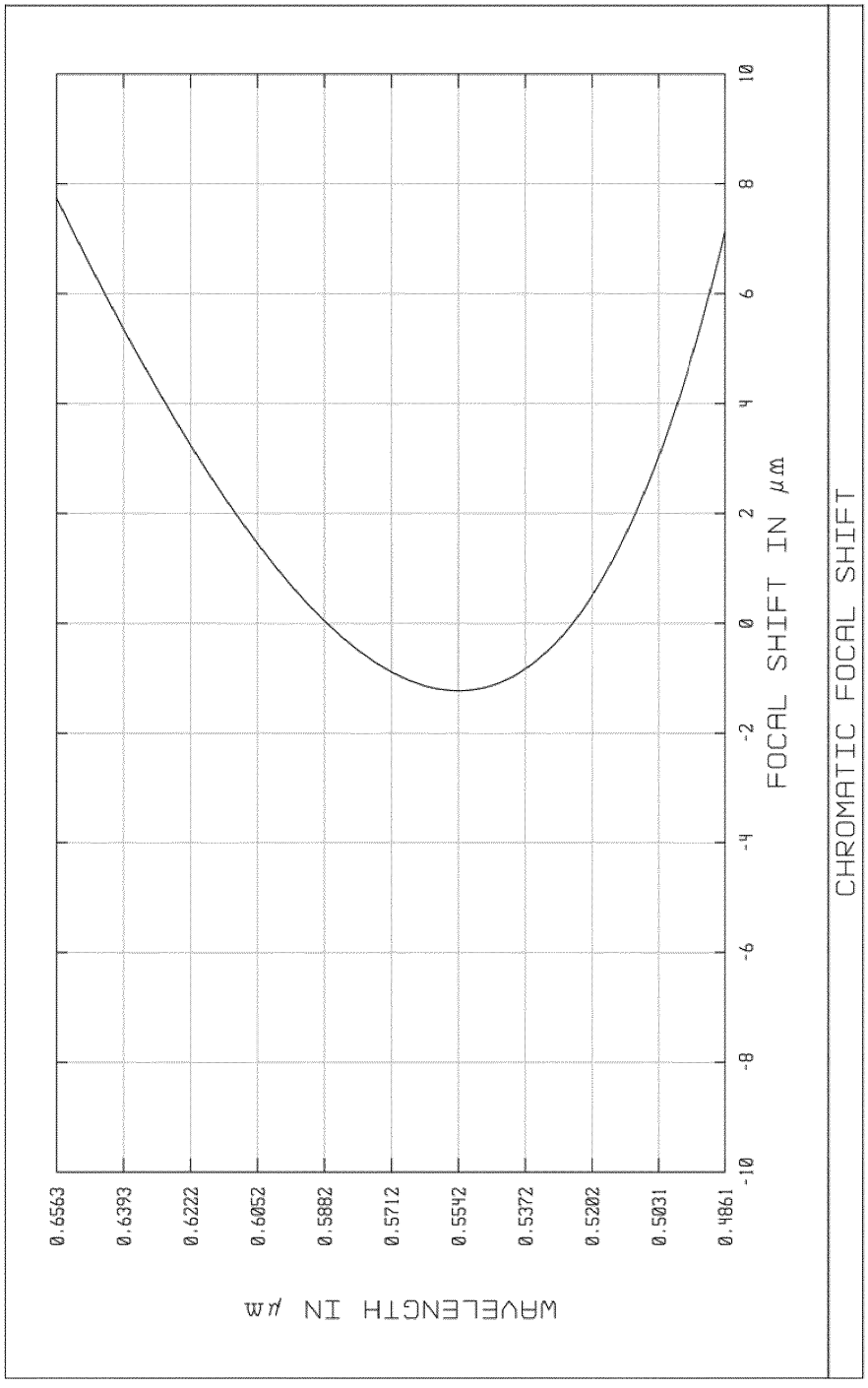
CHROMATIC FOCAL SHIFT
FOCAL SHIFT IN µm
10
8
6
4
2
0
-2
-4
-6
-8
-10
WAVELENGTH IN µm
0.6563
0.6393
0.6222
0.6052
0.5882
0.5712
0.5542
0.5372
0.5202
0.5031
0.4861

Fig. 20

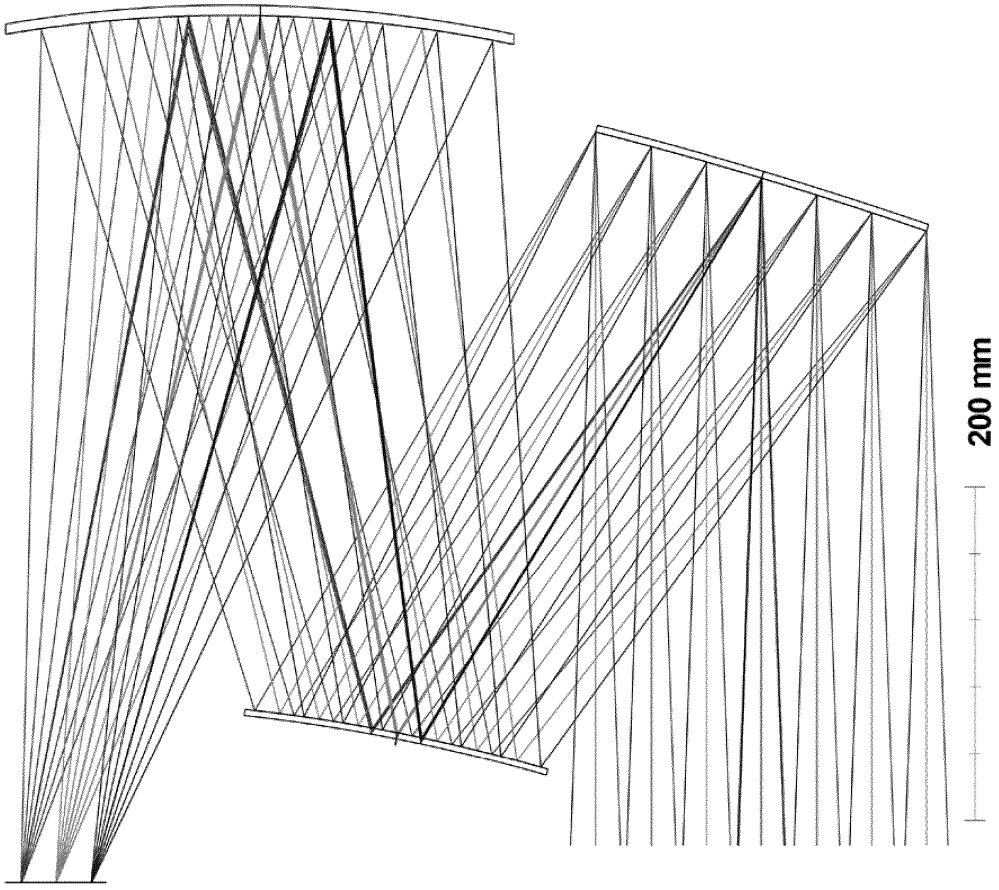

Fig. 21

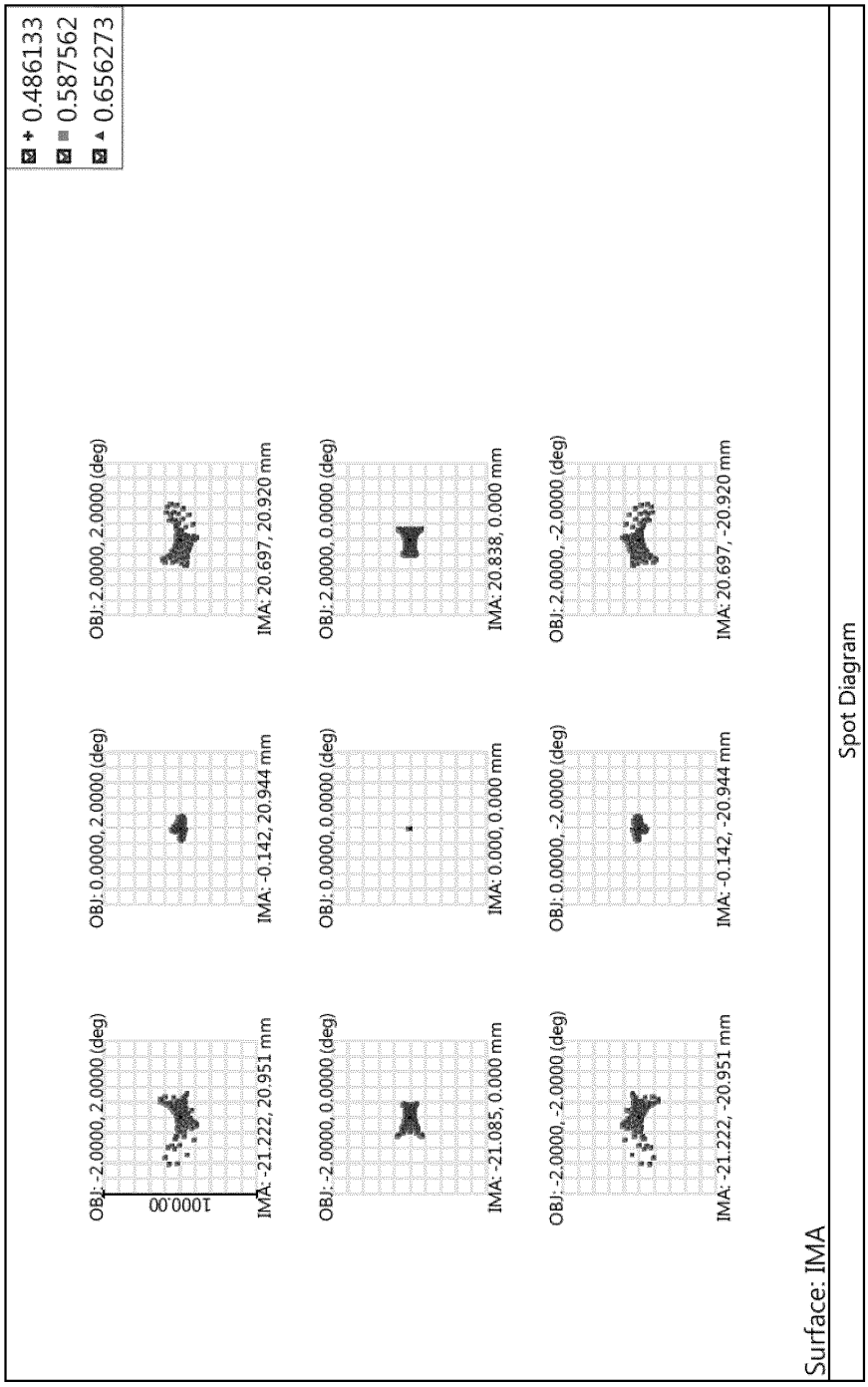
0.486133
0.587562
0.656273
OBJ: -2.0000, 2.0000 (deg)
IMA: -21.222, 20.951 mm
OBJ: 0.0000, 2.0000 (deg)
IMA: -0.142, 20.944 mm
OBJ: 2.0000, 2.0000 (deg)
IMA: 20.697, 20.920 mm
OBJ: -2.0000, 0.0000 (deg)
IMA: -21.085, 0.000 mm
OBJ: 0.0000, 0.0000 (deg)
IMA: 0.000, 0.000 mm
OBJ: 2.0000, 0.0000 (deg)
IMA: 20.838, 0.000 mm
OBJ: -2.0000, -2.0000 (deg)
IMA: -21.222, -20.951 mm
OBJ: 0.0000, -2.0000 (deg)
IMA: -0.142, -20.944 mm
OBJ: 2.0000, -2.0000 (deg)
IMA: 20.697, -20.920 mm
1000.00
Surface: IMA
Spot Diagram

Fig. 22

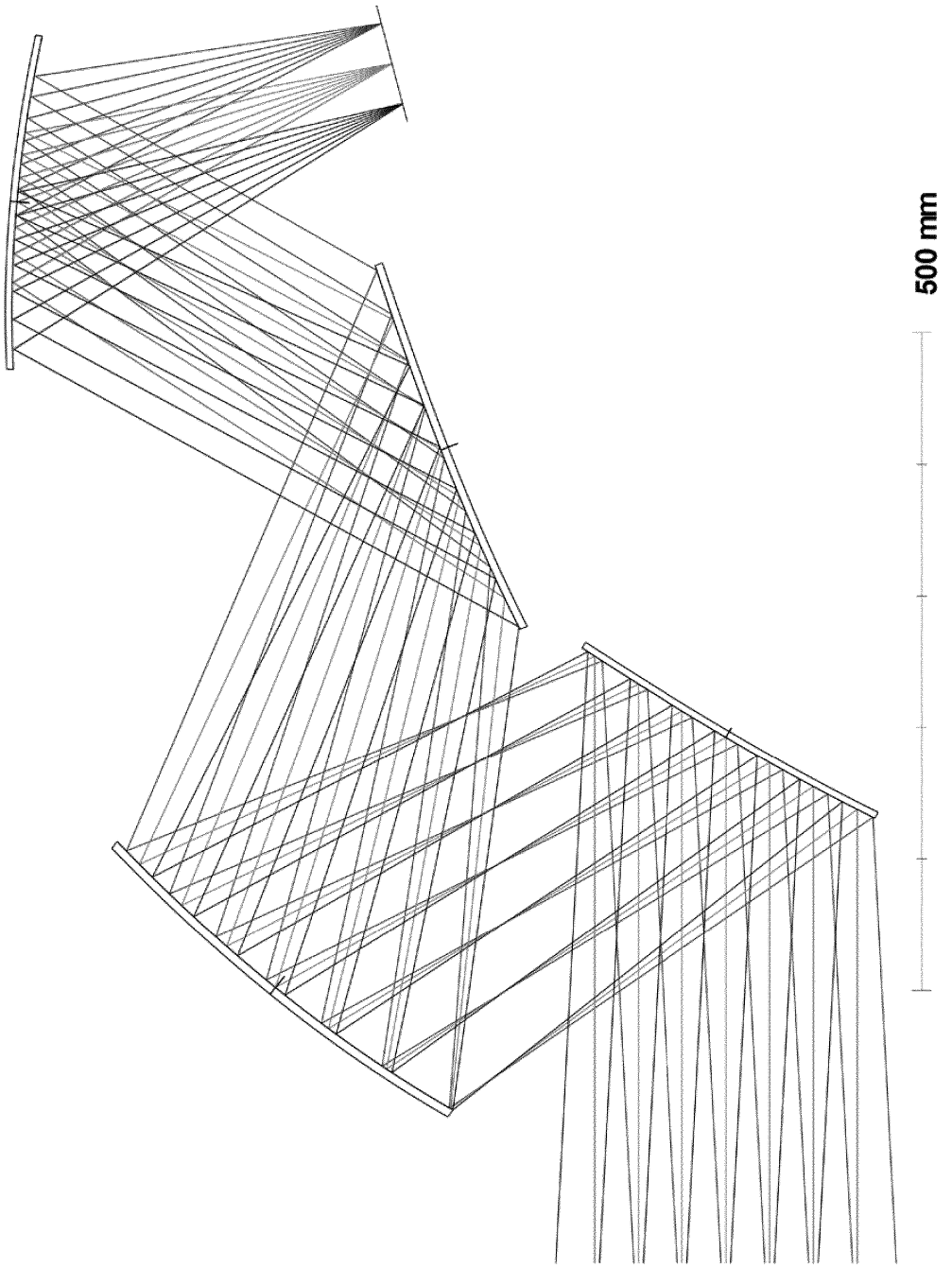

Fig. 23

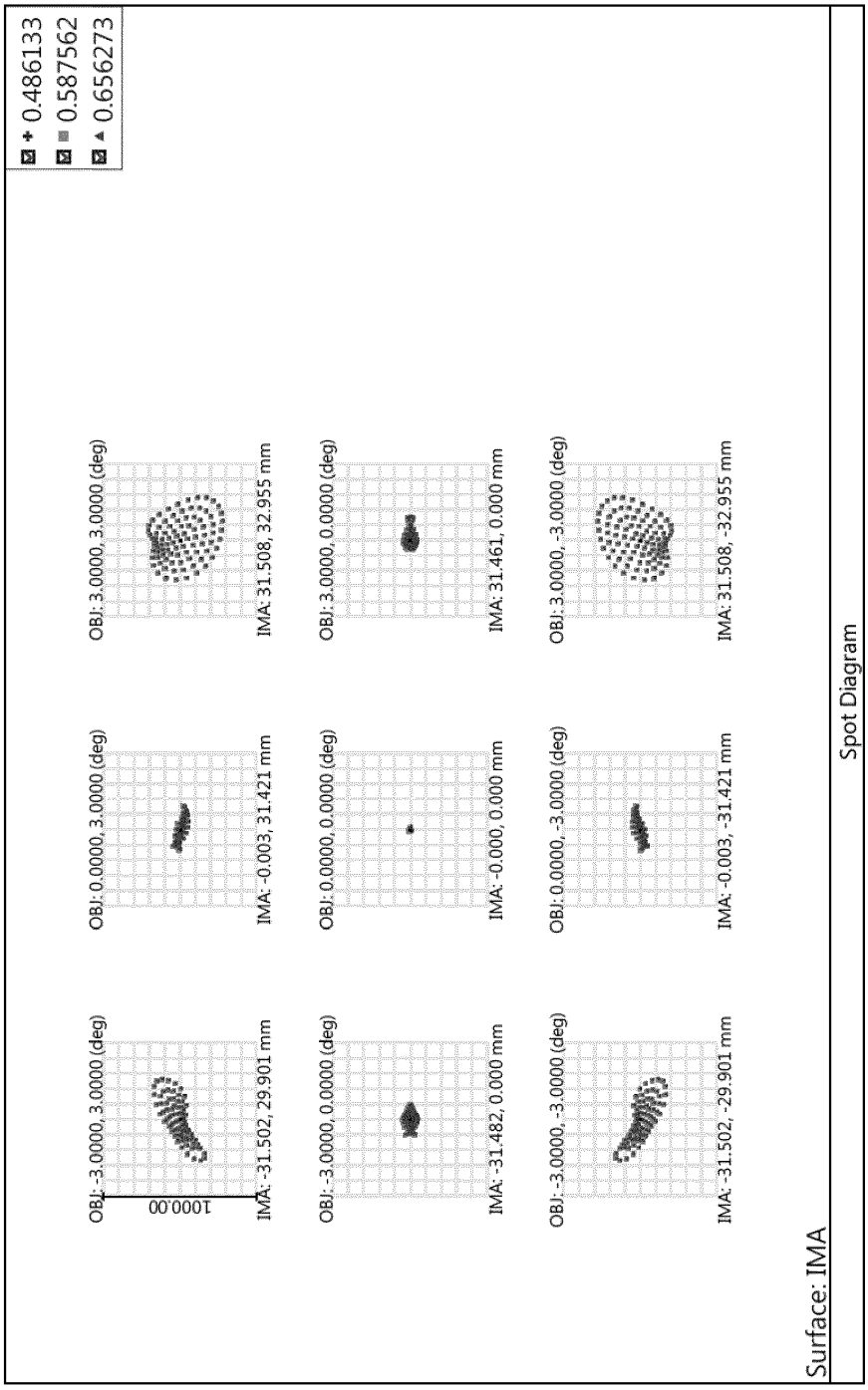
0.486133
0.587562
0.656273
OBJ: -3.0000, 3.0000 (deg)
IMA: -31.502, 29.901 mm
1000.00
OBJ: 0.0000, 3.0000 (deg)
IMA: -0.003, 31.421 mm
OBJ: 3.0000, 3.0000 (deg)
IMA: 31.508, 32.955 mm
OBJ: -3.0000, 0.0000 (deg)
IMA: -31.482, 0.000 mm
OBJ: 0.0000, 0.0000 (deg)
IMA: -0.000, 0.000 mm
OBJ: 3.0000, 0.0000 (deg)
IMA: 31.461, 0.000 mm
OBJ: -3.0000, -3.0000 (deg)
IMA: -31.502, -29.901 mm
OBJ: 0.0000, -3.0000 (deg)
IMA: -0.003, -31.421 mm
OBJ: 3.0000, -3.0000 (deg)
IMA: 31.508, -32.955 mm
Surface: IMA
Spot Diagram

Fig. 24