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ZERNIKE ABERRATIONS AND THEIR FAR FIELDS INTENSITIES.(U)
SEP 80 J HERRMANN F19628-80-C-0002
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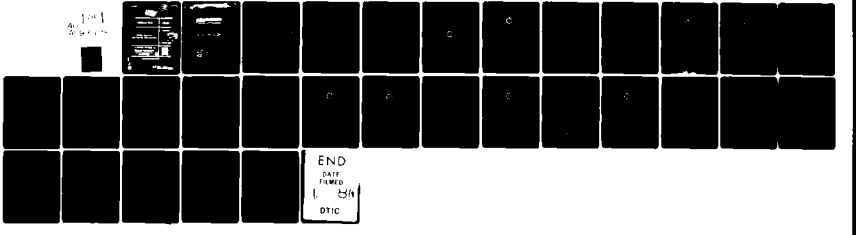

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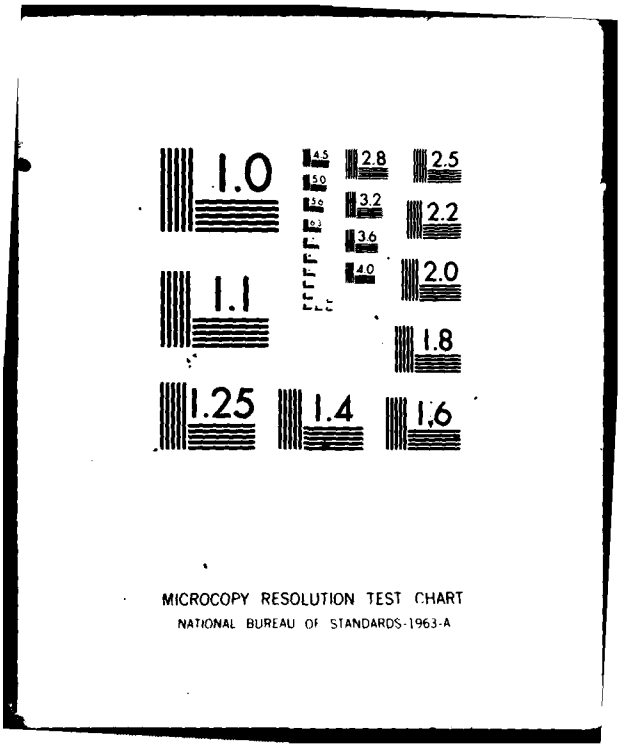

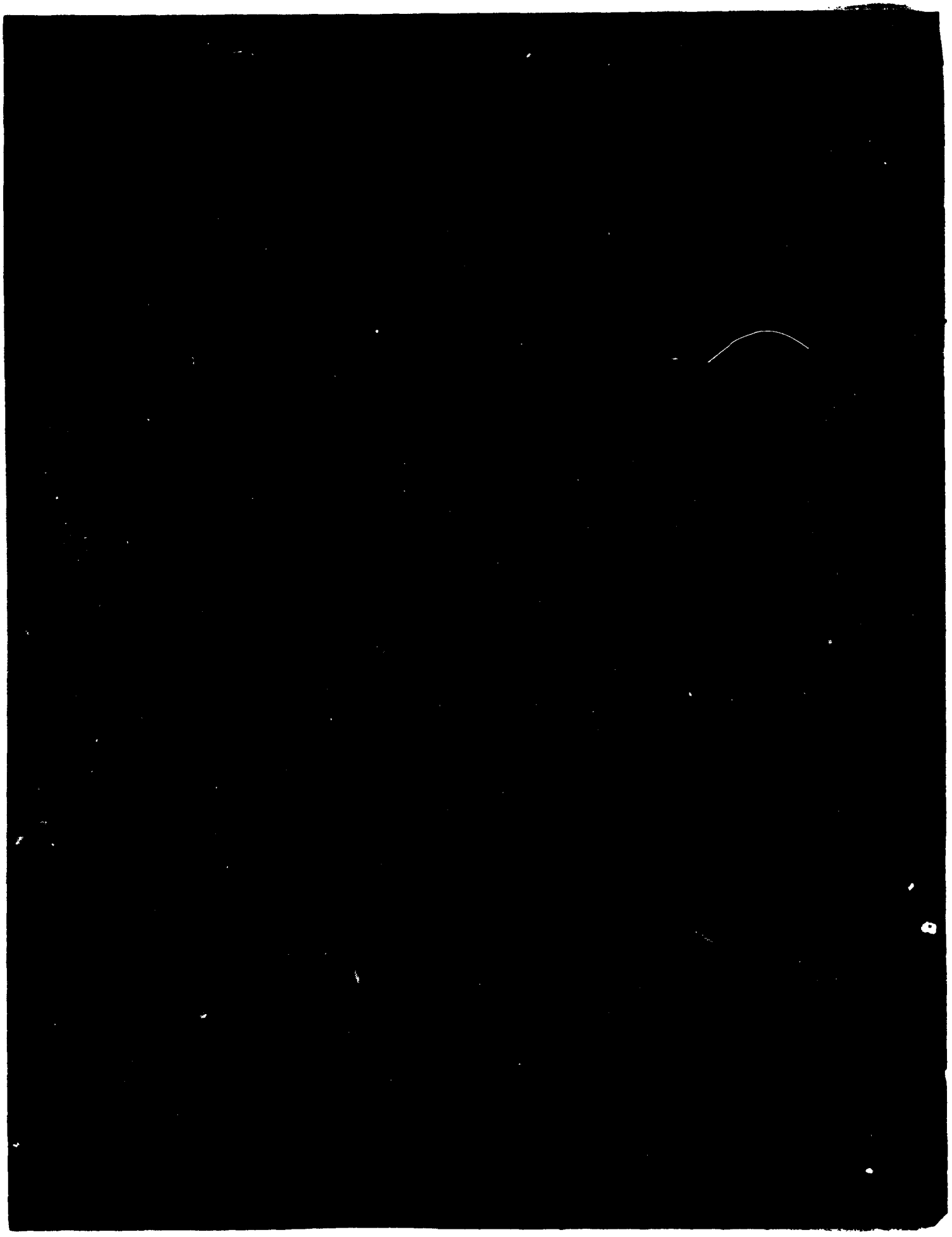

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY

LINCOLN LABORATORY

ZERNIKE ABERRATIONS AND THEIR FAR FIELD INTENSITIES

J. HERRMANN

Group 55

TECHNICAL NOTE 1980-42

25 SEPTEMBER 1980

LEXINGTON MASSACHUSETTS

ZERNIKE ABERRATIONS AND THEIR FAR FIELD INTENSITIES.

We present in this report the phase of a wave front as described by the Zernike polynomials[1] and the corresponding intensities in the focal plane. All aberration up to n=8 are included. The numbering of the Zernike aberration is shown in Table I.

If the phase is expressed in terms of Zernike polynomials

$$\phi = \sum_{n=1}^{\infty} \sum_{m=0}^{n} A_{nm} R_n^m \cos m\theta$$

then the variance of the phase becomes

$$\langle \phi^2 \rangle = \sum_{n=1}^{\infty} \sum_{m=0}^{n} \frac{A_{nm}^2}{n+1} \frac{1 + \delta_{mo}}{2}$$

We present two sets of figures: The phase of the aberrations on the unit circle (in radians) and the intensity in the focal plane on a grid spaced by $R\lambda/D$ (with a contourline spacing of 2dB). A uniform intensity distribution is assumed for the aperture. The Strehl ratio (peak intensity) is indicated on each figure and also given in Table I. The extended Maréchal formula $\exp-\langle \phi^2 \rangle$ gives a value 0.674 for the Strehl ratio. Only the cos $m\theta$ terms are presented because the sin $m\theta$ terms can be obtained by a rotation. The assignment of the orders is in accordance with Ref. 1. Sec. 5.1 which was uses m + n for the order of wave aberrations.

The far field intensities were calculated using a descrete Fourier transform with a 256 by 256 computational mesh for most cases. For some aberrations (k=16, 29, 37, 42) 512 by 512 mesh points were used.

The most striking feature of the irradiances is the shape of the central lobe which is nearly constant for higher aberrations ($n \geq 5$).

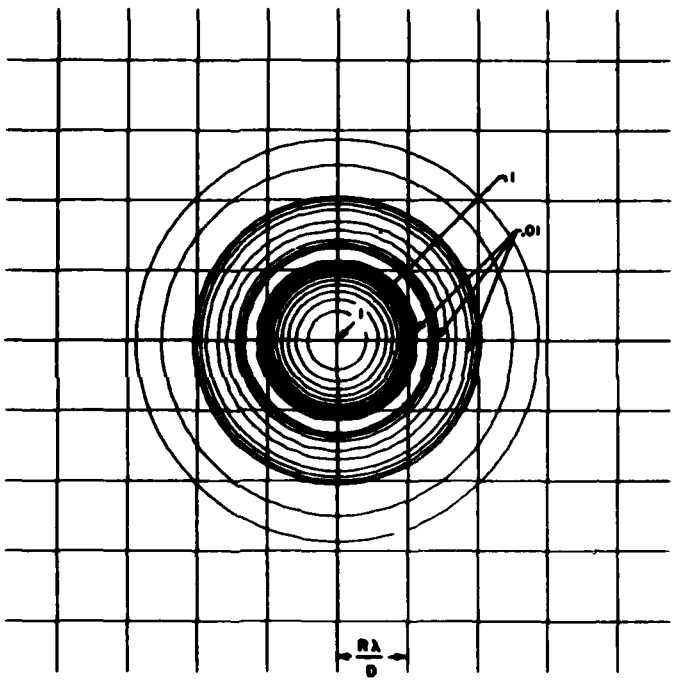
[1] M. Born and E. Wolf, Principles of Optics (Pergamon, New York, 1965), Sec. 9.2.

Table I

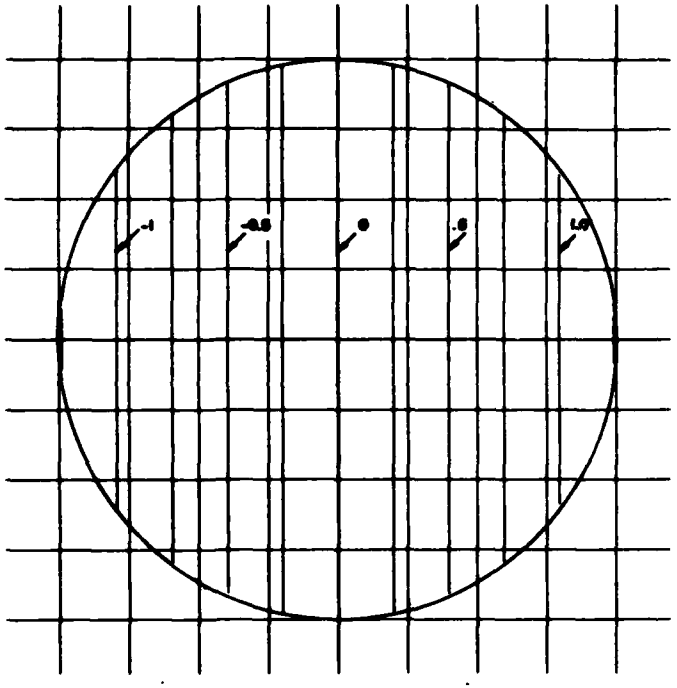
Zernike Aberrations

k	n	m	A_k [a)]	Strehl Ratio
2	1	1	1.257	-
4	2	0	1.088	0.653
5		2	1.539	0.667
7	3	1	1.777	0.651
9		3	"	0.671
11	4	0	1.405	0.627
12		2	1.987	0.645
14		4	"	0.675
16	5	1	2.177	0.644
18		3	"	0.634
20		5	"	0.677
22	6	0	1.662	0.604
23		2	2.351	0.622
25		4	"	0.638
27		6	"	0.681
29	7	1	2.513	0.641
31		3	"	0.625
33		5	"	0.640
35		7	"	0.684
37	8	0	1.885	0.626
38		2	2.666	0.614
40		4	"	0.596
42		6	"	0.654
44		8	"	0.689

a) Chosen to give a mean-square phase deformation of $\lambda/10$ for each aberration.

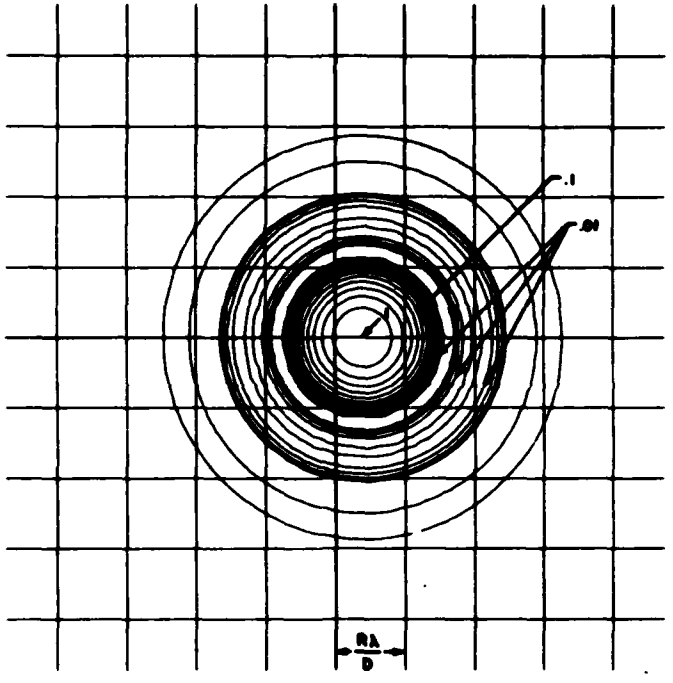


REFERENCE INTENSITY



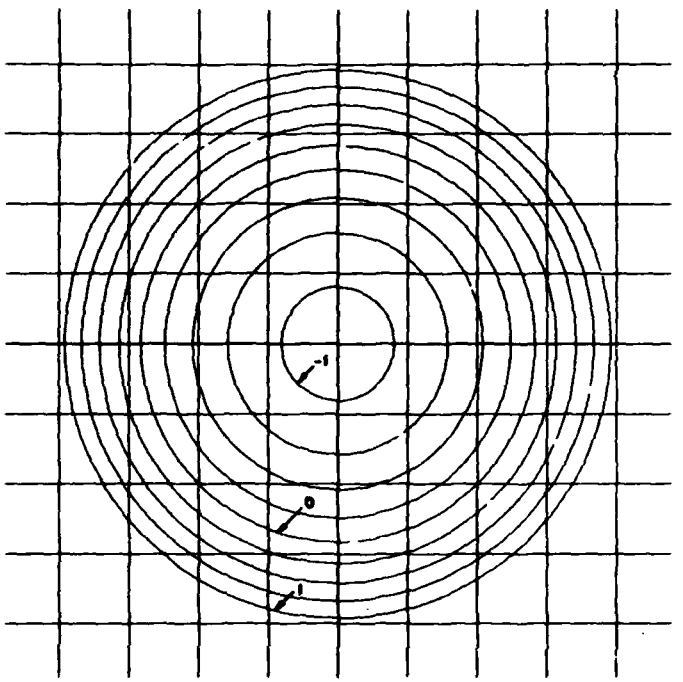
PHASE

k= 2, n= 1, m= 1



INTENSITY

TILT



PHASE

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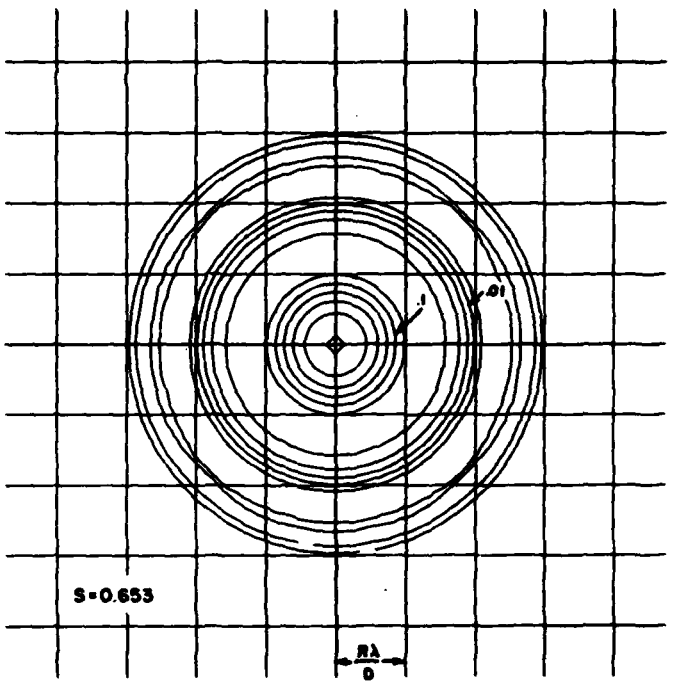
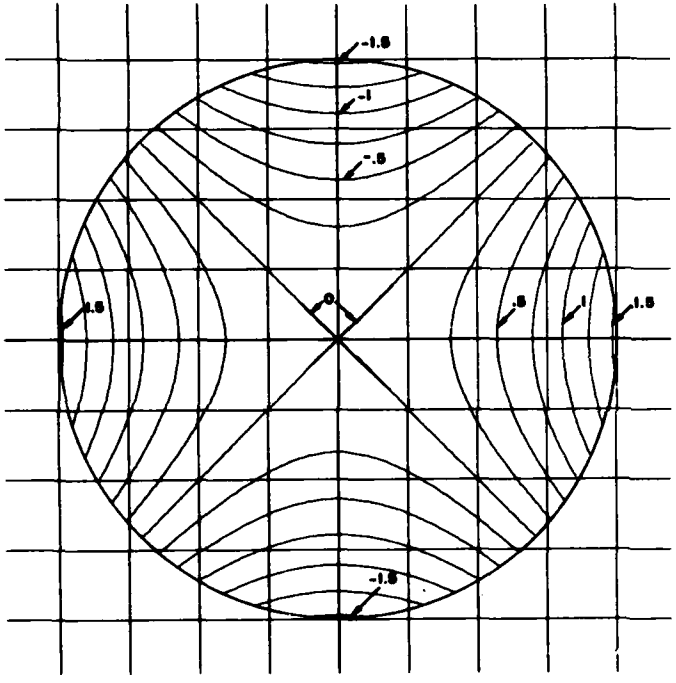


INTENSITY

FOCUS



PHASE

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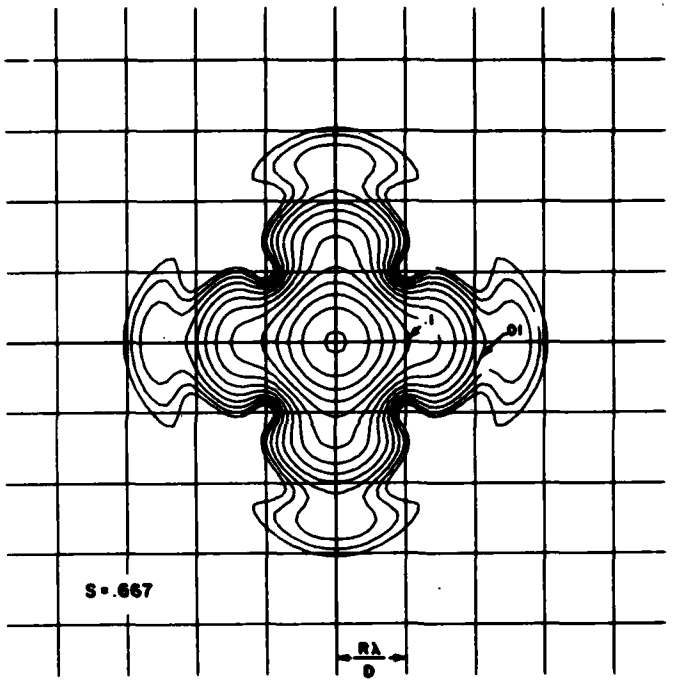
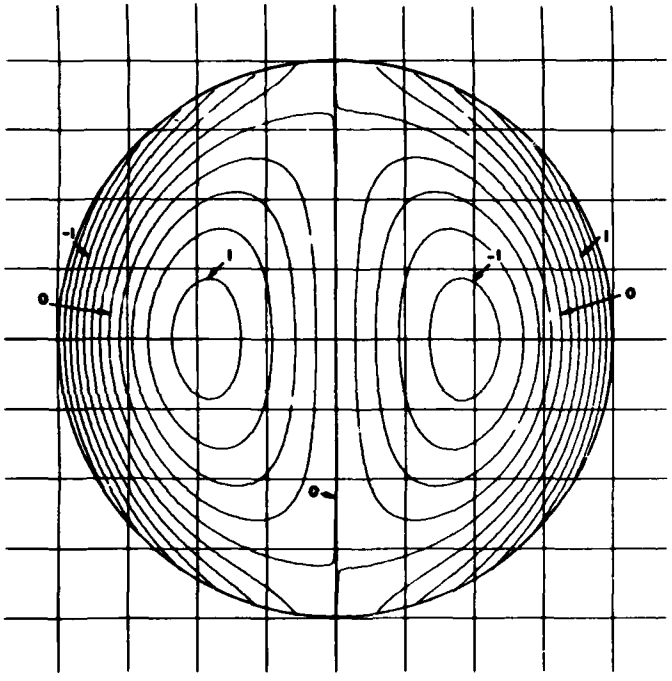


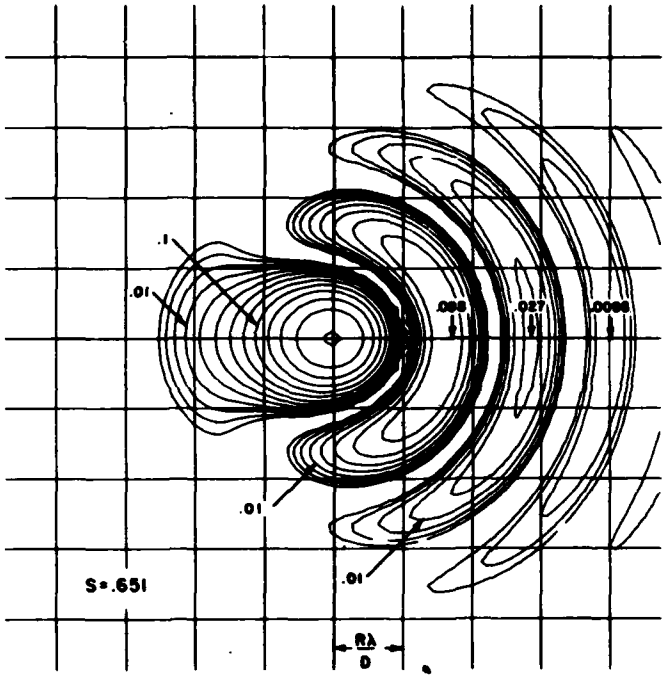
INTENSITY

ASTIGMATISM



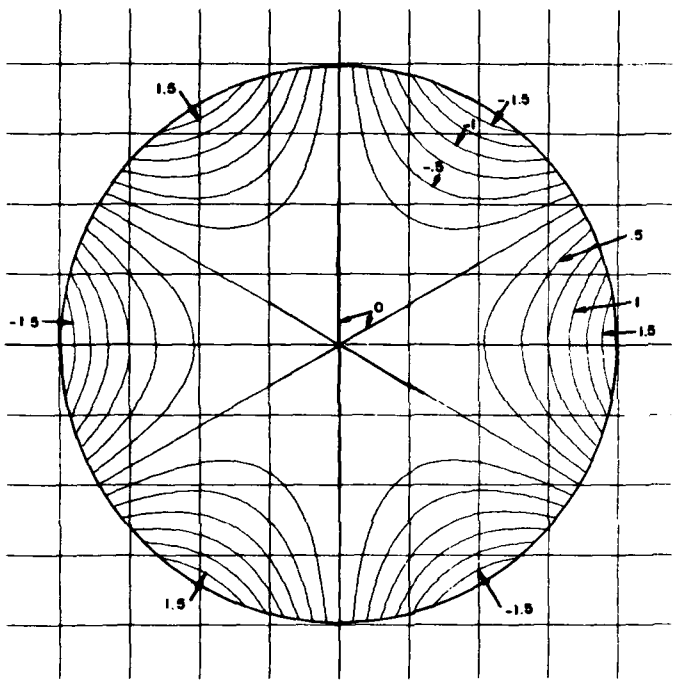
PHASE

k= 7, n= 3, m= 1



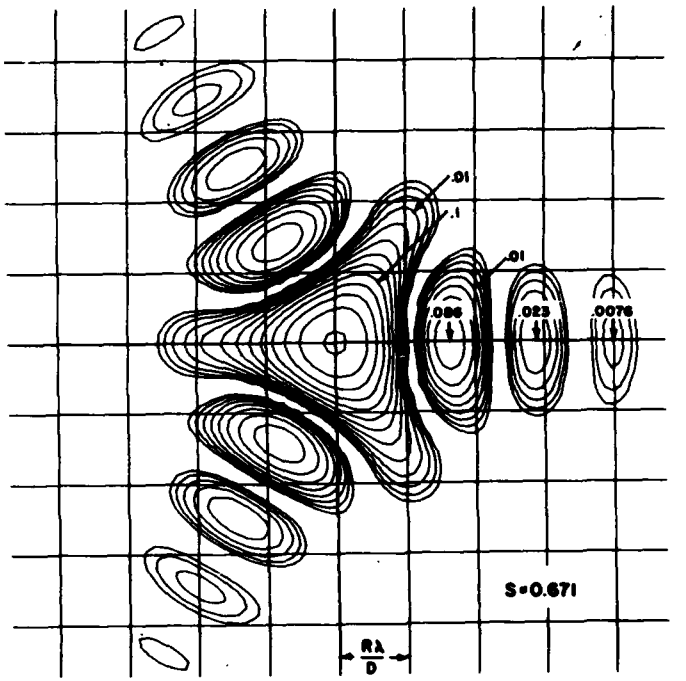
INTENSITY

COMA



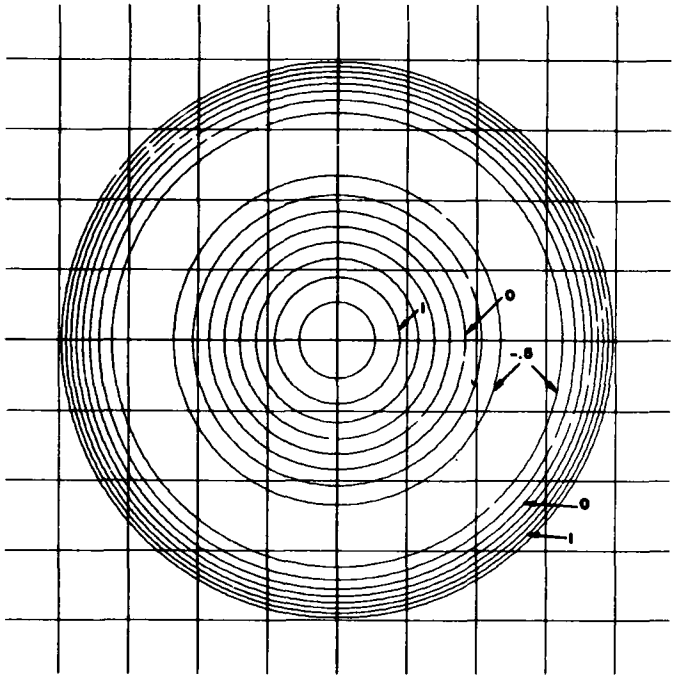
PHASE

k= 9, n= 3, m= 3

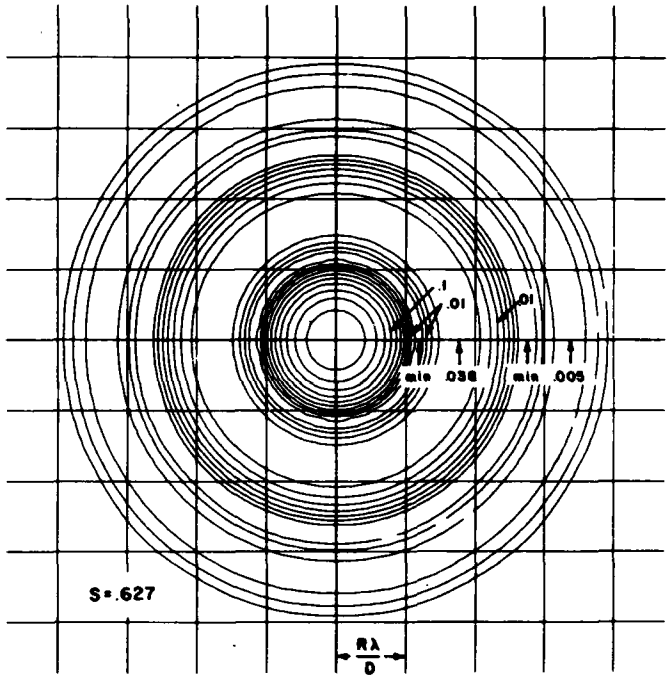


INTENSITY

CLOVER
(SIXTH ORDER)



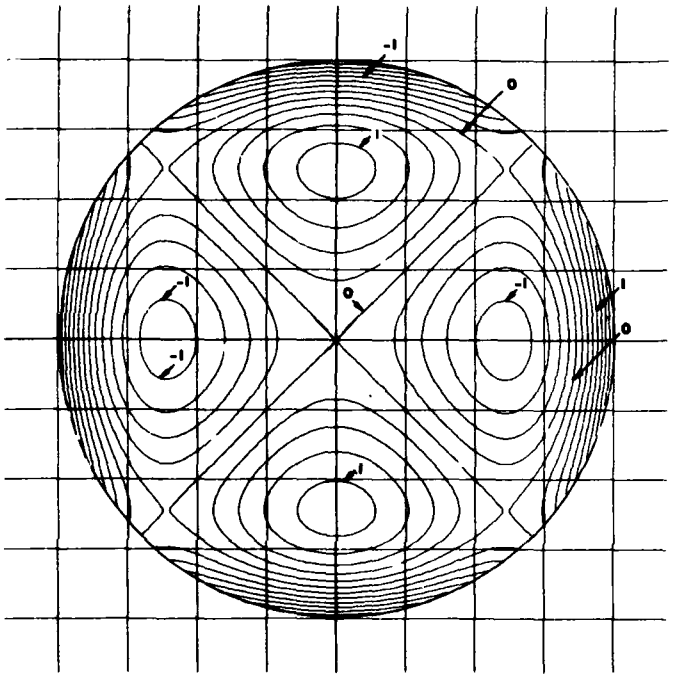
PHASE



INTENSITY

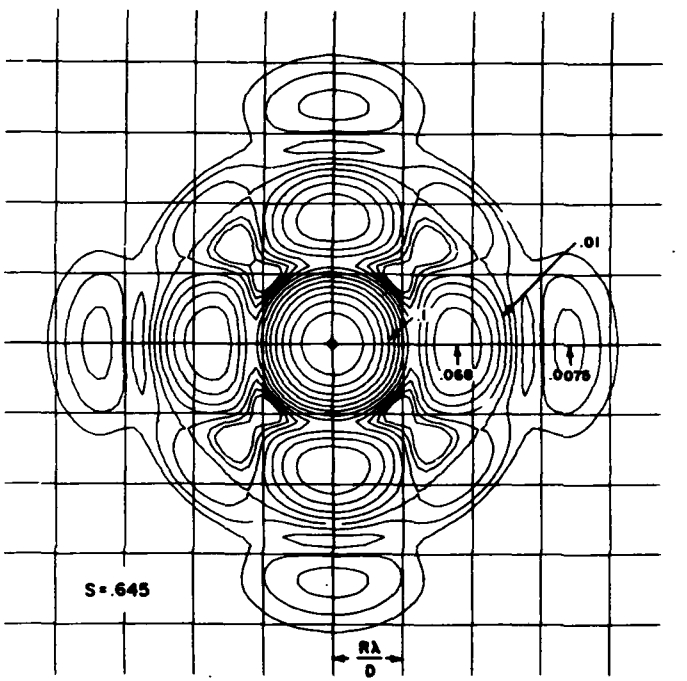
k= 11, n= 4, m= 0

SPHERICAL ABERRATION



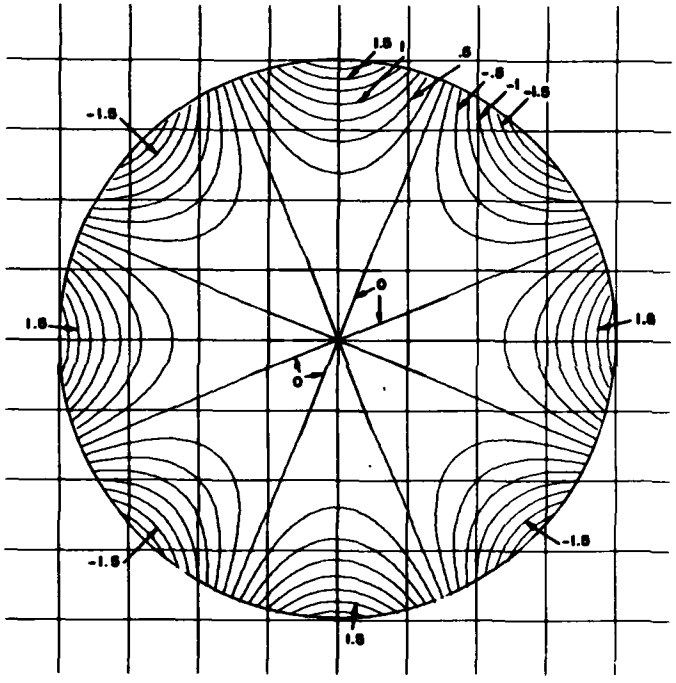
PHASE

k= 12, n= 4, m= 2



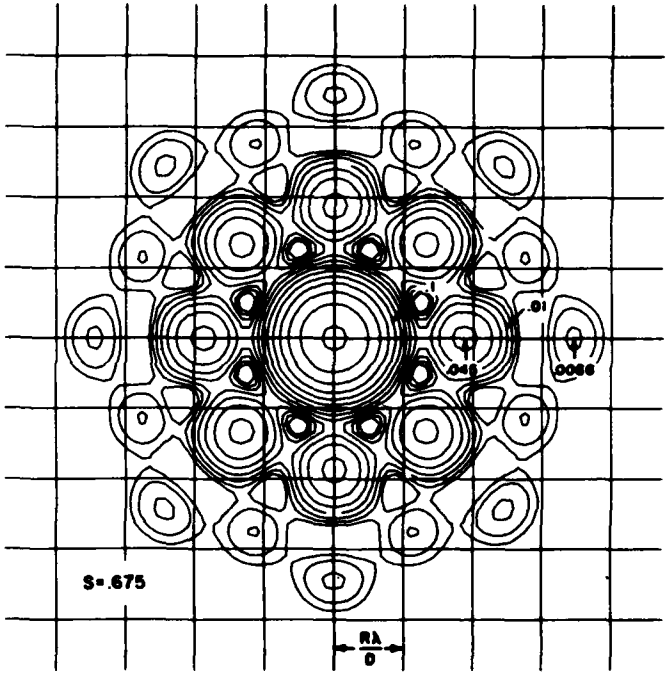
INTENSITY

ASTIGMATISM
(SIXTH ORDER)



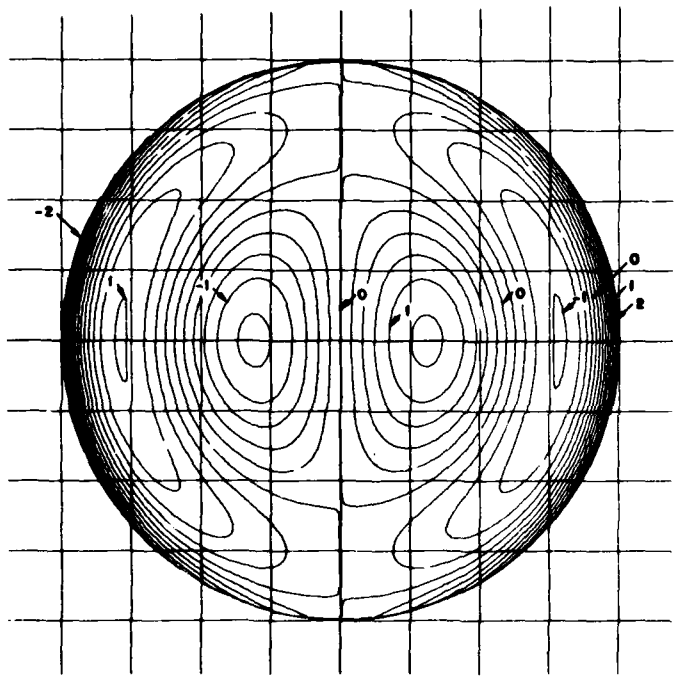
PHASE

k= 14, n= 4, m= 4



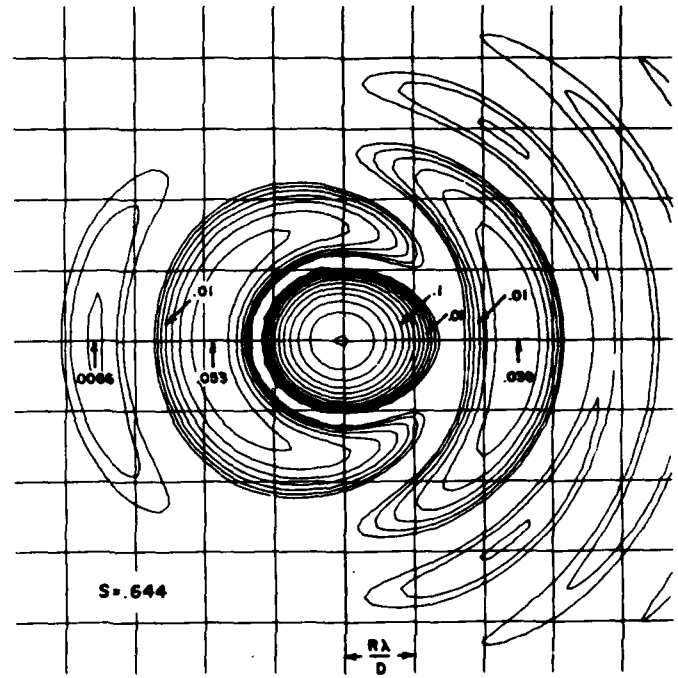
INTENSITY

LUCKY CLOVER
(EIGHTH ORDER)



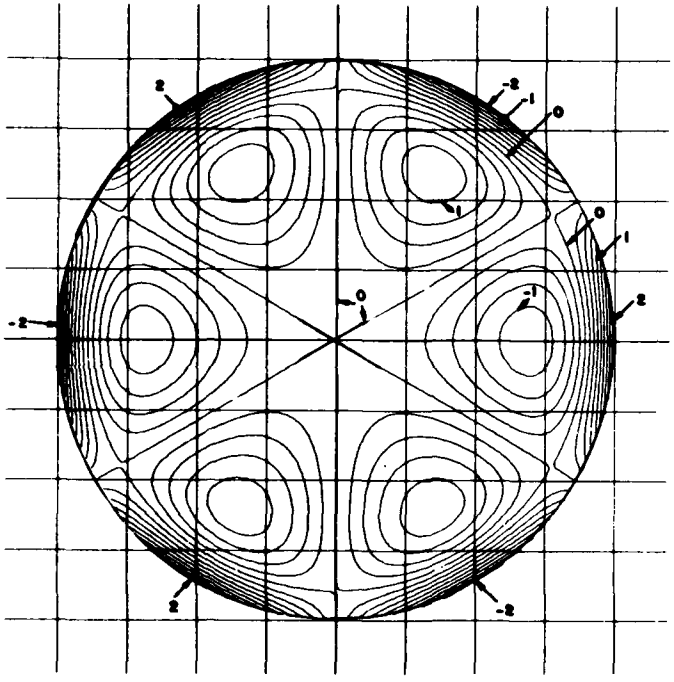
PHASE

k= 16, n= 5, m=1



INTENSITY

COMA
(SIXTH ORDER)



PHASE

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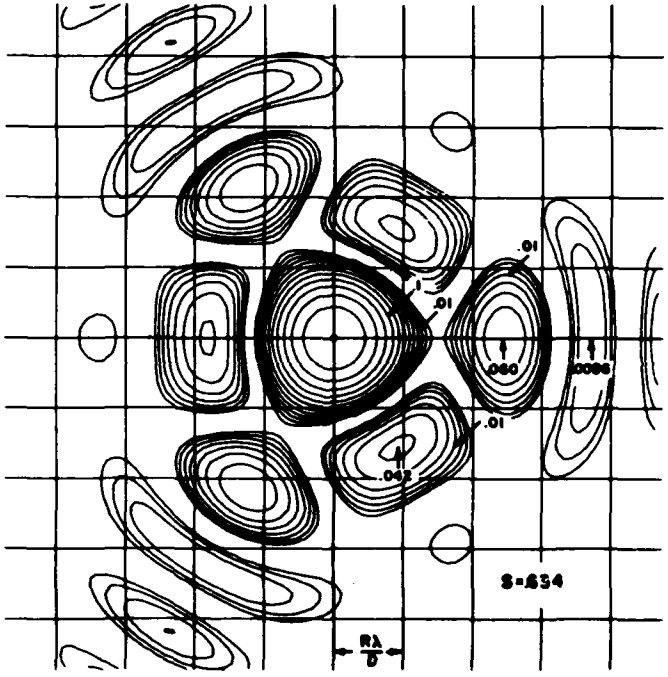
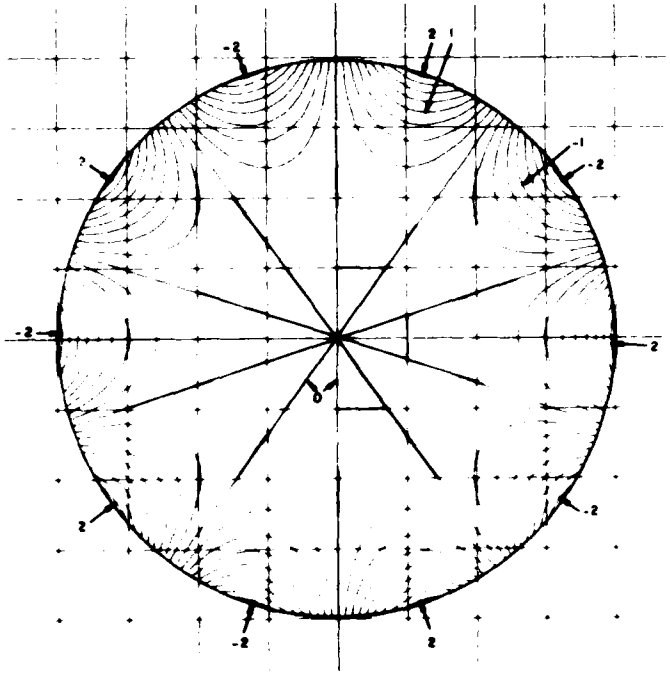


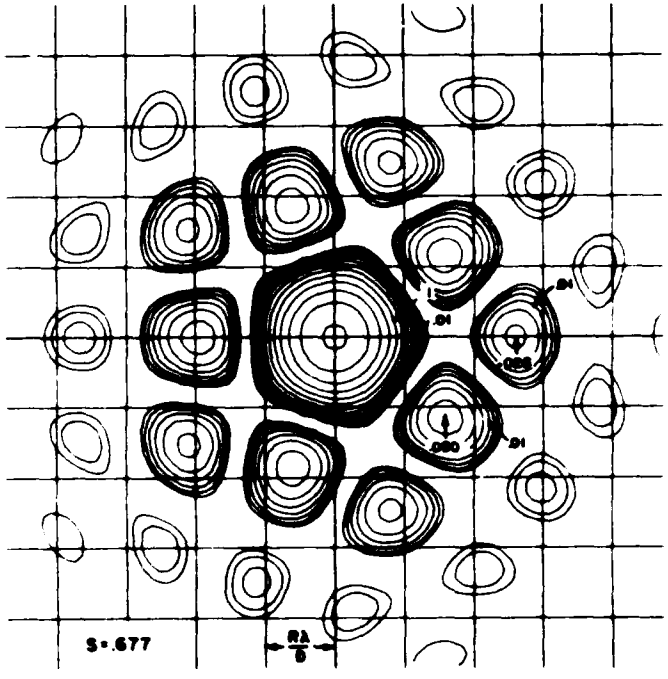
INTENSITY

CLOVER
(EIGHTH ORDER)



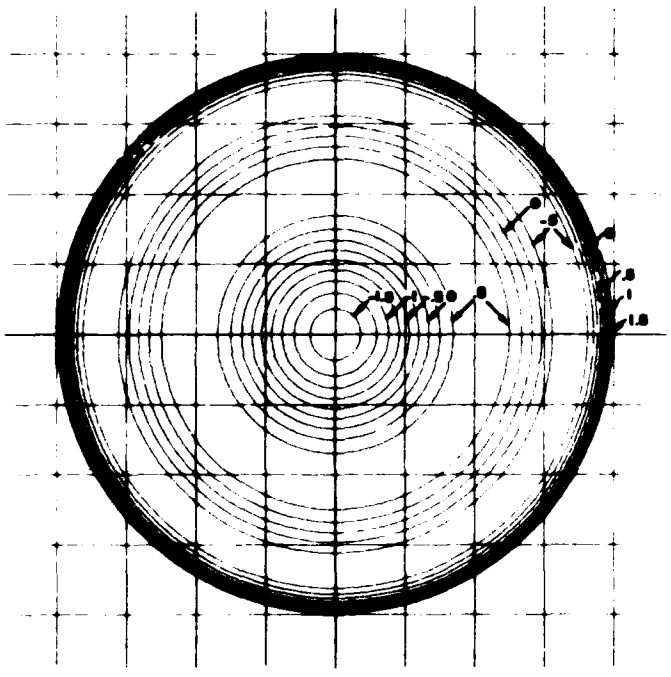
PHASE

k= 20, n= 5, m= 5



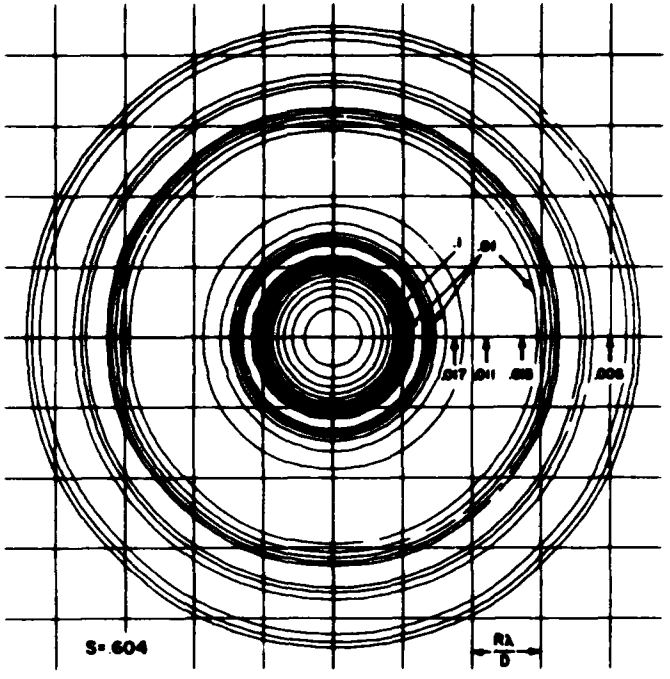
INTENSITY

ROSETTE
(TENTH ORDER)



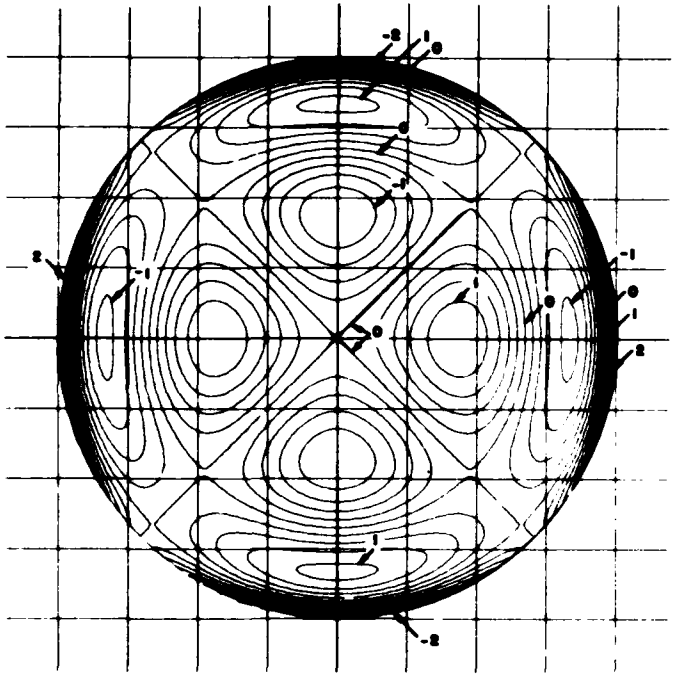
PHASE

k= 22, n= 6, m= 0



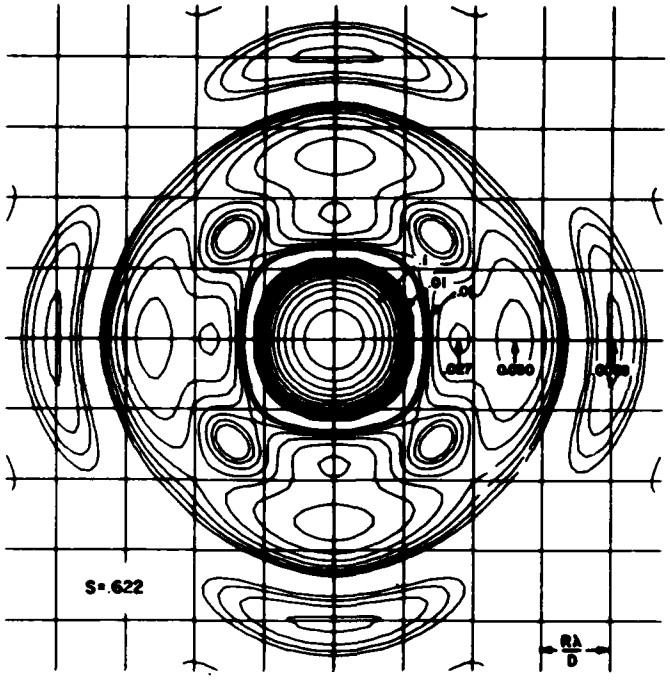
INTENSITY

SPHERICAL ABERRATION
(SIXTH ORDER)



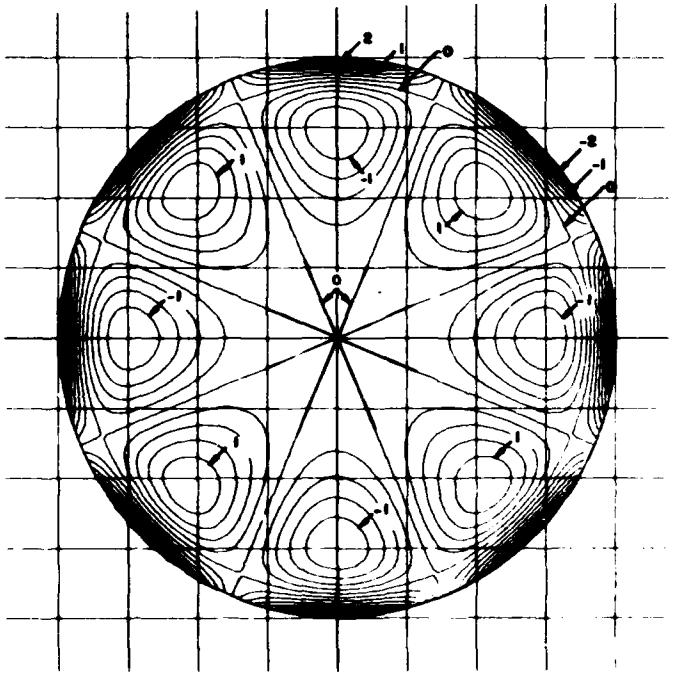
PHASE

k= 23, n= 6, m= 2



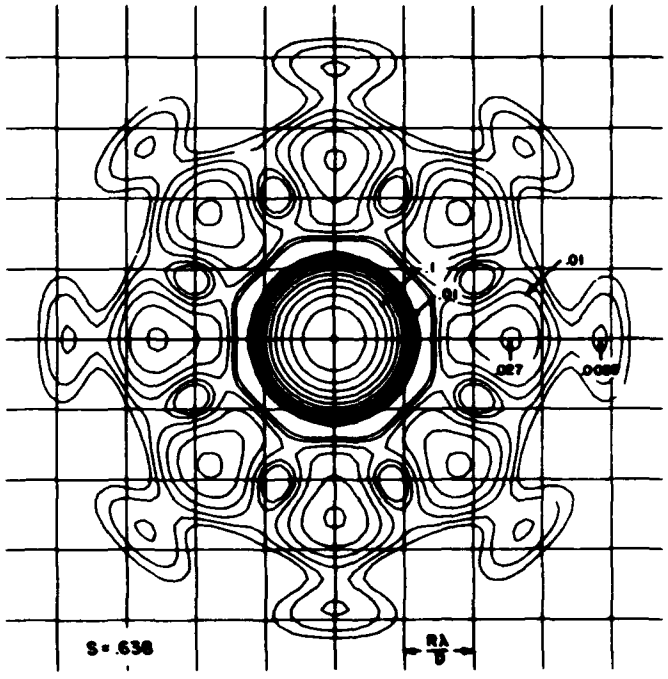
INTENSITY

ASTIGMATISM
(EIGHTH ORDER)



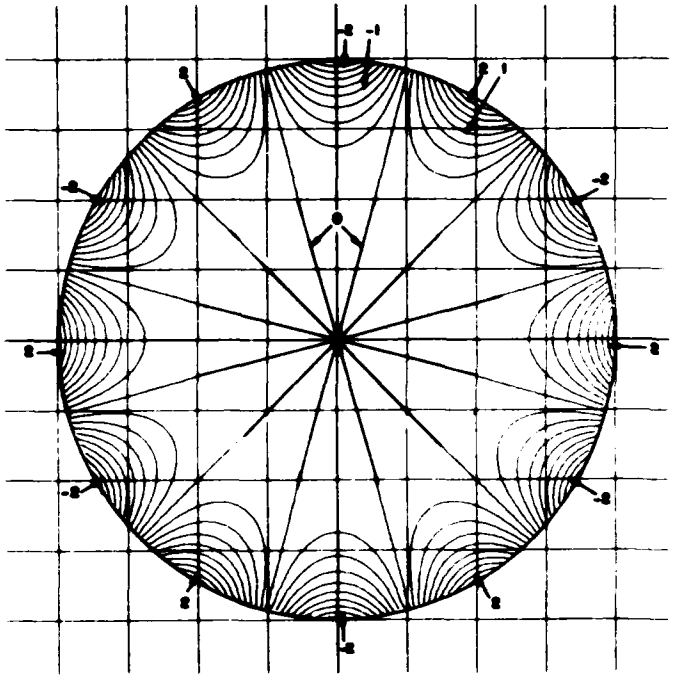
PHASE

k= 25, n= 6, m= 4



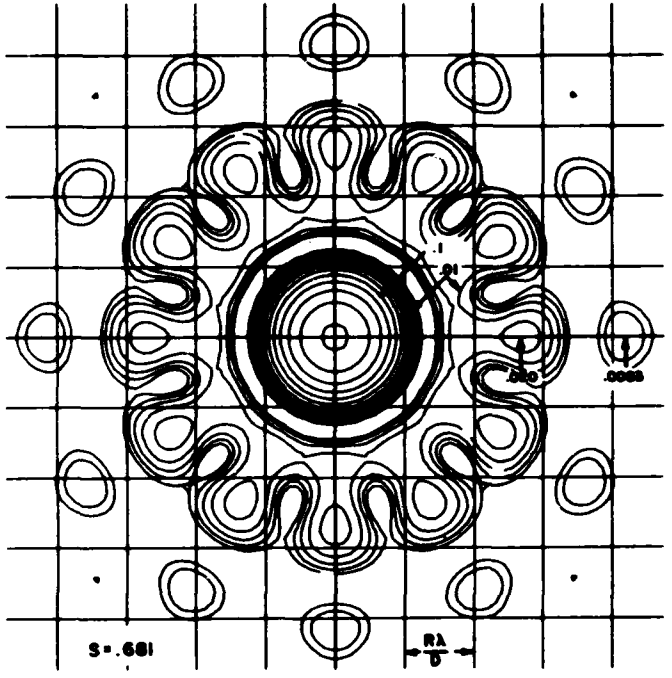
INTENSITY

LUCKY CLOVER
(TENTH ORDER)



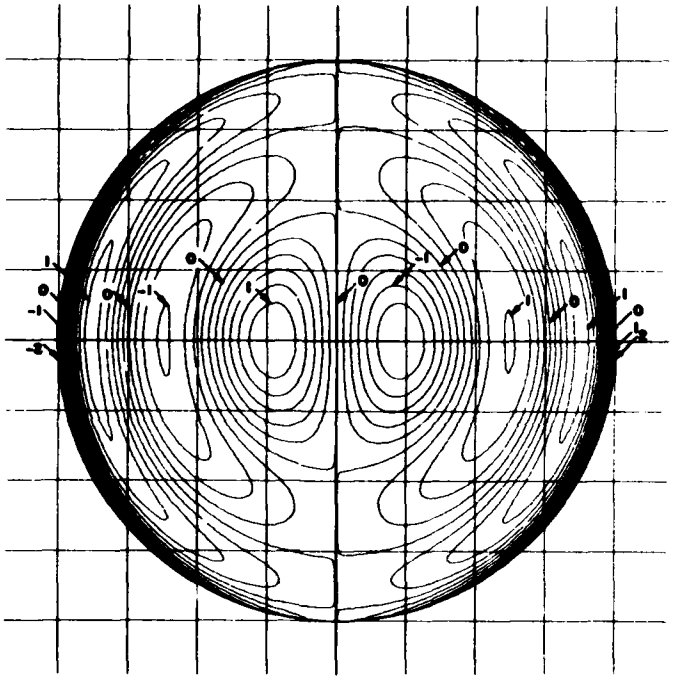
PHASE

k= 27, n= 6, m= 6



INTENSITY

LILY
(TWELFTH ORDER)



PHASE

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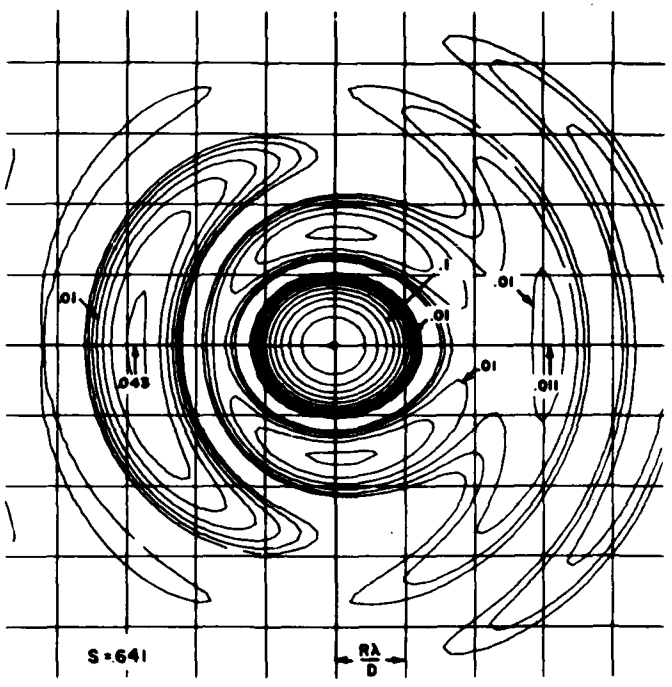
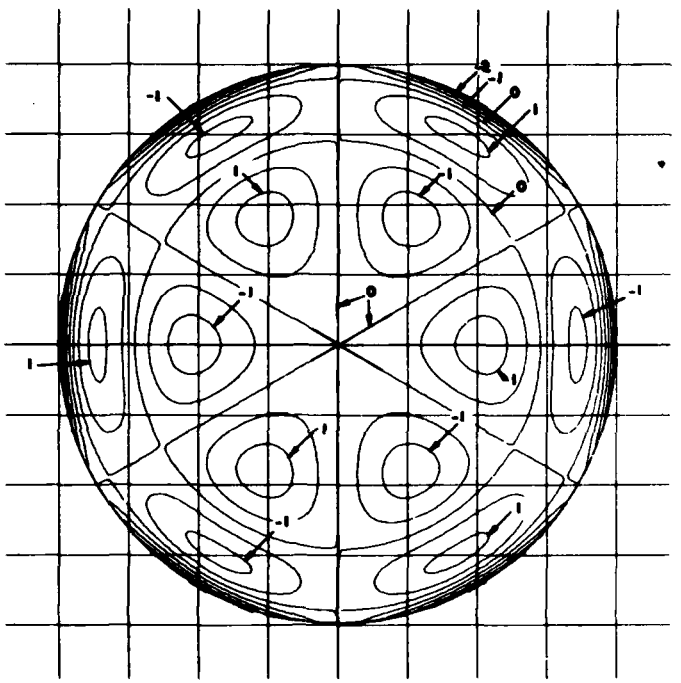


INTENSITY

COMA
(EIGHTH ORDER)



PHASE

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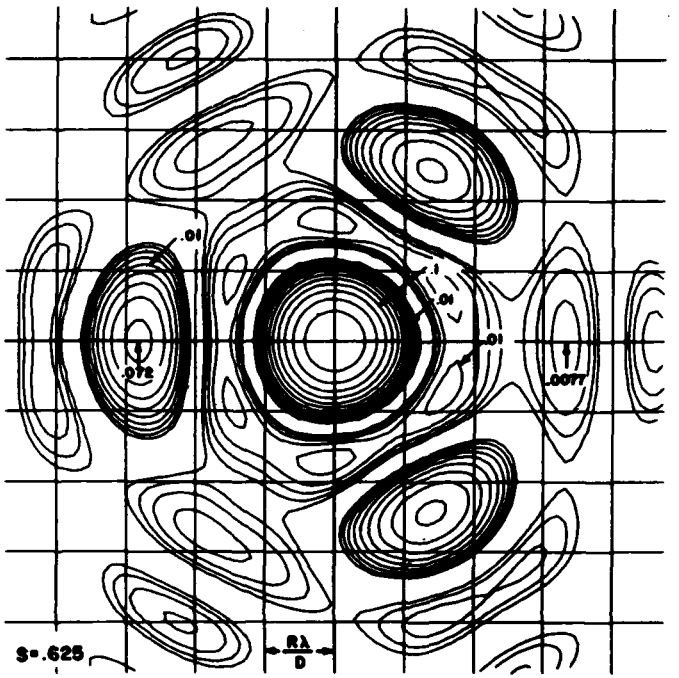
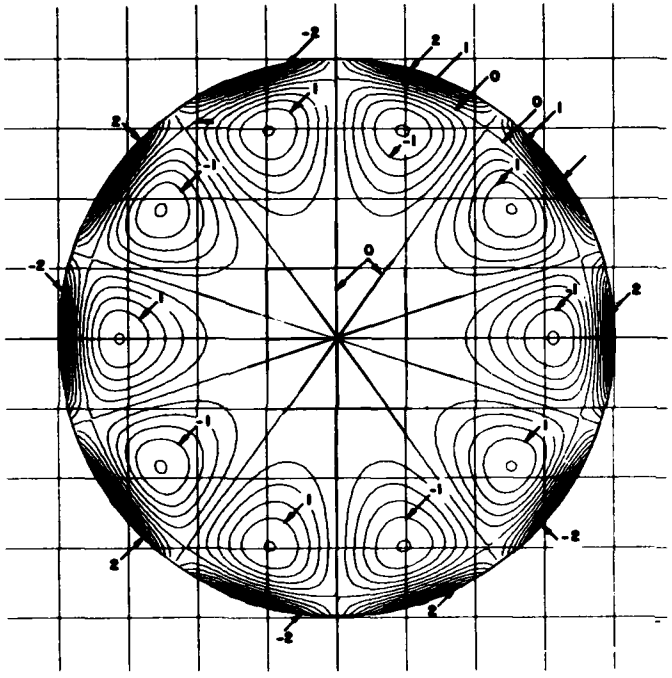


INTENSITY

CLOVER
(TENTH ORDER)



PHASE

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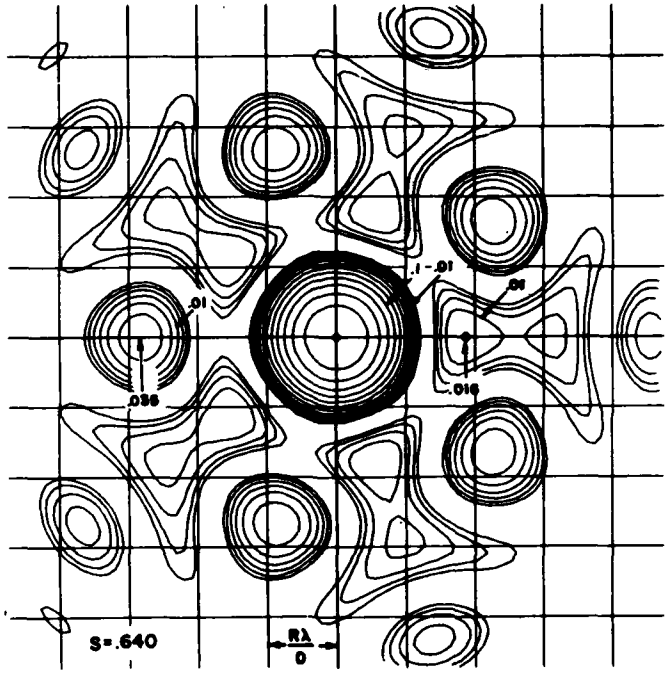
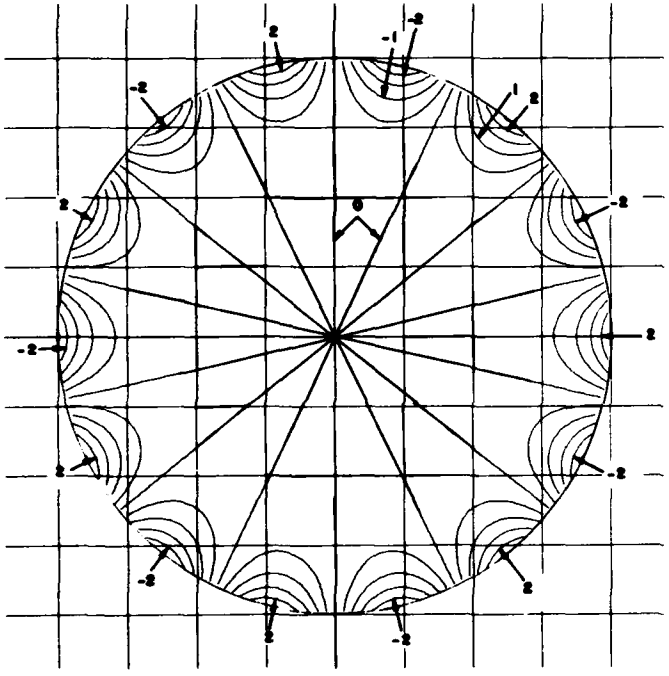


INTENSITY

ROSETTE
(TWELFTH ORDER)



PHASE

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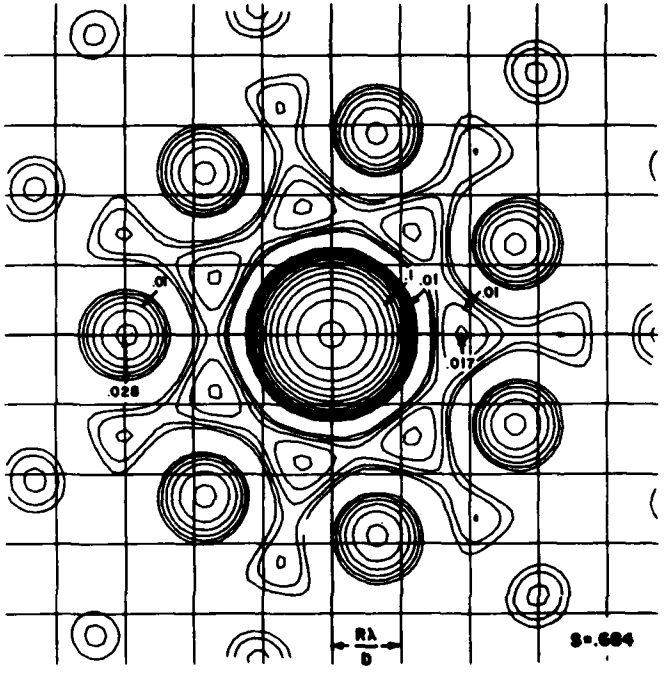
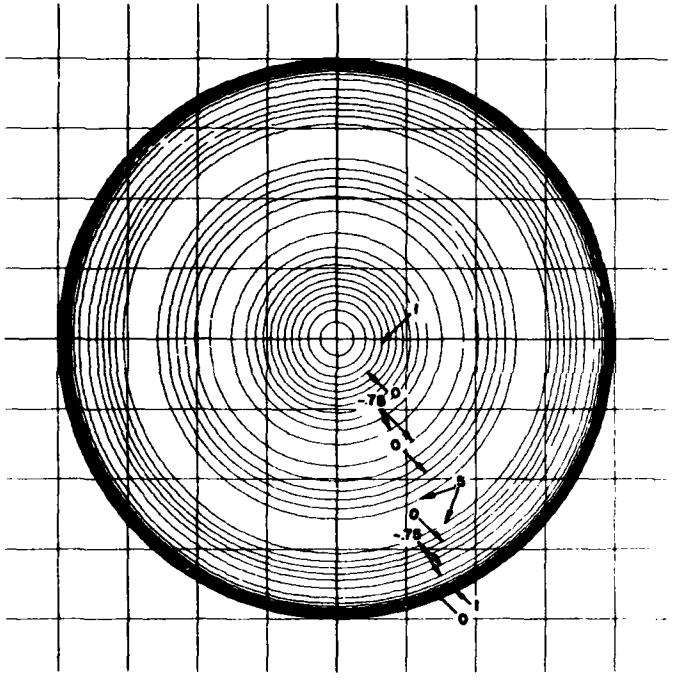


INTENSITY

SEVEN LEAF
(FOURTEENTH ORDER)



PHASE

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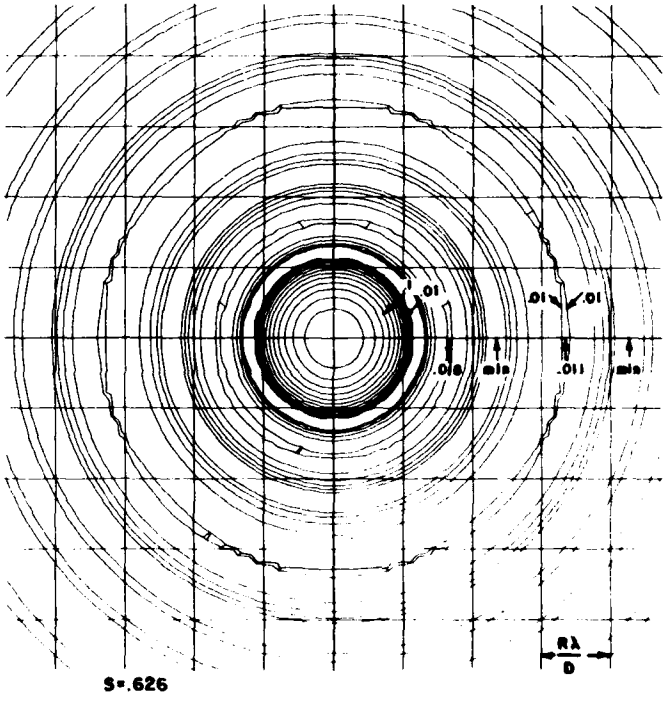
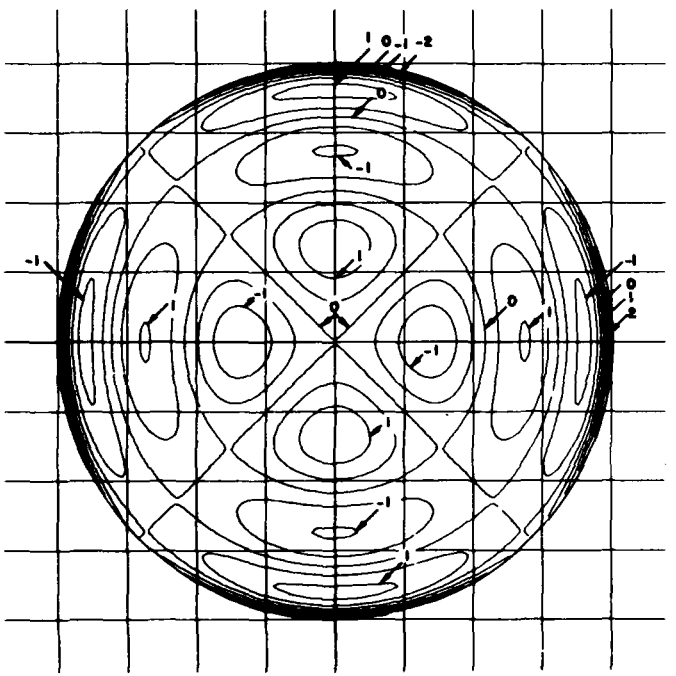


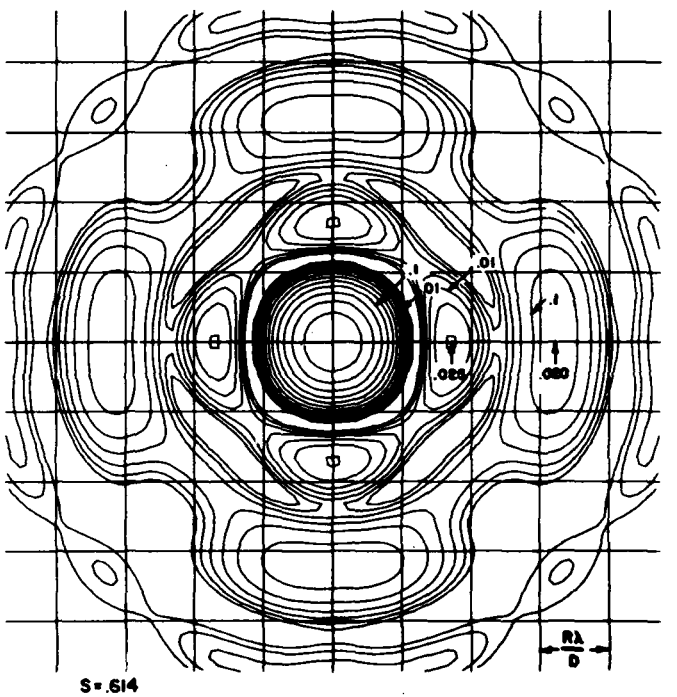
INTENSITY

SPHERICAL ABERRATION
(EIGHTH ORDER)



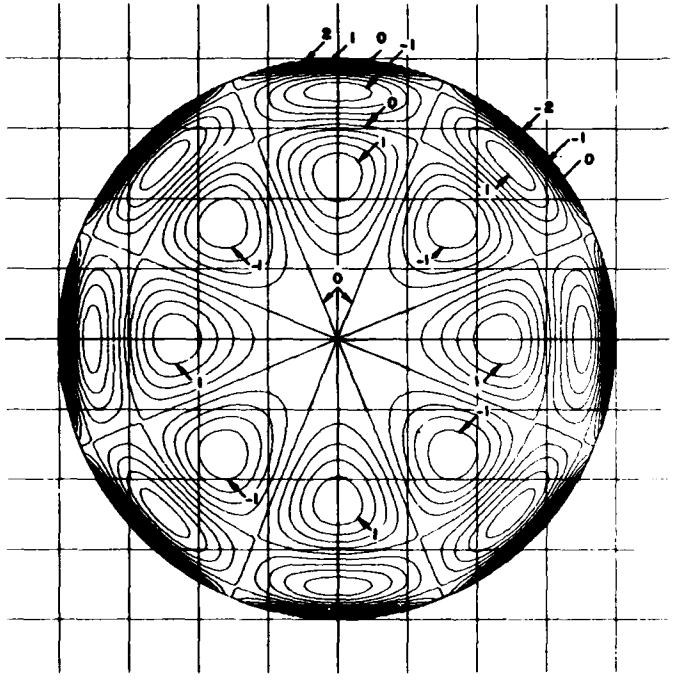
PHASE

k=38, n=8, m=2



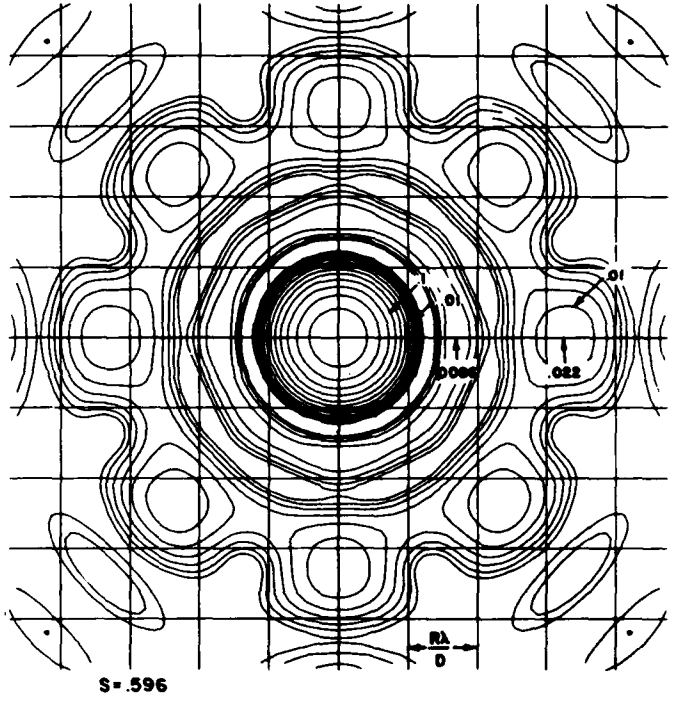
INTENSITY

ASTIGMATISM
(TENTH ORDER)



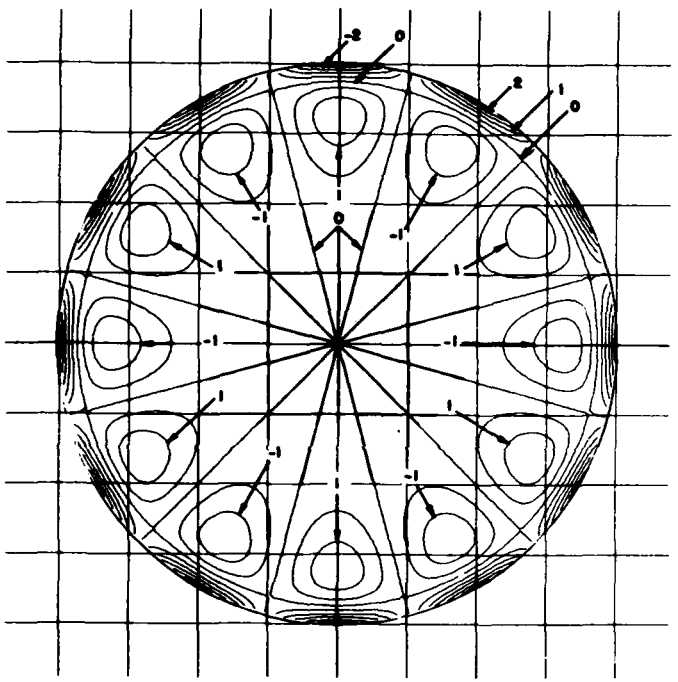
PHASE

k= 40, n=8, m=4



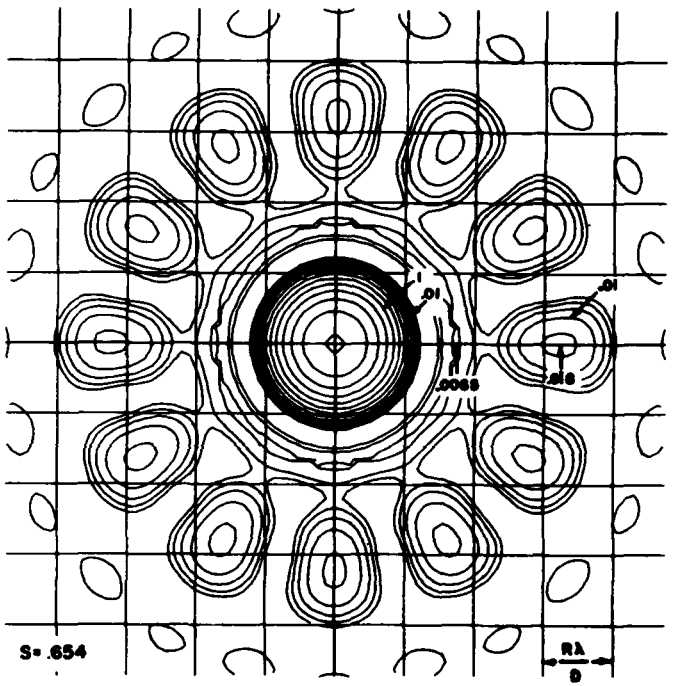
INTENSITY

LUCKY CLOVER
(TWELFTH ORDER)



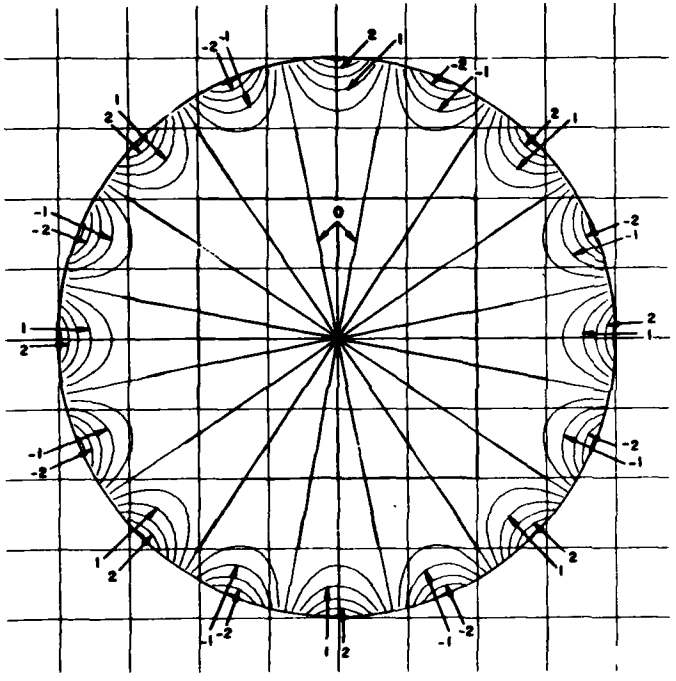
PHASE

k= 42, n= 8, m= 6



INTENSITY

LILY
(FOURTEENTH ORDER)



PHASE

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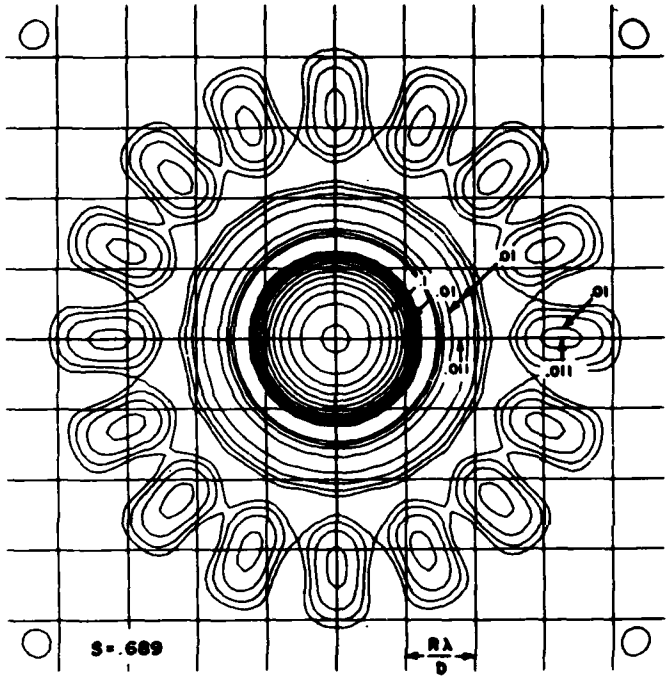

INTENSITY

SPIDER
(SIXTEENTH ORDER)

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

We present in this report the phase of a wave front as described by the Zernike polynomials and the corresponding intensities in the focal plane.

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