THE MAKSUTOV CLUB.

Circular No. 60

Membership List.

Please add to your membership list (Circular No. 8) the following:

Mr. John E. Welch
107 Lower Beverly Hills
West Springfield
Mass.

Richard W. Scott M.D.
38 School St.
Springfield
Mass.

These members should have been included in the list published in Dec. 1957 for Mr. Lindberg's group for 6" Maks - apologies for the omission.

Appendix to this Circular.

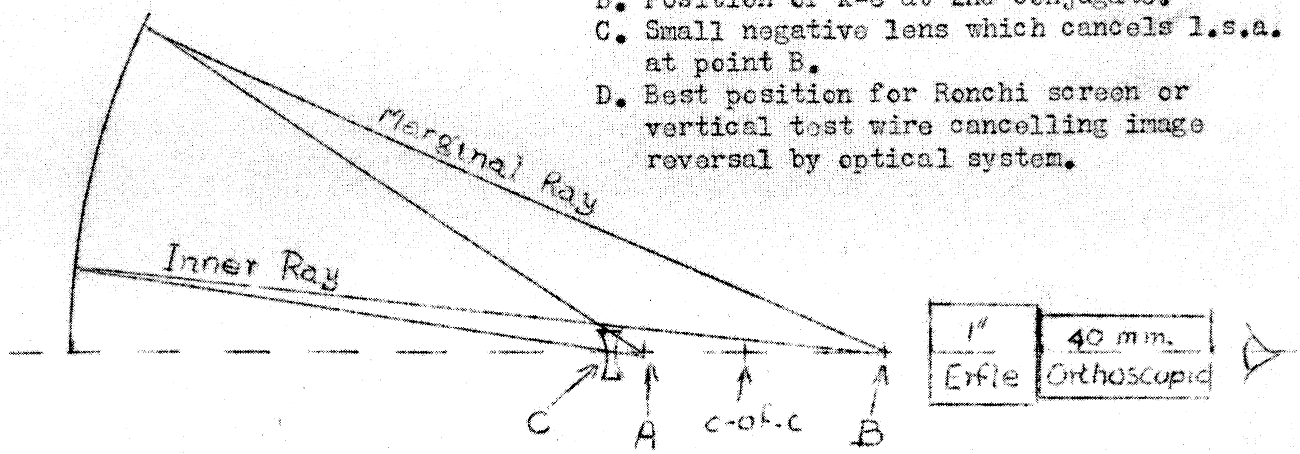
The appendix to this circular consists of an investigation into the five designs for 11" Maks which have so far been published in the circulars. This investigation was undertaken by Mr. H.B. Gibbons of Dallas, Texas, and can only be described as monumental. Mr. Gibbons fortunately has access to one of the large I.B.M. computers and has run off 200 ray traces on each of the designs. Before the advent of the computers, such an investigation would have been impossible, but readers should not be under the impression that everything is done by the computer; programming the machine for such an investigation is no light task and involves many hours of work. My sincere thanks to Mr. Gibbons for the time that he put in on this - we can now be quite satisfied that our designs have been investigated as closely as any professional job.

Testing the Concave Surface of Correctors.

Mr. E.G. Onions of Bulawayo, South Rhodesia, has sent me the following very interesting account of his method of testing the concave:

"As it is quite impossible for me to see the Foucault shadows at c-of-c of the Mak corrector surfaces, I have adapted a system of working at conjugates. By placing the light source inside c-of-c, we get a new focal point at a 2nd conjugate with a much flatter cone angle (the positions given in my diagram, 1/2 size as used for my 7" Mak corrector, give a cone angle approximately 45° as against 60° at c-of-c). But now, of course, our old enemy spherical aberration has taken a hand and our spherical curve is beginning to look like an oblate spheroid, increasingly so as the conjugates are separated. We now place a small negative lens of suitable diameter and power in front of the light source, and the longtitudinal spherical aberration at B disappears. When things are right, this small lens appears to be the same size, or a bit larger, than the surface under test. There is, of course, an optimum position for this lens for any pair of conjugates we wish to use, but I am afraid that the mathematics of this are beyond me. There is no distortion apparent with this setup. But if the 45° angle is still to much for my sight, (I have found it to be so), I introduce the double eyepiece viewing idea of Mr. Cox in S & T, March issue, and things are fine. I think the distortion found by Mr. Cox must be due to using giant Erfles at c-of-c direct - both Foucault and Ronchi work well with my setup. It will be noticed that all components in my diagram are in line of sight on the axis, so if horizontal supports for the hot wire are used, a tiny shield must be attached to screen it from direct vision; if vertical supports are used, this is not necessary as the filament is hidden by its posterior support".

A. Hot wire at 1st conjugate inside of c-of-c.
B. Position of k-e at 2nd conjugate.
C. Small negative lens which cancels l.s.a. at point B.
D. Best position for Ronchi screen or vertical test wire cancelling image reversal by optical system.



The following three ideas come from Mr. Frank W. Phillips of Marion, Ohio:

Trepanning Blanks.

I am making two smaller 6" Maks in order to get my hand in for the 11" job. I bought two square pieces of slab glass from Edmunds and cut them circular on a drill press, using a one gallon paint can as tool. This was the only thing handy of the correct size, and when I had finished each blank there were three pieces left - it cut right to the edge of the Edmund blank on three sides. It was necessary to turn a couple of thick pieces of plywood to fit the inside diameter of the can closely and against the bottom of the can. The arbor was fastened through a hole in the bottom of the can and plywood. I did not have an intermediate pulley to slow the speed of the drill so I made a wooden pulley about a foot in diameter. Used No. 80 and it took about 2½ or maybe 3 hours to get through each blank, hand feeding water and abrasive.

Curve Generating.

Mr. Schumacher, of Erie, Penna., sent me an abrasive wheel that cuts glass with ease and is not diamond. The wheel is marked Norton 39C60 - J7V 4/3 x 1½ x 1½ ME - 19237. Mr. Shumacher tells me that he used a lathe setup and was very successful - he tells me that he turned the wheel at 4,000 r.p.m. I just tried it on the shaft of a ¼ H.P. 1750 r.p.m. motor and it seemed to cut pyrex just fine - without any coolant.

Painting Cement Tools with Resin.

I am using tile and cement tools for grinding and cement (Hydrocal All)

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tools painted with fiber-glass resin solution for polishing tools. This worked fine on two tools but not on another where the stuff seemed to come loose and the water eventually softened the cement underneath. It may be that it was not thoroughly coated, but it would be well to make sure that the tool has all the water removed first and let the first coat soak into the surface.

(Comments. Substitution of a can instead of the usual thin-walled brass or steel tubing for trepanning is distinctly novel and will be much cheaper than the conventional tool; cutting the can with the usual kitchen can-opener will result in a smooth edge which can be gashed with a pair of tin shears. A good standard wheel for glass-cutting has long been needed and Mr. Phillips information on this particular Norton wheel will be appreciated by many. The idea of painting cement tools with resin is excellent as it will prevent contamination by the previous grade of abrasive if it is done after each grade; the idea of painting a cement tool with resin for a polishing tool I will accept with caution until I have tried it out - it appears to me that there may not be sufficient elasticity in the polisher to bring up a good surface, in any case the surface presumably should be finished off with the conventional pitch and rouge lap - it is a fine idea for prepolishing, however, and should work well. - A.M.)

My best wishes for Christmas and the New Year to all members of the Club and readers of the circulars.

Yours sincerely

Allan Mackintosh

97 McLoughlin St
Glen Cove N.Y.
Dec 14 1959

Circular No. 60 (Appendix)

Ray Tracing Studies.

By H.B. Gibbons.

This is a progress report of a ray tracing study of the five 11" Maksutov designs submitted to the Club since its inception. The study was made to become more familiar with the detail of the images formed and to determine the effect of some dimensional tolerances on the image produced.

To date the ray tracing has only been carried to the primary focus. Skew rays were included. Only rays from objects at an infinite distance were considered. All diffraction effects have been ignored.

The five designs analyzed were those submitted in the circulars by Dr. Crocker, Norman, Sjogren, Raab and Cole. For each design an entrance pupil was assumed 1 inch forward of the pole of the 1st surface of the corrector. (The pole being the intersection of the surface with the optical axis.) Sufficient rays were traced to insure a good picture of the image. The rays chosen lay in circular zones spaced at half inch intervals radially from the optical axis to the marginal ray at $5\frac{1}{2}$" radius. In each of these eleven zones, nine rays were traced at $22\frac{1}{2}^\circ$ intervals around the optical axis from zero to 180°. The rays were traced for two colors C and F with indexes of refraction $n = 1.51462$ and 1.52264 representing the red and blue ends of the spectrum. Sample traces were made at intermediate indexes to insure that all intermediate values would be covered by the above two extremes. Oblique rays were considered. Pencils of rays at 0, 1, 2 and $2\frac{1}{2}$ degrees from the optical axis pemitted comparisons of the image out to 5 degrees field of ciew. (The effects of vignetting were neglected.) This gave a total (including the principal rays) of $2(11 \times 9 + 1)$ or 200 rays to construct a picture of the image aberration at each of four angles of obliquity. The image of any given pencil of rays was examined at any position along the optical axis by plotting the intersection of each of the rays with an image plane normal to the optical axis at the chosen position.

One way the results can be summarized is by denoting the minimum size of the rectangle which would contain all 200 rays in each pencil. The rectangle is oriented in the image plane so that the sides are disposed radially and tangentially with respect to the optical axis. The position of the image planes chosen for comparative purposes had to be arbitrary. Two planes were examined, one, a tangential focus (D_t) being at the intersection of the two marginal tangential rays (rays at 0° and 180° and $5\frac{1}{2}$ inches from the optical axis at the entrance pupil) for the index of refraction 1.51462 and the other (D_m) being that image plane which gave the smallest total area of rectangle (presumably the highest concentration of light and therefore the brightest image). This generally occurred when the tangential dimension was a minimum. The minimum radial dimension occurred at the D_t image plane for three of the designs (Sjogren, Raab and Norman) but not for the other two.

The data results are given in the enclosed tables and are also plotted up for convenience in visualization. Please note a change in scale among the graphs. The position of the image planes D_t and D_m is given as the distance of the planes from the center of curvature of the primary mirror. The distance of the image plane from the centroid of the rectangle to the optical axis is also given. All dimensions are in inches.

/1A

Some general comment can be made which is not obvious from the data. The separation of the C and F principal rays at the image planes is nearly constant for all designs and amounts approximately to 1.7×10^{-4} inches per degree of obliquity of the pencil. This is of some consequence for the designs having relatively small aberrations. To illustrate this a plot of the image of the tangential focus (D_t) for the Cole design for a pencil of rays at 2° obliquity is given. The separation of the C and F rays and the distortion of the zones that were circular at the entrance pupil is apparent.

The data submitted in the tables can be used to determine the shape of the image surface at the primary focus. Using the D_t image locations a reasonably constant radius of curvature will result. If, however, the D_m image location is considered more desirable a constant radius of curvature will not suffice. It could easily result that a lack of accuracy in constructing the image surface at the prime focus could nullify an extreme amount of care in producing close tolerance optics in the rest of the system.

H.B. Gibbons
11/5/59

CROOKER

Image at Prime Focus
(all dimensions in inches)

	Obliquity	Rectangle Dimensions Tangential	Radial	Area	@@ Position of Image Plane	Distance of Centroid to Optical Axis
D_t	0	4.4×10^{-4}	4.4×10^{-4}	19×10^{-8}	44.431871	0
	1	4.4	5.7	25	44.425571	.770388
	2	4.7	9.2	43	44.406666	1.540495
	2½	6.4	11.2	72	44.392476	1.925410
D_m	0	3.2	3.2	10	44.432530	0
	1	3.3	5.0	17	44.426200	.770363
	2	4.2	10.5	44	44.406450	1.540450
	2½	4.6	12.1	56	44.391670	1.925429

@@ Distance of the image plane from the center of curvature of the primary mirror.

/3A

NORMAN

Image at Prime Focus.
(all dimensions in inches)

Obliquity		Rectangle Dimensions Tangential	Radial	Area	@@ Position of Image Plane	Distance of Centroid to Optical Axis
D_t	0	5.5×10^{-4}	5.5×10^{-4}	30×10^{-8}	46.296900	0
	1	9.4	12.5	117	46.292218	.805745
	2	24.3	24.8	603	46.278163	1.61138
	2½	33.8	30.5	1030	46.267612	2.01413
D_m	0	3.2	3.2	10	46.29820	0
	1	8.2	13.5	111	46.29146	.805785
	2	14.5	32.2	466	46.27240	1.61168
	2½	17.5	43.9	768	46.25810	2.01456

SJOGREN

D_t	0	4.9	4.9	24	45.635254	0
	1	11.4	14.5	165	45.630991	.795263
	2	29.0	29.0	840	45.618196	1.59055
	2½	40.0	36.0	1440	45.608585	1.98809
D_m	0	2.7	2.7	7.3	45.63624	0
	1	9.2	16.2	150	45.62975	.759294
	2	17.0	38.0	650	45.61125	1.59092
	2½	21.0	52.0	1090	45.59735	1.98864

@@ Distance of the image plane from the center of curvature of the primary mirror.

/4A

RAAB

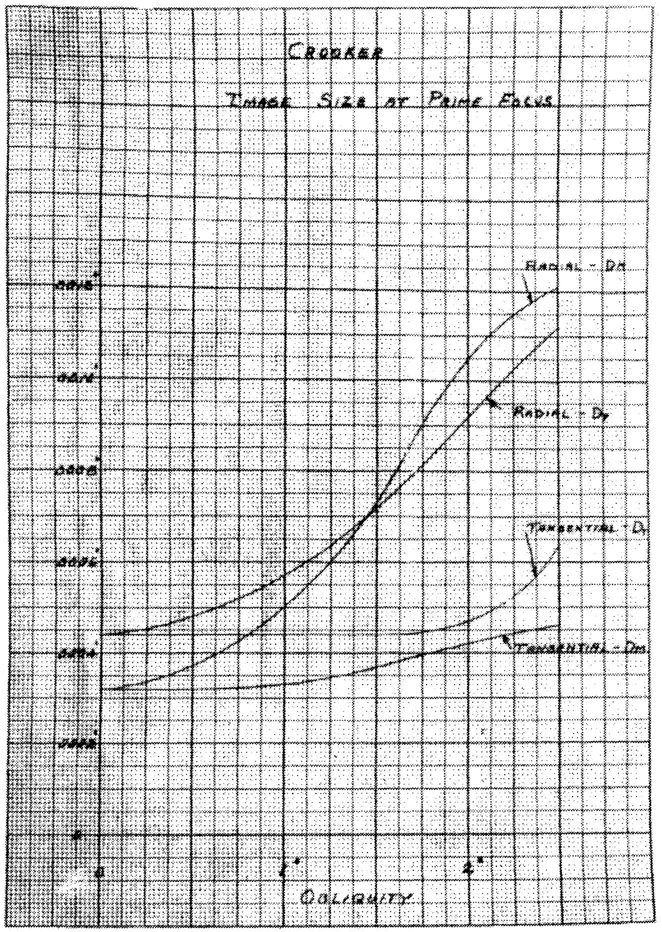
Image at Prime Focus
(all dimensions in inches)

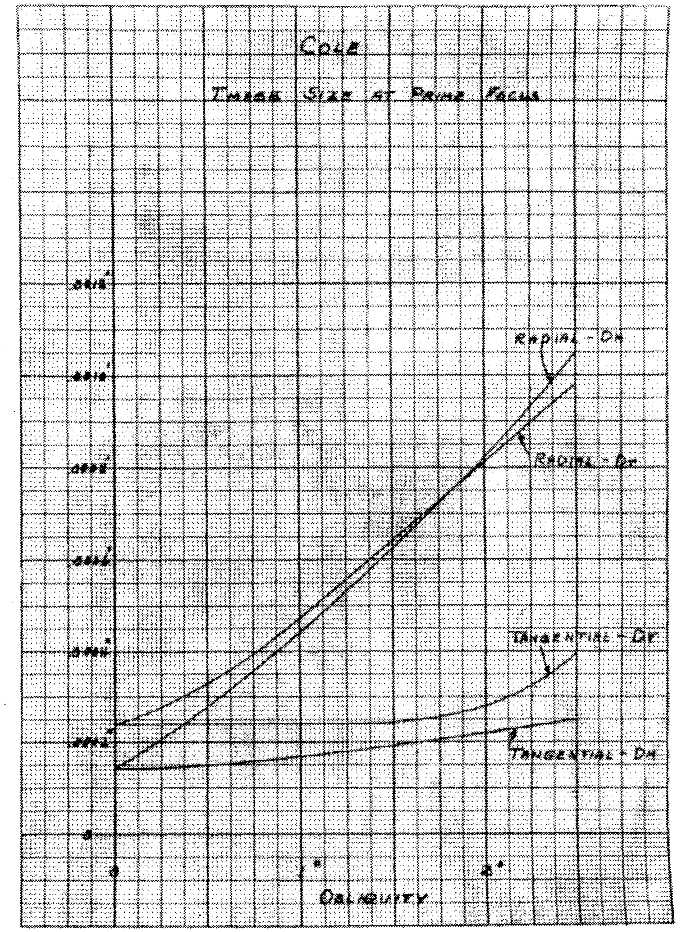
Obliquity		Rectangle Dimensions Tangential	Radial	Area	@@ Position of Image Plane	Distance of Centroid to Optical Axis
D_t	0	$7.5x10^{-4}$	$7.5x10^{-4}$	$56x10^{-8}$	44.300540	0
	1	18.7	22.3	417	44.298326	.774840
	2	48.2	44.4	2140	44.291673	1.54962
	2½	67.5	55.2	3730	44.286670	1.93696
D_m	0	4.4	4.4	19	44.30230	0
	1	14.5	26.0	377	44.29600	.774970
	2	27.4	61.2	1670	44.28000	1.55029
	2½	34.0	82.0	2790	44.26790	1.93800

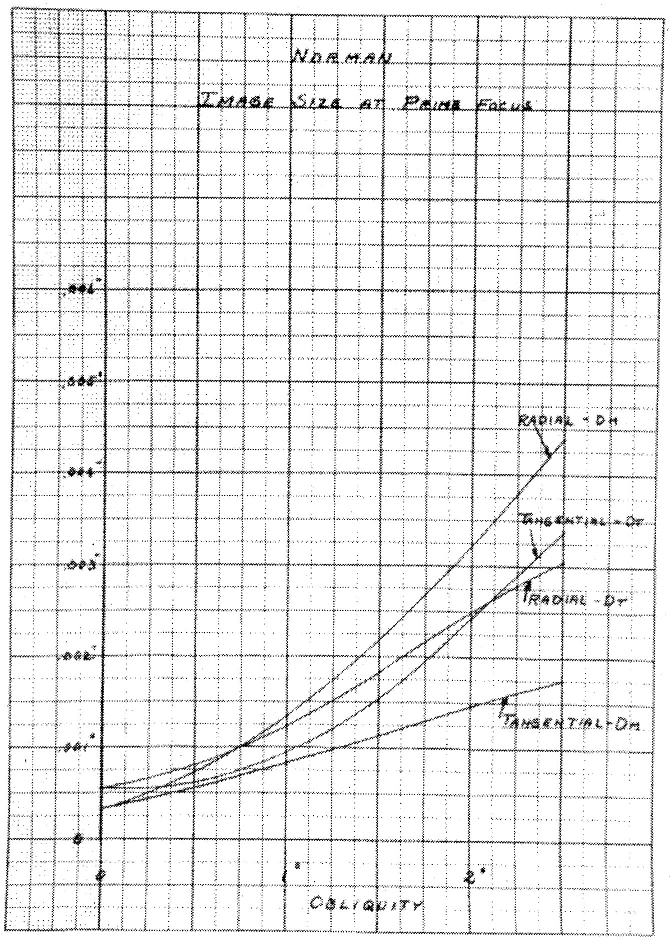
COLE.

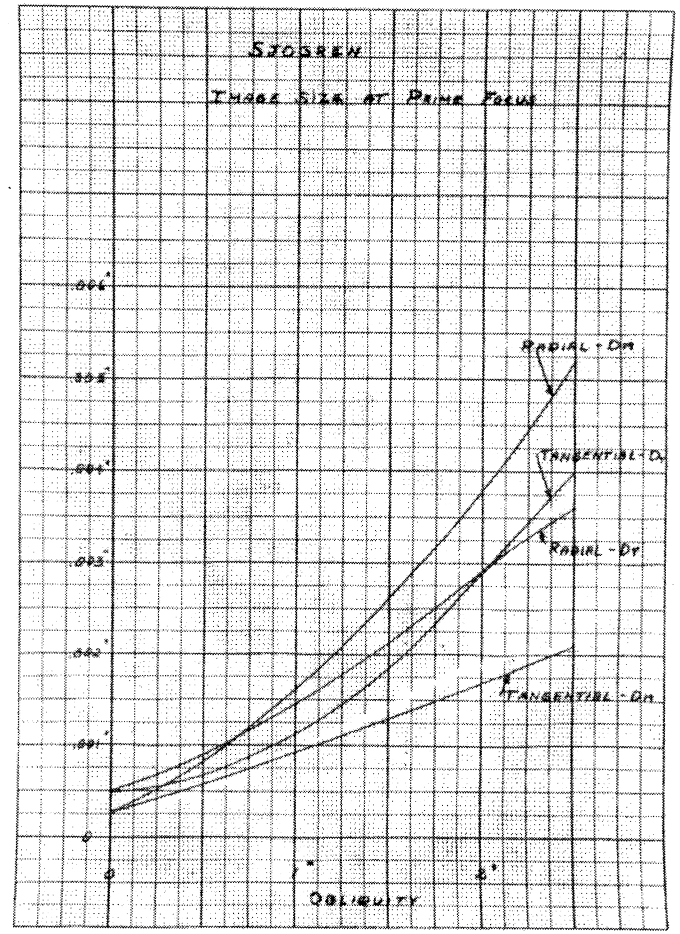
D_t	0	1.4	1.4	2.0	43.145263	0
	1	2.4	4.7	11.3	43.138659	.747209
	2	2.8	8.1	22.7	43.120142	1.494198
	2½	4.0	9.8	39.2	43.106247	1.867768
D_m	0	1.4	1.4	2.0	43.145263	0
	1	1.7	4.4	7.5	43.139040	.747186
	2	2.2	8.2	18.0	43.119950	1.494207
	2½	2.5	10.5	26.2	43.105610	1.867790

@@ Distance of the image plane from the center of curvature of the primary mirror.


Crocker
Image Size at Prime Focus
.0012"
.0010"
.0008"
.0006"
.0004"
.0002"
0
Radial - DM
Radial - DT
Tangential - DT
Tangential - DM
0
1°
2°
Obliquity


Cole
Image Size at Prime Focus
.0012"
.0010"
.0008"
.0006"
.0004"
.0002"
0
Radial - DM
Radial - DT
Tangential - DT
Tangential - DM
0
1°
2°
Obliquity


NORMAN
IMAGE SIZE AT PRIME FOCUS
.006"
.005"
.004"
.003"
.002"
.001"
0
RADIAL - DM
TANGENTIAL - DT
RADIAL - DT
TANGENTIAL - DM
0
1°
2°
OBLIQUITY


SJOGREN
IMAGE SIZE AT PRIME FOCUS
.006"
.005"
.004"
.003"
.002"
.001"
0
RADIAL - DM
TANGENTIAL - D
RADIAL - DT
TANGENTIAL - DM
0
1°
2°
OBLIQUITY

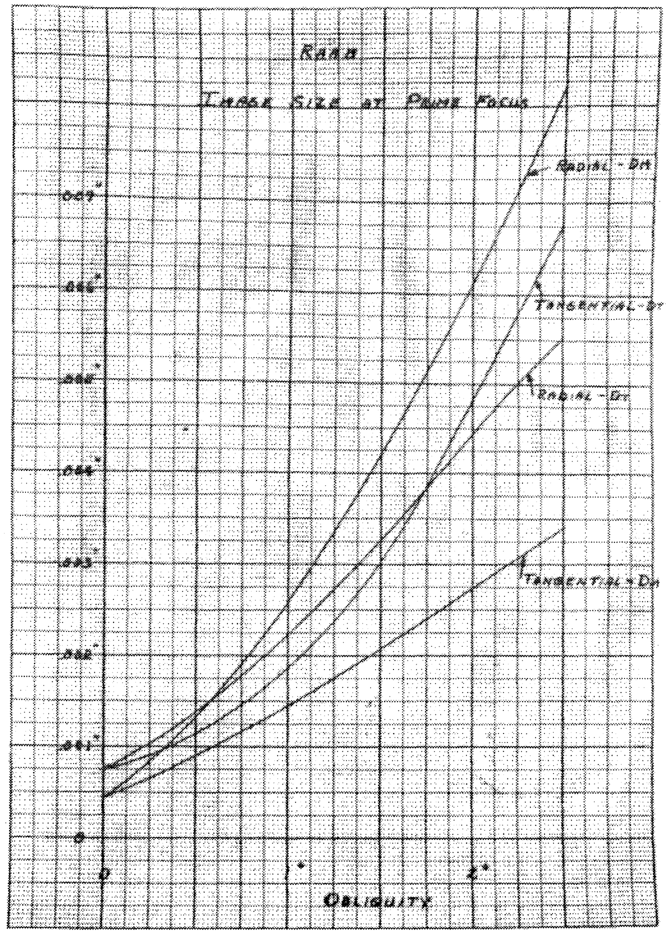
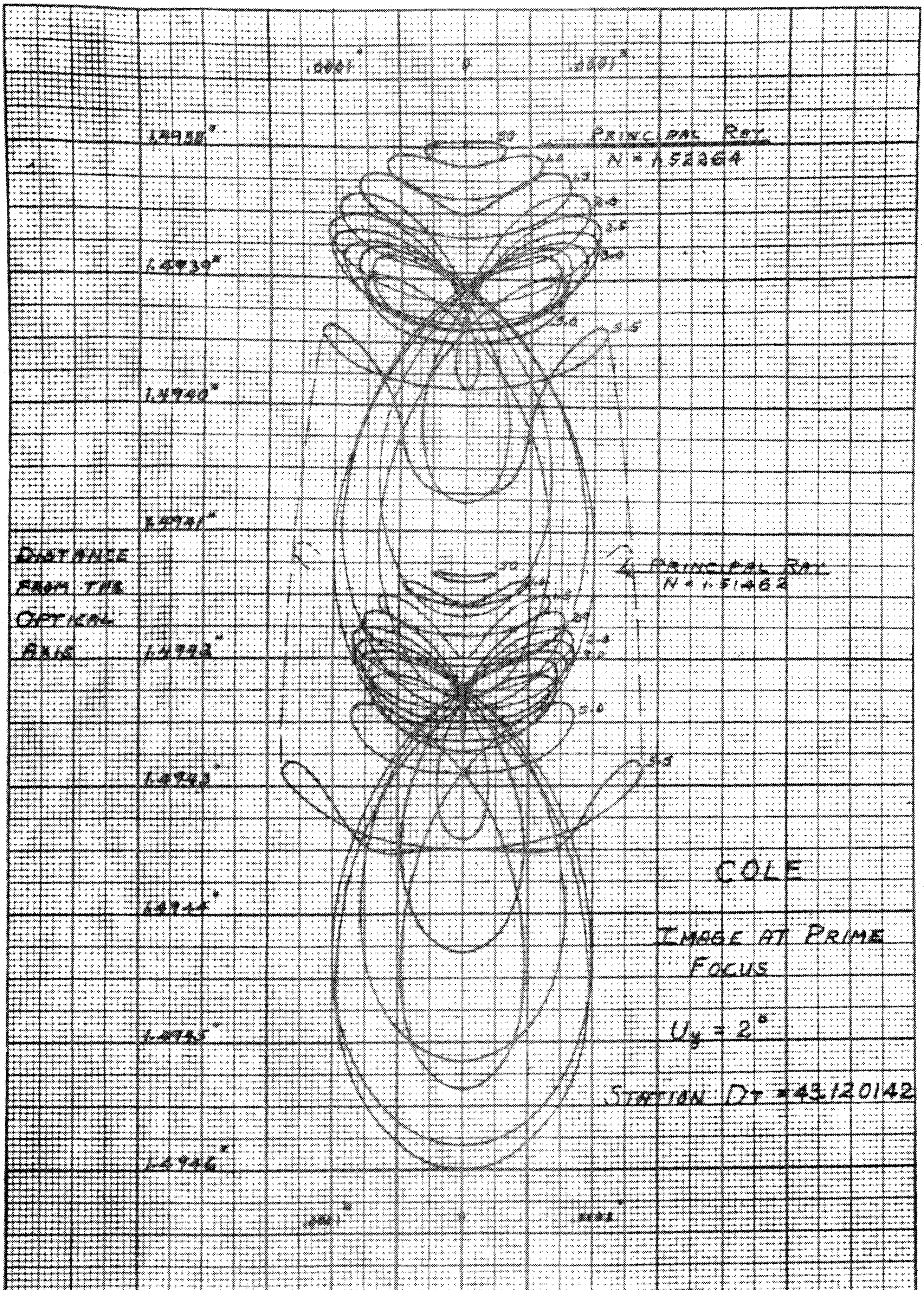
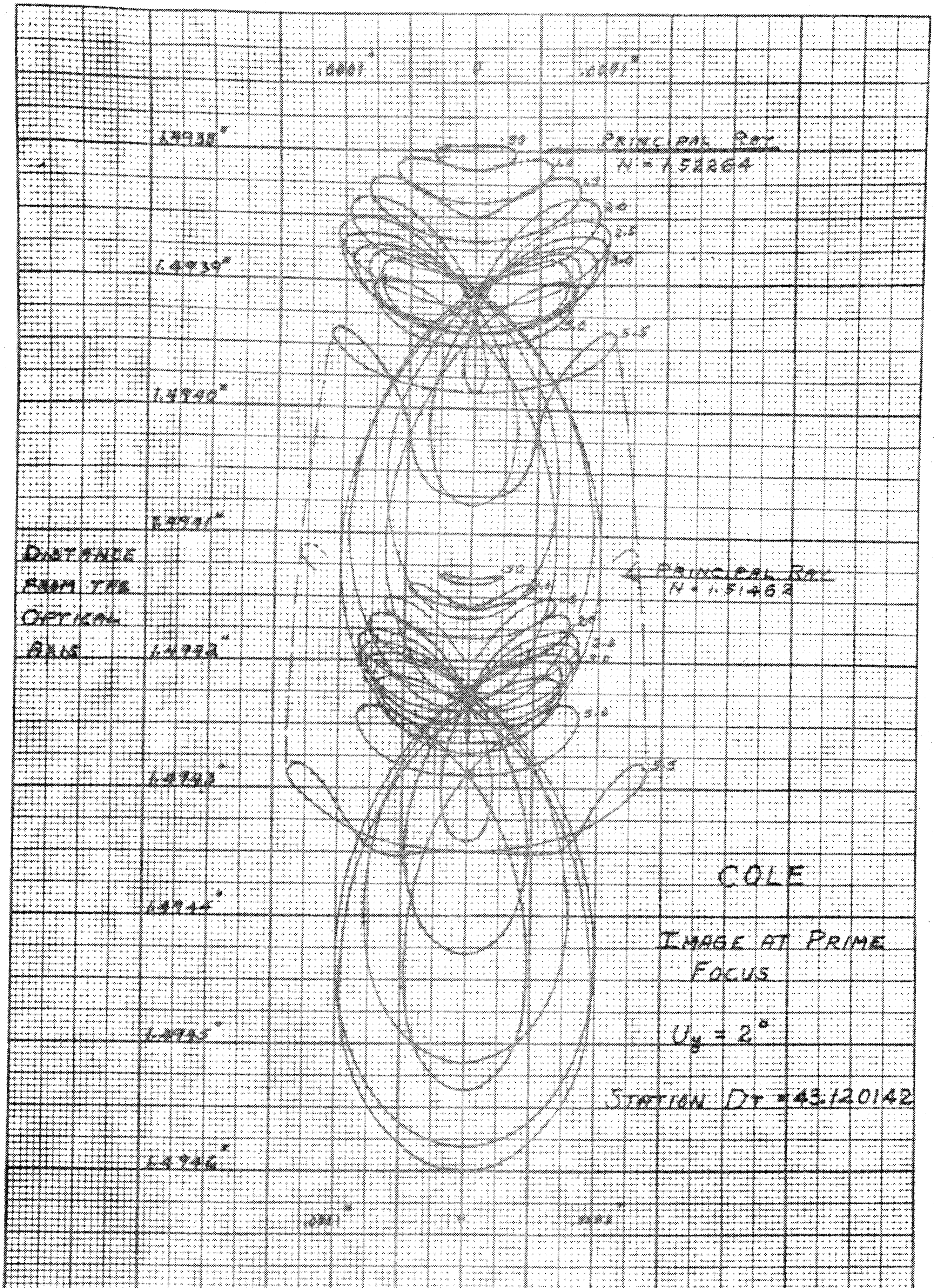


Image Size at Prime Focus
Radial - Dm
Tangential - Dt
Radial - Dt
Tangential - Dm
.007"
.006"
.005"
.004"
.003"
.002"
.001"
0
0
1°
2°
Obliquity



.0001"
0
.0001"
1.4938"
PRINCIPAL RAY
N = 1.52264
1.4939"
1.4940"
1.4941"
DISTANCE FROM THE OPTICAL AXIS
PRINCIPAL RAY
N = 1.51462
1.4942"
1.4943"
1.4944"
1.4945"
1.4946"
COLE
IMAGE AT PRIME FOCUS
Uy = 2°
STATION DT = 43.120142
.0001"
0
.0001"


PRINCIPAL RAY
N = 1.52264
1.4939"
1.4940"
DISTANCE
FROM THE
OPTICAL
AXIS
PRINCIPAL RAY
N = 1.51462
1.4945"
1.4946"
COLE
IMAGE AT PRIME
FOCUS
Uy = 2°