

KG

11366  
v.870



1990phae-proj











Flint

23

lead separation = .250

$$\cancel{d_4}(\tau_4) = \frac{51.483}{2.133}$$

$$\tau_4 = 49.350$$

B

p.21.  $d_4 = 77.425$

$$\tau_4 = \frac{49.350}{28.075}$$

$$\sin \tau = \frac{1.44832}{8.64447}$$

$$\tau_4 = \frac{0.09279}{1.69329}$$

$$i = 1^\circ 26' 15.7'' = \sin 8.39950$$

$$0.19864$$

$$l = 2^\circ 16' 18.6'' = \sin 8.59814$$

$$1.69329$$

$$b = \frac{0^\circ 50' 2.9''}{2^\circ 31' 39.8''} = \frac{0.29143}{8.47062}$$

$$1^\circ 41' 36.9'' = 1.82081$$

$$\frac{66.193}{49.350} = 1.34181$$

$$\frac{115.543}{115.532} = 1.00009$$

Flint mark

$$d_4 = 77.425$$

$$\tau_4 = \frac{49.208}{28.217}$$

$$\frac{1.45051}{8.64447}$$

$$0.09498$$

$$i = 1^\circ 26' 56.8'' = \sin 8.40294$$

$$0.19864$$

$$l = 2^\circ 17' 23.8'' = \sin 8.60158$$

$$1.69204$$

$$0^\circ 50' 27.0'' = 0.29362$$

$$2^\circ 31' 39.8'' = 8.46890$$

$$1^\circ 41' 12.8'' = 1.82472$$

$$66.791$$

$$f_4 = \frac{49.208}{115.999}$$

$$76.990$$

$$\frac{49.350}{27.640}$$

7

$$= \frac{1.44154}{8.64677}$$

$$0.08831$$

$$1.69329$$

$$i = 1^\circ 25' 22.6'' = \sin 8.39502$$

$$0.20295$$

$$l = 2^\circ 16' 15.4'' = \sin 8.59797$$

$$1.69329$$

$$0^\circ 50' 52.8'' = 0.29126$$

$$2^\circ 32' 28.3'' = 8.47052$$

$$1^\circ 41' 35.5'' = 1.82074$$

$$66.182 = 1.82074$$

$$\frac{49.350}{115.532}$$

$$76.990$$

$$\frac{49.208}{27.782}$$

$$= \frac{1.44376}{8.64677}$$

$$0.09053$$

$$1.69204$$

$$i = 1^\circ 26' 3.7'' = \sin 8.39849$$

$$0.20295$$

$$l = 2^\circ 17' 21.0'' = \sin 8.60144$$

$$1.69204$$

$$0^\circ 51' 17.3'' = 0.29348$$

$$2^\circ 32' 28.3'' = 8.46877$$

$$1^\circ 41' 11.0'' = 1.82471$$

$$66.790 = 1.82471$$

$$f_4 = \frac{49.208}{115.998}$$

lead couch



# Coron Spherical Aberration B

Marginal

Central

See p. 12

$$n = 0.18547 \checkmark$$

$$24.023 = \tau = \underline{1.38062 \checkmark}$$

$$1.56609 \checkmark$$

$$n-1 = \underline{9.72651 \checkmark}$$

$$f_1 = 69.116 \checkmark = 1.83958 \checkmark$$

$$\underline{.900 \checkmark}$$

$$d_2 = 68.216 \checkmark = 1.83389 \checkmark$$

$$\tau_2 = \underline{1.38062 \checkmark}$$

$$3.21451 \checkmark$$

$$\left. \begin{array}{l} n = \\ \tau = \end{array} \right\} = 36.821 \checkmark$$

$$\begin{array}{l} d = 9.72651 \checkmark \\ n-1 = \underline{1.83389 \checkmark} \\ 1.56040 \checkmark = 36.341 \checkmark \end{array}$$

$$73.162 \checkmark = \underline{1.86429 \checkmark}$$

$$f_2 = 22.399 \checkmark = 1.35022 \checkmark$$



Flint

25

## Spherical Aberration

B

Marginal

Central

see p. 21.

$$f_2 = 22.399 \checkmark$$

$$\underline{.250 \checkmark}$$

$$d_3 = 22.149 \checkmark = 1.34535 \checkmark$$

$$n = 0.19864 \checkmark$$

$$\tau_3 = 23.350 \checkmark \quad \underline{1.36829 \checkmark}$$

$$2.91228 \checkmark$$

$$d_3 = 1.34535 \checkmark$$

$$n-1 = 9.76339 \checkmark$$

$$23.350 \checkmark$$

$$1.10874 \checkmark = \underline{12.8452 \checkmark}$$

$$10.505 \checkmark = \underline{1.02140 \checkmark}$$

$$f_3 = 77.782 \checkmark = 1.89088 \checkmark$$

$$\underline{.250 \checkmark}$$

$$d_4 = 77.532 \checkmark = 1.88948 \checkmark$$

$$\tau_4 = 49.208 \checkmark \quad \underline{1.69204 \checkmark}$$

$$3.58152 \checkmark$$

see p. 23

$$n = 0.19864 \checkmark$$

$$\tau = 1.69204 \checkmark$$

$$1.89068 \checkmark = 77.747 \checkmark$$

$$d = 1.88948 \checkmark$$

$$n-1 = 9.76339 \checkmark$$

$$1.65287 \checkmark = \underline{44.965 \checkmark}$$

$$32.782 \checkmark = \underline{1.51564 \checkmark}$$

$$f_4 = 115.999$$

$$f_4 = 116.380 \checkmark = 2.06588 \checkmark$$

$$\underline{115.999}$$

$$0.381 \quad \text{Flint weak}$$



To preserve color  $B = \frac{1}{\tau_3} + \frac{1}{\tau_4} = \frac{1}{23.350} + \frac{1}{49.208}$

$$\begin{array}{rcl} & \tau_3 = & 1.36829 \\ .042826 & = & 8.63171 \end{array}$$

$$\begin{array}{rcl} & \tau_4 = & 1.69204 \\ & = & 8.30796 \\ \underline{.020322} & & \\ B = & .063148 & \end{array}$$

try

$$\begin{array}{rcl} & \tau_3 = \underline{23.150} = & 1.36455^- \\ & = & 8.63545^- \\ \underline{.043197} & & \\ \frac{1}{\tau_4} = & .019951 & = 8.29996 \\ & \tau_4 = \underline{50.123} = & 1.70004 \end{array}$$



# Flint Spherical Aberration B

Marginal

Central

p. 21

$$d_3 = 21.288 \checkmark$$

$$r_3 = 23.150 \checkmark$$

$$44.438 \checkmark =$$

$$\sin v = 9.19784 \checkmark$$

$$0.845559 \checkmark$$

$$1.364555 \checkmark$$

$$17 \ 37 \ 16.0 \checkmark = \sin 9.48104 \checkmark$$

$$n = 0.19864 \checkmark$$

$$11 \ 2 \ 46.4 \checkmark = \sin 9.28240 \checkmark$$

$$6 \ 34 \ 29.6 \checkmark r_3 = 1.36455 \checkmark$$

$$9 \ 4 \ 24.8 \checkmark 0.64695 \checkmark$$

$$v = 2 \ 29 \ 55.2 \checkmark = \sin 8.63948 \checkmark$$

$$101.742 \checkmark = 2.00750 \checkmark$$

$$r_3 = 23.150 \checkmark$$

$$f_3 = 78.592 \checkmark$$

$$d_4 = 78.342 \checkmark$$

$$r_4 = 50.123 \checkmark$$

$$28.219 \checkmark =$$

$$1.45054 \checkmark d = 1.89411 \checkmark$$

$$8.63945 \checkmark n = 9.76339 \checkmark$$

$$0.08999 \checkmark 1.65750 \checkmark = 45.446 \checkmark$$

$$1.70004 \checkmark 33.746 \checkmark = 1.52822 \checkmark$$

$$1 \ 24 \ 23.1 \checkmark = \sin 8.38995 \checkmark$$

$$0.19864 \checkmark 0.19864 \checkmark$$

$$2 \ 13 \ 20.6 \checkmark = \sin 8.58859 \checkmark$$

$$0 \ 48 \ 57.5 \checkmark r_4 = 1.70004 \checkmark$$

$$2 \ 29 \ 55.2 \checkmark 0.28863 \checkmark$$

$$1 \ 40 \ 57.7 \checkmark = \sin 8.46782 \checkmark$$

$$66.193 \checkmark = 1.82081 \checkmark$$

$$50.123 \checkmark$$

$$f_4 = 116.316 \checkmark$$

$$n =$$

$$0.19864 \checkmark$$

$$d_3 = 22.149 \checkmark 1.34535 \checkmark$$

$$r_3 = 23.150 \checkmark 1.36455 \checkmark$$

$$2.90854 \checkmark$$

$$d = 1.34535 \checkmark$$

$$n = 9.76339 \checkmark 23.150 \checkmark$$

$$1.10874 \checkmark = 12.845 \checkmark$$

$$10.305 \checkmark = 1.01305 \checkmark$$

$$f_3 = 78.612 \checkmark = 1.89549 \checkmark$$

$$.250 \checkmark$$

$$d_4 = 78.362 \checkmark = 1.89411 \checkmark$$

$$r_4 = 50.123 \checkmark = 1.70004 \checkmark$$

$$3.59415 \checkmark$$

$$n = 0.19864 \checkmark$$

$$r = 1.70004 \checkmark$$

$$1.89868 \checkmark = 79.192 \checkmark$$

p. 26

d =

$$.316$$

$$.078$$

Flint weak



$\tau_3$	Sph. Ab.
23.350	.381
23.150	.078
23.098	.000

$$\begin{aligned}
 \text{Try } \tau_3 &= 23.098 &= 1.36357 \\
 \frac{1}{\tau_3} &= .043294 &= 8.63643 \\
 B &= .063148 \\
 \frac{1}{\tau_4} &= .019854 &= 8.29785 \\
 \tau_4 &= 50.367 &= 1.70215
 \end{aligned}$$

Approximate curves

$$\left. \begin{aligned} \tau_1 &= 24.023 \\ \tau_2 &= 24.023 \end{aligned} \right\} t_1 = .900$$

$$\text{Separation} = .250$$

$$\left. \begin{aligned} \tau_3 &= 23.098 \\ \tau_4 &= 50.367 \end{aligned} \right\} t_2 = .250$$

$$f_4 = 116.39$$

$$7 \times 16 =$$

$$112.$$

$\frac{1}{80}$ off.	Rhodes $\frac{1}{x}$ off
23.72	23.065
23.72	23.065
	.240
22.81	22.177
49.74	48.359
114.94	111.75



Approximate curves - to give  $f_4 = 111.75$   
which gives focal length of 112 equal to 16 times  
the clear aperture -

check

$$\tau_1 = \tau_2 = 24.023 = \begin{array}{r} 1.38062 \\ 9.98233 \\ \hline 23.065 = 1.36295 \end{array}$$

$$\tau_3 = 23.098 = \begin{array}{r} 1.36357 \\ 9.98233 \\ \hline 22.177 = 1.34590 \end{array}$$

$$\tau_4 = 50.367 = \begin{array}{r} 1.70215 \\ 9.98233 \\ \hline 48.369 = 1.68449 \end{array}$$

$$f_4 = 116.39 = \begin{array}{r} 2.06593 \\ 9.98233 \\ \hline 111.75 = 2.04826 \end{array}$$

$$\text{Separation} = .250 = \begin{array}{r} 9.39794 \\ 9.98233 \\ \hline .240 = 9.38027 \end{array}$$

$$t_1 = \begin{array}{r} 942 \\ .90 \\ .864 \end{array} = \begin{array}{r} 9.974 \\ 9.982 \\ 9.95424 \\ 9.98233 \\ \hline 9.93657 \end{array}$$

$$t_2 = \begin{array}{r} .261 \\ .25 \end{array} = \begin{array}{r} 9.416 \\ 9.982 \\ 9.398 \end{array}$$

$$t_1 = .864$$

$$t_2 = .240$$



$$\tau_1 = \tau_2 = 23.065^- \quad t_1 = .900$$

$$\text{Separation} = .250$$

$$\tau_3 = 22.177$$

$$t_2 = .250$$

$$\tau_4 = 48.359$$

$$f_4 = 111.75^-$$

Lesson

I

B	k = 0.54407
	$\tau_1 = 1.36295^-$
$i = 8^\circ 43' 41.5'' \checkmark = \sin$	$9.18112^-$
	$0.18547^-$
$\lambda = 5^\circ 40' 54.5'' \checkmark = \sin$	$8.99563^-$
$\mu = 3^\circ 2' 47.0'' \checkmark$	$1.36295^-$
	$0.35860^-$
	$8.72546^-$
	$= 1.63314^-$
$\tau_1 = 42.9675^- \checkmark$	
$\tau_1 = 23.065^- \checkmark$	
$f_1 = 66.0325^- \checkmark$	
	$.900$
$d_2 = 65.1325^- \checkmark$	

F	
$i = 8^\circ 43' 41.5'' \checkmark = \sin$	$9.18112^-$
	$0.18875^-$
$\lambda = 5^\circ 38' 20.0'' \checkmark = \sin$	$8.99237^-$
$\mu = 3^\circ 5' 21.5'' \checkmark$	$1.36295^-$
	$0.35532^-$
	$8.73153^-$
	$= 1.62379^-$
$42.052^- \checkmark$	
$23.065^- \checkmark$	
$f_1 = 65.117^- \checkmark$	
	$.900$
$d_2 = 64.217^- \checkmark$	

II

$\tau_2 = 23.065^- \checkmark$	$88.1975^- \checkmark = 1.94546^-$
	$\sin 8.72546^-$
	$0.67092^-$
	$1.36295^-$
$i = 11^\circ 43' 31.5'' \checkmark = \sin$	$9.30797^-$
	$0.18547^-$
$\lambda = 18^\circ 8' 56.0'' \checkmark = \sin$	$9.49344^-$
$6^\circ 25' 24.5'' \checkmark$	$1.36295^-$
$3^\circ 2' 47.0'' \checkmark$	$0.85639^-$
$\mu = 9^\circ 28' 11.5'' \checkmark = \sin$	$9.21624^-$
	$1.64015^-$
$43.667^- \checkmark$	
$23.065^- \checkmark$	
$f_2 = 20.602^- \checkmark$	

$23.065^- \checkmark$	$87.282^- \checkmark = 1.94092^-$
	$8.73153^-$
	$0.67245^-$
	$1.36295^-$
$i = 11^\circ 46' 2.6'' \checkmark = \sin$	$9.30950^-$
	$0.18875^-$
$18^\circ 21' 30.0'' \checkmark = \sin$	$9.49825^-$
$6^\circ 35' 27.4'' \checkmark$	$1.36295^-$
$3^\circ 5' 21.5'' \checkmark$	$0.86120^-$
$9^\circ 40' 48.9'' \checkmark = \sin$	$9.22570^-$
	$1.63550^-$
$43.202^- \checkmark$	
$23.065^- \checkmark$	
$f_2 = 20.137^- \checkmark$	



Hint  
color

31

B

$$f_2 = 20.602 \checkmark$$

$$d_3 = \frac{22.177}{.250} \checkmark$$

$$r_3 = \frac{22.177 \checkmark}{42.529 \checkmark} = 1.62869 \checkmark$$

$$\sin \theta = \frac{9.21624 \checkmark}{0.84493 \checkmark}$$

$$i = 18^\circ 23' 32.4'' = \sin^{-1} \frac{1.34590 \checkmark}{9.49903 \checkmark}$$

$$n = 0.19864 \checkmark$$

$$\lambda = \frac{11 \ 31 \ 11.0 \checkmark}{6 \ 52 \ 21.4 \checkmark} = \sin^{-1} \frac{9.30039 \checkmark}{1.34590 \checkmark}$$

$$\theta' = \frac{9 \ 28 \ 11.5 \checkmark}{2 \ 35 \ 50.1 \checkmark} = \sin^{-1} \frac{0.64629 \checkmark}{8.65624 \checkmark}$$

$$97.735 \checkmark = 1.99005$$

$$f_3 = \frac{22.177 \checkmark}{75.558 \checkmark}$$

$$d_4 = \frac{1.250}{75.308}$$

$$r_4 = \frac{48.359}{26.949} = 1.43054$$

$$\sin \theta = \frac{8.65624}{0.08678}$$

$$i = 1^\circ 26' 49.2'' = \sin^{-1} \frac{1.68448}{8.40230}$$

$$0.19864$$

$$\frac{2 \ 17 \ 11.53}{0 \ 50 \ 22.33} = \sin^{-1} \frac{8.60094}{1.68448}$$

$$\frac{2 \ 35 \ 50.1}{1 \ 45 \ 27.77} = \sin^{-1} \frac{0.28542}{8.48676}$$

$$62.901 = 1.79866$$

$$48.359$$

$$111.260$$

$$.179$$

.081 Hint mark

F

$$f_2 = 20.137 \checkmark$$

$$d_3 = \frac{22.177}{.250} \checkmark$$

$$r_3 = \frac{22.177 \checkmark}{42.064 \checkmark} = 1.62391 \checkmark$$

$$\sin \theta = \frac{9.22570 \checkmark}{0.84961 \checkmark}$$

$$i = 18^\circ 35' 55.9'' = \sin^{-1} \frac{1.34590 \checkmark}{9.50371 \checkmark}$$

$$n = 0.20295 \checkmark$$

$$\lambda = \frac{11 \ 31 \ 46.8 \checkmark}{7 \ 4 \ 9.1 \checkmark} = \sin^{-1} \frac{9.30076 \checkmark}{1.34590 \checkmark}$$

$$\theta' = \frac{9 \ 40 \ 48.9 \checkmark}{2 \ 36 \ 39.8 \checkmark} = \sin^{-1} \frac{0.64666 \checkmark}{8.65853 \checkmark}$$

$$97.299 \checkmark = 1.98811$$

$$f_3 = \frac{22.177 \checkmark}{75.122 \checkmark}$$

$$d_4 = \frac{1.250}{74.872}$$

$$r_4 = \frac{48.359}{26.513} = 1.42346$$

$$\sin \theta = \frac{8.65853}{0.08201}$$

$$i = 1^\circ 25' 52.3'' = \sin^{-1} \frac{1.68448}{8.39783}$$

$$0.20295$$

$$\frac{2 \ 17 \ 2.81}{0 \ 51 \ 10.51} = \sin^{-1} \frac{8.60048}{1.68448}$$

$$\frac{2 \ 36 \ 39.8}{1 \ 45 \ 29.29} = \sin^{-1} \frac{0.28496}{8.48686}$$

$$62.820 = 1.79810$$

$$48.359$$

$$111.179$$

$$r_4 = \frac{48.359}{1.138}$$

$$r_4 = 47.221$$

try







Flint  
Color

33

B

F

IV

$$d_4 = 75.308$$

$$r_4 = \frac{47.221}{28.087} = 1.44851 \checkmark$$

$$\sin \theta = \frac{8.65624 \checkmark}{0.10475 \checkmark}$$

$$r_4 = \frac{1.67414 \checkmark}{8.43061 \checkmark}$$

$$i = 1^\circ 32' 40.7'' \checkmark = \sin \frac{0.19864 \checkmark}{8.62925 \checkmark}$$

$$\lambda = \frac{2 \ 26 \ 26.30 \checkmark}{0 \ 53 \ 46.13 \checkmark} = \sin \frac{1.67414 \checkmark}{0.30339 \checkmark}$$

$$d = \frac{2 \ 35 \ 50.1 \checkmark}{1 \ 42 \ 3.97 \checkmark} = \sin \frac{8.47255 \checkmark}{67.739 \checkmark}$$

$$\frac{47.221 \checkmark}{114.960 \checkmark} = 1.83084$$

$$d_4 = 74.872$$

$$r_4 = \frac{47.221}{27.651} = 1.44171 \checkmark$$

$$\sin \theta = \frac{8.65855 \checkmark}{0.10026 \checkmark}$$

$$r_4 = \frac{1.67414 \checkmark}{8.42612 \checkmark}$$

$$i = 1^\circ 31' 43.0'' \checkmark = \sin \frac{0.20295 \checkmark}{8.62907 \checkmark}$$

$$\lambda = \frac{2 \ 26 \ 22.66 \checkmark}{0 \ 54 \ 39.66 \checkmark} = \sin \frac{1.67414 \checkmark}{0.30321 \checkmark}$$

$$d = \frac{2 \ 36 \ 39.8 \checkmark}{1 \ 42 \ 0.14 \checkmark} = \sin \frac{8.47227 \checkmark}{67.755 \checkmark}$$

$$\frac{47.221 \checkmark}{114.976 \checkmark} = 1.83094$$

$$.960$$

.016 Flint strong

$r_4 = 47.287$  should give perfect color

$$d_4 = \frac{75.308}{47.287} = 1.44748 \checkmark$$

$$\sin \theta = \frac{8.65624 \checkmark}{0.10372 \checkmark}$$

$$r_4 = \frac{1.67474 \checkmark}{8.42898 \checkmark}$$

$$i = 1^\circ 32' 19.33'' \checkmark = \sin \frac{0.19864 \checkmark}{8.62762 \checkmark}$$

$$\lambda = \frac{2 \ 25 \ 53.38 \checkmark}{0 \ 53 \ 34.05 \checkmark} = \sin \frac{1.67474 \checkmark}{0.30236 \checkmark}$$

$$d = \frac{2 \ 35 \ 50.1 \checkmark}{1 \ 42 \ 16.05 \checkmark} = \sin \frac{8.47340 \checkmark}{67.447 \checkmark}$$

$$\frac{47.287 \checkmark}{114.734 \checkmark} = 1.82896$$

$$f_4 = \frac{47.287}{114.734} = 1.82896$$

$$d_4 = \frac{74.872}{47.287} = 1.44067 \checkmark$$

$$\sin \theta = \frac{8.65855 \checkmark}{0.09922 \checkmark}$$

$$r_4 = \frac{1.67474 \checkmark}{8.42448 \checkmark}$$

$$i = 1^\circ 31' 22.22'' \checkmark = \sin \frac{0.20295 \checkmark}{8.62743 \checkmark}$$

$$\lambda = \frac{2 \ 25 \ 49.54 \checkmark}{0 \ 54 \ 27.32 \checkmark} = \sin \frac{1.67474 \checkmark}{0.30217 \checkmark}$$

$$d = \frac{2 \ 36 \ 39.8 \checkmark}{1 \ 42 \ 12.48 \checkmark} = \sin \frac{8.47315 \checkmark}{67.456 \checkmark}$$

$$\frac{47.287 \checkmark}{114.743 \checkmark} = 1.82902$$

$$f_4 = \frac{47.287}{114.743} = 1.82902$$

.009 Flint strong

~~Flint strong for color although focal length was shortened~~

$$f = \frac{114.960}{734} = 1.226$$

$$r_4 = \frac{47.221}{47.287} = 0.66$$

$$\text{Sph. H. } .016$$

$$.009$$

$$.007$$

$$.009$$

$$r_4 = \frac{47.287}{.085} = 47.372$$

$$r_4 = 47.372 \text{ to give perfect color correction}$$

color correction



Redder correctionThin to strong $f_4$  for Blin =

$$\tau_4 = 47.221$$

$$\overset{L}{0.016}$$

$$114.960$$

$$47.287 - 56$$

$$.009 - 7$$

$$114.734 - .226$$

$$47.372 - 85$$

$$.003 - 6$$

$$114.444 - .290$$

From diagram below

$$47.403 - 31$$

$$.000$$

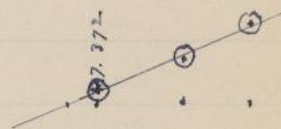
$$114.338 \checkmark$$

$$48.359$$

$$- \overset{weak}{.081}$$

$$114.260$$

-48.359





Flint

35

color

B

F

$$d_4 = 75.308 \checkmark$$

$$\tau_4 = \frac{47.372 \checkmark}{27.936 \checkmark} =$$

air

$$1.44616 \checkmark$$

$$8.65624 \checkmark$$

$$0.10240 \checkmark$$

$$1.67552 \checkmark$$

$$8.42688 \checkmark$$

$$0.19864 \checkmark$$

$$8.62552 \checkmark$$

$$1.67552 \checkmark$$

$$0.30104 \checkmark$$

$$8.47450 \checkmark$$

$$1.82654 \checkmark$$

$$67.072 \checkmark =$$

$$47.372 \checkmark$$

$$114.444 \checkmark$$

$$74.872 \checkmark$$

$$\frac{47.372 \checkmark}{27.500 \checkmark} =$$

$$1.43933 \checkmark$$

$$8.65855 \checkmark$$

$$0.09788 \checkmark$$

$$1.67552 \checkmark$$

$$8.42236 \checkmark$$

$$0.20295 \checkmark$$

$$8.62531 \checkmark$$

$$1.67552 \checkmark$$

$$0.30083 \checkmark$$

$$8.47427 \checkmark$$

$$1.82656 \checkmark$$

$$67.075 \checkmark =$$

$$47.372 \checkmark$$

$$114.447 \checkmark$$

$$.444$$

$$.003$$

Flint too strong

color correction is perfect

when  $\tau_4 = 47.403$  and  $f_4 = 114.338$ 

$$B = \frac{1}{\tau_3} + \frac{1}{\tau_4}$$

$$\frac{1}{\tau_3}$$

$$=$$

$$.045092 \checkmark$$

$$.0210955 \checkmark$$

$$B =$$

$$.0661875 \checkmark$$

$$\tau_3 = 22.177 = 1.34590 \checkmark$$

$$= 8.65410 \checkmark$$

$$\tau_4 = 47.403 = 1.67581 \checkmark$$

$$= 8.32419 \checkmark$$

LessonSpherical Ab. Bray

Marginal  
- see p. 30 -

Central

$$n = 0.18547 \checkmark$$

$$\tau_1 = \frac{1.36295 \checkmark}{1.54842 \checkmark}$$

$$1.54842 \checkmark$$

$$n-1 = \frac{9.72651 \checkmark}{1.54842 \checkmark}$$

$$f_1 = 66.361 \checkmark = \frac{1.82191 \checkmark}{.900 \checkmark}$$

$$d_2 = \frac{65.461 \checkmark}{1.81598 \checkmark} = 1.81598 \checkmark$$

$$\tau_2 = \frac{1.36295 \checkmark}{3.17893 \checkmark}$$

$$3.17893 \checkmark$$

$$n = 0.18547 \checkmark$$

$$\tau = \frac{1.36295 \checkmark}{1.54842 \checkmark} = 35.352 \checkmark$$

$$d = 1.81598 \checkmark$$

$$n-1 = \frac{9.72651 \checkmark}{1.54249 \checkmark} = 34.873 \checkmark$$

$$70.225 \checkmark = \frac{1.84649 \checkmark}{.250}$$

$$f_2 = 21.500 \checkmark = 1.33244 \checkmark$$

$$.250$$

$$d_3 = 21.250 \checkmark$$



Flint

37

## Spherical ab. B ray

Marginal

see p. 31

Central

$$\begin{aligned}
 d_3 &= 21.250 = 1.32736 \\
 n &= 0.19864 \\
 \tau_3 &= 22.177 = \frac{1.34590}{2.87190}
 \end{aligned}$$

$$d = 1.32736$$

$$\begin{aligned}
 n-1 &= \frac{9.76339}{1.09095} = \frac{22.177}{12.324} \\
 &= \frac{9.853}{0.99357}
 \end{aligned}$$

$$f_3 = 75.567 = \frac{1.87833}{.250}$$

$$d_4 = 75.317 = 1.87689$$

$$\tau_4 = 47.493 = \frac{1.67581}{3.55270}$$

see p. 35

$$\begin{aligned}
 n &= 0.19864 \\
 \tau &= \frac{1.67581}{1.87445} = 74.895
 \end{aligned}$$

$$d = 1.87689$$

$$\begin{aligned}
 n-1 &= \frac{9.76339}{1.64028} = \frac{43.680}{31.215} = 1.49436 \\
 f_4 &= 114.377 = 2.05834
 \end{aligned}$$

.338 Marginal  
.039 Flint weak

p. 35

$$\begin{aligned}
 B &= .0661875 \checkmark \\
 \frac{1}{\tau_3} &= .045153 \checkmark \\
 \frac{22.177}{.030} &= \frac{.0210345 \checkmark}{22.147} = \tau_3 \\
 \tau_3 &= 22.147 = \frac{1.345315 \checkmark}{8.654685 \checkmark} \\
 \tau_4 &= 47.541 \checkmark = \frac{8.32293 \checkmark}{1.67708}
 \end{aligned}$$



$22.177$ 
 $\frac{7}{3}$ 
 $22.147$ 
 $22.126$ 
 $.021$ 
 $+ 0.39$  Flit weal

 $+ .016$  Flit weal  
 $- .003$  a strong  
 $.019$ 
 $22.142$ 

30

 $\frac{1}{2} \text{ min}$   
 $25 \frac{1}{2}$   
 $32$ 

23

 $42$   
 $21 \frac{1}{2}$   
 $26$







Spherical Aberration  
~~Color correction~~ for 56.4 ray should be correct when  
 Sph. Ab for B line is .014 short marginal -

$r_3 = 22.147$	gives sph. Ab. .016 short
$r_3 = \underline{22.126}$	" " <u>.003</u> long
.021	.019
22.147	.016
<u>.002</u>	<u>.002</u>
22.145	

p. 35

$$r_3 = 22.145 = 1.34527\frac{1}{2}$$

$$B = .0661875 = 8.65472\frac{1}{2}$$

$$\frac{1}{r_3} = \underline{.0451570}$$

$$\frac{1}{r_4} = .0210305 = 8.32285$$

$$r_4 = 47.530 = 1.67715$$



## Spherical Ab. B ray

Marginal

$$d_3 = 20.352 \checkmark$$

$$p.30. \quad \tau_3 = \frac{22.126}{42.478} \checkmark = \frac{1.62816}{9.21624} \checkmark$$

$$\sin \alpha = \frac{0.84440}{1.34490} \checkmark$$

$$18^\circ 24' 46.7 \checkmark = \sin \frac{9.49950}{0.19864} \checkmark$$

$$11 \ 31 \ 56.6 \checkmark = \sin \frac{9.30086}{1.34490} \checkmark$$

$$6 \ 52 \ 50.1 \checkmark \quad \tau_3 = \frac{0.64576}{8.65491} \checkmark$$

$$9 \ 28 \ 11.5 \checkmark$$

$$2 \ 35 \ 21.4 \checkmark = \frac{97.915}{22.126} \checkmark$$

$$f_3 = \frac{75.789}{.250} \checkmark$$

$$d_4 = \frac{75.539}{47.639} \checkmark$$

$$T_4 = \frac{27.900}{1.44560} \checkmark$$

$$T_4 = \frac{8.65491}{0.10051} \checkmark$$

$$T_4 = \frac{1.67796}{8.42255} \checkmark$$

$$T_4 = \frac{0.19864}{8.62119} \checkmark$$

$$1 \ 30 \ 57.90 \checkmark = \sin \frac{1.67796}{0.29915} \checkmark$$

$$2 \ 23 \ 44.65 \checkmark = \sin \frac{8.47471}{1.82444} \checkmark$$

$$0 \ 52 \ 46.75 \checkmark \quad \tau_4 = \frac{66.748}{47.639} \checkmark$$

$$2 \ 35 \ 21.4 \checkmark$$

$$1 \ 42 \ 34.65 \checkmark$$

$$114.387 \checkmark$$

$$.384$$

$$.003$$

Central

p.36

$$n = 0.99864 \checkmark$$

$$d_3 = 1.32736 \checkmark$$

$$T_3 = \frac{1.34490}{2.87090} \checkmark$$

$$d = 1.32736 \checkmark$$

$$n-1 = \frac{9.76339}{1.09075} \checkmark$$

$$22.126 \checkmark$$

$$f_3 = \frac{75.785}{.250} \checkmark = \frac{9.802}{0.99131} \checkmark$$

$$d_4 = \frac{75.535}{75.535} \checkmark = 1.87815 \checkmark$$

$$T_4 = \frac{1.67796}{3.55611} \checkmark$$

$$n = 0.19864 \checkmark$$

$$T = \frac{1.67796}{1.87660} \checkmark$$

$$75.266 \checkmark$$

$$d = 1.87815 \checkmark$$

$$n-1 = \frac{9.76339}{1.64154} \checkmark$$

$$43.807 \checkmark$$

$$31.459 \checkmark$$

$$114.384 \checkmark = \frac{1.49774}{2.05836} \checkmark$$

Spherical Ab. is correct for B ray

# Result

Sph. Ab. } and color correct when  
for B ray

$$\begin{array}{l} \tau_1 = \tau_2 = 23.065 \\ \text{Thickness} = .900 \\ \text{Separation} = .250 \end{array} \left. \vphantom{\begin{array}{l} \tau_1 = \tau_2 = 23.065 \\ \text{Thickness} = .900 \\ \text{Separation} = .250 \end{array}} \right\} \text{Crown}$$

P. 30

$$\begin{array}{l} \tau_3 = 22.126 \\ \tau_4 = 47.639 \\ \text{Thickness} = .250 \end{array} \left. \vphantom{\begin{array}{l} \tau_3 = 22.126 \\ \tau_4 = 47.639 \\ \text{Thickness} = .250 \end{array}} \right\} \text{Flint}$$

P. 41

$$\text{Focal length} = 114.384$$

For Focal length 111.750 see next page

$$\begin{array}{l} \tau_1 = \tau_2 = 22.534 \\ \text{Thickness} = .900 \end{array} \left. \vphantom{\begin{array}{l} \tau_1 = \tau_2 = 22.534 \\ \text{Thickness} = .900 \end{array}} \right\} \text{Crown}$$

$$\text{Separation} = .250$$

Sph. Ab. correct for  
B. ray

$$\begin{array}{l} \tau_3 = 21.616 \\ \tau_4 = 46.542 \\ \text{Thickness} = .250 \end{array} \left. \vphantom{\begin{array}{l} \tau_3 = 21.616 \\ \tau_4 = 46.542 \\ \text{Thickness} = .250 \end{array}} \right\} \text{Flint}$$



$$114.384 = 2.05836\frac{1}{2}$$

$$111.750 = \frac{2.04825}{0.01011\frac{1}{2}}$$

$$\tau_1 + \tau_2$$

$$23.065 = \frac{1.36295}{0.01011\frac{1}{2}}$$

$$22.534 = \frac{1.35283\frac{1}{2}}$$

$$\tau_3$$

$$22.126 = \frac{1.34490}{0.01011\frac{1}{2}}$$

$$21.616\frac{1}{2} = \frac{1.33478\frac{1}{2}}$$

$$\tau_4$$

$$47.639 = \frac{1.67796}{0.01011\frac{1}{2}}$$

$$46.542 = \frac{1.66784\frac{1}{2}}$$

For  $\rho_{ph} A h = 0$  for  $\lambda = 56.4$

$$B = \begin{array}{r} .0661875 \\ .045165 \\ \hline .0210225 \end{array}$$

$$f_4 = 114.384$$

$$\tau_3 = 22.141 = \frac{1.34520}{8.65480}$$

$$= 8.32268\frac{1}{2}$$

$$\tau_4 = 47.568 = \frac{1.67731\frac{1}{2}}$$

l crown $\lambda = 5614$  Spherical St.

Marginal

Central

p. 30

$$i = 8^{\circ} 43' 41.5'' = \sin 9.18112$$

$$n = 0.18712$$

p. 10

$$\lambda = 53936.6 = \sin 8.99400$$

$$\lambda = 344.9 = \sin 8.72853$$

$$= 1.62842$$

$$f_1 = \frac{42.503}{23.065}$$

$$f_1 = \frac{65.568}{.900}$$

$$d_2 = 64.668$$

$$r_2 = \frac{23.065}{87.733}$$

$$= 1.94816$$

$$\sin \lambda = \frac{8.72853}{0.67169}$$

$$r_2 = \frac{1.36295}{1.36295}$$

$$11^{\circ} 44' 47.5'' = \sin 9.30874$$

$$n = 0.18712$$

$$181513.9 = \sin 9.49586$$

$$63026.4 = \frac{1.36295}{0.85881}$$

$$344.9 = \sin 9.22101$$

$$r = 93431.3 = \sin 9.22101$$

$$43.431 = 1.63780$$

$$23.065$$

$$f_2 = 20.366$$

$$n = 0.18712$$

$$r = \frac{1.36295}{1.55007}$$

$$n-1 = \frac{9.73124}{1.81883}$$

$$f_1 = 65.892 = 1.81883$$

$$d_2 = \frac{.900}{64.992}$$

$$r = \frac{1.81286}{1.36295}$$

$$3.17581$$

$$n = 0.18712$$

$$r = \frac{1.36295}{1.55007}$$

$$= 35.487$$

$$d = 1.81286$$

$$n-1 = \frac{9.73124}{1.54410}$$

$$= 35.003$$

$$70.490 = 1.84813$$

$$f_2 = 21.266 = 1.32768$$

check

p. 30

$$\sin 20.607$$

$$.236$$

$$\frac{21.500}{.234}$$

p. 36



$$\lambda = 5614$$

Spherical Ab.

$$\begin{array}{r} f_2 = 20.366 \\ \quad .250 \\ d_3 = 20.116 \\ r_3 = \frac{22.141}{42.257} = 1.62590 \end{array}$$

$$\begin{array}{r} 18 \quad 30 \quad 37.1 \\ r_3 = \frac{1.34520}{9.50171} = \sin \end{array}$$

$$\begin{array}{r} 11 \quad 32 \quad 3.4 \\ n = \frac{0.20078}{9.30093} = \sin \end{array}$$

$$\begin{array}{r} 6 \quad 58 \quad 33.7 \\ 9 \quad 34 \quad 31.3 \\ 0.64613 \end{array}$$

$$v = \frac{2 \quad 35 \quad 57.6}{8.65659} = \sin$$

$$\begin{array}{r} 97.620 \\ r_3 = \frac{22.141}{76.479} = 1.98954 \end{array}$$

$$\begin{array}{r} f_3 = 76.479 \\ \quad .250 \end{array}$$

$$d_4 = 76.229$$

$$r_4 = \frac{47.568}{27.661} = 1.44187$$

$$\begin{array}{r} 8.65659 \\ 0.09846 \\ r_4 = \frac{1.67731\frac{1}{2}}{8.42114\frac{1}{2}} = 0.20078 \end{array}$$

$$\begin{array}{r} 1 \quad 30 \quad 40.27 \\ r_4 = \frac{1.67731\frac{1}{2}}{8.42114\frac{1}{2}} = \sin \end{array}$$

$$\begin{array}{r} 2 \quad 23 \quad 59.27 \\ 0 \quad 53 \quad 19.00 \\ 0.20078 \end{array}$$

$$\begin{array}{r} 2 \quad 35 \quad 57.6 \\ 1 \quad 42 \quad 38.6 \\ 0.29924 \end{array}$$

$$\begin{array}{r} 66.719 \\ 47.568 \\ 1.67731\frac{1}{2} \end{array}$$

$$f_4 = \frac{114.287}{1.82425} = \sin$$

$$.260$$

$$.027$$

Flint strong

$$\begin{array}{r} f_2 = 21.266 \checkmark \\ \quad .250 \checkmark \\ d_3 = 21.016 \checkmark = 1.32253 \checkmark \\ n = 0.20078 \checkmark \\ r = 1.34520 \checkmark \\ 2.86853 \checkmark \end{array}$$

$$\begin{array}{r} d = 1.32253 \checkmark \\ n-1 = \frac{9.76918 \checkmark 22.141 \checkmark}{1.09173 \checkmark 12.3518 \checkmark} = 0.99075 \checkmark \\ 9.7892 \checkmark \end{array}$$

$$f_3 = 75.471 \checkmark = 1.87778 \checkmark$$

$$d_4 = 75.221 \checkmark = 1.87634 \checkmark$$

$$r_4 = \frac{1.67731\frac{1}{2} \checkmark}{3.55365\frac{1}{2} \checkmark} = 1.67731\frac{1}{2} \checkmark$$

$$\begin{array}{r} n = 0.20078 \checkmark \\ r = 1.67731\frac{1}{2} \checkmark \\ 1.87809\frac{1}{2} = 75.526 \checkmark \end{array}$$

$$\begin{array}{r} d = 1.87634 \checkmark \\ n-1 = \frac{9.76918 \checkmark}{1.64552 \checkmark} = 44.210 \checkmark \\ 31.316 \checkmark \end{array}$$

$$\begin{array}{r} 1.49576\frac{1}{2} \checkmark \\ f_4 = 114.260 \checkmark = 2.05789 \checkmark \end{array}$$

$$r_4 = 1.49576\frac{1}{2} \checkmark$$

$$\begin{array}{r} r_3 = 22.141 \\ 22.174 \text{ same as } p. 37 \end{array}$$

$$r_3 = 22.177 \text{ same as } p. 37$$

$$r_4 = 47.403$$

$$r_4 = 47.403$$

$$r_4 = 47.403$$





Flint

47

$\lambda = 56.4$

Spherical Sh.

Marginal

$d_3 = 20.116$

$$\tau_3 = \frac{22.177}{42.293}$$

$$= \frac{1.62627}{9.22101}$$

$$0.84728$$

$$\tau_3 = \frac{1.34590}{9.50138}$$

$$18^\circ 29' 44.8'' = \sin$$

$$n = \frac{0.20078}{9.30060}$$

$$\frac{11 \ 31 \ 31.4}{6 \ 58 \ 13.4} = \sin$$

$$\frac{1.34590}{0.64650}$$

$$\frac{9 \ 34 \ 31.3}{2 \ 36 \ 17.9} = \sin$$

$$\frac{8.65753}{1.98897}$$

$$\frac{97.492}{22.177} =$$

$$f_3 = \frac{75.315}{0.250}$$

$$d_4 = 75.065$$

$$\tau_4 = \frac{47.403}{27.662}$$

$$= \frac{1.44188}{8.65753}$$

$$0.09941$$

$$\tau_4 = \frac{1.67581}{8.42360}$$

$$1^\circ 31' 11.12'' = \sin$$

$$n = \frac{0.20078}{8.62438}$$

$$\frac{2 \ 24 \ 48.28}{0 \ 53 \ 37.16} = \sin$$

$$\frac{1.67581}{0.30019}$$

$$\frac{2 \ 36 \ 17.9}{1 \ 42 \ 40.74} = \sin$$

$$\frac{8.47874}{1.82505}$$

$$\frac{66.842}{47.403} =$$

$$f_4 = 114.245$$

Central

$$d_3 = 1.32253$$

$$n = 0.20078$$

$$\tau_3 = \frac{1.34590}{2.86923}$$

$$d = 22.177$$

$$\frac{12.3518}{9.8252}$$

$$= \frac{0.99234}{1.87689}$$

$$f_3 = \frac{75.3165}{250} = 1.87689$$

$$d_4 = \frac{75.0665}{3.55126} = 1.87545$$

$$\tau = \frac{1.67581}{3.55126}$$

$$n = 0.20078$$

$$\tau = \frac{1.67581}{1.87659} = 75.2645$$

$$d = 1.87545$$

$$n = \frac{9.76918}{1.64463} = 44.1195$$

$$\frac{31.145}{114.254} = \frac{1.49339}{2.05787}$$

$$114.254 = 2.05787$$

$$.245$$

$$.009 \text{ Flint weak}$$

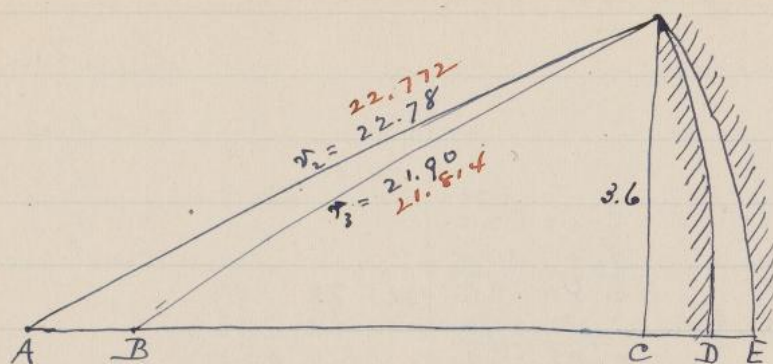
$$\text{Try } \tau_3 = 22.168 = 1.34573$$

$$B = .0661875 = 8.65427$$

$$\frac{.045110}{.0210775} = 8.32382$$

$$\tau_4 = 47.444 = 1.67618$$

$$f_4 = 114.245$$



$$\frac{3.6}{12.960} = \frac{0.53639}{1.11260}$$

$$\begin{aligned} \underline{AC} \quad 22.78 &= \frac{1.35753}{2} \\ 578.92 &= \frac{2.71510}{12.96} \\ 505.96 &= 2.70412 \\ AC &= 22.494 = 1.35206 \\ CD &= \frac{22.78}{.286} \end{aligned}$$

$$\begin{aligned} \underline{BC} \quad 21.90 &= \frac{1.34048}{2} \\ 479.60 &= \frac{2.68088}{12.96} \\ 466.64 &= 2.66898 \\ BC &= 21.602 = 1.33449 \\ CE &= \frac{21.90}{.298} \\ &= \frac{.286}{.012} \end{aligned}$$

Thickness of ring =  $\frac{.2465}{.2585}$  *see below*

Distance between inner surfaces

Dec. 17  
1915

P. 136

$$\begin{aligned} 22.772 &= \frac{1.35740}{2} \\ 518.56 &= \frac{2.71480}{13.32} \\ 505.24 &= 2.70350 \\ AC &= 22.4776 = 1.35175 \\ CD &= \frac{22.772}{.2944} \end{aligned}$$

$$\begin{aligned} 3.65 &= \frac{0.56229}{2} \\ 13.3223 &= \frac{1.12458}{.0131} \end{aligned}$$

$$\begin{aligned} AC &= 22.4776 = 1.35175 \\ CD &= \frac{22.772}{.2944} \end{aligned}$$

$$\begin{aligned} CE &= .3075 \\ CD &= .2944 \\ DE &= .0131 \end{aligned}$$

Ring =  $\frac{.1909}{1909}$

Separation =  $\frac{.2070}{.2070}$

$$\begin{aligned} 21.814 &= \frac{1.33873}{2} \\ 495.85 &= \frac{2.67747}{13.32} \\ 482.53 &= 2.66514 \\ 21.5065 &= 1.33257 \\ CE &= \frac{21.814}{.3075} \end{aligned}$$



## Color correction

In  $4\frac{1}{2}''$  the B. + F. central rays are united  
and the a + F marginal rays -

In this object glass the color is about as perfect  
as can be -

By previous figures -

Q. 4. to unite B + F marginal rays - correct for  
spherical Ab. reduced to basis of  $r_1 = 22.780$

$$r_1 = r_2 = 22.780$$

$$t_1 = .89$$

$$D = .258$$

$$r_3 = 21.894$$

$$r_4 = 46.858$$

$$t_2 = .25$$

$$\left\{ \begin{array}{r} CD = .2944 \\ .2944 \\ .300 \\ \hline .889 \end{array} \right.$$

$$\left\{ \begin{array}{r} CD = .2944 \\ .2944 \\ .300 \\ \hline .889 \end{array} \right.$$

lesumleolorB.F

$$\begin{aligned}
 n &= 0.18547 \checkmark \\
 22.780 \quad \tau_1 &= \frac{1.35753 \checkmark}{1.54302 \checkmark} \\
 n-1 &= \frac{9.72651 \checkmark}{1.81651 \checkmark} \\
 65.5406 \checkmark &= \frac{1.890 \checkmark}{1.81057 \checkmark} \\
 d_2 &= \frac{64.6506 \checkmark}{1.35753 \checkmark} = 1.81057 \checkmark \\
 \tau_2 &= \frac{3.16812 \checkmark}{1.35753 \checkmark}
 \end{aligned}$$

$$\begin{aligned}
 n &= 0.18547 \checkmark \\
 \tau &= \frac{1.35753 \checkmark}{1.54302 \checkmark} = 34.9157 \checkmark
 \end{aligned}$$

$$d = 1.81057$$

$$\begin{aligned}
 n-1 &= \frac{9.72651 \checkmark}{1.53708 \checkmark} = 34.4424 \\
 \tau &= \frac{69.357 \checkmark}{1.32703 \checkmark} = 1.84109 \checkmark
 \end{aligned}$$

$$f_2 = 21.234 \checkmark \quad 1.32703 \checkmark$$

$$\begin{aligned}
 &\frac{.258 \checkmark}{d_3 = 20.976 \checkmark}
 \end{aligned}$$

$$\begin{aligned}
 &0.18875 \checkmark \\
 &\frac{1.35753 \checkmark}{1.54630 \checkmark} \\
 &\frac{9.73589 \checkmark}{1.81041 \checkmark} \\
 64.626 \checkmark &= \frac{1.890 \checkmark}{1.80438 \frac{1}{2} \checkmark} \\
 63.736 \checkmark &= \frac{1.35753 \checkmark}{3.16193 \checkmark}
 \end{aligned}$$

$$\begin{aligned}
 &0.18875 \checkmark \\
 &\frac{1.35753 \checkmark}{1.54630 \checkmark} = 35.1803
 \end{aligned}$$

$$1.80438 \frac{1}{2} \checkmark$$

$$\begin{aligned}
 &\frac{9.73589 \checkmark}{1.54027 \frac{1}{2} \checkmark} = 34.6957 \checkmark \\
 &\frac{69.876 \checkmark}{1.84432 \checkmark}
 \end{aligned}$$

$$20.778 \checkmark = 1.317607 \checkmark$$

$$\frac{.258 \checkmark}{d_3 = 20.520 \checkmark}$$



Flint

51

color

B

$$\begin{aligned}
 20.976 \quad d_3 &= 71.32172 \\
 n &= 0.19864 \\
 21.894 \quad \tau_3 &= \frac{1.34033}{2.86069}
 \end{aligned}$$

$$\begin{aligned}
 d &= 1.32172 \\
 n-1 &= \frac{9.76339}{1.08511} = \frac{21.894}{12.165} \\
 &\quad \frac{9.729}{0.98807}
 \end{aligned}$$

$$f_3 = \frac{74.580}{.250} = 1.87262$$

$$\begin{aligned}
 d_4 &= \frac{74.330}{.250} = 1.87116 \\
 \tau_4 &= \frac{46.858}{3.54194} = \frac{1.67078}{3.54194}
 \end{aligned}$$

$$\begin{aligned}
 n &= 0.19864 \\
 \tau &= \frac{1.67078}{1.86942} = 74.032
 \end{aligned}$$

$$\begin{aligned}
 d &= 1.87116 \\
 &\frac{9.76339}{1.63455} = 43.107 \\
 &\quad \frac{30.925}{1.49031}
 \end{aligned}$$

$$112.624 = 2.05163$$

$$\begin{aligned}
 &\frac{.567}{.067} \quad \text{Flint too weak}
 \end{aligned}$$

F

$$\begin{aligned}
 d_3 &= 20.520 = 1.31218 \\
 &\quad 0.20295 \\
 &\quad \frac{1.34033}{2.85546}
 \end{aligned}$$

$$\begin{aligned}
 &1.31218 \\
 &\frac{9.77503\frac{1}{2}}{1.08721\frac{1}{2}} = \frac{21.894}{12.2240} = \frac{0.98543}{9.670} = 1.87003
 \end{aligned}$$

$$f_3 = \frac{74.186}{.250} = 1.86856$$

$$\begin{aligned}
 d_4 &= \frac{73.886}{.250} = 1.86856 \\
 &\quad \frac{1.67078}{3.53934}
 \end{aligned}$$

$$\begin{aligned}
 &0.20295 \\
 &\frac{1.67078}{1.87373} = 74.770
 \end{aligned}$$

$$\begin{aligned}
 &1.86856 \\
 &\frac{9.77503\frac{1}{2}}{1.64359\frac{1}{2}} = \frac{44.014}{30.756} = \frac{1.48793}{112.567} = 2.05141
 \end{aligned}$$

$$112.567 = 2.05141$$

p. 18 Spherical Ab. correct when

$r_3 = 22.168$	=	$1.34573$
$r_f = 47.444$	=	$1.67618$
$\alpha = .46725$	=	$9.66955$
$1 + \alpha = 1.46725$	=	$0.16650$
$B = .067297$	=	$8.82800$
$r_3 = 21.802$	=	$1.33850$
$\alpha = .46661$	=	$9.66955$
$r_f = 46.661$	=	$1.66895$
		$8.66150$
		$8.33105$

$\frac{1}{r_3} = .045867$
$\frac{1}{r_f} = .021431$
$B = .067298$



Hint  
color

53

B	F
$d_4 = 74.330 = 1.87116$	$1.86856$
$\tau_4 = 46.061 = \frac{1.66333}{3.53449}$	$\frac{1.66333}{3.53189}$
$n = 0.19864$	$0.20295$
$\tau = \frac{1.66333}{1.86197} = 72.773$	$\frac{1.66333}{1.86628} = 73.499$
$d(n-1) = \frac{43.107}{29.666} = \frac{1.47226}{2.06223}$	$d(n-1) = \frac{44.014}{29.485} = \frac{1.46960}{1.06229}$
$115.406$	$115.422$
	$.406$
	$.016$ Hint strong

$d_4 = 1.87116$	$1.86856$
$46.216 = \tau_4 = \frac{1.66479}{3.53595}$	$\frac{1.66479}{3.53335}$
$n = 0.19864$	$0.20295$
$\tau = \frac{1.66479}{1.86343} = 73.018$	$\frac{1.66479}{1.86774} = 73.746$
$\frac{43.107}{29.911} = \frac{1.47583}{2.06012}$	$\frac{44.014}{29.732} = \frac{1.47322}{2.06013}$
$114.847$	$114.845$
	$.847$
	$.003$ Hint strong

$$\tau_4 = 46.247 \text{ mill correct.}$$

$$B = \frac{1}{\tau_3} + \frac{1}{\tau_4}$$

$$\tau_3 = 21.894 = 1.34033$$

$$\frac{1}{\tau_3} = .045674 = 8.659.67$$

$$\tau_4 = 46.247 = 1.66508$$

$$= 8.33492$$

$$\frac{1}{\tau_4} = .021623$$

$$B = .067297$$

$$\tau_3 = 21.802$$

$$\tau_4 = 46.661 \quad \left. \vphantom{\begin{matrix} \tau_3 \\ \tau_4 \end{matrix}} \right\} \text{see opposite page}$$



Crown

$\lambda = 56.4$

## Spherical Aberration

Marginal		Central
$K = 3.5^-$	$= 0.54407 \checkmark$	
$r_1 = 22.780$	$= \frac{1.35753 \checkmark}{9.18652 \checkmark}$	$n = 0.18712 \checkmark$
$i = 8^\circ 50' 17.7 \checkmark$	$= \sin$	$r_1 = \frac{1.35753 \checkmark}{1.54467 \checkmark}$
	$n = 0.18712 \checkmark$	$n-1 = \frac{9.73124 \checkmark}{1.81343 \checkmark}$
$\lambda = 5^- 43 52.4 \checkmark$	$= \sin 8.99940 \checkmark$	$f_1 = 65.077 \checkmark$
$2l' = 3 \quad 6 \quad 25.3 \checkmark$	$r = \frac{1.35753 \checkmark}{0.35695 \checkmark}$	$d_2 = \frac{64.187 \checkmark}{.890 \checkmark} = 1.80745 \checkmark$
	$r_2 = \frac{8.73401 \checkmark}{1.62294 \checkmark}$	$r_2 = \frac{1.35753 \checkmark}{3.16500 \checkmark}$
$41.970 \checkmark$		$n = 0.18712 \checkmark$
$22.780 \checkmark$		$r_2 = \frac{1.35753 \checkmark}{1.54467 \checkmark} = 35.0485 \checkmark$
$f_1 = 64.750 \checkmark$		$d = 1.80745 \checkmark$
$.890 \checkmark$		$\frac{9.73124 \checkmark}{1.53869 \checkmark} = 34.5693 \checkmark$
$d_2 = 63.860 \checkmark$		$69.619 = \frac{1.84272 \checkmark}{1.32228 \checkmark}$
$r_2 = \frac{22.780 \checkmark}{86.640 \checkmark}$	$= 1.93772 \checkmark$	$f_2 = 21.003 \checkmark = 1.32228 \checkmark$
	$\frac{8.73401 \checkmark}{0.67173 \checkmark}$	$d_3 = 20.745 \checkmark$
	$\frac{1.35753 \checkmark}{9.31418 \checkmark}$	
$11 \quad 53 \quad 48.2 \checkmark$	$= \sin 9.50130 \checkmark$	
	$\frac{1.35753 \checkmark}{0.85885 \checkmark}$	
$18 \quad 29 \quad 32.0 \checkmark$	$= \sin 9.22668 \checkmark$	
$6 \quad 35 \quad 43.8 \checkmark$	$= 1.63217 \checkmark$	
$3 \quad 6 \quad 25.3 \checkmark$		
$9 \quad 42 \quad 9.1 \checkmark$		
$42.872 \checkmark$		
$22.780 \checkmark$		
$f_2 = 20.092 \checkmark$		
$.258 \checkmark$		
$d_3 = 19.834 \checkmark$		



$\lambda = 5614$

## Spherical Aberration

Marginal

Central

$d_3 = 19.834 \checkmark$

$r_3 = \frac{21.802 \checkmark}{41.636 \checkmark}$

$18 \ 46 \ 2 \ \sin \nu = \frac{1.61947 \checkmark}{9.22668 \checkmark}$

$r_3 = \frac{0.84615 \checkmark}{1.33850 \checkmark}$

$18 \ 46 \ 28.9 \checkmark = \sin \nu = \frac{9.50765 \checkmark}{0.20078 \checkmark}$

$11 \ 41 \ 43.2 \checkmark = \sin \nu = \frac{9.30687 \checkmark}{1.33850 \checkmark}$

$7 \ 4 \ 45.7 \checkmark = \frac{0.64537 \checkmark}{8.66055 \checkmark}$

$9 \ 42 \ 9.1 \checkmark = \sin \nu = \frac{8.66055 \checkmark}{1.98482 \checkmark}$

$2 \ 37 \ 23.4 \checkmark = \sin \nu = \frac{96.565 \checkmark}{21.802 \checkmark}$

$f_3 = \frac{74.763 \checkmark}{.250 \checkmark}$

$d_4 = 74.513 \checkmark$

$r_4 = \frac{46.661 \checkmark}{27.852 \checkmark}$

$\sin \nu = \frac{1.44486 \checkmark}{8.66055 \checkmark}$

$r_4 = \frac{0.10541 \checkmark}{1.66895 \checkmark}$

$1 \ 33 \ 55.58 \checkmark = \sin \nu = \frac{8.43646 \checkmark}{0.20078 \checkmark}$

$2 \ 29 \ 9.53 \checkmark = \sin \nu = \frac{8.63724 \checkmark}{1.66895 \checkmark}$

$0 \ 55 \ 13.97 \checkmark = \frac{0.30619 \checkmark}{8.47293 \checkmark}$

$2 \ 37 \ 23.40 \checkmark = \sin \nu = \frac{8.47293 \checkmark}{1.83326 \checkmark}$

$1 \ 42 \ 9.43 \checkmark = \sin \nu = \frac{68.118 \checkmark}{46.661 \checkmark}$

$f_4 = \frac{114.779 \checkmark}{.647 \checkmark}$

$.132 \checkmark$

$.132 \checkmark$

$.132 \checkmark$

$.132 \checkmark$

$.132 \checkmark$

$.132 \checkmark$

$.132 \checkmark$

$.132 \checkmark$

$.132 \checkmark$

$.132 \checkmark$

$.132 \checkmark$

$.132 \checkmark$

$.132 \checkmark$

$n = 0.20078 \checkmark$

$20.745 \checkmark = d_3 = \frac{1.31691 \checkmark}{1.33850 \checkmark}$

$r_3 = \frac{1.33850 \checkmark}{2.85619 \checkmark}$

$d = 1.31691 \checkmark$

$n = 0.20078 \checkmark$

$21.802 \checkmark = \frac{9.76918 \checkmark}{1.08609 \checkmark}$

$12.1924 \checkmark = \frac{9.6096 \checkmark}{0.98270 \checkmark}$

$f_3 = 74.728 \checkmark = \frac{1.87348 \checkmark}{1.250 \checkmark}$

$d_4 = 74.478 \checkmark = \frac{1.87203 \checkmark}{1.66895 \checkmark}$

$r_4 = \frac{1.66895 \checkmark}{3.54098 \checkmark}$

$n = 0.20078 \checkmark$

$r = 1.66895 \checkmark$

$1.86973 \checkmark = 74.085 \checkmark$

$d = 1.87203 \checkmark$

$9.76918 \checkmark = \frac{1.64128 \checkmark}{43.773 \checkmark}$

$117.858 \checkmark = \frac{1.48161 \checkmark}{30.312 \checkmark}$

$f_4 = 114.647 \checkmark = \frac{2.05936 \checkmark}{1.48161 \checkmark}$

$r_4 = \frac{1.48161 \checkmark}{2.05936 \checkmark}$

$f_4 = 114.647 \checkmark$

$f_4 = 114.647 \checkmark$

$f_4 = 114.647 \checkmark$

$f_4 = 114.647 \checkmark$

$f_4 = 114.647 \checkmark$

$f_4 = 114.647 \checkmark$

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$f_4 = 114.647 \checkmark$

$f_4 = 114.647 \checkmark$

$f_4 = 114.647 \checkmark$





## Spherical Aberration

$\lambda = 56.4$

Marginal

$d_3 = 19.834 \checkmark$

$r_3 = 21.934 \checkmark$

$41.768 = 1.62084 \checkmark$

$\text{inv} \frac{9.22668 \checkmark}{0.84752 \checkmark}$

$r_3 = 1.34112 \checkmark$

$18^\circ 43' 7.4 \checkmark = \text{inv} \frac{9.50640 \checkmark}{0.20078 \checkmark}$

$11 \ 39 \ 40.5 \checkmark = \text{inv} \frac{9.30562 \checkmark}{1.34112 \checkmark}$

$7 \ 3 \ 26.9 \checkmark \frac{0.64674 \checkmark}{8.66416 \checkmark}$

$9 \ 42 \ 9.1 \checkmark$

$2 \ 38 \ 42.2 \checkmark = 1.98258 \checkmark$

$96.068 \checkmark = 1.98258 \checkmark$

$21.934 \checkmark$

$f_3 = 74.134 \checkmark$

$.250$

$d_4 = 73.884 \checkmark$

$r_4 = 46.070 \checkmark$

$27.814 \checkmark = 1.44426 \checkmark$

$8.66416 \checkmark$

$0.10842 \checkmark$

$r_4 = 1.66342 \checkmark$

$1^\circ 35' 47.53 \checkmark = \text{inv} \frac{8.44500 \checkmark}{0.20078 \checkmark}$

$2 \ 32 \ 7.40 \checkmark = \text{inv} \frac{8.64578 \checkmark}{1.66342 \checkmark}$

$0 \ 56 \ 19.87 \checkmark$

$2 \ 38 \ 42.20 \checkmark$

$1 \ 42 \ 22.33 \checkmark = 8.47384 \checkmark$

$68.448 \checkmark = 1.83536 \checkmark$

$46.070 \checkmark$

$114.578 \checkmark$

Central

$n = 0.20078 \checkmark$

$d = 1.31691 \checkmark$

$r = 1.34112 \checkmark$

$r = 21.934 \quad 2.85881 \checkmark$

$d(n-1) = \frac{12.1924 \checkmark}{9.7416 \checkmark} = 0.98863 \checkmark$

$f_3 = 74.162 \checkmark = 1.87018 \checkmark$

$.250$

$d_4 = 73.912 \checkmark = 1.86871 \checkmark$

$r_4 = 1.66342 \checkmark$

$3.53213 \checkmark$

$n = 0.20078 \checkmark$

$r = 1.66342 \checkmark$

$1.86420 \checkmark = 73.148 \checkmark$

$d = 1.86871 \checkmark$

$n = 9.76918 \checkmark$

$1.63789 \checkmark = 43.4405 \checkmark$

$29.7075 \checkmark = 1.47286 \checkmark$

$f_4 = 114.623 \checkmark = 2.05927 \checkmark$

$.518 \checkmark$

$.105 \checkmark$

$.105 \checkmark$

$.105 \checkmark$

$.105 \checkmark$

$.105 \checkmark$

$.105 \checkmark$

$.105 \checkmark$

$.105 \checkmark$

$.105 \checkmark$

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$.105 \checkmark$

$.105 \checkmark$

$.105 \checkmark$

$.105 \checkmark$

$.105 \checkmark$

$.105 \checkmark$

$.105 \checkmark$





$$\lambda = 56.4$$

Spherical Ab.

Marginal

$$d_3 = 19.834$$

$$r_3 = \frac{21.876}{41.710} =$$

$$1.62024$$

$$\sin \theta = \frac{9.22668}{0.84692}$$

$$r_3 = \frac{1.33997}{9.50695}$$

$$18^\circ 44' 35.9'' = \sin \theta = \frac{0.20078}{9.30617}$$

$$\frac{7}{9} \frac{4}{42} \frac{1.5}{9.1} = \sin \theta = \frac{1.33997}{0.64614}$$

$$\frac{2}{38} \frac{7.6}{7.6} = \sin \theta = \frac{8.66258}{1.98356}$$

$$\frac{11}{7} \frac{40}{4} \frac{34.4}{1.5} = \sin \theta = \frac{96.285}{21.876}$$

$$\frac{9}{2} \frac{42}{38} \frac{9.1}{7.6} = \sin \theta = \frac{74.409}{.250}$$

$$d_4 = \frac{74.159}{46.329}$$

$$r_4 = \frac{27.830}{1.44451}$$

$$8.66258$$

$$0.10709$$

$$r_4 = \frac{1.66585}{8.44224}$$

$$0.20078$$

$$2 \frac{30}{0} \frac{48.61}{55} = \sin \theta = \frac{8.64202}{1.66585}$$

$$0.30787$$

$$1 \frac{42}{38} \frac{16.97}{7.6} = \sin \theta = \frac{8.47347}{68.297}$$

$$46.329 = 1.83440$$

$$f_4 = \frac{114.626}{114.626}$$

$$114.626$$

$$114.626$$

$$114.626$$

$$114.626$$

$$114.626$$

$$114.626$$

$$114.626$$

$$114.626$$

$$114.626$$

$$114.626$$

$$114.626$$

$$114.626$$

Central

$$d_3 = 1.31691 \checkmark$$

$$n = 0.20078 \checkmark$$

$$r_3 = \frac{1.33997}{2.85766} \checkmark$$

$$r_3 = 2.85766 \checkmark$$

$$r_3 = 21.876 \checkmark$$

$$d(n) = \frac{12.1924}{9.6836} \checkmark = 0.98604 \checkmark$$

$$f_3 = \frac{74.408}{.250} \checkmark = 1.87162 \checkmark$$

$$d_4 = \frac{74.158}{1.87016} \checkmark = 1.87016 \checkmark$$

$$r_4 = \frac{1.66585}{3.53601} \checkmark$$

$$n = 0.20078$$

$$r = \frac{1.66585}{1.86663} = 73.538$$

$$d = 1.87016$$

$$n = \frac{9.76918}{1.63934} = 43.585$$

$$29.973 = 1.47673$$

$$114.626 = 2.05928$$

$$114.626$$

$$114.626$$

$$114.626$$

$$114.626$$

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$$114.626$$

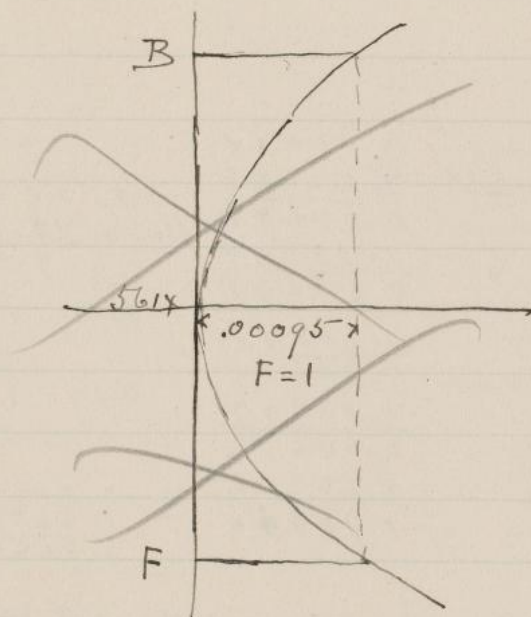
$$114.626$$

$$114.626$$

$$114.626$$

Spherical Ab. correct

23 - 31



Sep 104



## check on color Central Ray

p. 50

B

$$\begin{aligned}
 51 \quad d_3 &= 20.976 = 1.32172 \\
 n &= 0.19864 \\
 r_3 &= 1.33997 \\
 &\quad \underline{2.86033}
 \end{aligned}$$

$$d = 1.32172$$

$$\begin{aligned}
 n-1 &= 9.76339 \quad 21.8760 \\
 1.08511 &= 12.1650 \\
 &\quad \underline{9.7110} = 0.98726
 \end{aligned}$$

$$f_3 = 74.657 = 1.87307$$

$$\begin{aligned}
 &\quad \underline{.250} \\
 74.407 &= 1.87161 \\
 r &= 1.66585 \\
 &\quad \underline{3.53746}
 \end{aligned}$$

$$\begin{aligned}
 n &= 0.19864 \\
 r &= 1.66585 \\
 1.86449 &= 73.196
 \end{aligned}$$

$$\begin{aligned}
 d &= 1.87161 \\
 n-1 &= 9.76339 \\
 1.63500 &= 43.152 \\
 &\quad \underline{30.044} = 1.47776
 \end{aligned}$$

$$f_4 = 114.736 = 2.05970$$

$$\underline{.732}$$

$$.004 \text{ Flint peak}$$

$$B + F \quad 114.734$$

$$\begin{aligned}
 b &= 56.4 \quad 114.628 \\
 114.7 & \quad \underline{.10900} \quad (.0009 \\
 &\quad \underline{10283}
 \end{aligned}$$

$$\begin{aligned}
 114.9 & \quad \underline{.10900} \quad (.00095 \\
 &\quad \underline{10341} \\
 &\quad \underline{5590}
 \end{aligned}$$

F

$$\begin{aligned}
 d_3 &= 20.520 = 1.31218 \\
 &\quad \underline{0.20295} \\
 &\quad \underline{1.33997} \\
 &\quad \underline{2.85510}
 \end{aligned}$$

$$1.31218$$

$$\begin{aligned}
 9.77503\frac{1}{2} \quad 21.8760 \\
 1.08721\frac{1}{2} &= 12.2240 \\
 &\quad \underline{9.6520} = 0.98462
 \end{aligned}$$

$$f_3 = 74.213 = 1.87048$$

$$\begin{aligned}
 &\quad \underline{.250} \\
 73.963 &= 1.86901\frac{1}{2} \\
 &\quad \underline{1.66585} \\
 &\quad \underline{3.53486\frac{1}{2}}
 \end{aligned}$$

$$\begin{aligned}
 n &= 0.20295 \\
 r &= 1.66585 \\
 1.86880 &= 73.926\frac{1}{2}
 \end{aligned}$$

$$\begin{aligned}
 1.86901\frac{1}{2} \\
 9.77503\frac{1}{2} \\
 1.64405 &= 44.060\frac{1}{2} \\
 &\quad \underline{29.866} = 1.47518 \\
 114.732 &\quad \underline{2.05968\frac{1}{2}}
 \end{aligned}$$

$$\begin{aligned}
 46.329 \\
 &\quad \underline{.038} \\
 r_4 &= 46.291 \text{ second}
 \end{aligned}$$

By formulae on p. 18.



Formulae on p 18.

Spherical aberration correct.

$$\begin{array}{rcl} \text{when } r_3 = 21.876 & \left. \vphantom{\begin{array}{l} r_3 = 21.876 \\ r_4 = 46.329 \end{array}} \right\} & 1.33997 \\ r_4 = 46.329 & & 1.66585 \\ & & \hline \alpha = 0.47219 = & & 9.67412 \end{array}$$

color ~~was~~ correct

$$\begin{array}{rcl} \text{when } r_3 = 21.876 & \left. \vphantom{\begin{array}{l} r_3 = 21.876 \\ r_4 = 46.291 \end{array}} \right\} & 1.33997 \\ r_4 = 46.291 & & 8.66003 \\ & & \hline & .045712 = & 8.66550 \\ & & \hline & .021602 = & 8.33450 \\ B = & .067314 & \end{array}$$

$$\begin{array}{rcl} 1 + \alpha = 1.47219 & = & 0.16796 \\ B = & = & 8.82810\frac{1}{2} \\ r_3 = 21.8703 & = & 1.33985\frac{1}{2} \\ \alpha = & 9.67412 & \\ r_4 = 46.3164 & = & 1.66573\frac{1}{2} \end{array}$$

---

Result -  $r_1 = r_2 = 22.780$   $t_1 = .890$  finished on glass 22.768  
 $D = .258$   
 $r_3 = 21.870$  21.858  
 $r_4 = 46.316$   $t_2 = .250$  46.291

This corrects the B and F central rays - giving the same color correction as in  $4\frac{1}{2} \approx 0.9$  also  $3\frac{1}{2} \approx 0.9$ .

July 7<sup>th</sup> 1902. When the crown lens was ground ready to polish, no care having been taken to bring it exactly to the calculated radius - both sides measured alike

$$r_1 = r_2 = 22.768 \text{ inches radius}$$

The corresponding curves for the flint lens were found by proportion to be -

$$r_3 = 21.858 \text{ inches}$$

$$r_4 = 46.291 \text{ "}$$

The spherometer reading for these surfaces is

$$r_1 = r_2 = 8.801 \text{ <sup>rev</sup> convex}$$

$$r_3 = 9.189 \text{ concave}$$

$$r_4 = 4.332 \text{ "}$$

The focal length would about  $114\frac{3}{4}$  inches from back surface.



Oct. 27 1902. The two lenses having been centered, and partly polished, and the object glass roughly tested by a small hole in sheet tin in front of acetylene lamp all the surfaces were reground to take out scratches. When ready to polish the spherometer readings were as follows -

B+7 central miter p. 63	$r_1 = 8.801$	Error = 0
	$r_2 = 8.802$	" = +0.001
	$r_3 = 9.189$	" = 0
	$r_4 = 4.330$	" = -0.002

See p. 136 for finished curves

Lecron

## Record of Polishing

1<sup>st</sup> Surface <sup>7.62" d</sup>1902  
Oct 302 hours with 8.45 Polisher  
cut into 1 in squares. holes graded from  
center out.

Nov. 4

" 7

2 hours. same pol.

" 8

not clear. edge hazy

" 9

1 hr. some cut little more  
at center by holes in squares.

" 11

1 hr. same pol.

" 25

2 hr. same pol. not quite  
so strong at center holes  
smooth out to edge. but little smaller

" 28

" 30

1 hr.

1903  
Jan 9<sup>th</sup> $\frac{3}{4}$  hr. holes made uniformlarger Pol.  $9\frac{3}{8}"$  d.

Feb 10

 $1\frac{1}{2}$  hr. " " holes graded <sup>2nd change</sup>

" 12

 $1\frac{1}{2}$  hr. " " cut center <sup>3rd change</sup>  
<sup>edge long brownish</sup>

" 16

 $2\frac{1}{4}$ 

9" Pol

no change in 2<sup>nd</sup> ab. Cont. 19032<sup>nd</sup> Surface <sup>7.62" d</sup> (Scratch) $1\frac{1}{2}$  hours with 8.45 Polishersame polisher as for 1<sup>st</sup> $2\frac{1}{2}$  hr with same pol.

not clear. edge hazy

1 hr. same as 1<sup>st</sup> surface

1 hr. same pol.

1 hr.

3 hr. same

 $\frac{3}{4}$  hr. holes made uniform

1903

Feb 25

 $1\frac{1}{2}$  hr 7<sup>th</sup> pol

Mar 6

 $\frac{3}{4}$  hr 8 $\frac{1}{2}"$ 

" 8

1

8 $\frac{1}{4}"$  final

Apr. 28

 $\frac{1}{2}$ 

9.0



1902 Record of Polishing  
3<sup>rd</sup> Surface <sup>7.52 d</sup>

Oct 29 2 hours 8.48<sup>in</sup>  
cut into 1<sup>st</sup> square. cleared  
edge more than center

Nov 8 2 hrs. 8.50<sup>in</sup> Polish  
" 9  
not clear center hazy

-12 2 hrs. <sup>top a little</sup> 8.10<sup>in</sup> Pol  
13 cut, change at center

e 30 2 hrs  
1903 Jan 25 2 " Pol cut even - little smaller <sup>1/4</sup>

4<sup>th</sup> Surface <sup>7.10 d</sup>

2 hours 8.00<sup>in</sup>  
cut into 1<sup>st</sup> square. cleared the  
grinding uniformly -

~~2 hours. 8.10<sup>in</sup> polish~~  
2 hours 8.10<sup>in</sup> - polish  
not clear center hazy

2 hrs 8.10<sup>in</sup> Pol

1 1/2 hrs.

Flint too strong for color  
this surface was reground  
see p. 68 + 71  
Repolished

## Lind

4<sup>th</sup> Surface

1903

Repolished after curvature was changed  
by grinding -

Jan. 2 2 hrs  
Jan 18 3 hrs  
" 27 2 "  
Feb 1 3 "  
Mar 8 1 " Found on  $8\frac{1}{4}$ " pol

Reground May 18<sup>th</sup>

May 18 1 hr.  $8\frac{1}{4}$ " even  
20 1 " " "

Reground May 24<sup>th</sup>

May 25 1 hr.  $8\frac{1}{4}$ " even

## Reground May 26

May 29  $\frac{3}{4}$  h  $8\frac{1}{4}$ " even

## Reground May 31

May 31  $1\frac{1}{4}$  h  $8\frac{1}{4}$ " even

June 1  $1\frac{1}{4}$  h " "

2  $1\frac{1}{2}$  " "

4 2 " "

Oct 18  $1\frac{3}{4}$  " "

" "  $1\frac{3}{4}$  " " do cut - center + edge

" 22  $1\frac{3}{4}$  " "

" 25  $1\frac{3}{4}$  " "

3<sup>rd</sup> Surface

Sph. Ab. changed - by pol on  
polisher 7<sup>th</sup> d. cut away towards edge

March, 1<sup>st</sup> 2 hrs  
" 8<sup>th</sup> 1 Found on  $8\frac{1}{4}$ " pol

## Reground

Apr. 14 1 hr even pol

" 20 1 " do cut center

" 21 1 " even pol

" 23 1 " "

May 3 2 " 9" - ( $1\frac{1}{2}$  h figure)

" 4  $\frac{1}{2}$  " even pol.

" 5 1 " 9" recut

" 7  $1\frac{1}{2}$  "  $8\frac{1}{2}$  "

" 11 1 " "

" 12 2 " "

" 13  $\frac{1}{2}$  " " long stroke (more)

" 14 1 " short stroke

" 15 1 "  $7\frac{3}{4}$  do cut center

" 17  $\frac{1}{2}$  " even polisher <sup>total</sup> 15<sup>h</sup>

Continued on p 93



2<sup>nd</sup> Surface

192 1/2 <sup>hr</sup> - from page 66.  
1903

May 8 1<sup>hr</sup> " "

4 9 1 <sup>hr</sup> 4 4

10  $\frac{1}{2}$   $\frac{h}{m}$

$$10 \frac{1}{2}^{\frac{5}{2}}$$

Aug 14 1

4 16  $1\frac{1}{4}$  " " the  $19\frac{3}{4}$  mi

Sept. 4 1 4 4

11  $\delta^- 1\frac{1}{2}$  "

6 1  $\frac{1}{2}$  on 9 w,  $\frac{1}{2}$  on 8 w

4.  $7 \cdot 1\frac{1}{2}$

$$9 \quad 8 \quad \frac{3}{4}$$

Oct 17 1 on 8<sup>th</sup> bench center

1. 4 9  $\frac{1}{2}$  1 edge

Continued on p 92.

to change curvature

March 6  $\frac{3}{4}$  hr. 8.4" pol

8 / 4 4 9

12 1 1/4 " Out at a Centre

15 2 4

7 15- 1  $\frac{3}{4}$  a . . . . .

20 1 1/4 (8) special

30  $\frac{3}{4}$  on special  $9\frac{1}{8}-4\frac{1}{2}$

Wtwd 8  $\frac{3}{4}$

April 5 - 1 hr. on  $8\frac{5}{4}$  cut even

April 10  $1\frac{1}{2}$  hr. 8.4 sub even

12  $1\frac{1}{2}$  m 9.0 cut  $\frac{1}{2}$  way out

19 2 9.0

21  $\frac{1}{2}$  9.0

23 / 9.0

27	$\frac{1}{2}$	9.0
----	---------------	-----

28	1	9.0
----	---	-----

May 17 9.0

1<sup>st</sup> Surface - continued

→ 1903  
Aug 16<sup>th</sup> 1 hr 9<sup>h</sup> 5 figs

Sept. 2 1 2 4 (11 total)

Continued on page 92

1902  
Dec 2<sup>nd</sup>

Tested on  $\alpha$  Lepus & Altair, Spherical Ab. almost correct  
lens a little the stronger. but very little

lens was quite perceptibly off. the third being the stronger.  
Probably the B and F marginal rays should have been united  
instead of central rays (sup 63)

Dep.  $\frac{40}{39-41}$  B and F marginal rays are united  
when

$$\begin{aligned} r_1 = r_2 &= 23.065 & t_1 &= .900 & D &= .250 \\ r_3 &= 22.145 & & & & \\ r_4 &= 47.550 & t_2 &= .250 & & \end{aligned}$$

$$f = 114.386$$

$$r_1 = \frac{22.768}{23.065} = 1.35732 \checkmark$$

$$114.386 = 2.05837 \checkmark$$

$$23.065 = \frac{1.36295}{9.99437} \checkmark$$

$$\frac{9.99431}{9.99437}$$

$$9.99437 \checkmark$$

$$f = \frac{112.897}{2.05268}$$

$$22.145 = \frac{1.34527}{21.869} \checkmark$$

$$r_3 = \frac{21.869}{+1.002} = 1.33964$$

$$s = \frac{9.188}{-1.001}$$

$$\frac{23.068}{47.550} =$$

$$47.550 = \frac{1.67715}{9.99437} \checkmark$$

$$9.99437$$

$$r_4 = \frac{46.938}{+1.647} = 1.67152$$

$$s = \frac{4.272}{-1.060}$$

$$\text{Separation} = .250 = \frac{9.39794}{9.99437}$$

$$.900 = \frac{9.9542}{9.9944}$$

$$.247 = \frac{9.39231}{9.99437}$$

$$.888 = \frac{9.9486}{9.99437}$$

$$.250$$



Result.

Marginal B & F superimposed  
Spherometer

$$r_1 = r_2 = 22.768$$

$$r_3 = 21.860$$

$$r_4 = 46.938$$

$$Z = 112.897$$

$$t_1 = 0.888$$

$$t_2 = 0.247$$

$$D = 0.247$$

$$\begin{array}{r} 0.172 \\ 0.247 \\ \hline 0.259 \end{array} \text{ exp. 48}$$

$$8.801 \text{ convex } 0$$

$$9.188 \text{ concave } -1$$

$$\begin{array}{r} 330 \\ 4.272 \\ \hline 0.058 \end{array} \text{ " } -58$$

at first

Jan. 2, 1903. 4<sup>th</sup> Surface was reground 4-6 pm. and polished  
2 hours in the evening, - (finest emery = 10 min in water)  
3 " Jan 18<sup>th</sup>

Jan 4<sup>th</sup> - Curvature measured as follows  
S = 4.271 by Spherometer

Jan 10<sup>th</sup> Q. G. tested, seeing nearly perfect  
color, perfect  
Spherical Ab. about right except <sup>2 or 3</sup> dif. rings were  
considerably too bright - could not decide that flint was either too strong  
or too weak. Disc or ring opened out about alike both sides of focus  
Figure - Edge slightly long focused



1903.

March 6

After all four surfaces were brought to a clear polish when the lenses were separated  $.0.260^{\frac{1}{2}}$  by the "thick ring" (P.71) the color was correct, but the spherical aberration was slightly "off" the crown being too strong -

When the lenses were separated  $0.230^{\frac{1}{2}}$  by the "thin ring" the spherical aberration was correct but the color was plainly "off" the crown being too weak -

The 1<sup>st</sup> surface of "crown" was then polished for  $5\frac{1}{4}$  hrs. with large polisher cut away at center - but no change in spherical aberration was produced -

The 2<sup>nd</sup> surface of the crown was then polished  $1\frac{1}{2}$  hrs on 7<sup>th</sup> polisher cut away at edges, but no change in spherical aberration was produced.

The 3<sup>rd</sup> surface - (1<sup>st</sup> of Flint) was then polished  $2\frac{1}{2}$  hrs on 7<sup>th</sup> polisher cut away at edges - and still not the slightest change in the spherical aberration was caused

Mch 6<sup>th</sup>

The first surface of the crown was then ground to give spherometer reading 8.827 instead of 8.801 this much "deepening" of the curvature being estimated to strengthen the "crown" for color and weaken it for spherical aberration to bring the two corrections "together".

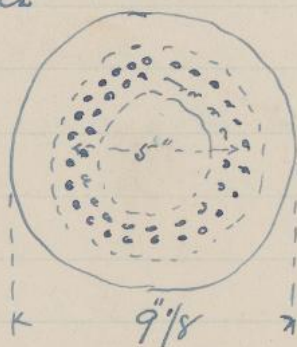
The surface was then polished  $\frac{3}{4}$  hr. and <sup>0.9.</sup> tested and both color and spherical aberration were found to be correct.



1902phae-proj  
70)  
1  
Mch 8 The 2<sup>nd</sup>, 3<sup>rd</sup> and 4<sup>th</sup> Surfaces were <sup>each</sup> polished for 1 hour on evenly cut polisher  $8\frac{1}{4}$ " diam to true them.

The spherical aberration with thin ring (.230) was now different - The crown being too strong (slightly) - while with this separation the it was too weak for color -

Mch 20. The first surface was then polished 8 hours more ( $8\frac{3}{4}$  in all) in an attempt to alter the spherical aberration, see p. 69 - but without any success - The last  $\frac{3}{4}$  hr. was on a polisher  $9\frac{1}{8}$ " diam - cut thus



While polishing the central part  $4\frac{1}{2}$ " in diam. did not touch the glass - This did not change the spherical aberration at all - and did not injure the figure - or short focus the edge.

Apr. 3 The first surface was then reground the curvature being made more convex - the spherometer reading being  $S = 8.873$  instead of  $8.827$



1903

Apr. 5

1<sup>st</sup> Surface was polished 1 hr. and the C. G. tested in the evening - air being very good - with thin ring. (.230) the spherical aberration was exactly the same as before - the crown slightly strong - the color however was decidedly different the crown being now slightly too strong -

Apr. 9

The ring was turned down thinner to  $.186 + \frac{.048}{.012} = .198$

Apr. 10

1<sup>st</sup> Surface reground, to less convex - spherometer reading changed from 8.873 to 8.855

Polished 1 1/2 hr. on 8.4" polisher cut even - & tested in the evening with thin ring -

Color was right but crown too strong for sph. ab.

Apr. 12

Polished 1 1/2 hr. on 9.0" polisher cut as shown on previous pag. bearing equally all over -

Test. no change - color right crown too strong, edge long focused -

It was now evident that no change of spherical aberration could be made by working on the outside surface but color changed decidedly



Apr. 14 - The 3<sup>rd</sup> Surface - 1<sup>st</sup> of Flint was reground  
the curvature being "deepened" - Spherometric reading  
changed from 9.189 to 9.198

No change in the spherical aberration could be  
detected - but the color was changed decidedly - the  
flint being now too strong with narrow ring -

May 18 The 4<sup>th</sup> Surface - 2<sup>nd</sup> of Flint was reground,  
the curvature being "flattened" - Spherometric reading  
changed from 4.271 to 4.255

With narrow ring (separation = 0.198) the spherical  
aberration was about right - but the flint was slightly  
too strong for color - Edge slightly long focussed.

May 24 4<sup>th</sup> S. 4.256 to 4.250  
Flint too strong for color

May 26 4<sup>th</sup> S. 4.250 to 4.247  
Flint too strong for color

May 31 4<sup>th</sup> S. 4.247 to 4.237  
color correct.

1903

May 8<sup>th</sup>

The four surfaces are measured with spherometer as follows -

Dec. 16 1915 see p. 136.

Ground Apr 10 1903	1 <sup>st</sup>	lens convex	$S = 8.851$	$r_1 = 22.641$
" Oct 27 1902	2 <sup>nd</sup>	" "	$r = 8.799\frac{1}{2}$	$r_2 = 22.772\frac{1}{2}$
" Apr 14 1903	3 <sup>rd</sup>	Flint concave	$r = 9.200$	$r_3 = 21.814$
" May 31 1903	4 <sup>th</sup>	" May 31 " changed to (0.75)	$r = 4.271$ $4.237$ $4.242$	$r_4 = 46.944$ $47.287$ $47.232$ <small>unfinished</small>

On star object glass tested as follows  
color-

With thin ring, separation =  $0.198^{\mu}$  Flint decidedly too strong -

With thick ring separation =  $0.259^{\mu}$  Flint slightly too weak -

Therefore with separation =  $0.244$  the color should be correct -

### Spherical Aberration

With thin ring - crown too strong at center and too weak at edge -

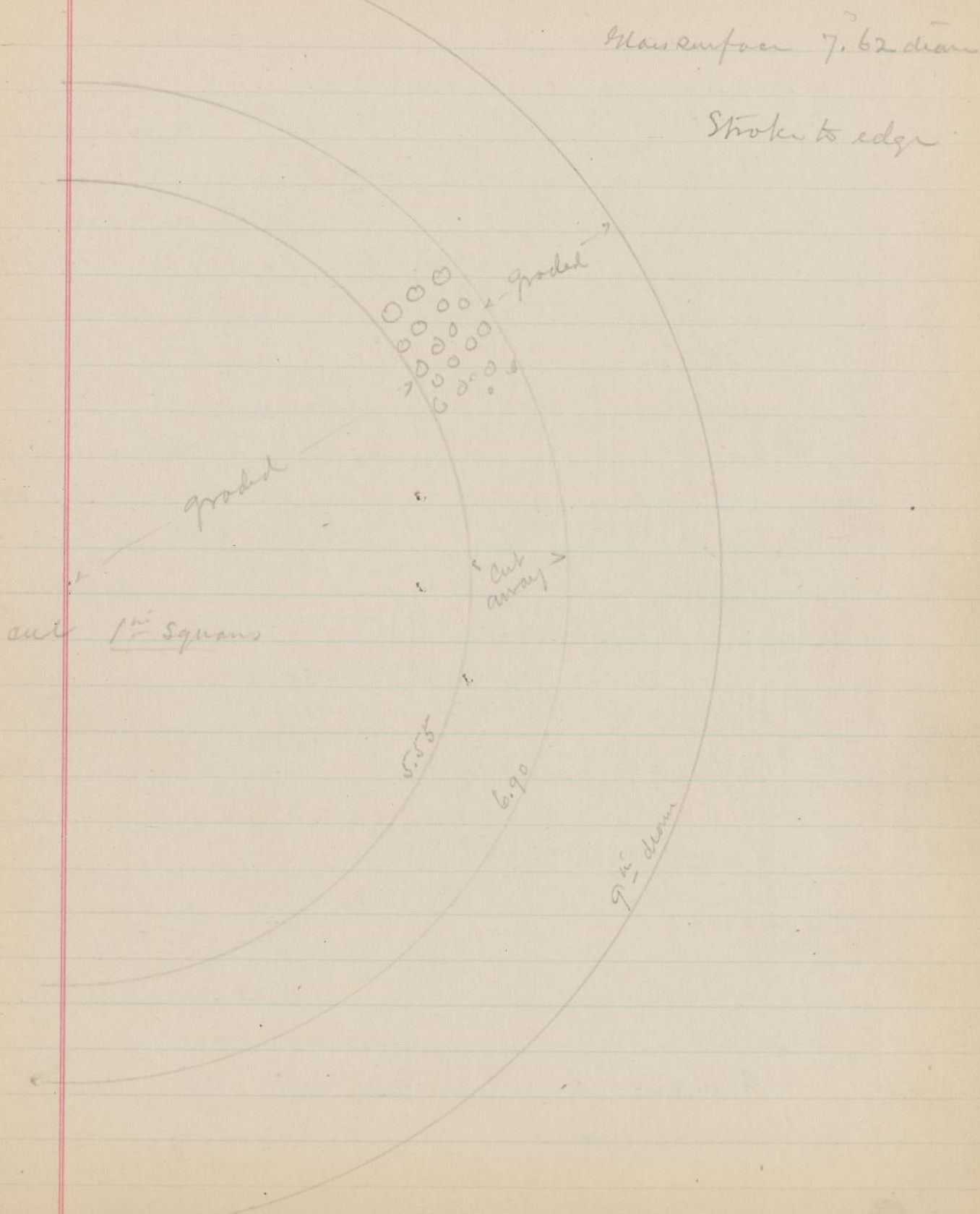
With thick ring - crown very much too strong at center -

Jan 4 1905

Finished Rings =  $0.1903$  at steps

$$\frac{10131}{0.2034} = \text{separation}$$





78

1923  
May 9<sup>th</sup>Lerown  
sph. At.

$\lambda = 5614$

$\kappa = 2.500 = 0.39794 \checkmark$

$r_1 = 22.615 = 1.35440 \checkmark$

$i = 6^\circ 20' 48.3'' = \sin 9.04354 \checkmark$

$n = 0.18712 \checkmark$

$\lambda = 4^\circ 7' 12.7'' = \sin 8.85642 \checkmark$

$r_2 = 2 \ 13 \ 35.6 \checkmark \quad r = 1.35440 \checkmark$

$0.21082 \checkmark$

$\rightarrow \sin 8.58940 \checkmark$

$41.823 \frac{1}{2} \checkmark = 1.62142 \checkmark$

$r_1 = 22.615 \checkmark$

$f_1 = 64.438 \frac{1}{2} \checkmark$

$.880 \checkmark$

$d_2 = 63.558 \frac{1}{2} \checkmark$

$r_2 = 22.774 \checkmark$   
 $86.332 \frac{1}{2} \checkmark = 1.93617 \checkmark$

$8.58940 \checkmark$

$0.52557 \checkmark$

$r_2 = 1.35744 \checkmark$

$i = 8^\circ 28' 8.6'' = \sin 9.16813 \checkmark$

$n = 0.18712 \checkmark$

$\lambda = 13^\circ 5' 48.0'' = \sin 9.35525 \checkmark$

$4 \ 37 \ 39.4 \checkmark = r_1 = 1.35744 \checkmark$

$r_2 = 2 \ 13 \ 35.6 \checkmark \quad 0.71269 \checkmark$

$r_1 = 6 \ 51 \ 15.0 \checkmark = \sin 9.07680 \checkmark$

$43.240 \checkmark = 1.63589 \checkmark$

$r_2 = 22.774 \checkmark$

$f_2 = 20.466 \checkmark$

$D = 0.244 \checkmark$

$d_3 = 20.222 \checkmark$

$A = \frac{1}{r_1} + \frac{1}{r_2}$

$r_1 = 22.615 = 1.35440$   
 $8.64560 = .044218$

$r_2 = 22.774 = 1.35744$   
 $8.64560 = .043910$

$A = .088128$

Lerown

$n = 0.18712 \checkmark$

$r = 1.35440 \checkmark$

$1.54152 \checkmark$

$n-1 = 9.73124 \checkmark$

$f_1 = 64.607 \checkmark = 1.81028 \checkmark$

$.880$

$d_2 = 63.727 \checkmark = 1.80432 \checkmark$

$r_2 = 22.774 \checkmark = 1.35744 \checkmark$   
 $3.16176 \checkmark$

$n = 0.18712 \checkmark$

$r = 1.35744 \checkmark$

$1.54456 = 35.040 \checkmark$

$d = 1.80432 \checkmark$

$n-1 = 9.73124 \checkmark$

$1.53556 = 34.321 \checkmark$

$69.361 = 1.84112 \checkmark$

$f_2 = 20.924 \checkmark = 1.32064 \checkmark$

$0.244$

$d_3 = 20.680 \checkmark$



## Flint

Marginal

Spherical Aberration

Central

$$d_3 = 20.222 \checkmark$$

$$\tau_3 = \frac{21.806}{42.028} \checkmark = 1.62354 \checkmark$$

$$\sin \nu = 9.07680 \checkmark$$

$$0.70034 \checkmark$$

$$\tau_3 = 1.33858 \checkmark$$

$$i = 13^\circ 17' 53.1'' \checkmark \sin \nu = 9.36176 \checkmark$$

$$n = 0.20078 \checkmark$$

$$\lambda = 8^\circ 19' 47.2'' \checkmark \sin \nu = 9.16098 \checkmark$$

$$4^\circ 58' 56.9'' \checkmark \tau = 1.33858 \checkmark$$

$$\nu = 6^\circ 51' 15.0'' \checkmark 0.49956 \checkmark$$

$$\nu' = 1^\circ 53' 9.1'' \checkmark \sin \nu = 8.51736 \checkmark$$

$$95.998 \checkmark = 1.98226 \checkmark$$

$$21.806$$

$$f_3 = 74.192$$

$$1.250$$

$$d_y = 73.942$$

$$\tau_4 = 46.914 \checkmark$$

$$27.028 \checkmark = 1.43181 \checkmark$$

$$\sin \nu = 8.51736 \checkmark$$

$$9.94908 \checkmark$$

$$\tau_4 = 1.67130 \checkmark$$

$$i = 1^\circ 5' 10.47'' \checkmark \sin \nu = 8.27788 \checkmark$$

$$0.20078 \checkmark$$

$$\lambda = 1^\circ 43' 29.43'' \checkmark \sin \nu = 8.47854 \checkmark$$

$$0^\circ 38' 18.96'' \checkmark \tau = 1.67130 \checkmark$$

$$\nu = 1^\circ 53' 9.1'' \checkmark 0.14984 \checkmark$$

$$1^\circ 14' 50.14'' \checkmark \sin \nu = 8.33780 \checkmark$$

$$64.872 \checkmark = 1.81206 \checkmark$$

$$\tau_4 = 46.914 \checkmark$$

$$f_4 = 111.786 \checkmark$$

$$111.785 \checkmark$$

Calculation repeated on separate sheet

} correct

$$24. \tau_3 = 21.794 \checkmark$$

$$B = \frac{1}{\tau_3} + \frac{1}{\tau_4} \checkmark$$

$$\frac{1}{\tau_4} = B - \frac{1}{\tau_3} \checkmark$$

$$\tau_4 = 46.968 \checkmark$$

$$d_3 = 20.680 \checkmark = 1.31553 \checkmark$$

$$\tau = 1.33858 \checkmark$$

$$n = 0.20078 \checkmark$$

$$2.85491 \checkmark$$

$$d = 1.31553 \checkmark$$

$$n-1 = \frac{9.76918}{1.08473} \checkmark$$

$$21.806 \checkmark$$

$$12.1543 \checkmark$$

$$9.6527 \checkmark = 0.98460 \checkmark$$

$$f_3 = 74.184 \checkmark = 1.87031 \checkmark$$

$$1.250 \checkmark$$

$$d_y = 73.934 \checkmark = 1.86884 \checkmark$$

$$\tau_y = 1.67130 \checkmark$$

$$3.54014 \checkmark$$

$$n = 0.20078 \checkmark$$

$$\tau = 1.67130 \checkmark$$

$$f = 1.87208 \checkmark = 74.487 \checkmark$$

$$d = 1.86884 \checkmark$$

$$n-1 = 9.76918 \checkmark$$

$$1.63802 \checkmark = 43.453 \checkmark$$

$$3.1034 \checkmark = 1.49184 \checkmark$$

$$111.764 \checkmark = 2.04830 \checkmark$$

Calculation repeated on separate sheet  
111.764

$$111.786 \checkmark$$

.022 { Crown too strong  
Flint too strong

$$\tau_3 = \log 1.33858 \checkmark$$

$$8.66142 \checkmark = .045859 \checkmark$$

$$\tau_4 = \log 1.67130 \checkmark$$

$$8.32870 \checkmark = .021316 \checkmark$$

$$B = .067175 \checkmark$$

(see below)  $\tau_3 = 21.762 = \frac{1.33770}{8.66230} = \frac{.067178}{.045982} = B$

$\tau_4 = 47.118 = \frac{8.32681}{1.67319} = .021223$

		Common weak
$\tau_3 = 21.806$	Spr. H <sub>1</sub> =	.022
$= 21.794$		<u>.016</u>
Change .012		.006

$$6 : 12 : 16 : x$$

$$\frac{12}{6} = \frac{16}{x}$$

$$6 \overline{) 192}$$

$$\underline{32}$$

$$\tau_3 = \frac{21.794}{.032} = 21.762 \text{ should give 0 spr. H}_1$$



Hint  
sph. Ab.

81

$d_3 = 20.222$   
 $\tau_3 = \frac{21.794}{42.016} = 1.62341$   
 $\sin \nu = \frac{9.07680}{0.70021}$   
 $\tau_3 = \frac{1.33834}{9.36187}$   
 $i = 13^\circ 18' 5.5'' \sin$   
 $\lambda = \frac{8 \ 19 \ 54.9}{4 \ 58 \ 10.6} \sin$   
 $\tau_3 = \frac{1.33834}{0.49943}$   
 $\nu' = \frac{6 \ 51 \ 15.0}{1 \ 53 \ 4.4} \sin$   
 $96.033 = 1.98242$   
 $\tau = \frac{21.794}{.250}$   
 $f_3 = 74.239$   
 $d_4 = 73.989$   
 $\tau_4 = \frac{46.968}{27.021} = 1.43170$   
 $\sin \nu = \frac{8.51701}{9.94871}$   
 $\tau_4 = \frac{1.67180}{8.27691}$   
 $i = 1^\circ 5' 2.67'' \sin$   
 $\lambda = \frac{1 \ 43 \ 17.0}{38 \ 14.33} \sin$   
 $\tau_4 = \frac{1.67180}{0.14949}$   
 $\nu' = \frac{1 \ 53 \ 4.4}{1 \ 14 \ 50.1} \sin$   
 $64.817 = 1.81169$   
 $46.968$   
 $f_4 = 111.785$   
 $.769$   
 $.016$  known to mark

$d_3 = 20.680 = 1.31555$   
 $\tau = 1.33834$   
 $n = \frac{0.20078}{2.85467}$   
 $d = 1.31555$   
 $n-1 = \frac{9.76918}{1.08473} = 21.794$   
 $12.1543$   
 $9.6397 = 0.98406$   
 $f_3 = 74.235 = 1.87061$   
 $.250$   
 $d_4 = 73.985 = 1.86914$   
 $\tau_4 = 1.67180$   
 $3.54094$   
 $n = 0.20078$   
 $\tau = \frac{1.67180}{1.87258} = 74.573$   
 $d = 1.86914$   
 $n-1 = \frac{9.76918}{1.63832} = 43.483$   
 $31.090 = 1.49262$   
 $f_4 = 111.769 = 2.04832$   
 $\tau_3 = 21.806$   
 $.207$   
 $\tau_3 = 21.799$  should correct for sph. Ab.





(sup 80)  
-032

$$d_3 = 20.222 \checkmark$$

$$\tau_3 = \frac{21.762 \checkmark}{41.984 \checkmark}$$

$$\sin \nu = \frac{1.62308 \checkmark}{9.07680 \checkmark}$$

$$0.69988 \checkmark$$

$$\tau_3 = \frac{1.33770 \checkmark}{9.36218 \checkmark}$$

$$\delta = 13^\circ 18' 40.0'' \checkmark \sin$$

$$\dot{n} = \frac{0.20078 \checkmark}{9.16140 \checkmark}$$

$$d = 1.31533 \checkmark$$

$$\lambda = 8^\circ 20' 16.4'' \checkmark \sin$$

$$4 \ 58 \ 23.6 \checkmark \tau_3 = \frac{1.33770 \checkmark}{0.49910 \checkmark}$$

$$\tau_3 = \frac{1.33770 \checkmark}{0.49910 \checkmark}$$

$$22' = 1 \ 52 \ 51.4 \checkmark \sin$$

$$96.144 \checkmark = \frac{1.98292 \checkmark}{1.67319 \checkmark}$$

$$\tau_3 = \frac{21.762 \checkmark}{74.382 \checkmark}$$

$$f_3 = \frac{250 \checkmark}{74.132 \checkmark}$$

$$d_4 = 74.132 \checkmark$$

$$\tau_4 = \frac{47.118 \checkmark}{27.014 \checkmark} = \frac{1.43159 \checkmark}{8.51618 \checkmark}$$

$$\delta = 1^\circ 4' 41.78'' \checkmark \sin$$

$$\lambda = 1^\circ 42' 43.82'' \checkmark \sin$$

$$0 \ 38 \ 2.04 \checkmark$$

$$1 \ 52 \ 51.4 \checkmark$$

$$22' = 1 \ 14 \ 49.36 \checkmark \sin$$

$$64.688 \checkmark = \frac{1.81082 \checkmark}{1.67319 \checkmark}$$

$$\tau_4 = \frac{47.118 \checkmark}{111.806 \checkmark}$$

$$f_4 = 111.806 \checkmark$$

$$d_4 = 111.806 \checkmark$$

$$.769$$

$$.037 \text{ lesson too weak}$$

$$n' = 0.20078$$

$$d = 1.31533 \checkmark$$

$$\tau_3 = \frac{1.33770 \checkmark}{2.85403 \checkmark}$$

$$n-1 = \frac{9.76918 \ 21.762}{1.08473} = 12.1543$$

$$9.6097 = 0.98262$$

$$f_3 = 74.372$$

$$= 1.87141$$

$$d_4 = 74.122$$

$$= 1.86995$$

$$\tau_4 = \frac{1.67319 \checkmark}{3.54314 \checkmark}$$

$$n = 0.20078$$

$$\tau_4 = \frac{1.67319 \checkmark}{1.87397} = 74.812$$

$$1.87397 = 74.812$$

$$d = 1.86995$$

$$n-1 = \frac{9.76918}{1.63913} = 43.564$$

$$1.63913 = 43.564$$

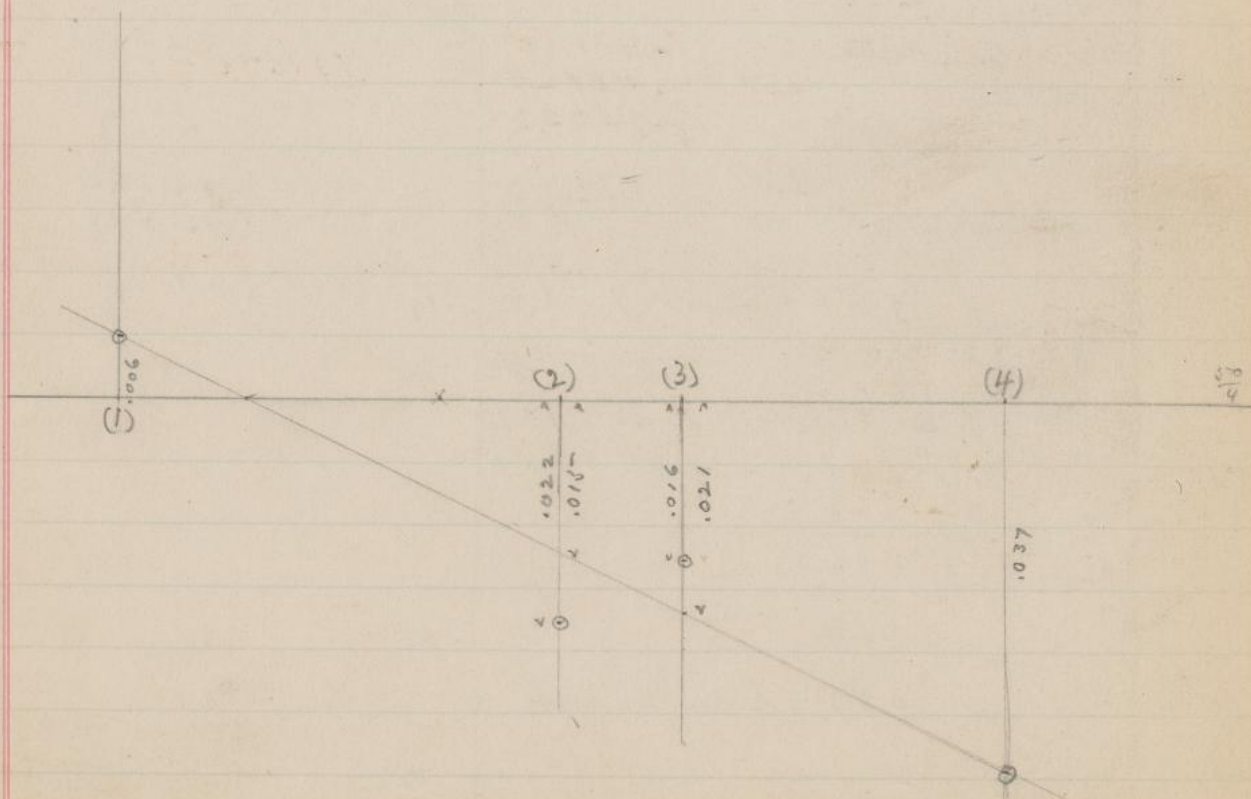
$$31.248 = 1.49482$$

$$f_4 = 111.769 = 2.04832$$

$$\begin{aligned}
 \text{By } \tau_3 &= 21.850 &= 1.33945 & .067175 \\
 & & 8.66055 &= .045767 \\
 & & 8.33058 &= .021408 \\
 \tau_4 &= 46.711 &= 1.66942
 \end{aligned}$$

Result -

spherometer	$\tau_3$	change	sph. sh.	change	Corresponding $\tau_4$
(1) 9.185 038	21.850 21.837	.088	Cruc. strong + .006	.043	4.290 27 46.711 .407
(2) 9.204 021	21.806	.044	" weak - .015	22	4.271 18 46.914 .204
(3) 9.209 014	21.794	.032	" " - .021	16	4.266 13 46.968 .150
(4) 9.223 0	21.762	0	" " - .037	0	4.253 0 47.118 0





$$d = 20.222$$

$$\tau_3 = \frac{21.850}{42.072} =$$

$$\sin \nu \quad 1.62399 \checkmark$$

$$9.07680 \checkmark$$

$$0.70079 \checkmark$$

$$\tau_3 = 1.33945 \checkmark$$

$$i = 13^\circ 17' 6.0'' = \sin 9.39134 \checkmark$$

$$0.20078 \checkmark$$

$$\lambda = 8^\circ 19' 18.0'' = \sin 9.86056 \checkmark$$

$$4^\circ 57' 48.0'' \checkmark$$

$$6^\circ 51' 15.0'' \checkmark$$

$$1^\circ 53' 27.0'' \checkmark$$

$$95.843 \checkmark = 1.98156 \checkmark$$

$$21.850 \checkmark$$

$$f_3 = 73.993 \checkmark$$

$$.250$$

$$d_4 = 73.743 \checkmark$$

$$\tau_4 = 46.711 \checkmark$$

$$27.032 \checkmark = 1.43188 \checkmark$$

$$\sin \nu \quad 8.51845 \checkmark$$

$$9.95033 \checkmark$$

$$1.66942 \checkmark$$

$$i = 1^\circ 5' 38.78'' = \sin 8.28091 \checkmark$$

$$0.20078 \checkmark$$

$$8.48169 \checkmark$$

$$\lambda = 1^\circ 44' 14.34'' = \sin 1.66942 \checkmark$$

$$0^\circ 38' 35.56'' \checkmark$$

$$p = 1^\circ 53' 27.0'' \checkmark$$

$$p' = 1^\circ 14' 51.44'' \checkmark$$

$$65.040 \checkmark = 1.81318 \checkmark$$

$$\tau_4 = 46.711 \checkmark$$

$$111.751 \checkmark$$

$$n = 0.20078 \checkmark$$

$$d = 1.31555 \checkmark$$

$$\tau_3 = 1.33945 \checkmark$$

$$2.85578$$

$$21.850$$

$$12.1543 \checkmark$$

$$9.6957 \checkmark = 0.98658 \checkmark$$

$$73.995 \checkmark = 1.86920 \checkmark$$

$$.250 \checkmark$$

$$d = 73.745 \checkmark = 1.86773 \checkmark$$

$$1.66942 \checkmark$$

$$3.53785 \checkmark$$

$$n = 0.20078 \checkmark$$

$$\tau = 1.66942 \checkmark$$

$$1.87020 \checkmark = 74.665 \checkmark$$

$$d = 1.86773 \checkmark$$

$$n = 9.76918 \checkmark$$

$$1.63691 \checkmark = 43.342 \checkmark$$

$$30.823 \checkmark = 1.48887 \checkmark$$

$$.37885 \checkmark$$

$$2.04812 \checkmark$$

$$2.47 \checkmark$$

$$111.757 \checkmark$$

$$.751 \checkmark$$

$$.006 \checkmark$$

$$lesons two strong$$

Measured May 19<sup>th</sup>

$$\tau_3 \quad S = 9.203$$

$$\tau_4 \quad S = 4.272 \quad \text{this surface not finished}$$

from March 5<sup>th</sup> May 31 changed to 4.227

$$p = 76$$





Effect of changing  $\tau_4$  on Sph. H.From p. 85-  $\tau_4 = 46.711 \checkmark$ 

$$\text{add } \frac{.250}{\tau_4 = 46.961 \checkmark}$$

central

$$d_4 = 73.743 \checkmark$$

$$\frac{46.961 \checkmark}{26.782 \checkmark} = 1.42784 \checkmark$$

$$\sin 2\theta = 8.51845 \checkmark$$

$$\sin 9.94629 \checkmark$$

$$\delta_4 = 1.67174 \checkmark$$

$$i = 1^\circ 4' 41.51'' \sin 8.27455 \checkmark$$

$$0.20078 \checkmark$$

$$\lambda = 1.4243.39 \checkmark \sin 8.47533 \checkmark$$

$$0.381.88 \checkmark \frac{1.67174 \checkmark}{0.14707 \checkmark}$$

$$\frac{1.5327.0 \checkmark}{1.1525.12 \checkmark} \sin 8.34117 \checkmark$$

$$63.959 \checkmark \frac{1.80590 \checkmark}{46.961 \checkmark}$$

$$f_4 = 110.920 \checkmark$$

$$d = 73.745 \checkmark = 1.86773 \checkmark$$

$$\tau_4 = 1.67174 \checkmark$$

$$\frac{3.53947 \checkmark}{1.87252 \checkmark} = 74.8625 \checkmark$$

$$n = 0.20078 \checkmark$$

$$\tau = 1.67174 \checkmark$$

$$1.87252 \checkmark = 74.8625 \checkmark$$

$$d = 1.86773 \checkmark$$

$$n_1 = 9.76918 \checkmark$$

$$\frac{1.63691 \checkmark}{31.2205 \checkmark} = 1.49444 \checkmark$$

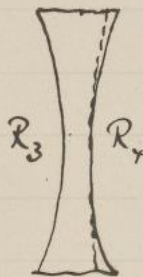
$$\frac{43.3420 \checkmark}{2.04503 \checkmark}$$

$$f_4 = 110.925 \checkmark = 2.04503 \checkmark$$

$$\frac{110.920 \checkmark}{0.005 \checkmark} \text{ brown string}$$

$$\frac{.006}{.001} \text{ no change}$$

$$\text{change} = .001 \text{ no change}$$

changing  $\tau_4 + 0.250 \frac{c}{s}$ No change for Sph. H.  $0.001 \frac{c}{s}$ This weakened fiber shortened  $f_4$   $0.832$





Effect of changing  $\sigma_4$  on Sph. Ab. continued -  
 $\sigma_4$  changed 1.250  $\mu$

From p 88:

$$\begin{array}{r} \sigma_4 = 46.711 \\ \text{add } 1.250 \\ \hline \sigma_4 = 47.961 \end{array}$$

$$d_4 = 73.743$$

$$\sigma_4 = \frac{47.961}{25.782} = \sin i = \frac{1.41132}{8.51845}$$

$$i = 1^\circ 0' 58.70'' = \sin \sigma_4 = \frac{1.68089}{8.24888}$$

$$\lambda = \frac{1 \ 36 \ 49.53}{0 \ 35 \ 50.85} = \sin \sigma_4 = \frac{0.20078}{8.44966}$$

$$\frac{1 \ 53 \ 27.00}{1 \ 17 \ 36.15} = \sin \sigma_4 = \frac{1.68089}{8.35356}$$

$$\frac{59.839}{1.77698}$$

$$\sigma_4 = \frac{47.961}{107.800}$$

$$f_4 = 107.800$$

Central

$$\begin{array}{r} d_r = 1.86773 \\ \sigma_r = 1.68089 \\ \hline 3.54862 \end{array}$$

$$n = 0.20078$$

$$\sigma_r = \frac{1.68089}{1.88167} = 76.150$$

$$d(n-1) = \frac{43.342}{32.808} = 1.51598$$

$$f_4 = 107.805 = 2.03264$$

$$\frac{107.800}{.005} \text{ known strong}$$

No change in spherical Aberration

but considerable change in color

$$\text{change in focal length} = \frac{111.757}{107.805} = 3.952$$



# Reflection from inner surfaces

Separation = 0.198

P. 78

$$f_2 = 20.466 \checkmark$$

$$d = \frac{.198}{20.466} \checkmark$$

$$r_3 = 21.806$$

$$\frac{42.074 \checkmark}{21.806} = 1.62401$$

$$\sin i = \frac{9.07680 \checkmark}{1.62401}$$

$$0.70081$$

$$r = 1.33858$$

$$i = 13^\circ 18' 45.8'' = \sin 9.36223$$

$$2i = 26 37 31.6$$

$$d = \frac{6 51 15.0 \checkmark}{19 46 16.6} = \sin 0.70081 \checkmark$$

$$d' = 19 46 16.6 = \sin 9.52926$$

$$14.844 = 1.17155$$

$$r = \frac{21.806 \checkmark}{1.17155}$$

$$f = 6.962$$

$$.198$$

$$d = \frac{6.962}{.198} \checkmark$$

$$r_2 = 22.774 \checkmark$$

$$\frac{16.010 \checkmark}{22.774} = 1.20439$$

$$\sin i = \frac{9.52926}{1.20439}$$

$$0.73365$$

$$r = 1.35744$$

$$i = 13^\circ 45' 24.0'' = \sin 9.37621$$

$$2i = 27 30 48.0$$

$$d = \frac{19 46 16.6}{7 44 31.4} = \sin 0.73365$$

$$d' = 7 44 31.4 = \sin 9.12941$$

$$40.201 = 1.60424$$

$$r_2 = \frac{22.774 \checkmark}{1.60424}$$

$$f = 17.427$$

$$.198$$

$$d_3 = \frac{17.427}{.198}$$

$$d_3 = 17.229$$

$$d_3 = 17.229 \checkmark$$

$$r_3 = 21.806 \checkmark$$

$$\frac{39.035 \checkmark}{21.806} =$$

$$\sin i = \frac{1.59145 \checkmark}{9.12941 \checkmark}$$

$$0.72086 \checkmark$$

$$r = \frac{1.33858 \checkmark}{9.38228 \checkmark}$$

$$a = \frac{0.20078 \checkmark}{9.18150 \checkmark}$$

$$1.33858 \checkmark$$

$$0.52008 \checkmark$$

$$8.64377 \checkmark$$

$$1.87631$$

$$\lambda = \frac{8 44 9.5 \checkmark}{5 13 6.1} = \sin$$

$$7 44 31.4 \checkmark$$

$$d = \frac{2 31 25.3}{75.216} = \sin$$

$$21.806$$

$$f_3 = \frac{53.410}{.250}$$

$$d_4 = 53.160$$

$$r_4 = \frac{46.914}{6.246}$$

$$= \frac{474496}{8.42472 \checkmark}$$

$$0.16968 \checkmark$$

$$r = \frac{1.60130}{8.42472 \checkmark}$$

$$0.20078 \checkmark$$

$$8.64377 \checkmark$$

$$1.87631$$

$$i = 1^\circ 48' 19.53'' = \sin$$

$$2 52 2.18 = \sin$$

$$1 3 42.63$$

$$1 31 25.3$$

$$d' = 0 27 42.67 = \sin$$

$$291.13 =$$

$$46.91$$

$$f_y = \frac{338.04}{2.46409}$$



## Reflected Ray

$$d_4 - r_7 = 6.246 = 0.79560$$

$$\sin v = \frac{8.64377}{9.43937}$$

$$r = \frac{1.67130}{7.76807}$$

$$i = 0^\circ 20' 9.20'' = \sin \frac{0.20078}{7.96885}$$

$$\lambda = \frac{0 \quad 31 \quad 59.91}{0 \quad 11 \quad 50.71} = \sin \frac{1.67130}{9.64015}$$

$$v = \frac{2 \quad 31 \quad 25.3}{2 \quad 19 \quad 34.59} = \sin \frac{8.60842}{1.03173}$$

$$r' = \frac{10.758}{46.914} =$$

$$f_4 = 57.672$$

(Principal focal length = 111.75)

$$\frac{57.67}{54.08}$$





1903

3<sup>rd</sup> SurfaceFrom p. 68 15<sup>h</sup> hrz. in all.Nov. 10  $1\frac{1}{2}$  "  $7\frac{1}{4}$  " bent C.

" 11 1 " " "

" 13  $\frac{3}{4}$  "  $8\frac{3}{8}$  " " $18\frac{1}{4}$  hrz4<sup>th</sup> SurfaceFrom p. 68  $11\frac{1}{2}$  hrz

Oct 26 1 " "

" 30  $1\frac{1}{2}$  " "Nov. 1  $1\frac{1}{4}$  " "" 11  $1\frac{3}{4}$  " "

" 12 1 " "

" 13  $1\frac{3}{4}$  " "" 14 2 "  $8\frac{3}{8}$  even (21 $\frac{3}{4}$ )" 17  $1\frac{1}{4}$  " (23)" 18 1 "  $7\frac{1}{2}$  cut center" 19 1-10<sup>m</sup>  $8\frac{1}{2}$  cut to C." 20 1 even  $8\frac{1}{2}$ " 21  $\frac{3}{4}$  leg.

" 22 1 " (28)

" 23  $1\frac{3}{4}$   $8\frac{1}{2}$  plain" 24  $1\frac{1}{4}$   $8\frac{1}{4}$  big (32)" 25  $1\frac{1}{2}$  " "

" 26 1 " "

" 27  $1\frac{1}{4}$  " "" 28  $1\frac{1}{2}$   $7\frac{1}{2}$  bent center" 29  $1\frac{10}{12}$  " cut half way out" 30  $1\frac{1}{4}$  " " "

" 31 2 " " "

" 32 2 " " "

" 33 1 " " "

" 34  $1\frac{1}{2}$  " " "

O. G.  
 nearly correct  
 Equal rounded  
 center short

nearly perfect →

$$\begin{array}{r} 4950 \\ 843 \\ \hline 67 \end{array}$$

3.92

$$\begin{array}{r} 14 \\ 7 \\ \hline 7 \end{array}$$

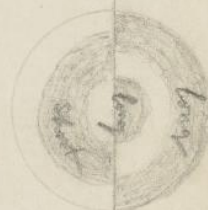
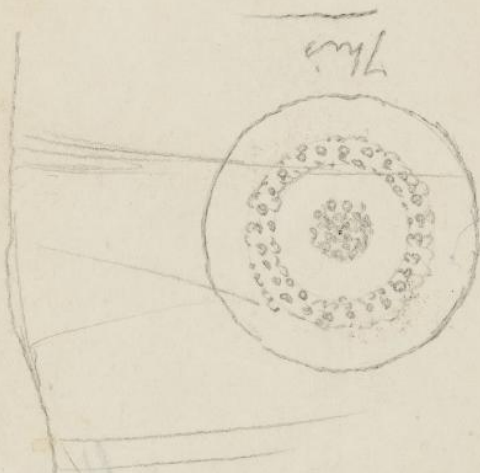
$$\begin{array}{r} 22.00 \\ 15- \\ \hline 31.00 \end{array} \quad \begin{array}{r} 700.00 \\ .2 \end{array}$$



$$\begin{array}{r} 32 \\ 29 \\ \hline 22 \\ 250 \end{array}$$

$$\begin{array}{r} 12 \\ 11 \\ \hline 11 \\ 11 \\ \hline 11 \\ 11 \end{array}$$

$$\begin{array}{r} 821 \\ 128 \\ \hline 1689 \end{array}$$



May 18-1911

1 thin

$$\begin{array}{r} \text{center } 802 \\ .120 \checkmark \\ \hline 682 \\ 689 \\ \hline .007 \text{ flat} \end{array}$$

$$\begin{array}{r} \text{Edge} \\ .120 \checkmark \end{array}$$

4 brown

$$\begin{array}{r} \text{center } 802 \\ .115 \checkmark \\ \hline 687 \\ 2.684 \\ \hline .002 \text{ flat} \end{array}$$

$$\begin{array}{r} \text{Edge} \\ .114 \checkmark \end{array}$$



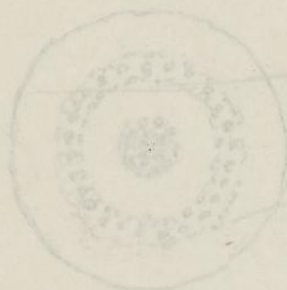
$3\frac{1}{2}$   
 F  
 54.11  
 11576  
 90  
 132



51 - 26 6  
 12.5  
 2.8  
 5.294  
 1.43  
 2.5



31.00  
 100.00  
 11.5  
 35.50



May 16

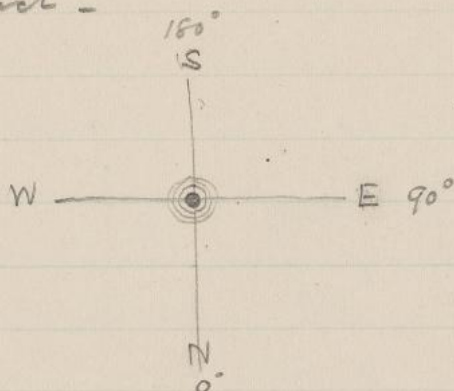
191-81  
 Reground (3)

16  
 191  
 811  
 777  
 316  
 46

3rd  
 177  
 317  
 460

777  
 3221  
 4382  
 500

Feb 5<sup>th</sup> 1904. Saw companion of Sirius <sup>steadily</sup> -  $(7'' \pm 0.9)$   
 Seeing nearly perfect -



Distance about three times  $\beta$  Orionis.

On this date the Lick Observatory observations make its  
 position -  $111.5^\circ$   $6''.52$  - (May 21 1905-)



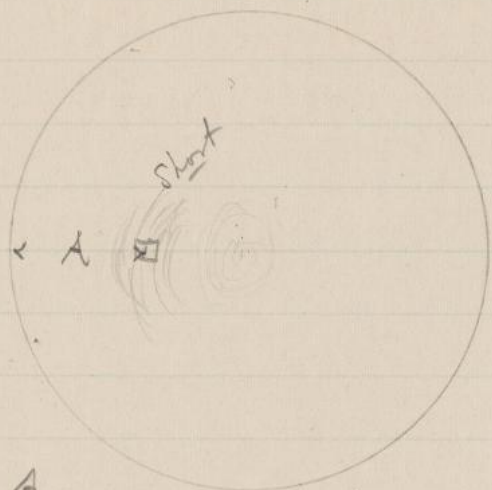










4<sup>th</sup> Surface (back) by Reflection



A  
Dec. 4  $2\frac{3}{16}$  inches - Edge to short focus area before pol.  
" "  $2\frac{3}{4}$  " after 1 hr pol. to move the other way  
" " near center {short center / long edge} " 1 " " " " "  
" 5  $1\frac{7}{8}$  " " 40 min. "  
" 6 Edge long - center short  
" 10 " " " " no change

" 18 after 2 hrs  center long (on star center short directed)  
Edge near  
half as short.  
with eye piece out  (same as on star)

" 23 same

" 24 "

June 3 Edge long - center short as mirror





From 692

1<sup>st</sup> Surface

1905-

28  $\frac{1}{2}$  hours

June 18

 $\frac{1}{4} + \frac{1}{4} + \frac{1}{20} = 5\frac{1}{8}$ "

from 693

4<sup>th</sup> Surface

99

1904

1<sup>st</sup> Sur 48  $\frac{3}{4}$ 

Dec - 4

1

" "

1

" 5-

 $\frac{40}{60}$ 

" 6

 $1\frac{1}{4}$ 

" 10

 $1\frac{1}{2}$ 

" 11

 $1\frac{1}{4}$ 

" 18 Sunday

 $\frac{3}{4}$ 

" "

 $1\frac{1}{4}$ 

even pole

" 23

 $\frac{35}{60}$ out  $\frac{1}{2}$  way out

" 24

1

(59)

" 25-

1

"

Frige + laster  $6\frac{1}{2}$ 

" 26

 $\frac{1}{2} = 7\frac{1}{2}$  down1905-

Jan 2

 $1\frac{1}{4}$   $7\frac{1}{2}$  down

" 3

 $1\frac{1}{4}$ 

" 5

 $\frac{1}{4}$  } $1\frac{3}{4}$ 

" 11

1

" 12

1

" 13

 $\frac{3}{4}$ 

" 15

 $\frac{1}{2}$ 

(68)

" 16

 $\frac{1}{2}$ 

" 18

 $\frac{1}{2}$ 

" 23

 $\frac{1}{2}$ (69  $\frac{1}{2}$ )







Color correction in finished Glass -  
As finished (p. 76.)

Dec. 16  
1915-

P. 136  
P. 78  
partial calculation  
Morgan & Cannon  
May 1914

$$\left. \begin{array}{l} \tau_1 = 22.641 \checkmark \\ \tau_1 = 22.615 \checkmark \\ \tau_2 = 22.772 \frac{1}{2} \checkmark \\ \tau_2 = 22.774 \checkmark \end{array} \right\} \begin{array}{l} t. = 0.900 \\ t. = 0.880 \end{array} \quad \text{— brown in front —} \quad \begin{array}{l} \log \\ \tau_1 = 1.35489 \frac{1}{2} \checkmark \\ \tau_2 = 1.35741 \checkmark \end{array}$$

$$D = 0.2023 \checkmark \quad \text{see p. 76.}$$

$$\left. \begin{array}{l} \tau_3 = 21.814 \checkmark \\ \tau_3 = 21.806 \checkmark \\ \tau_4 = 47.232 \checkmark \\ \tau_4 = 47.287 \checkmark \\ \tau_4 = 47.226 \checkmark \end{array} \right\} \begin{array}{l} t = 0.220 \\ t = 0.240 \end{array} \quad \text{— Flint —} \quad \begin{array}{l} \tau_3 = 1.33873 \frac{1}{2} \checkmark \\ \tau_4 = 1.67418 \frac{1}{2} \checkmark \\ 1.67418 \checkmark \end{array}$$

Index of Refraction see pp. 10 and 11. <sup>132-135-</sup> 2104-105

		<sup>No 23 brown</sup> <sup>log</sup>	<sup>No 31 Flint</sup> <sup>log</sup>
$n = \left\{ \begin{array}{l} B \\ F \end{array} \right.$		0.185419 ✓	0.198591 ✓
		0.188699 ✓	0.202899 ✓
$n-1 = \left\{ \begin{array}{l} B \\ F \end{array} \right.$		9.726372 ✓	9.763249 ✓
		9.735747	9.774888 ✓

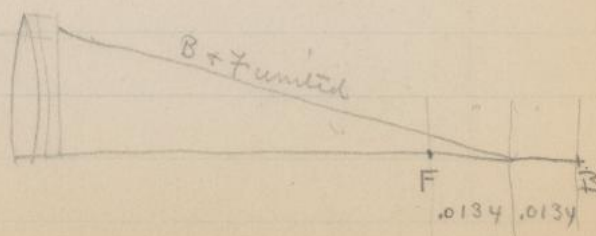
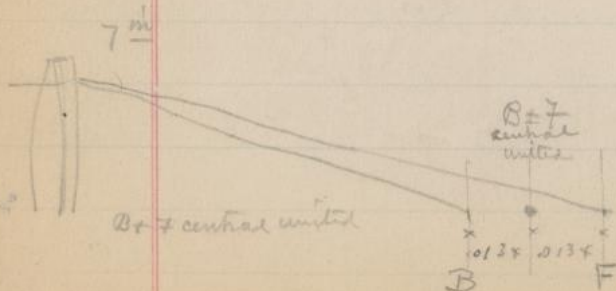
Note

In 4 1/2" = 0.4. with curves as finished see 2 leaves from end of old book

for F ray  $f_4 = 59.362$  (central ray)

" B "  $f_4 = 59.354$  " "

.008





Central

I  
II  
III  
IV

B

$$n = 0.18546\frac{1}{2} \checkmark$$

$$\tau = \frac{1.35489\frac{1}{2}}{1.53986} \checkmark$$

$$n-1 = \frac{9.72651}{9.72651} \checkmark$$

$$f_1 = \frac{68.0654}{.880} \checkmark = 1.81335 \checkmark$$

$$d_2 = \frac{64.1854}{.880} \checkmark = 1.80743\frac{1}{2} \checkmark$$

$$\tau_2 = \frac{1.35744}{3.16487\frac{1}{2}} \checkmark$$

$$n = 0.18546\frac{1}{2} \checkmark$$

$$\tau = \frac{1.35744}{1.54290\frac{1}{2}} \checkmark$$

$$= 34.9064 \checkmark$$

$$d = 1.80743\frac{1}{2} \checkmark$$

$$n-1 = \frac{9.72651}{1.53394\frac{1}{2}} \checkmark$$

$$= \frac{34.1926}{69.1000} \checkmark$$

$$f_2 = \frac{21.1541}{.2023} \checkmark = 1.32539\frac{1}{2} \checkmark$$

$$d_3 = \frac{20.9518}{.2023} \checkmark$$

$$= 1.32122 \checkmark$$

$$n = 0.19864\frac{1}{2} \checkmark$$

$$\tau = \frac{1.33857\frac{1}{2}}{2.85844} \checkmark$$

$$d = 1.32122 \checkmark$$

$$n-1 = \frac{9.76339}{1.08461} \checkmark$$

$$= 21.806 \checkmark$$

$$= \frac{9.6550}{0.98475\frac{1}{2}} \checkmark$$

$$f_3 = \frac{74.763}{.240} \checkmark = 1.87368\frac{3}{4} \checkmark$$

$$d_4 = \frac{74.523}{.240} \checkmark = 1.87229 \checkmark$$

$$\tau_4 = \frac{1.67474}{3.54703} \checkmark$$

$$= 1.67474 \checkmark$$

$$n = 0.19864\frac{1}{2} \checkmark$$

$$\tau = \frac{1.67474}{1.87338\frac{1}{2}} \checkmark$$

$$= 74.7110 \checkmark$$

$$d = 1.87229 \checkmark$$

$$n-1 = \frac{9.76339}{1.63568} \checkmark$$

$$= 43.2195 \checkmark$$

$$= \frac{31.4915}{1.49819\frac{1}{4}} \checkmark$$

$$f_4 = 111.902 \checkmark = 2.04883\frac{3}{4} \checkmark$$

$$= \frac{.861}{.041} \checkmark$$

$$= 7 \text{ short "Thick neck"}$$

F

$$n = 0.18875\frac{1}{4} \checkmark$$

$$\tau = \frac{1.35439\frac{1}{2}}{1.54314\frac{3}{4}} \checkmark$$

$$n-1 = \frac{9.73590}{9.73590} \checkmark$$

$$f_1 = \frac{64.1875}{.880} \checkmark = 1.80724\frac{3}{4} \checkmark$$

$$d_2 = \frac{63.2775}{.880} \checkmark = 1.80125 \checkmark$$

$$\tau_2 = \frac{1.35744}{3.15869} \checkmark$$

$$= 1.35744 \checkmark$$

$$n = 0.18875\frac{1}{4} \checkmark$$

$$\tau = \frac{1.35744}{1.54619\frac{1}{4}} \checkmark$$

$$= 35.1716 \checkmark$$

$$d = 1.80125 \checkmark$$

$$n-1 = \frac{9.73590}{1.53715} \checkmark$$

$$= 34.4470 \checkmark$$

$$f_2 = \frac{20.6997}{.2023} \checkmark = 1.84272\frac{1}{2} \checkmark$$

$$d_3 = \frac{20.4974}{.2023} \checkmark = 1.31170 \checkmark$$

$$n = 0.20295\frac{1}{2} \checkmark$$

$$\tau = \frac{1.33857\frac{1}{2}}{2.85323} \checkmark$$

$$= 1.33857\frac{1}{2} \checkmark$$

$$d_3 = 1.31170 \checkmark$$

$$n-1 = \frac{9.77503\frac{1}{2}}{1.08673\frac{1}{2}} \checkmark$$

$$= 21.806 \checkmark$$

$$= \frac{9.5955}{0.98206\frac{3}{4}} \checkmark$$

$$f_3 = \frac{74.330}{.240} \checkmark = 1.87116\frac{1}{4} \checkmark$$

$$d_4 = \frac{74.090}{.240} \checkmark = 1.86976 \checkmark$$

$$\tau_4 = \frac{1.67474}{3.54480} \checkmark$$

$$= 1.67474 \checkmark$$

$$n = 0.20295\frac{1}{2} \checkmark$$

$$\tau = \frac{1.67474}{1.87769\frac{1}{2}} \checkmark$$

$$= 75.456 \checkmark$$

$$d = 1.86976 \checkmark$$

$$n-1 = \frac{9.77503\frac{1}{2}}{1.64479\frac{1}{2}} \checkmark$$

$$= 44.1362 \checkmark$$

$$= \frac{31.3798}{1.49582} \checkmark$$

$$f_4 = 111.861 \checkmark = 2.04868 \checkmark$$

$$= \frac{.861}{.041} \checkmark$$

$$= 7 \text{ short "Thick neck"}$$

This = B + F marginal united  
almost exactly

See page 105-

Corrected measurements

$$7m \quad 7-1 = .000366$$



04

Central 5614

4<sup>th</sup> as made.

P. 78.

P. 10

$$\begin{aligned}
 n &= 0.18712 \checkmark \\
 &\quad \frac{8.35439 \frac{1}{2} \checkmark}{1.54151 \frac{1}{2} \checkmark} \\
 n-1 &= 9.73124 \checkmark \\
 f_1^p &= 64.606 \checkmark = 1.81027 \frac{1}{2} \checkmark \\
 &\quad \frac{1.810 \checkmark}{63.726 \checkmark} = 1.80431 \frac{1}{2} \checkmark \\
 d_2 &= 63.726 \checkmark \\
 \tau_2 &= \frac{1.35744 \checkmark}{3.16175 \frac{1}{2} \checkmark}
 \end{aligned}$$

$$\begin{aligned}
 n &= 0.18712 \checkmark \\
 \tau &= \frac{1.35744 \checkmark}{1.54456 \checkmark} = 35.0397 \checkmark
 \end{aligned}$$

$$d = 1.80431 \frac{1}{2} \checkmark$$

$$\begin{aligned}
 n-1 &= 9.73124 \checkmark \\
 n-1 &= \frac{1.53555 \frac{1}{2} \checkmark}{69.3603 \checkmark} = 34.3206 \checkmark
 \end{aligned}$$

$$f_2 = 20.924 \checkmark = 1.32064 \frac{1}{2} \checkmark$$

$$d_3 = 20.924 \checkmark = 1.32064 \frac{1}{2} \checkmark$$

$$d_3 = 20.7217 \checkmark = 1.31642 \frac{1}{2} \checkmark$$

$$\begin{aligned}
 n &= 0.20077 \frac{1}{2} \checkmark \\
 \tau_3 &= \frac{1.33857 \frac{1}{2} \checkmark}{2.85577 \frac{1}{2} \checkmark}
 \end{aligned}$$

$$\begin{aligned}
 d_3 &= 1.31642 \frac{1}{2} \checkmark \\
 n-1 &= 9.76918 \checkmark \\
 n-1 &= \frac{1.08560 \frac{1}{2} \checkmark}{9.6272 \checkmark} = 12.1788 \checkmark
 \end{aligned}$$

$$f_3 = 74.5204 \checkmark = 0.98350 \checkmark$$

$$f_3 = 74.5204 \checkmark = 1.87227 \frac{1}{2} \checkmark$$

$$d_4 = 74.2804 \checkmark = 1.87087 \frac{1}{2} \checkmark$$

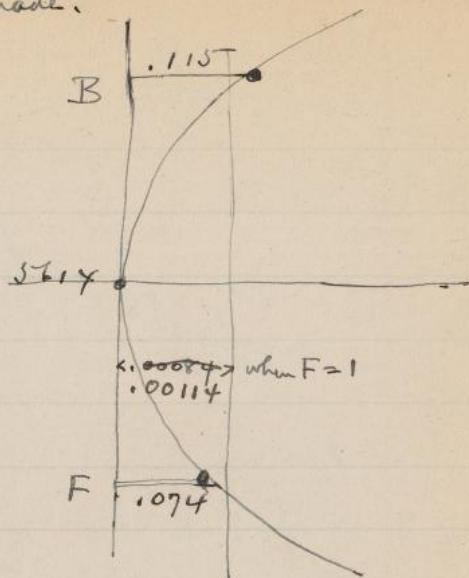
$$\begin{aligned}
 \tau_4 &= \frac{1.67474 \checkmark}{3.54561 \frac{1}{2} \checkmark} \\
 n &= 0.20077 \frac{1}{2} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \tau &= \frac{1.67474 \checkmark}{1.87551 \frac{1}{2} \checkmark} = 75.0784 \checkmark \\
 d &= 1.87087 \frac{1}{2} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 n-1 &= 9.76918 \checkmark \\
 n-1 &= \frac{1.64005 \frac{1}{2} \checkmark}{43.6571 \checkmark} = 43.6571 \checkmark
 \end{aligned}$$

$$\begin{aligned}
 f_4 &= 111.787 \checkmark = 1.49722 \frac{1}{2} \checkmark \\
 &\quad \frac{31.4213 \checkmark}{2.04839 \checkmark} \\
 &\quad \frac{641}{260}
 \end{aligned}$$

continued on p. 107



$$\begin{aligned}
 B &= 111.902 - p_{103} \\
 &\quad \frac{.787 - p_{104}}{.115}
 \end{aligned}$$

$$\begin{aligned}
 F &= 111.861 - p_{103} \\
 &\quad \frac{.787}{.074}
 \end{aligned}$$

$$\begin{aligned}
 &\quad \frac{.115}{.074} \\
 &\quad \frac{2}{.189} \\
 112.3 & \left| \begin{array}{r} .09450 \\ .00094 \\ 8984 \\ 14660 \end{array} \right.
 \end{aligned}$$

$$(.00065 \approx 12'')$$

$$(.00066 \approx 4\frac{1}{2}'')$$



Finished Q. Q.

7<sup>m</sup>  
Central

105

$$\text{Dec 17 } 1915 = 1.53257 \quad B = 0.18542 \checkmark$$

$$\tau_1 = 1.35789 \frac{1}{2} \checkmark$$

$$1.54031 \frac{1}{2} \checkmark$$

$$n-1 = 9.72637 \checkmark$$

$$65,1546 \checkmark = 1.813.94 \frac{1}{2} \checkmark$$

$$d_2 = \frac{.900 \checkmark}{64.2546 \checkmark} = 1.80790 \frac{1}{2} \checkmark$$

$$\tau_2 = 1.35741 \checkmark$$

$$3.16531 \frac{1}{2} \checkmark$$

$$n = 0.18542 \checkmark$$

$$\tau_2 = 1.35741 \checkmark$$

$$1.54283 \checkmark = 34.900 \checkmark$$

$$d = 1.80790 \frac{1}{2} \checkmark$$

$$n-1 = 9.72637 \checkmark$$

$$1.53427 \frac{1}{2} \checkmark = 34.2196 \checkmark$$

$$69.1200 \checkmark = 1.83960 \frac{1}{2} \checkmark$$

$$21.169 \checkmark = 1.32571 \checkmark$$

$$d_3 = \frac{.2034 \checkmark}{20.9661 \checkmark} = 1.32152 \checkmark$$

$$1.57976 = n = 0.19859 \checkmark$$

$$\tau_3 = 1.33873 \frac{1}{2} \checkmark$$

$$2.85884 \frac{1}{2} \checkmark$$

$$d = 1.32152 \checkmark$$

$$n-1 = 9.76325 \checkmark$$

$$1.08477 \checkmark = 12.1584 \checkmark$$

$$9.6586 \checkmark = 0.9849 \frac{1}{2} \checkmark$$

$$f_3 = \frac{.220 \checkmark}{74.8050 \checkmark} = 1.87393 \checkmark$$

$$d_4 = \frac{.220 \checkmark}{74.5850 \checkmark} = 1.87265 \checkmark$$

$$\tau_4 = 1.67423 \frac{1}{2} \checkmark$$

$$3.54688 \frac{1}{2} \checkmark$$

$$n = 0.19859 \checkmark$$

$$\tau_4 = 1.67423 \frac{1}{2} \checkmark$$

$$1.87282 \frac{1}{2} \checkmark = 74.615 \checkmark$$

$$d = 1.87265 \checkmark$$

$$n-1 = 9.76325 \checkmark$$

$$1.63590 \checkmark = 43.2414 \checkmark$$

$$31.3736 = 1.49656 \frac{1}{2} \checkmark$$

$$f_4 = \frac{.2665 \checkmark}{112.2845 \checkmark} = 2.05032 \checkmark$$

$$112.2845 \checkmark$$

$$.1752 \checkmark$$

$$.1093 \checkmark$$

$$.2665 \checkmark$$

$$.10180 \checkmark$$

$$.5510 \checkmark$$

$$2.76 \checkmark$$

trans strong

$$n = 1.54419$$

$$F = 0.18870 \checkmark$$

$$1.35789 \frac{1}{2} \checkmark$$

$$1.54359 \frac{1}{2} \checkmark$$

$$9.73574 \frac{1}{2} \checkmark$$

$$64.247 \checkmark = 1.80785 \checkmark$$

$$d_2 = \frac{.900 \checkmark}{63.347 \checkmark} = 1.80172 \frac{1}{2} \checkmark$$

$$\tau_2 = 1.35741 \checkmark$$

$$3.15913 \frac{1}{2} \checkmark$$

$$n = 0.18870 \checkmark$$

$$\tau_2 = 1.35741 \checkmark$$

$$1.54611 \checkmark = 35.165 \checkmark$$

$$d = 1.80172 \frac{1}{2} \checkmark$$

$$n-1 = 9.73574 \frac{1}{2} \checkmark$$

$$1.53747 \checkmark = 34.4723 \checkmark$$

$$69.6373 \checkmark = 1.84284 \checkmark$$

$$20.7155 \checkmark = 1.31629 \frac{1}{2} \checkmark$$

$$d_3 = \frac{.2034 \checkmark}{20.5121 \checkmark} = 1.31201 \checkmark$$

$$1.59537 = n = 0.20290 \checkmark$$

$$\tau_3 = 1.33873 \frac{1}{2} \checkmark$$

$$2.85364 \frac{1}{2} \checkmark$$

$$d = 1.31201 \checkmark$$

$$n-1 = 9.77489 \checkmark$$

$$21.814 \checkmark = \tau_3$$

$$1.08690 \checkmark = 12.2152 \checkmark$$

$$9.5988 = 0.98221 \frac{1}{2} \checkmark$$

$$= 1.87143 \checkmark$$

$$f_3 = \frac{.220 \checkmark}{74.3755 \checkmark}$$

$$d_4 = \frac{.220 \checkmark}{74.1555 \checkmark}$$

$$= 1.87014 \frac{1}{2} \checkmark$$

$$\tau_4 = 1.67423 \frac{1}{2} \checkmark$$

$$3.54438 \checkmark$$

$$n = 0.20290 \checkmark$$

$$\tau_4 = 1.67423 \frac{1}{2} \checkmark$$

$$1.87713 \frac{1}{2} \checkmark = 75.359 \checkmark$$

$$d = 1.87014 \frac{1}{2} \checkmark$$

$$n-1 = 9.77489 \checkmark$$

$$1.64503 \frac{1}{2} \checkmark = 44.1606 \checkmark$$

$$31.198 \checkmark = 1.49413 \checkmark$$

$$f_4 = \frac{.1752 \checkmark}{112.2665 \checkmark} = 2.05025 \checkmark$$

$$.1752 \checkmark$$

$$.0913 \checkmark$$



7<sup>th</sup>

$$S = 4.242 \text{ for the 4<sup>th</sup> surface}$$

Effect on the color correction of a change in this reading of 0.001 ~~m~~

$$S = 4.243$$

$$\therefore \tau_4 = 47.220$$

B

$$d_4 = 74.5850 = 1.87285$$

$$\tau_4 = 47.220 = 1.67412\frac{1}{2}$$

$$\frac{3.54677\frac{1}{2}}{1.87285} = 74.596$$

$$n = 0.19859$$

$$\tau = \frac{1.67412\frac{1}{2}}{1.87285} = 74.596$$

$$\frac{43.2414}{31.3546} = 1.49630$$

$$112.3246 = 2.05047\frac{1}{2}$$

$$112.3052 - F$$

$$\text{When } S = 4.243 - .0194$$

$$= 4.242 - .0180$$

$$\text{Change} - .0014$$

F

$$d_4 = 1.87014\frac{1}{2}$$

$$\frac{1.67412\frac{1}{2}}{1.87014\frac{1}{2}} = 75.340$$

$$n = 0.20290$$

$$\tau = \frac{1.67412\frac{1}{2}}{1.87014\frac{1}{2}} = 75.340$$

$$\frac{44.1606}{31.1794} = 1.49387$$

$$112.3052 = 2.05040$$



7<sup>th</sup>

107

From p. 105 central 56.4

$$f_3 = \frac{74.5204}{1.220} = 74.3004$$

$$f_1 = 64.69250 \checkmark = 1.8108540 \checkmark$$

$$d_2 = \frac{63.79250 \checkmark}{.900 \checkmark} = 1.8047696 \checkmark$$

$$n = 0.1870721 \checkmark$$

$$T_2 = \frac{1.3574100 \checkmark}{3.1621796 \checkmark}$$

$$T_2 = \frac{1.3574100 \checkmark}{1.5444821 \checkmark} = 35.03338 \checkmark$$

$$d_2 = 1.8047696$$

$$n-1 = \frac{9.7311131 \checkmark}{1.5358827 \checkmark} = 34.34652 \checkmark$$

$$f_2 = \frac{20.93852 \checkmark}{.2034 \checkmark} = 1.8412336 \checkmark$$

$$d_3 = \frac{20.73512 \checkmark}{.2034 \checkmark} = 1.3209460 \checkmark$$

$$d_1 = 1.3167063 \checkmark$$

$$n-1 = \frac{9.7690374 \checkmark}{1.0857439 \checkmark} = 21.814 - \pi \checkmark$$

$$f_3 = \frac{74.53584 \checkmark}{.220 \checkmark} = 12.18288 \checkmark$$

$$d_4 = \frac{74.33584 \checkmark}{.220 \checkmark} = 9.63129 \checkmark$$

$$n = 0.2007246 \checkmark$$

$$T_4 = \frac{1.6742350 \checkmark}{3.5454 \checkmark} = 1.8724817 \checkmark$$

$$T_4 = \frac{1.6742350 \checkmark}{1.8742350 \checkmark} = 1.8711982 \checkmark$$

$$d_4 = 1.8711982 \checkmark$$

$$n-1 = \frac{9.7690374 \checkmark}{1.6402356 \checkmark} = 43.67523 \checkmark$$

$$f_4 = \frac{112.1474 \checkmark}{.2755 \checkmark} = 31.30719 \checkmark$$

$$112.75 - .2755 \quad \frac{1}{2}(C+F) p 105$$

$$112.75 - .12860 \quad (.00114)$$

$$\begin{array}{r} 112.75 \\ 15350 \\ 11275 \\ \hline 40750 \end{array}$$

see p 107

56.4

$$n = 0.1870721 \checkmark$$

Aug 27 '21  
0.1870533

$$T_1 = \frac{1.3548950 \checkmark}{1.5419671 \checkmark}$$

$$n-1 = \frac{9.7311131 \checkmark}{1.5358827 \checkmark}$$

$$T_2 = \frac{1.3574100 \checkmark}{3.1621796 \checkmark}$$

$$T_2 = \frac{1.3574100 \checkmark}{1.5444821 \checkmark}$$

$$T_2 = \frac{1.3574100 \checkmark}{1.5444821 \checkmark}$$

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$$T_2 = \frac{1.3574100 \checkmark}{1.5444821 \checkmark}$$





Central 56.4

$$n = \frac{0.1870532}{0.1854224}$$

$$f_1 = \frac{1.3548951}{1.5419503}$$

$$n-1 = \frac{9.7310647}{1.8108856}$$

$$f_1 = \frac{64.69722}{1.900}$$

$$d_2 = \frac{63.79722}{1.8048018}$$

$$f_2 = \frac{1.3574100}{3.1622118}$$

$$n = 0.1870532$$

$$f_2 = \frac{1.3574100}{1.5444652} = 35.03202$$

$$d = 1.8048018$$

$$n-1 = \frac{9.7310647}{1.5358665} = \frac{34.34554}{69.37726}$$

$$f_2 = \frac{20.94087}{2.034}$$

$$d_3 = \frac{20.73747}{1.3167558}$$

$$n' = 0.2007112$$

$$f_3 = \frac{1.3387350}{2.8562020}$$

$$d_3 = 1.3167558$$

$$n-1 = \frac{9.7690012}{1.0857570} = \frac{21.814 = f_3}{12.183078}$$

$$f_3 = \frac{74.56484}{1.220} = \frac{0.9836679}{1.8725341}$$

$$n' = 0.2007112$$

$$f_4 = \frac{1.6742350}{1.8749462} = 74.98014$$

$$d = 1.8712508$$

$$n-1 = \frac{9.7690012}{1.6402520} = \frac{43.67692}{31.30322}$$

$$d_4 = \frac{74.34484}{1.6742350} = \frac{1.8712508}{3.5454858}$$

$$f_4 = \frac{112.1752}{1.4955890} = \frac{2.0498968}{1.4955890}$$

$$\frac{1}{2}(C+F) = 112.2755$$

$$112.75) \begin{array}{r} .1752 \\ .100300 \\ 90200 \\ \hline 101000 \end{array} \begin{array}{l} .00080 \\ .00065 \end{array}$$

.00065 on p. 224 last black box



12<sup>47</sup> from prism Clutride curves alikeForward from  
page 173.

$$\tau_1 = \tau_4 = 180.985 = \log 2.25764$$

$$\tau_2 = 35.0703 = \text{" } 1.54594$$

$$\tau_3 = 33.9285 = \text{" } 1.53056\frac{1}{2}$$

I

flint

Barryta

XIII

$$n'_B = 0.20844\frac{1}{2}$$

$$n_B = 0.19309\frac{1}{2}$$

XI

$$n'_B - 1 = 9.78959$$

$$n_B - 1 = 9.74810$$

II

$$D = .33$$

$$T = 1.07$$

$$D = .500$$

central (B)

$$n' = 0.20844\frac{1}{2}$$

$$d_4 = 627.22 = 2.79742$$

$$180.985$$

$$\tau = 2.25764$$

$$\tau = \frac{2.25764}{5.05506}$$

$$n' - 1 = 9.78959$$

$$d = 2.79742$$

$$f_1 = 474.783 = 2.67649\frac{1}{2}$$

$$n - 1 = 9.74810$$

$$2.54552 = 351.17$$

$$d_2 = 474.453 = 2.67619\frac{1}{2}$$

$$n = 0.19309\frac{1}{2}$$

$$\tau = \frac{1.54594}{4.22213\frac{1}{2}}$$

$$\tau = 2.25764$$

$$2.45073\frac{1}{2} = 282.316$$

$$d_2 = 2.67619\frac{1}{2}$$

$$n - 1 = 9.78959$$

$$633.486 = 2.80173\frac{1}{2}$$

$$n = 0.20844\frac{1}{2}$$

$$\tau = 1.54594$$

$$1.75438\frac{1}{2} = 56.805$$

$$235.465 = 2.37192\frac{1}{2}$$

$$f_2 = 70.829 = 1.85021$$

$$d_3 = 71.329 = 1.85326\frac{1}{2}$$

$$n = 0.19309\frac{1}{2}$$

$$\tau = 1.53056\frac{1}{2}$$

$$3.57692\frac{1}{2}$$

$$d = 1.85326\frac{1}{2}$$

$$n - 1 = 9.74810$$

$$1.60136\frac{1}{2} = 399.36$$

$$33.9285$$

$$6.0685 = 0.77876\frac{1}{2}$$

$$f_3 = 628.29 = 2.79816$$

$$1.07$$

$$d_4 = 627.22$$

$$f_4 = 179.194 = 2.25332\frac{1}{2}$$

$$\frac{177.875}{1.319} \text{ Marginal}$$

leson strong



Marginal

B

$$\begin{aligned}
 k=5 &= 0.69897 \checkmark \\
 T_1 &= 2.25764 \checkmark \\
 i &= 1^\circ 34' 59.15 \checkmark = \sin 8.44133 \checkmark \\
 n &= 0.20844 \frac{1}{2} \checkmark \\
 \lambda &= 0 \ 58 \ 46.40 \checkmark = \sin 8.23288 \frac{1}{2} \checkmark \\
 \varphi' &= 0 \ 36 \ 12.75 \checkmark = \sin 2.25764 \checkmark \\
 &= \sin 0.49052 \frac{1}{2} \checkmark \\
 &= \sin 8.02257 \frac{1}{2} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 293.73 \checkmark &= 2.46795 \checkmark \\
 T_1 &= 180.985 \checkmark \\
 f_1 &= 474.715 \checkmark \\
 &= 1.33 \\
 d_2 &= 474.385 \checkmark \\
 T_2 &= 35.0703 \checkmark \\
 439.3147 \checkmark &= 2.64277 \frac{1}{2} \checkmark \\
 &= 8.02257 \frac{1}{2} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 T_2 &= 0.66535 \checkmark \\
 &= 1.54594 \checkmark \\
 7^\circ 33' 53.1 \checkmark &= \sin 9.11941 \checkmark \\
 n &= 0.20844 \frac{1}{2} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 12 \ 16 \ 59.3 \checkmark &= \sin 9.32785 \frac{1}{2} \checkmark \\
 4 \ 43 \ 6.2 \checkmark &= 1.54594 \checkmark \\
 0 \ 36 \ 12.75 \checkmark &= 0.87379 \frac{1}{2} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \varphi' &= 4 \ 6 \ 53.45 \checkmark = \sin 8.85386 \checkmark \\
 104.216 \checkmark &= 2.01793 \frac{1}{2} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 T_2 &= 35.070 \checkmark \\
 f_2 &= 69.146 \checkmark \\
 &= 1.500 \checkmark
 \end{aligned}$$

$$d_3 = 69.646 \checkmark$$

$$\begin{aligned}
 T_3 &= 33.9285 \checkmark \\
 103.5745 \checkmark &= 2.01525 \frac{1}{2} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 T_3 &= 0.87111 \frac{1}{2} \checkmark \\
 &= 1.53056 \frac{1}{2} \checkmark \\
 12^\circ 39' 12.4 \checkmark &= \sin 9.34055 \checkmark \\
 n &= 0.19309 \frac{1}{2} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 8 \ 4 \ 21.5 \checkmark &= \sin 9.14745 \frac{1}{2} \checkmark \\
 4 \ 34 \ 50.9 \checkmark &= 1.53056 \frac{1}{2} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 4 \ 6 \ 53.45 \checkmark &= 0.67802 \checkmark \\
 \varphi' &= 0 \ 27 \ 57.45 \checkmark = \sin 7.91022 \checkmark
 \end{aligned}$$

$$585.87 \checkmark = 2.76780 \checkmark$$

$$\begin{aligned}
 T_3 &= 33.93 \checkmark \\
 f_3 &= 619.80 \checkmark \\
 &= 1.07 \checkmark
 \end{aligned}$$

$$d_4 = 618.73 \checkmark$$

$$\begin{aligned}
 d_4 &= 618.73 \checkmark \\
 T_4 &= 180.985 \checkmark \\
 799.715 \checkmark &= 2.90293 \frac{1}{2} \checkmark \\
 &= 7.91022 \checkmark
 \end{aligned}$$

$$\begin{aligned}
 T_4 &= 0.81315 \frac{1}{2} \checkmark \\
 &= 2.25764 \checkmark \\
 2 \ 3 \ 33.68 \checkmark &= \sin 8.55551 \frac{1}{2} \checkmark \\
 n &= 0.19309 \frac{1}{2} \checkmark
 \end{aligned}$$

$$\begin{aligned}
 3 \ 12 \ 48.12 \checkmark &= \sin 8.74861 \checkmark \\
 1 \ 9 \ 14.44 \checkmark &= 2.25764 \checkmark \\
 0 \ 27 \ 57.45 \checkmark &= 1.00625 \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \varphi' &= 1 \ 37 \ 11.89 \checkmark = \sin 8.45132 \frac{1}{2} \checkmark \\
 358.86 \checkmark &= 2.55492 \frac{1}{2} \checkmark \\
 180.985 \checkmark &=
 \end{aligned}$$

$$f_4 = 177.875 \checkmark$$



$$\begin{cases} \tau_2 = 32.338 \\ \tau_3 = 37.038 \end{cases}$$

Outside curve alike

$$t_1 = 0.33$$

$$D = 0.500$$

$$t_2 = 1.07$$

$$f_4 = 179.200$$

2.646 flint strongest

$$\tau_1 = \tau_4 =$$

$$\begin{aligned} \tau_1 = \tau_4 = 166.45 &= 2.22126 \\ 7.77874 &= .0060081 \\ &\quad .022923 = B \\ 8.46136 &= .0289311 \\ \tau_2 = 34.565 &= 1.53863 \frac{1}{2} \end{aligned}$$

$$\begin{aligned} &\quad .034999 = A \\ &\quad .0060081 \\ 8.46226 &= .028991 \\ \tau_3 = 34.494 &= 1.53774 \end{aligned}$$

This should give perfect color and spherical aberration —  
but bad internal reflection —  
(central Band 7 rays unite)

$$\begin{aligned} &0.309 \\ &170 \\ &0.309 \\ &170 \end{aligned}$$

$$\begin{aligned} \tau_2 &= 34.716 \\ \tau_3 &= 34.345 \end{aligned}$$

$$\begin{aligned} 180.985 \\ 180.985 \end{aligned}$$

13.9 flint weak

$$\begin{aligned} \tau_2 &= 35.070 \\ \tau_3 &= 33.928 \end{aligned}$$



Temp.  $228.6229$  B central F 237  
 $152.75$   $d_4 = 2.91380\frac{1}{2}$   $152.75$   $d_4 = 2.93607\frac{1}{2}$   
 $r_4 = 2.18398$   $r_4 = 2.18398$   $r_4 = 2.18398$   
 $n = 0.19309\frac{1}{2}$   $n = 0.19651\frac{1}{2}$   
 $r = 2.18398$   $r = 2.18398$   
 $2.37707\frac{1}{2} = 238.273$   $2.38049\frac{1}{2} = 240.157$   
 $d(n-1) = \frac{459.10}{697.373} = 2.84346\frac{1}{2}$   $\frac{493.907}{734.064} = 2.86573\frac{1}{2}$   
 $f_4 = 179.606$   $f_4 = 179.606$   $f_4 = 179.606$

1 central B and F united when

P. 228

$\tau_2 = 36.000$ $\tau_4 = 178.22$ $\tau_3 = 36.000$ $\tau_4 = 152.75$ $f_4 = 179.606$	$179.30 = 2.253580$ $179.606 = 2.254320$ $36.000 = 1.556302$ $\tau_2 = \tau_3 = 35.9387 = 1.555562$  $178.22 = 2.250956$ $\tau_1 = 177.916 = 2.250216$  $152.75 = 2.183981$ $152.49 = 2.183241$
---	--

$\tau_2 = 35.939 = 1.55556$ $\tau_1 = 177.916 = 2.250216$  $\tau_4 = 152.49 = 2.183241$	$8.44444 = .0278253$ $7.749784 = .0056206$ $.0222047 = B$  $.0278253$ $7.816759 = .0065578$ $.0343831 = A$
--	--

To unite central B and F, and give  $f_4 = 179.30$ .

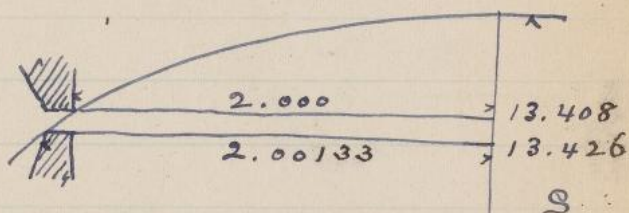
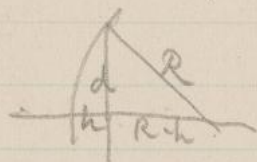






# Spherometer

Repaired by Mr. Lemdin in 1901 after being damaged by fire -



$$R^2 = d^2 + (R-h)^2$$

$$R^2 = d^2 + R^2 - 2Rh + h^2$$

$$2Rh = d^2 + h^2$$

$$R = \frac{d^2}{2h} + \frac{h}{2}$$

$$h = R - \sqrt{R^2 - d^2}$$

$$2Rh - h^2 = d^2$$

$$h = \frac{d^2}{2R - h}$$

Lemoux  $R = \frac{(2.000)^2}{.26816} + .06704$

$$4 = 0.602060$$

$$.26816 = 9.428394$$

$$14.9165 = 1.173666$$

$$.0670$$

$$R = 14.9835$$

Lemcave

$$R = \frac{(2.00134)^2}{.26852} + .06713$$

$$2.00134 = 0.301320\frac{1}{2}$$

$$0.602641$$

$$.26852 = 9.428977$$

$$14.9164 = 1.173664$$

$$.0671$$

$$R = 14.9835$$

This was calculated backwards to find  $d = 2.00134$



$S$  = number of turns of screw to measure sagitta.

$$\therefore h = \frac{S}{100}$$

$$R = \frac{k}{S} + \frac{h}{2} = \frac{d^2}{2h} + \frac{h}{2} \quad \therefore \frac{k}{S} = \frac{d^2}{2 \frac{S}{100}} \quad \therefore k = \frac{d^2}{50}$$

$$\therefore k = 50 d^2$$

convex  $k = 50 d^2 = 50 \times 4 = 200 = \log 2.30103$

concave  $k = 50 d^2 = 50 \times (2.00134)^2 = \log 2.30161 \checkmark$

$R$  given to find  $S$  -

$$(h = \frac{S}{100})$$

$$h_0 = R - \sqrt{R^2 - d^2} \quad \checkmark \quad \frac{k}{S} = R - \frac{h}{2} \quad \checkmark$$

$$S = \frac{k}{R - \frac{h}{2}} \quad \checkmark$$

convex -  $d^2 = 4.00000 = \log 2.30103$

concave  $d^2 = 4.00535 \checkmark$  "

$$h = \frac{d^2}{2R - h_0}$$

Nov. 28<sup>th</sup> 1902. Measurement of 9.4" black Object Nov.

1<sup>st</sup> Surface convex

$$P_{\text{Horn}} = 4.489$$

$$\text{center} = .392$$

$$\text{Edge} = .391$$

$$S = 4.097$$

$$K = \log. 2.30103$$

$$S = " \quad \underline{0.61247}$$

$$48.816 = 1.68856$$

$$\underline{.020}$$

$$R_1 = 48.836$$

2<sup>nd</sup> Surface convex

$$P_{\text{Horn}} = 5.489$$

$$\text{center} = .472$$

$$\text{Edge} = .470$$

$$5.018$$

$$K = \log 2.30103$$

$$S = " \quad \underline{0.70053}$$

$$39.857 = 1.60050$$

$$\underline{.025}$$

$$R_2 = 39.882$$



Continued

3 <sup>rd</sup> Surface	concave	center	5.567	}
		Edge	.570	
		Plane	<u>.486</u>	
			5.082	

$$K = \log 2.30161$$

$$S = \frac{0.70603}{}$$

$$39.408 = 1.59558$$

$$\begin{array}{r} 39.408 \\ .025 \\ \hline 39.433 \end{array}$$

$$R_3 =$$

4 <sup>th</sup> Surface	convex	Plane	0.488	}
		center	.373	
		Edge	<u>.368</u>	
			0.117	

$$K = \log 2.30103$$

$$S = \frac{9.06819}{}$$

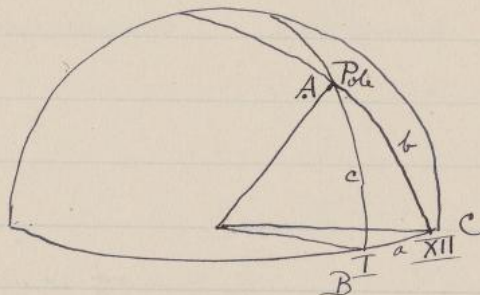
$$170.94 = 3.23284$$

$$\begin{array}{r} 170.94 \\ .00 \\ \hline 170.94 \end{array}$$

$$R_4 =$$

# Sun Dial

## Horizontal



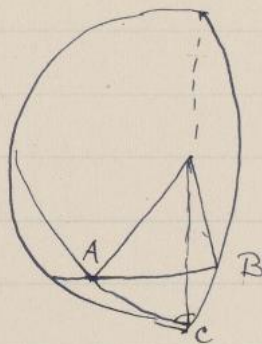
$$\tan a = \tan A \sin b.$$

For Houtford = Latitude  $41^{\circ} 46'$

	Hour Angle	
	A	a
	$7\frac{1}{2}$	$5^{\circ}.01$
I	15	10.12
	$22\frac{1}{2}$	15.43
II	30	21.05
	$37\frac{1}{2}$	27.08
III	45	33.67
	$52\frac{1}{2}$	40.96
IV	60	49.09
	$67\frac{1}{2}$	58.13
V	75	68.09
	$82\frac{1}{2}$	78.82
VI	90	90.00
	$97\frac{1}{2}$	101.18
VII	105	111.92

Good for any latitude when { Gnomon is set parallel to axis of Earth  
and E. & W. line is horizontal



Sun Dial - continuedVertical

$$\tan a = \tan A \sin b$$

$$b = 90^\circ - \text{Lat.}$$







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(Prism made by Mr. Leungdin)

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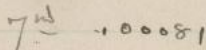
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Kitchen - March 29 1916

Wall		Woodwork
White		White
Raw Sienna	} 2 shut	Raw Umber
Golden Ochre		Leach Black } equal parts
Raw Umber		Raw Sienna
		Burnt Umber }



Paint for Dome of Observatory

Dec 1<sup>st</sup> 1901

White -

Coach Black } about equal possibly more R. U. than C. B.  
Raw Umber }

Raw Sienna

Venezian Red

In order of quantity used.    be low Warm Gray

Paint for Woodwork of House

April 5<sup>th</sup> 1902

White

French ochre }  
Raw Umber    5<sup>th</sup> }

Coach Black }  
Venezian Red } small quantity



