

KG  
11366  
v. 760

*Investigation of Corals*

*May 1<sup>st</sup> 1877 - June 3 1879*



R6.

21













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# Division Errors of the Mulliken Circle.

The following investigation had for its object the determination of the systematic error in the divisions of the circle of the <sup>west</sup> Mulliken instrument. Two microscopes were mounted on a ~~cat~~ cathetometer stand and a wooden circle was placed against the brass circle of the instrument. Twelve glass plates were attached to the wooden circle at intervals of  $30^\circ$  adjustable in position by the hand and pulled by screw.



May 1st. 1877. Two plates were ruled thus <sup>BC</sup> 1 ||  
the distance from B to C being 2".60

Blue M 88.	(1) $\frac{1}{4}$ "	(2)
Insulated lines measured	57.5	54.0
with $\frac{1}{2}$ " and $\frac{1}{4}$ "	.0	3.3
	.2	3.7
	.1	3.2
	<u>.1</u>	<u>3.7</u>
	.9	.9
	57.18	53.58

May 2d 1877. Insulated band of lines  $\frac{1}{480}$ " apart  
each line about  $\frac{1}{6000}$ " wide

(3)	(4)	(5)	(6)
8.7	220.6	3' 21".9	3' 50".3
7.8	21.6	21.9	50.3
8.2	21.2	22.2	50.4
8.8	21.2	22.0	50.2
<u>8.8</u>	<u>21.6</u>	<u>21.5</u>	<u>50.3</u>
2.3	1.2	4.3	15
8.46	221.24	3' 21".86	3' 50".30

$$\begin{array}{r}
 8.46 \\
 221.24 \\
 \hline
 229.70 \\
 + 13.37 \\
 \hline
 243.07
 \end{array}$$

$$\begin{array}{r}
 28.44 \\
 21.278 \\
 7.620 \\
 63.834 \\
 \hline
 77.880 \\
 63.8 \\
 \hline
 14.08
 \end{array}$$

$$\begin{array}{r}
 28.44 \\
 132.78 \\
 21.42 \\
 \hline
 184.64 \\
 132.78 \\
 \hline
 317.42 \\
 531.12 \\
 \hline
 25080
 \end{array}$$

$\text{Hence } \frac{1}{480}'' = \frac{132.78}{212.78} \text{ dis. of mic. H } \frac{1}{2}'' \text{ aperture} = 28.44$   
 $1 \text{ div} = .1337'' \text{ } 2142''$

width line		Reputed. (V) / Measured H		Circ. meas.	
(7)	(8)	(9)	(10)	(11)	(12)
16.8	25.2	29.7	46.9	4 0.0	2' 2.5
16.8	25.7	29.7	7.3	0.3	2.6
16.9	26.3	29.0	8.2	0.0	2.4
17.0	26.7	30.3	8.0	0.0	2.6
17.2	27.2	29.3	7.0	-0.3	2.5
47	6.3	3.0	2.4	4' 0.0	40 2.52
16.94	26.26	29.60	47.48		
	16.94		29.60		
9.32 dis. = width line		17.88 dis. = 2.52, 1 dis. = .141''			

Rippland  $\frac{1}{2}''$  by  $\frac{1}{4}''$  measured both edges of two lines  
 two" apart.

(13) upper edge	lower edge	(15) upper edge	lower edge	(17) upper edge	lower edge
34.0	57.8	719.1	744.2	4' 18.3	3 56.8
33.0	58.7	20.0	44.8	18.1	56.7
33.2	59.5	19.2	46.3	18.8	56.8
32.7	58.5	19.0	46.7	18.2	57.0
32.0	58.4	20.5	47.7	18.5	56.9
14.9	29	28	29.7	19	42
329.8	58.58	719.58	745.94	18.38	3 56.84
	32.98	32.98	19.58		4 48.38
width lines	25.60	646.60	826.30	439.58	465.94
internal "		646.60	687.36	32.98	58.58
		406.60	497.36	406.60	407.36



Hence the width of the lines =  $\frac{25.60}{26.36} = 25.98$  div.

and the interval =  $\frac{406.60}{407.36} = 406.98$  div. =  $21.84$ "  
 $\frac{406.60}{407.36} = 406.98$  div =  $21.84$

1 div. =  $.0313$ " width of lines =  $.814$ " =  $0.000788$  lines.  
 $= .050025$

Probable error of setting from last line (13) - (18)

1.0	0.8	5	1.7	1	0
.0	.1	4	1.1	3	1
2	9	4	.4	4	0
3	1	6	8	2	2
1.0	2	9	1.8	1	1
25	21	28	5.8	1.1	.4

.50	.42	.56	.116	.22	.08
.55			.17		
div. .43	.36	.48	.99	.19	.07

P.E. in sec.  $\frac{.021}{.013}$   $\frac{.018}{.011}$   $\frac{.12}{.014}$   $\frac{.050}{.034}$

The (16) line a little out of focus - neglecting this, mean probable error of one reading =  $.013$ " or with this  $.017$ "

May 2d Evening Accuracy of setting a line

6.6	0	6.0	8	37.0	1	36.2	3
5.7	9	6.2	10	6.7	2	5.5	10
6.4	2	5.7	1	7.2	3	6.3	2
6.9	3	4.4	7	6.7	2	6.2	3
7.5	9	4.2	9	6.7	2	8.3	18
3.12	23	5.9	35	4.3	10	2.5	36
6.62 $\pm .040$		5.18 $\pm .063$		36.86	.017	36.50	.062
$\pm .012$		$\pm .020$		.005		.020	

$\pm .015$  = mean



Rules of pp 12-14 must be altered since 1 inch equals  
60 div instead of 100.

For  $\frac{1}{2}$  inch objective 13278 div. =  $28.44$  or (div. =  $.2142$ "

For  $\frac{1}{4}$  inch objective.

May 8th Center shot letting 12 plates.

May 10th 9-11 P.M. tried new slotted plates.

May 11th. 10.15 A.M. set two lines remained nearly  
in focus but moved radially.

May 15th Set 12 plates. twice second time after  
522 divisions. Set 2

May 17th A.M. 16th. 22h 20m. began setting microscopes  
with 1" objectives. Adjusted mics. and let in 1 hour.

Set 12 plates twice 1st 23.25 & 23.50 second time  
17.20 h. - 0.33 set half an hour. for readings  
of mic. I. for each point.

Another scummed & Series II which gave me but  
two <sup>few?</sup> many. Magnitudes of 10 div. of mic. not found  
after Ser. I. thus: - 1st = 60 div. A =  $63.28 - 46.72 = 16.56$   
1 div. =  $.277$

After second Series 5 stars = 300 div. =  $129.02 - 42.86 = 86.16$   
" "  $88.86 - 3.34 = 85.52$

1 div. =  $.2872$  and  $.2834$

1st reading of mic. A was 54.0 at end but to be set at 54.9  
letting at 54.1 at end of Ser. II it became 49.72 or should have  
been ~~49~~ 53.7. Prob. E. 1 read of mic. A = .46 and .28 = .1"

The results of Series I & II are as follows:—

Series	<sup>2</sup> II	<sup>3</sup> II-I	<sup>5</sup> Dev. from mean I II		<sup>6</sup> Dev.	<sup>7</sup> Result
I						
1.58	3.58	+2.00	+ .79	-.17	+ .31	+ .10
1.44	2.78	+1.34	+ .93	+ .63	+ .78	+1.50
59.68	0.66	+ .98	+2.69	+2.78	+2.72	+2.40
57.78	59.30	+1.52	+4.59	+4.11	+4.35	+29.0
0.88	1.42	+ .54	+1.49	+1.99	+1.74	+27.0
59.46	1.62	+1.16	+2.91	+1.79	+2.35	+2.10
1.24	1.90	+0.66	+1.13	+1.57	+1.33	+1.20
2.14	1.72	-.42	+ .23	+1.69	+ .96	.00
6.06	5.19	-.96	-3.69	-1.69	-2.69	-2.00
5.82	6.48	+ .66	-3.45	-3.07	-3.26	-3.30
6.32	7.46	+1.14	-3.95	-4.05	-4.00	-3.60
5.12	7.10	+1.98	-2.75	-3.69	-3.22	-2.90
3.28	5.78	+1.90	-.91	-1.77	-1.34	-1.30
						29.04

Each of Cols I & II are mean of 5 readings.

Cols 4 & 5 give deviations from mean of Cols 7 and 8.

Col 8 shows that the method of velocities reduces the errors deviations from 29.04 to 6.48 and increases the number of changes of sign from 1 to 7.



Al. - Retard

+21

-72

+32

+1.45

-96

+25

+12

+96

-69

+04

-40

-32

-04

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6.48





May 22d 1877 8 P.M. Let 12 shots 1st line  
much too low. Let by circle 53.7 alt.  
Set and repeated without touching plates.  
All agreed exactly but 9, +.6, 10, -.7 and  
10, ".2 alt.

Microscope H at full. 6.7 at end 6 59.7 = 413.0

$$\text{Set at } 41.1 = \frac{4130 - 6.7}{12} + 6.7 = 34.4 + 6.7$$

Round to 7 minutes. 41.1 H

changed to 39.74

$$\text{Error} = 1.16 \text{ dis.} = ".15$$

40.7

39.4

39.4

39.5

40.7

39.74

Let us V, VI, VII, VIII 212.2 Microscope at 41.0 1003 P.M.

4.48	21.62	17.14
2.24	22.70	20.46
59.34	25.00	25.66
59.76	24.36	24.60
1.30	25.42	24.12
1.04	23.74	22.70
2.04	22.84	20.80
3.72	22.14	18.42
6.70	18.78	12.08
5.34	17.88	12.52
7.68	18.68	11.00
7.04	20.66	13.62



Measured H 41.0

49.7

Changed to 50.20

49.3

50.8

50.2

50.0

50.20

Went round again without using H or plates.  
estimated and the left micrometer. Repeated.

Pl.	alt.	reading	alt. = +	10.2	A-41.0, B-41.0,
2	right	40.3	+ .9	34.7	- .7 - 6.3
3	right	39.2	+ .4	35.0	- 1.8 - 6.0
4	+ .4	34.0	+ .2	34.5	- 6.3 - 6.5
5	alt right	38.0	+ .6	36.2	- 3.0 - 4.8
6	right	42.5	- .3	43.0	+ 1.5 + 2.0
7	right	36.5	+ .3	36.0	+ 4.5 - 5.0
8	- .3 bal	37.2	0.0	39.7	- 3.8 - 1.3
9	+ .3 above	35.2	+ .9	33.4	- 5.8 - 7.6
10	+ .2 above	37.0	+ .1	40.4	- 4.0 - 0.6
11	right	39.9	+ .1	40.3	- 1.1 - 0.7
12	+ .1 above	39.7	- .2	42.7	- 1.3 + 1.7
1	- 1.1 below	45.8	- .9	46.2	+ 4.8 + 5.2
Set 7		Set 8	Set 9	Set 10	

Before taking readings this evening the attempt was made  
to fix the plates by helms but unfortunately since  
it fell off the coil base. Yellow compound was therefore  
used instead.



May 22d, 1877. <sup>20h+</sup> W.A.R. & J.H.C.  
 See Book A. 1, 1877. Barom. Therm. & under date of May 22d.  
 Determining num. lat plates and read fine miles

<del>7</del> E	<del>12</del> F	<del>13</del> G	<del>14</del> H	G-E	F-H
4.18	11.50	20.22	593.8	16.06	12.12
5970	12.32	19.50	58.60	19.80	13.72
55.50	12.52	21.16	55.34	25.66	17.18
53.56	10.68	18.36	53.44	24.80	17.24
54.46	11.58	19.42	57.46	24.96	20.12
54.62	13.56	16.54	47.72	21.92	25.84
56.64	11.86	15.62	46.50	18.98	25.36
55.68	13.24	12.90	46.58	17.22	26.66
57.74	10.06	8.26	46.02	18.52	24.04
55.92	7.32	5.58	46.94	9.66	20.38
56.22	3.74	5.80	47.46	9.58	16.38
54.76	<del>54.90</del> 0.60	<del>12.2</del> 6.48	50.60	11.72	10.00
11	12	13	14		

Thiers read 46.3. Went round table without using plates and extremely deviation then measuring it by micrometer. The other the first time is coming out was  $1 \ 46.3 - 20.0 = .863$  the second time  $1 \ 46.3 - 21.3 = .850$  or the correction  $-.1$  dis.  $46.3 - 7.1 = 39.2$

During these settings it was noticed that ~~the~~ way the lamp affected the reading of micrometer. It accordingly after this date the lamps were ~~not~~ placed on one side and two reflectors were used ~~close~~ <sup>near</sup> to the micrometer.

In the following two series <sup>15h 16</sup> the lamps were placed near the micrometer. As this is objectionable account of the heat.



<sup>15</sup> Ed.	<sup>16</sup> Ready.	<sup>17</sup> Ed.	<sup>18</sup> Ready.	<sup>263</sup> $\Delta 1$	$\Delta 2$
0.6	49.8	1.2	56.1	+3.5	+9.8
2.0	62.2	2.4	67.6	+15.9	+21.3
1.0	53.5	1.1	55.1	+7.2	+8.8
0.3	49.0	0.7	52.6	+2.7	+6.3
0.6	52.0	1.0	53.8	+5.7	+7.5
2.3	63.5	3.1	72.4	+18.2	+26.1
1.5	57.8	2.2	65.3	+11.5	+18.0
0.6	50.8	1.0	53.8	+4.5	+9.5
0.7	51.3	1.9	62.3	+5.0	+16.0
0.3	48.0	0.1	48.2	+1.7	+1.9
1.4	56.2	2.6	65.2	+9.9	+18.9

The above of little value the effect on  $\Delta$  large

<sup>15</sup> Ed.	<sup>16</sup> Ready.	<sup>17</sup> Ed.	<sup>18</sup> Ready.
+0.8	49.2	0	52.4
+2	49.8	+0	52.4
+2	49.2	+1	50.8
+0	52.2	+1	51.0
+2	49.3	+5	46.2
-9	58.2	-8	60.2
-4	55.9	-4	56.6
+3	47.2	+3	46.1
-7	59.2	-13	58.8
-1	55.1	+0	52.6
-3	53.5	-4	55.2
-3.2	73.2	-3.1	73.7
19	20	21	22

Going around



May 23<sup>d</sup> 1877. 8.45 H. dist. 12 plate distance mic. way.  
 Let by circle. F. changed. 4.2 to 43.7 H. 13.7 to 57.190  
 23 H. alt. 309.8 dist. - 13.7 = 305.0. Let at -13.7 +  $\frac{305.0}{12}$   
 24 = 13.7 + 25.4 = 39.1 Let at 39.1 at 9.02  
 25 Hand. 39.2 becomes. 57.0. Page 17, 18 at 9.12

G-I	23 E <sub>1</sub>	24 F <sub>1</sub>	25 18.6	E+G	$\frac{1}{2}E+G$ cor.	$\Sigma$	$\frac{1}{2}E+G+\Sigma$
15.90	+1	7.38	23.28	30.66	15.33 0	15.33 0	15.3
19.28	+1	6.42	25.70	32.12	16.06 2	15.86 +1	16.1
25.12	-1	4.06	29.18	33.24	16.62 4	16.22 0	16.5
23.86	-1	4.22	28.08	32.30	16.15 6	15.55 -1	15.8
23.30	-1	5.38	28.88	34.46	17.23 8	16.43 -2	16.8
21.64	-2	6.80	28.44	35.24	17.62 10	16.62 -4	16.9
19.72	-1	8.10	27.82	35.92	17.96 12	16.76 -5	17.2
17.76	-2	8.82	26.88	35.40	17.70 14	16.30 -7	16.6
10.62	-3	12.70	23.32	36.02	18.01 16	16.41 -10	16.9
10.36	0	11.84	22.20	33.04	16.52 18	15.72 -10	
10.40	0	13.10	23.50	36.60	18.30 20	16.30 -10	
12.70	-4	12.22	24.92	37.14	18.57 22	16.37 -14	

Milwaukee H becomes 39.1 to 57.50  
 change = 18.4 div. = 2.4

58.1  
 57.0  
 57.2  
 58.2  
 57.0  
 57.50



	Let. with <sup>20</sup> ready			F. and C.			
	<del>20</del>	Ext.	<del>20</del>	Rel.	$\Delta$	F"	
23							
26	2	+1	-1	-1	39.7	-0.6	-0.08
27	3	-1	-1	-1	40.8	-1.7	-0.22
	4	-1	+1	+1	37.8	+1.3	+0.17
	5	-1	-1	-1	39.8	-0.7	-0.09
	6	-2	+6	+6	36.2	+2.9	+0.38
	7	0	-1	-1	41.2	-2.1	-0.27
	8	-2	+3	+3	42.3	-3.2	-0.42
	9	-3	-2	-2	41.2	-2.1	-0.27
	10	0	-1	-1	40.0	-0.9	-0.12
	11	0	-1	-1	41.3	-2.2	-0.29
	12	-4	-7	-7	48.2	9.1	-1.18
	1	-3.1	+1	+1	61.0	last ready. H	61.0
	least ready			-3.1 a little			60.0
	out of focus.						59.9
							61.0
							61.2
							60.62

	1st	2d	3d
May Oct 1877, 8.15 H 1.3 5 2	3.7	52.7	26.8
	4.9	53.2	27.4
Let H at 1.3 + $\frac{124.48-1.3}{12} = 1.3 + 10.3 = 11.6$	4.7	52.6	27.4
	4.7	53.2	27.6
Next time H 11.6 5 52.88	4.4	52.7	27.8
Let at 11.6 + $\frac{52.88-11.6}{12} = 11.6 + 3.52 = 15.1$	4.48	52.88	27.40

3d time 15.1 5 27.40 after 12.3 comet 1.0 left H at 15.1

Ready of H. at each time at 15.1

Time	9.01 <sup>28</sup>	9.12 <sup>29</sup>	9.12 <sup>30</sup>	10.01 <sup>32</sup>	10.01 <sup>33</sup>	10.45 <sup>34</sup>	10.45 <sup>35</sup>
	Est.	Obs.	Est.	Obs.	Est.	Obs.	Obs.
-2	17.6	0	14.7	+1	13.1	+2	12.0
0	14.7	+1	12.7	+3	13.4	-1	18.0
+2	11.2	0	14.3	+2	13.4	0	14.8
+3	10.2	+5	10.3	+2	11.3	0	14.8
0	15.1	-2	17.2	+3	9.8	+2	13.6
.6	8.6	+2	11.7	+2	12.0	+1	14.0
0	14.2	0	13.2	+1	12.7	-1	16.1
+4	9.2	+3	8.3	+8	7.3	0	16.1
-1	15.6	0	14.7	-1	16.3	-3	18.3
0	15.4	-1	15.8	0	14.2	-2	19.7
+1	12.8	0	13.2	0	14.2	-4	19.2
-1.4	25.7	-1.7	28.40	-1.7	27.86	-1.8	29.92
? should be less 1.7		9.264	mean of five		mean of five		mean of five

July 10.45 ready next F. and G for next days after at  
11.27 took another set of readings of H



Reading of  $\frac{36}{E}$  at 10.55

$\frac{36}{E}$	$\frac{36}{G}$	$E+G$	at	$E+G$	cm.	$G-E$
14.94	31.12	46.06	0	46.06	23.03	16.18
13.32	32.56	45.88	31	45.57	22.78	19.24
10.10	<del>31.70</del> 37.70	47.80	62	47.18	23.59	27.60
10.64	35.94	46.58	93	45.65	22.82	25.30
11.96	36.22	48.21	124	46.97	23.48	24.26
12.28	35.64	47.92	155	46.37	23.18	23.36
13.60	35.20	48.80	186	46.94	23.47	21.60
15.00	33.74	48.74	217	46.57	23.28	18.74
18.42	29.90	48.32	248	45.84	22.92	11.48
18.18	30.14	48.32	277	45.55	22.77	11.96
20.20	30.64	50.84	310	47.74	23.87	10.44
17.96	31.42	49.38	341	45.97	22.98	13.46
16.66	33.16	49.82	372	46.10	23.05	16.50

Reading of  $H$  at 15.1 each time

$H$	$11.27$	$21.02$	$41$	$21.26$	$42.43$	$25.4$	$44$	$45$	signature
	$38$	$40$	$41$	$42$	$43$	$44$	$45$	$46$	
	Est.	Obs.	Est.	Obs.	Est.	Obs.	Est.	Obs.	
+1	14.9		+3.0	53.9	+2.2	59.0	+1.5	6.1	2
-2	17.7		-.8	18.9	-.2	18.7	-2.2	33.4	4
0	15.3		+1.3	3.0	+1.9	9.0	+0.9	6.2	4
-3	16.9		+1.4	5.6	+1.3	4.8	+0.5	13.2	2
+2	16.2		+2.0	2.1	+1.5	5.7	-0.3	17.6	5
-2	17.6		+.8	8.7	+1.0	10.5	-0.9	21.3	5
-6	19.8		+1.8	0.8	+1.7	4.1	+0.8	8.7	4
-1	14.9		+3.6	52.4	+3.7	52.7	+0.9	8.0	4
-2	17.1		+.3	11.2	+.4	9.8	+0.3	11.7	4
-3	18.2		+.5	8.1	+.7	7.7	-1.1	24.1	2-
1.0	19.8		+.2	17.2	+.1	15.7	-1.7	26.7	5
1.9	29.3		+.3	12.7	-.7	16.2	-1.0	19.1	2







with microscopes the variations in altitude as the telescope is revolved. Repeat turning the micrometer  $90^\circ$  so as to measure the horizontal motions. The difference in motion of the two ends should be proportional to the sine of the angle of the telescope. Reduce this motion to its minimum and the difference in the pairs of readings will then be the change in the axis.

3d. Repetition of the telescope. Attach crosses to the objective and eye end of the telescope equidistant from the axis, with microscopes by which their position may be determined. The best plan is to use the reticle and a small plate of glass cemented to the objective of these are equidistant. Establish two points exactly  $180^\circ$  apart on the wooden circle so that the axis of the telescope may be revolved by exactly this amount. Read the position of the telescope crosses twice  $180^\circ$  and read them again. Let  $a$

and  $b$  be the readings they will

$$\begin{array}{ccc} M & \begin{array}{c} b \\ c+f \end{array} & \begin{array}{c} a \\ +f \\ N \end{array} \end{array}$$

here if there was no flexure and  $a+f$  and  $b+f$  that actually observed the  $N' = a+f$ ,  $M' = b+f$ .

Turn the telescope  $180^\circ$  when

$M$  will read  $a-f$  and  $N$ ,  $b-f$

$$\begin{array}{ccc} M & \begin{array}{c} a+f \\ c \end{array} & \begin{array}{c} f+f \\ N \end{array} \end{array}$$

or  $M'' = -a+f$   $N'' = -b+f$  Hence  $c, d$  the readings if the the line connecting the cross hairs passed through the axis of the telescope. Then the readings of the microscopes  $M$  and  $N$  will be  $M' = d - b - f$  and  $N' = c - a - f$  here the telescope  $180^\circ$  and we shall have  $M'' = d + a - f$  and  $N'' = c + b - f$ :  $M' - M'' + N' - N'' = 2(f - f')$



June 5th 1877 D. 12.11 8.15h <sup>739.2</sup>  
 I Let 12 photos at 8.15 a at 39.0 h at 54.7  
 h beam 448.64 (area 75) F. from 0 to 30.08  
 II Let h at 14.2 a at 39.2 at 8.50h  
 h beam 1110.44 F. 1054  
 III Let h at 18.9 at 9.05 h beam 0.58  
 IV Let h at 18.9 a at 19.2 let h area and other

17.0 46 47

47.4 22.1 22.1

+2 17.0

+2 17.4

+8 15.7

-1.1 24.0

-7 21.7

0 18.7

-2 20.7

-1.0 26.9

-1.4 26.2

-0.2 22.4

+0.1 18.0

+27 0.9



48	49	50	51
F	G	a	h
1.28	20.48		
1.26	22.80	38.84	17.94
56.98	26.56	38.22	17.24
55.54	27.64	37.00	17.66
58.62		36.64	

gan ut avg & deficits in a

52	53	54			
h	F	G	F+G	$\frac{F+G}{2}$	G-F
58.90	1.84	19.76	21.60	10.80	17.92
16.40	59.72	23.62	23.34	11.67	23.90
17.26	57.80	26.76	24.56	12.28	28.96
-17.76	57.92	25.22	23.14	11.57	27.30
27.68	58.56	26.80	25.16	12.58	28.04
20.80	58.02	23.92	21.94	10.97	25.90
15.44	58.76	22.48	21.24	10.62	23.72
19.34	59.72	21.58	21.30	10.65	21.76
-21.92	29.2	18.18	21.10	10.55	15.26
25.38	20.6	16.88	18.94	9.47	14.82
25.50	30.4	17.24	20.28	10.14	14.20
18.78	1.14	17.48	18.62	9.31	16.34
58.80	59.26	19.76	19.02	9.51	20.50

finished at 10.24

$22.3 - (52)$	$\Sigma_{(52)}^{22.2}$	Corr - Sub.	# $(18.9)$ $(52)$	$\Sigma_{(52)}^{18.9}$	"	Corr ?
		.0				10.8
+ 5.80	5.80	.7	+ 2.5	+ 2.5	+ .3	11.4
+ 4.94	10.74	1.3	+ 1.6	+ 4.1	+ .5	11.8
+ 4.45	15.19	1.9	+ 1.1	+ 5.2	+ .6	11.0
- 5.68	9.70	1.2	- 8.8	- 3.6	- .5	13.1
+ 1.40	11.10	1.4	- 1.9	- 5.5	- .7	11.7
+ 6.76	17.86	2.2	+ 3.5	- 2.0	- .2	10.8
+ 2.86	20.72	2.6	- .4	- 2.4	- .3	10.9
+ .28	21.00	2.8	+ 3.0	- 5.4	- .8	11.2
- 3.18	17.82	2.2	- 6.5	- 11.9	- 1.5	11.0
- 3.30	14.52	1.8	- 6.6	- 18.5	- 2.3	12.4
+ 3.22	17.74	2.2	- .1	- 18.6	- 2.3	11.6



55	56	189.	$\Sigma(56)$
est	$R_{ij}$	56-18.9	
+0.2	17.7	-1.2	-1.2
+0.4	16.2	-2.7	-3.9
+1.1	14.2	-4.7	-8.6
-1.3	26.1	+7.2	-1.4
-0.2	19.0	+ .1	-1.3
0.0	19.2	+ .3	-1.0
+0.2	16.3	-2.6	-3.6
-0.1	19.7	+ .8	-2.4
-0.6	21.2	+2.3	-0.1
-0.2	22.7	+3.8	+3.7
-0.1	20.2	+1.3	+5.0
-2.5	0.66	-18.2	

*Correction of 36 and 37 by 34 and 35*

34 + 15		$\Sigma 34$	15.1 - (35)	$\Sigma (15.1 - 35)$	$\frac{\Sigma}{8}$	$\frac{I+6}{2}$	$\frac{I+6}{2} + 23.4$	$\frac{I+6}{2} + 23.5$
+ .05	+ .05	+ .2	+ 3.1	+ 3.1	+ .4	23.03	23.03	23.03
- .25	- .20	+ .1	- 2.9	+ .2	.0	22.94	23.1	23.1
- .15	- .35	+ .0	+ .3	+ .5	+ 1	23.90	24.9	23.9
- .15	- .50	+ .1	+ .3	+ .8	+ 1	23.29	23.4	23.4
+ .05	- .45	+ .3	+ 1.5	+ 2.3	+ .3	24.10	24.2	24.2
- .05	- .50	+ .4	+ 1.1	+ 3.4	+ .4	23.96	24.3	24.3
- .25	- .75	+ 3	- 1.0	+ 2.4	+ .3	24.40	24.8	24.8
- .15	- .90	+ 3	- 1.0	+ 1.4	+ 2	24.37	24.7	24.7
- .45	- 1.35	0	- 3.2	- 1.8	- .2	24.16	24.5	24.4
- .35	- 1.70	- 2	- 4.6	- 6.4	- .8	24.16	24.2	24.0
- .55	- 2.25	- 6	- 4.1	- 10.5	- 1.3	25.42	25.2	24.4
						24.69	24.1	23.4

<i>Corrected</i> 24.15	<i>Corrected</i> 24.25
.0	15.3
.0	16.1
-.1	16.6
-.3	16.0
-.4	16.9
-.7	17.2
-.8	17.3
-1.1	16.9
-1.4	16.9
-1.5	15.0
-1.5	16.8
-2.0	16.6

May 1, 1877



55	56	107	$\Sigma(\frac{100}{107})$
col	col	col-107	
+0.2	17.7	-1.2	-1.2
+0.4	16.2	-2.7	-3.9
+1.1	14.2	-4.7	-8.6
-1.3	26.1	+7.2	-1.4
-0.2	19.0	+1.1	-1.3
0.0	17.2	+1.3	-1.0
+0.2	16.3	-2.6	-3.6
-0.1	19.7	+1.8	-2.4
-0.6	21.2	+2.3	-0.1
-0.2	22.7	+3.8	+3.7
-0.1	20.2	+1.3	+5.0
-1.5	0.66	-18.2	

Comet 7 36-137 34-135

36-135	$\Sigma 34$	137-135	$\Sigma(137-135)$	$\frac{\Sigma}{4}$	$\frac{I+6}{4}$	$\frac{I+6}{4+10.25}$	$\frac{I+6}{4+10.25}$
+0.5	+0.5	+2	+3.1	+3.1	+1.4	23.03	23.03
-2.5	-2.0	+1	-2.9	+2	.0	22.94	23.8
-1.5	-3.5	+0	+3	+5	+1	23.90	24.9
-1.5	-5.0	+1	+3	+8	+1	23.29	23.4
+0.5	-4.5	+3	+1.5	+2.3	+3	24.10	24.2
-0.5	-5.0	+4	+1.1	+3.4	+4	23.96	24.3
-2.5	-7.5	+3	-1.0	+2.4	+3	24.40	24.8
-1.5	-9.0	+3	-1.0	+1.4	+2	24.37	24.7
-4.5	-13.5	0	-3.2	-1.8	-2	24.16	24.5
-3.5	-17.0	-2	-4.6	-6.4	-8	24.16	24.2
-5.5	-22.5	-6	-4.1	-10.5	-13	25.42	25.2
						24.9	24.1
							23.4

Comet 7 36-135	Comet 7 34-135
0	15.3
0	16.1
-1	16.6
-3	16.0
-4	16.9
-7	17.2
-8	17.3
-1.1	16.9
-1.4	16.9
-1.5	15.0
-1.5	16.8
-2.0	16.6

From both 1877 a at 21.1 to at 20.0 nearly by circle came  
 $h = 0.0$  allowed 20 days for pleasure of circle(?)  
 $h = 1$  20.0 became  $h = 10.26$  at  $h$  at  $-\frac{80-10.26}{12} + 20 = 14.2$ .  
 $h$  became 41.44  $P$  year 5.40

57	58
est	only
+ 2	12.3
0	13.1
0	14.2
0	14.8
-1.1	20.0
- .7	18.2
0	16.1
- .7	18.7
- .4	16.8
- .7	22.5
- .1	15.7
-3.7	41.38

Went around pretty fine middles nearly each 5 times  
 from 835 to 10.03 + most of it at rate of 1 set in 6 minutes.  
 J. A. M. at miles. E, F, G, H, W. A. R. at  $h$  and made  
 all heads. Results a Page 36, 37



67	<del>9.7</del> <sup>6.8</sup>
est.	15.7
+6	9.92
+1	15.7
-3	16.5
-1	16.0
-9	20.4
+6	9.3
+7	9.0
-9	20.9
0	13.7
-11	25.1
-2	16.5
-3.2	38.2

Feb.	after	after	1	F	F	G	H	$\frac{F+G}{2}$	$\frac{F+H}{2}$
h	h'	h	h'	61	62	63	64		
59	65	60	66	578	18.08	26.64	9.28	15.91	13.68
		41.38	39.06	0.42	17.70	25.33		12.82	
+2	+2	130.8	<del>11.88</del>	<del>17.70</del>	<del>25.33</del>	<del>6.80</del>	6.80	<del>15.64</del>	12.25
0	+1	1390	13.48	58.66	19.18	29.54	7.00	14.10	13.09
-7	-5	17.80	17.34	58.72	21.08	28.46	5.86	13.58	13.47
0	0	14.26	13.66	59.28	21.62	29.56	4.78	14.42	13.20
-6	-5	180.8	17.38	0.68	25.18	28.78	2.68	14.73	13.92
-6	-5	18.90	17.58	2.62	24.28	27.70	1.26	15.16	13.77
+7	+9	9.32	9.80	24.6	25.98	26.14	1.84	14.30	13.91
-7	-6	20.42	19.62	7.16	25.48	<del>23.28</del>	4.394	15.22	14.71
+2	+2	13.12	13.04	5.94	24.32	22.30	4.64	14.12	14.48
-14	-13	25.60	24.86	8.12	22.08	23.28	6.88	15.70	14.48
0	0	14.74	14.76	5.16	17.36	23.14	8.86	14.15	13.11
-30	-30	34.28	33.58	4.46	17.18	25.86	8.38	15.16	12.78

69	h <sup>7p</sup>	h <sup>142</sup>	Feb.	after	$\Sigma$	H		
ex.	div.	div.	h-h'					
h-h'	2.32	.29	27.14	+3.53	+3.24	9.28	6.80	7.00
0	1.20	.15	-1.12	-.14	-.29	5.86	4.78	2.68
-1	.42	.05	-.30	-.04	-.09	1.26	1.84	3.94
-2	.46	.06	3.60	+4.45	+3.9	4.64	6.88	8.86
0	.60	.07	.06	+4.01	-.06	21.04	20.30	22.48
-1	.70	.09	3.88	+4.51	+4.2	5.26	5.08	5.62
-1	1.32	.16	4.70	+6.1	+4.5			
-2	4.8	-.06	-4.88	-.63	+5.7			
-1	.80	.10	+6.22	+8.1	+7.1			
0	.08	.01	-1.08	-.13	-.14			
-1	.74	.09	+11.40	+1.48	+1.39			
0	-.02	-.00	+.54	+0.7	+0.7			
0	.70	.09	20.08	+2.61	+2.52			
$\Sigma$		.87		+3.94				
$\Sigma - 9$		.06		-.92				
0								



$\frac{F+G}{2} + \Sigma$	$\frac{F+H}{2} + \Sigma$					$G-I$	$F-H$
						27.46	8.80
12.82	12.25	12.82	12.25	12.82	12.25	24.80	10.90
13.81	12.80	14.39	13.38	14.37	13.38	30.88	12.18
13.20	13.09	13.57	13.56	13.96	13.85	29.74	15.22
14.43	13.21	14.47	13.25	14.41	13.19	30.28	16.84
14.68	13.88	14.36	13.56	14.78	13.98	28.10	22.50
15.53	13.14	14.34	11.95	14.79	12.40	25.08	23.02
15.12	14.73	14.05	13.66	13.48	13.09	23.68	24.14
15.47	14.96	14.26	13.75	14.27	14.46	16.12	21.54
15.08	15.44	13.30	13.66	13.16	13.52	16.36	19.68
16.52	15.30			14.88	13.66	15.16	15.20
16.36	15.32			11.94	10.90	17.98	8.50
17.44	15.06			12.88	10.50	21.40	8.80

$F$			$F$			$G$		
5.18	0.42	58.66	1808	17.70	19.18	26.64	25.22	29.54
58.72	59.28	0.68	21.08	21.62	25.18	28.46	29.56	28.78
262	2.46	7.16	24.28	25.98	25.48	27.70	26.14	23.28
5.94	8.12	5.16	24.32	22.08	17.36	22.30	23.28	23.14
12.46	10.28	11.66	87.76	87.38	87.20	105.10	104.20	104.74
3.12	2.57	2.92	21.94	21.84	21.80	26.28	26.05	26.18

5.18	1808	26.64	9.28
5.86	58.72	21.08	28.46
27.70	126	2.62	24.28
24.32	22.30	4.64	5.94
63.06	40.36	54.98	47.96
15.76	10.09	13.74	11.99
-5.67	-2.02	-3.77	



June 6th 1877 22h Fastened plates by rest over whole of rear surface. Gave up owing to the in steadiness of the plate. It moves too easily and does not remain in focus.

Measured magnitude of divisions of eyepiece.

Set by micrometer A, B & C: mean of 5

A = 5.86 B = 32.30 C = 58.98 AB = 26.44 BC = 26.48  
= 3".44

June 11th 1877 Attached new plate holder. Plates held by screw clamps and wood catches. Set two plates to see if they remained.

E = 57.12 S = 13.76 F = 51.68 G = 13.82

June 11th 23h 1877 Found telescope had moved at 19h about 1" probably owing to spring of clamp but interval of plates was unchanged by .1". Began setting plates back.

Then eyepiece scale introduced (~~to front~~) with a scale of 4" divided to .2"

June 16th 1877 Tried new plates. Covered by two strips of tin foil set at  $7 + 15 = 22.0$

Noted observation of number by computing  $S' - E' + G' - E'$ .

June 28th 1877 .7 35 set at from 22.0 to 37.0 again  
37 - 52

June 30th 1877 8.40 A. G. Clark present. 48.0 C. 63.0

3.0 C 2 37.4 moved from 3.0 C 3. + 12.9 = 15.9.

15.9 - 1 38.7 moved from 15.9 C 15.9 +  $\frac{82.8}{12} = 15.9 + 6.9 = 22.8$

Detected a corner of mirror in placey hand on table as laying tangent rod down. Slipping of telescope probably due to spring of clamp.



+ 3.5	+ 1.40	+ 1.68	+ 1.60
- 1.9	- .68	- 1.00	- .88
+ .2	+ .08	+ .08	+ .08
- .8	- .32 (?)	+ .40	+ .48
- .1	- .04	+ .04	? omitted
- .5	- .20	- .60	- .64
+ .5	+ .20	+ .12	+ .12
+ .3	+ .12	+ .08	0
+ .2	+ .08	0	0
.8	+ .32	+ .28	+ .8
2	+ .08	8	+ 24
5.4	+ 2.16	1.60	1.52

July 1st 1877. Fainter plates from last night out of focus  
but still visible, lines about 10" too low.

h from 25.0 to 2 45.2 at h at 37.0

h from 10 38.6 to 8 48.0 at at 10 29.3

Knockout of plate h about 1 day.

Unaccountable deviation decidedly other by 12 does not big  
circle out correctly.

































# Index to the various sets of adjustments of plates.

	Date.	Page.	Plate.		Orig.	Copy.
1	May 17th	16	E 5 times	alt plates.	2.114	6.16
2	" "	"	E 5 times <del>5-22</del>		"	"
3	" 17th	18	E 5 times	} alt plates not both miles.	117	18
4	" "	"	G " "		"	"
5	" 22d	19	E " "	} alt plates 10h not both miles.	121	19
6	" "	"	G " "		"	"
7	" "	20	H est.	} 7-10 with moving plates from 5, 6	122	20
8	" "	"	alt-1		"	"
9	" "	"	" alt-		123	"
10	" "	"	" alt-1		"	"
11	" " 20h+	21	E 5	}		21
12	" "	"	F 5			"
13	" "	"	G 5			"
14	" "	"	H 5			"
15	" "	22	H est.	} D. v. large found after due to moving lamp		22
16	" "	"	" 1			"
17	" "	"	" est			"
18	" "	"	" 1			"
19	" "	"	H est-	}		"
20	" "	"	" 1			"
21	" "	"	" est			"
22	" "	"	" 1			"
23	" 23d 9h	23	" est	}	2.126	23
24	" "	"	E		"	"
25	" "	"	G		"	"
26	" "	24	est-	}	128	24
27	" "	"	1		"	"

	d.	h	Page	Mic.	Sett.	Orig.	Copy	Remarks
28	24.	9.01	25	H	est	129	6.25	Reprint 28-45 &
29	"	"	"	"	1	"	"	determine proportion
30	"	9.12	"	"	est	"	"	minutes. 25
31	"	"	"	"	1		129	6.25
32	"	10.01	"	"	est		"	"
33	"	"	"	"	1		"	"
34	"	10.45	"	"	est		"	"
35	"	"	"	"	1		"	"
36	"	"	26	E	5		<del>129</del>	26
37	"	"	"	G	5		"	"
38	"	11.27	"	H	est		141	"
39	"	"	"	"	1		"	"
40	"	20.02	"	"	est		140	"
41	"	"	"	"	1		"	"
42	"	21.26	"	"	est		"	"
43	"	"	"	"	1		"	"
44	25	0.0	21	H	est		"	"
45	"	"	"	"	1		"	"
46	5	8	"	"	est		"	29
47	"	"	"	"	1		"	"
48	"	"	"	E?	5		"	30
49	"	"	"	G	5		"	"
50	"	"	"	a	1		"	"
51	"	"	"	h	1		"	"
52	"	"	"	h	5		"	"
53	"	"	"	E	5		"	"
54	"	"	"	G	5		"	"
55	"	"	"	h	est		"	32
56	"	"	"	h	1		"	"



57

58

59

60

1

2

3

4

5

6

7

8

9

70

1

2

3

4

5

6

7

8

9

80





# Equator Point Correction.

The following determinations of this quantity were made by the micrometer levels B and C.

June 8<sup>th</sup> 1877 Level B was placed on the stand for reading the level of the transit circle and pointed first to one collimator and then to the other. In first setting the wire was turned to 1520 and the bubble read. Then the telescope was pointed to collimator and wire read, then turned back to 1520 and bubble read. This was repeated five times. (P.)

	Level.	mean sum of level.	Collim.	level corr.	level corrected.	coll - lev.
N	1520	51.7	17010	+533	151.47	+18.63
N	1490	49.18	13034	+139	149.14	-18.80
S	1390	50.86	15956	-.309	139.31	+20.93

Half the difference or  $\frac{20.93 - 18.80}{2} = \frac{2.13}{2} = 1.065$   
equals the collimation error in dir. of wire read.

Half the sum =  $\frac{39.73}{2} = 19.865$  dir. equals equator point  
correction =  $278.1'' = 4' 38.1''$

June 8<sup>th</sup> 1877. 21h. Repeated.

Level.	Level.	Collim.	level corr.	level corrected.	Coll - lev.
1530	48.98	172.62	+192	153.194	19.43
1580	51.88	140.78	-.581	157.42	16.64
1560	51.26	139.20	-.416	155.58	16.38
1510	52.84	171.50	-.837	150.16	21.34

Collim error =  $\frac{2.79}{2} = 1.395$  and  $\frac{4.26}{2} = 2.13$

Eq. pt corr. =  $\frac{36.07}{2} = 18.035$  and  $\frac{37.72}{2} = 18.86$

$252.5'' = 4' 12.5''$

$264.0'' = 4' 24.0''$

These large deviations are not easily accounted  
for. The extreme unsteadiness of the blend <sup>by</sup> as  
meas explains them. as the second <sup>independent</sup> level  
reading is under the circumstances remarkably good.  
Besides the alternate level and when reading would  
eliminate their effect in a great measure in the final  
result.



July 31st. 1877. Equator Point correction by level C.  
 Removed objects of large altitudes and  
 placed level ~~to~~ on three pins. Found telescope <sup>of the station</sup> level, set and read ~~with~~. Owing to the high frame, it  
 is difficult to see the wire of the level, therefore all  
 observations were made through level telescope. At first  
 the telescope was brought to coincide and the micrometer  
 screw was left untouched, but it was found impossible to  
 get true alike. The differences would amount to two or  
 three seconds. Later the setting was made by the micrometer  
 screw and reduced. At first the level was read after  
 each setting but later only at beginning and end of each  
 set of five.

Dist.	Circ. rdg.	Level corr.	Sen 7C.	Surf refr "	Corr for level.		
S	5' 30".66	3.06				5 33".72	
N	4 57.00	4.29				4 46".71	23".50 2nd corr. 5' 20".41
"	54.37	(2.20)*	60.46	1.69	(3.87)*	4 50".50	
"	"	2.18	60.54	1.97	4.15	50".22	50".96 (50.71)
"	5 05.46	2.28	3.18	11.58	13.86	51".60	
"	"	2.22	3.22	11.72	13.94	51".52	26.94 (27.06)
S	5 20.79	2.00	3.14	11.43	13.43	5' 44.42	
"	"	1.86	3.14	11.43	13.29	44.28	44".83
"	5 12.72	2.00	5.63	20.49	22.49	45.21	5th corr. 5' 17".40
"	"	2.00	5.68	20.68	22.68	45.40	

\* When these observations were taken the reading of the level were  
 100.5, 95.5, 95.4, 95.5. Evidently the bubble had not come to rest. Rejecting  
 the first reading gives the numbers interlined. It will be noted that the  
 further difference. Retaining the observed level <sup>equator point correction 0".12</sup> reading would increase the final



The first two measurements give 23.50 probably is  
 also from the causes mentioned above. The last which  
~~was made~~ was according give 26.94 for the collimation of C  
 the eq. H. Com in the two cases are  $5' 20''.41$  and  $5' 17''.40$ .

Aug 3d. (R. 12, 35 obj. 37 white) 1877 E.C.P. etc. W.H. used micrometer.

Rise Circle $\frac{E+G}{2}$	Σ bands	Scr.	Scr. "cm. for band	Red. nearly certain	
S 5' 3".66	76.1	9.26	28.15	31.79	Prelim
	80.4	8.42	26.81	30.40	
3.58	79.3	8.32	26.00	29.58	
	78.5	8.48	26.27	29.85	
19.11	77.7	4.32	10.88	29.99	29.87
	77.3	4.32	10.64	29.75	
N 12.89	80.7	6.46	19.79	6.90	6.64
	80.3	6.36	19.27	6.38	
27.15	79.4	10.34	33.40	6.25	6.24
E	79.2	10.36	33.39	6.24	
S 23.51	83.8	2.22	5.60	29.11	29.10
	83.4	2.26	5.59	29.10	
37.5	82.8	7.66	25.00	28.75	28.73
	82.7	7.66	24.96	28.71	
N 30.20	84.4	10.60	36.34	6.14	6.26
C	84.4	10.66	36.56	6.36	
47.93	88.3	11.06	39.58	51.65	51.56
49.47	88.4	11.00	39.40	51.47	

Prelim A. isoch.



These readings give three concordant values of the eq. ht.  $\cos. 5' 18''.25, 17''.67, 17''.49$  and coll. of  $C = 11.11, 11.43$  and  $11.24$ . The last two angles give the angle of pitch  $A = 74' 44''.2$


Aug 7th 1877 (R 12.38) E.C.P. at U.H. used. milled.

Dist	Angle	$\frac{E+C}{2}$	$\Sigma$ level	Sec.	Series computed		
S	4'	54.76	85.6	12.38	43.30	5' 38.06	Prelim
			82.9	12.50	42.58	37.34	
	5	21.69	79.2	5.38	15.26	36.95	
N	5	9.13	78.7	5.20	14.41	36.10	36.52
			84.6	3.66	11.16	4 57.97	
			83.8	3.66	10.84	58.29	
S	5	30.10	83.8	9.52	32.17	57.93	57.89
			83.6	9.58	32.31	57.81	
	5	11.87	82.5	7.58	24.59	36.46	36.60
			82.1	7.70	24.87	36.74	

These readings give two concordant values of the eq. ht.  $\cos. 5' 17''.32$  and  $5' 17''.23$  and coll. of  $C = 19''.19$  and  $19''.36$ . A computation of the equation 2d. cos. from 51 Ceph. and give  $5' 18''.4$  and  $5' 17''.4$  for Aug. But these are values for four miles and above readings only for 6.45.

All these measurements except the first two of July 31st were made as follows:— The level  $C$  was released on one point and carefully levelled. After the 3d a



cross level was used, before this can we take  
 that the lines of the eyepiece coincided with those  
 of the large telescope. The eyepiece of the latter  
 was removed and a lantern allowed to shine  
 through the diaphragm. The lines i —   
 then represent the lines in C. It was  
 brought to direct the ~~two~~ intersection of  
 the inclined lines with the center line and the  
 two dots were always brought to opposite sides of  
 the left hand ~~the~~ vertical line. The telescope being  
 placed nearly in position. The level was read, and  
 five intersections made by the center in C, and the level  
 read again. <sup>through the eyepiece and</sup> Meanwhile Widoschus F. and G. each  
 made five times. This was repeated ~~at the~~ on the  
 other pier. ~~The~~ result give a single determination  
 of the equator point correction and of the collimator  
 and level of C. A second determination was made  
 by repeating the measurement first without moving the  
 telescope slightly to get an independent reading and  
 then moving C back to the first pier.



Aug 7th 1877. 83420. E. C. D. sets U. A. R. made mixed.  
 In second determination U. A. R. makes all setting and  
 E. C. D. makes heads. These measurements are made like  
 the above. In third set, latitude is brought to  
 coincide with line of C set at 10.0 and level  
 read before and after this setting. This has great  
 advantage that C is not touched and is within  
 makes introduced no error.

	Circle	Sec.	Sec.	Sec. comp. for level		
S	4	34.03	85.6	17.36	61.43	5' 35.46
			85.9	17.18	60.90	5' 34.93
N	8	12.66	90.0	52.30	197.65	4 55.01
			89.8	52.14	196.99	4 55.67
N		26.30	89.7	8.22	29.80	4 56.50
			89.8	8.24	29.91	4 56.39
S		56.94	84.8	10.72	36.94	4 33.88
			84.4	10.76	36.92	4 33.86

The last is evidently 5' not 4'. The first eye at Com.  
 are 5' 15" 26 and 5' 15" 16 the cells 19" 92 and 18" 71

	Circle	$\Sigma$ Sec.	Sec.	Sec. comp. for level		
S	5	0.01	82.15	36.4	33.28	5 33.29
		0.47	81.4	"	32.96	33.43
S		30.91	79.45	"	32.18	4 57.73
		30.46	79.25	"	32.10	58.36

This gives eye at Com. 5' 15" 70 and cell. 17" 66

Aug. 10th. 1877. (R 12.46 <sup>city</sup> orig. = Baran Island G. 1877)  
 W. A. R. Adams J. F. McC. reads miles.  
 Circ. = mea of E. F. G. H.

Circ.	Lev.	Sec	Sec. an			
7.39	89.15	36.4	36.32	5	31.07	30.87
6.61	88.85		35.94		30.67	
31.82	91.1		36.84	4	8.66	8.26
31.02	91.1		36.84		7.86	

This gives an equator point correct to  $4'' 39.56$  and  
 alt.  $41.30$ . Probably the <sup>whole</sup> minutes are wrong and  
 the value should be  $5' 19.56$ . The error in altitude  
 may be due to moving the screen as it was found the  
 next day at  $14 34.0$  instead of  $15 10.0$ . Using the  
 reading of E and <sup>and correcting the minutes</sup> gives  $5' 18.84$  and  $13.77$  a result  
 more in accord.











March 9

$\lambda$	min-	13.46	6.14	9.35	6.16	49.62	6.18	53.80
$\phi$	$\theta$	15.50		11.28		51.67		55.75
		17.63		13.36		53.78		58.04
		19.68		15.49		55.90		0.20
		21.80		17.60		57.90		2.80

26.04	21.60	2.00	6.36
28.23	23.70	4.50	8.44
30.27	25.70	6.00	10.60
32.55	27.97	8.00	12.55
34.60	29.90	10.30	14.80
36.78	32.00	12.30	16.90
38.70	34.20	14.45	18.97
40.88	36.20	16.50	21.10
43.00	38.35	18.40	23.25

47.00	42.60	22.50	27.30
49.40	44.68	24.60	29.50
51.36	46.70	26.70	31.70
53.55	48.75	28.80	33.80
55.60	50.95	30.95	35.95



6.21	17.60	6.25	46.30	6.28	29.78	6.34	35.40
	19.50		48.45		31.79		37.67
	21.69		50.46		33.90		39.60
	23.78		52.66		36.00		41.64
	25.90		54.61		38.10		43.76
	29.90		58.70		42.10		47.90
	32.03		0.85		44.40		50.05
	34.05		2.85		46.35		52.20
	36.00		4.95		48.47		54.28
	38.22		7.00		50.58		56.37
	40.40		9.10		52.65		58.45
	42.48		11.20		54.75		0.55
	44.50		13.20		56.90		2.57
	46.60		15.27		58.90		4.70
	50.60		19.50		2.27		8.95
	52.67		21.48		5.00		11.00
	54.77		23.68		7.10		13.16
	56.80		25.72		9.28		15.24
	58.90		27.73		11.48		17.30







# Summary of E. N. Carr.

June 8th

4 38.1

Line (B)

4 12.5

4 24.

July 31st.

5 20.41

23.50

Settling the end time

5 17.40

26.94

5 days Sec. Min. P. - G

Aug 3rd.

18.25

11.11

17.67

11.43

17.49

11.24

7th

17.32

19.19

.23

19.36

17.23

~~17.56~~

8th

15.26

19.92

15.16

18.71

15.70

17.66

10th.

4 39.56

41.30

5 18.64

13.77

W. A. R. and J. H. C. <sup>4 miles</sup>

" " " Elk G. only



I	G
13.2	32.6
12.7	32.9
12.8	32.9
12.8	32.3
12.6	32.8
41	
12.82	

Determination of the effect of a  
change in the brightness of the star on the second  
time of transit. See R. ~~Stars observed~~  
~~with end groups and center group alternately~~  
Aperture reduced by plate held in front of telescope.  
Stars observed with end and center groups  
alternately reduced.

March 9

6.9	13.46	6.14	9.35	6.16	49.62	6.18	53.80
	15.50		11.28		51.67		55.75
	17.63		13.36		53.78		58.04
	19.68		15.49		55.90		0.20
	21.80		17.60		57.90		2.30
	8807	17614	6708	13.416	2688 <sup>7</sup>	5377 <sup>4</sup>	29009
							58.018
	26.04		21.60		2.00		6.36
	28.23		23.70		4.00		8.44
	30.27		25.70		6.00		10.60
	32.55		27.97		8.00		12.55
	34.60		29.90		10.30		14.80
	36.78		32.00		12.30		16.90
	38.70		34.20		14.45		18.97
	40.88		36.20		16.50		21.10
	43.00		38.35		18.40		23.25
	31105	34561	26962	29.958	9195	10217	13297
							14.774
	47.00		42.60		22.50		27.30
	49.40		44.68		24.60		29.50
	51.36		46.70		26.70		31.70
	53.55		48.75		28.80		33.80
	55.60		50.95		30.95		35.95
	691	51882	23368	46736	13355	26710	15825
							31600
		34498		30.076		10.243 <sup>2</sup>	14834
		+063		-118		-028 <sup>5</sup>	-060
		off		on		off	on



6.21	17.50	6.25	46.30	6.28	29.78	6.34	35.40
	19.50		48.45		31.78		37.57
	21.68		50.46		33.90		39.60
	23.78		52.66		36.00		41.64
	25.90		54.61		38.10		43.76
10837	21674	25248	50.496	169 <sup>5</sup> 47	33.8 <sup>91</sup> 94	19793	39.594
29.90		58.70		42.10		47.90	
32.03		0.85		44.40		50.05	
34.05		2.85		46.35		52.20	
36.50		4.95		48.47		54.28	
38.22		7.00		50.58		56.37	
40.40		9.10		52.65		58.45	
42.48		11.20		54.75		0.55	
44.50		13.20		56.90		2.57	
46.60		15.27		58.90		4.70	
34418	38242	6312	7.013	45510	50.567	50707	56.341
50.60		19.50		2.97		8.95	
52.67		21.48		5.00		11.00	
54.77		23.68		7.10		13.16	
56.80		25.72		9.28		15.24	
58.90		27.73		11.48		17.30	
2374	54748	11811	23.622	3583	7.166	6565	13.130
	38211		7.059		50.5 <sup>30</sup> 4		56.362
	+ .031		- .046		+ .037 <sup>2</sup>		- .021
	<i>M</i>		<i>on</i>		<i>M</i>		<i>on</i>

March 10

Revised

6.25	46.38	6.27	0.40	6.28	29.70	6.34	35.27
	48.47		2.45		31.80		37.46
	50.50		4.50		33.90		39.65
	52.57		6.50		36.00		41.70
	54.50		8.65		38.05		43.85
242	50.484	22.50	4.500	1945	33890	19797	39.694
58.70		12.88		42.18		48.00	
0.70		15.00		44.28		50.05	
2.70		17.12		46.40		52.20	
4.85		19.23		48.47		54.30	
6.90		21.30		50.50		56.34	
8.95		23.50		52.59		58.37	
11.00		25.60		54.75		0.53	
13.10		27.75		56.78		2.59	
15.20		29.93		58.92		4.60	
6210	69.000	19231	21368	45487	50.541	50698	56.381
19.39		34.00		3.00		8.72	
21.42		36.30		5.00		10.97	
23.50		38.40		7.00		13.15	
25.47		40.60		9.20		15.20	
27.63		42.70		11.40		17.20	
11741	23.482	19200	38.400	3560	7120	6524	13.048
	6988 <sup>3</sup>		21.450		50.505		56.321
	- .088 <sup>3</sup>		- .082		+ .036		+ .010
	on				W		on



6.37	26.22	6.38	46.20	6.40	13.00	6.41	49.60	6.43	52.05
	28.33		48.35		15.00		51.73		54.20
	30.45		50.55		17.22		53.80		56.37
	32.60		52.60		19.28		56.05		58.43
	34.75		54.70		21.38		58.02		0.58
									28168
15235	30.470	25240	50.480	8588	17.176	26920	53.840	56326	
38.90		58.87		25.60		2.05		4.78	
41.00		1.00		27.65		3.95		7.00	
43.25		3.15		29.77		6.05		9.20	
45.38		5.30		31.80		8.18		11.20	
47.40		7.40		33.85		10.28		13.25	
49.55		9.56		36.00		12.22		15.49	
51.75		11.58		38.15		14.40		17.52	
53.85		13.71		40.17		16.58		19.70	
56.00		15.90		42.23		18.60		21.85	
								11999	
42708	47.453	6647	7.386	30522	33.913	9231	10.257	13.332	
0.13		20.02		46.34		22.70		26.05	
2.22		22.20		48.50		24.70		28.15	
4.30		24.30		50.60		26.85		30.20	
6.50		26.40		52.70		28.90		32.35	
8.60		28.58		54.70		30.96		34.47	
								15122	
2475	4.350	2150	24.300	284	50.568	13410	26.820	30.244	
	47.410		7.390		33.872		10.330	13.285	
	+0.043		-0.004		+0.041		-0.073	+0.047	
	<i>M</i>		<i>m</i>		<i>M</i>		<i>m</i>	<i>M</i>	

March 11

6.16	49.60	6.18	6.40	6.21	17.62	6.23	13.86
	51.73		8.50		19.70		15.45
	53.80		10.60		21.80		17.49
	56.00		12.60		23.85		19.66
	58.05		14.80		26.01		21.70
26918	53836	5290	10.580	10897	21.794	8766	17.532
2.10		19.00		30.07		28.85	
4.15		21.00		32.05		27.92	
6.23		23.20		34.05		30.00	
8.37		25.30		36.06		32.03	
10.40		27.58		38.28		34.22	
12.40		29.65		40.28		36.28	
14.50		31.70		42.36		38.47	
16.55		33.80		44.35		40.48	
18.68		35.90		46.52		42.58	
9338	10.376	24713	27.459	34402	38.224	30783	34203
22.78		39.96		50.60		46.65	
24.87		42.07		52.68		48.70	
26.90		44.17		54.80		50.80	
29.00		46.30		56.85		52.83	
31.00		48.40		58.93		55.00	
13455	26.910	22090	44.180	2386	54.772	398	50.796
034.90	10.373		27380		38.283		34.164
	+0.003		+0.079		-0.059	-	+0.039
	<i>ff</i>		<i>u</i>		<i>ff</i>		<i>u</i>
	<i>on</i>		<i>u</i>		<i>u</i>		<i>u</i>



*Agist.*

6.25	46.56	6.27	0.35	6.28	30.05	6.34	35.60
	48.60		2.50		32.05		37.70
	50.68		4.50		34.18		39.70
	52.68		6.68		36.20		41.92
	54.80		8.90		38.30		43.93
332	50664	2293	45.86a	2078	34.156	19885	39.770
58.90		13.12		42.50		48.27	
1.00		15.35		44.55		50.29	
3.00		17.47		46.55		52.45	
5.10		19.60		48.75		54.40	
7.20		21.75		50.72		56.50	
9.25		23.80		52.85		58.60	
11.30		25.90		54.90		0.70	
13.35		28.04		56.95		2.70	
15.48		30.20		59.00		4.96	
6458	2176	19523	21692	45677	50.752	50887	56541
19.60		34.30		3.16		9.00	
21.70		36.50		5.30		11.15	
23.77		38.65		7.39		13.20	
25.80		40.70		9.50		15.30	
27.86		42.90		11.57		17.40	
11883	23766	19305	38.610	3692	7.384	6605	13210
	7.215		21.598		50.770		56.480
	-.039		+0.094		-.018		+0.051
<i>ff</i>				<i>en</i>		<i>ff</i>	
<i>en</i>			<i>N</i>	<i>a</i>		<i>N</i>	

March 16

6.18	55.70	6.21	19.40	6.22	55.12	6.25	48.27
	58.00		21.44		57.18		50.33
	0.07		23.50		59.35		52.45
	1.97		25.60		1.40		54.50
	4.40		27.70		3.50		56.60
014	0.028	11764	23.528	29655	59310	26215	52.430
8.45		31.75		7.55		0.73	
10.50		33.85		9.70		2.70	
12.68		35.95		11.79		4.80	
14.80		37.90		13.85		6.90	
16.80		40.03		15.85		8.90	
18.90		42.20		17.88		11.00	
20.95		44.17		20.00		13.00	
22.97		46.26		22.05		15.25	
25.25		48.27		24.20		17.25	
15130	16.811	36038	40.042	14287	15.874	8053	8.948
29.35		52.30		28.05		21.38	
31.50		54.48		30.20		23.38	
33.59		56.45		32.18		25.55	
35.66		58.55		34.28		27.53	
37.70		0.68		36.39		29.74	
16780	33.560	28246	56.492	16110	32.220	2758	25.516
	16794		40.010		15.765		8.973
	+0.017		+0.032		+0.109		-0.025

or  
N

or  
N

or  
N

or  
N



6.28	31.70	6.34	37.20	6.37	28.25	6.48	7.49
	33.75		39.40		30.25		9.70
	36.97		41.56		32.46		11.90
	38.00		43.66		34.57		13.90
	40.05		45.80		36.82		16.18
17947	35.894	20752	41.504	16285	32.470	5917	11.834
44.16		49.90		40.96		20.20	
46.47		51.92		43.18		22.33	
48.35		54.07		45.25		24.37	
50.35		56.05		47.33		26.60	
52.55		58.20		49.58		28.70	
54.60		0.38		51.60		30.77	
56.70		2.45		53.62		32.95	
58.80		4.50		55.86		35.00	
0.90		6.68		57.87		37.20	
47288	52.542	52415	58.239	44525	49.472	25812	28.680
4.85		10.97		2.00		41.35	
7.00		12.80		4.30		43.58	
9.20		15.00		6.35		45.60	
11.30		17.00		8.45		47.80	
13.35		19.45		10.65		50.00	
4570	9.140	2522	15.044	3175	6.350	22833	45.666
	52.517		58.274		49.410		28.750
	+ .025		- .035		+ .062		- .070

*m*  
*M*

*off*  
*m*

*m*  
*M*

*M*  
*m*

March 18

6. 16	57.97	6. 18	56.17	6. 21	19.95	6. 22	55.50
	59.98		58.17		22.00		57.50
	56.20		0.35		24.03		59.75
	58.35		2.38		26.05		1.70
	60.50		4.47		28.04		3.80
281 00	56200	30154	0.308	12 007	24014	29825	59.650
4.35		8.67		32.24		8.24	
6.53		10.77		34.20		10.00	
8.50		12.89		36.33		12.02	
10.58		15.00		38.35		14.03	
12.57		17.00		40.45		16.30	
14.60		19.27		42.48		18.28	
16.70		21.38		44.50		20.37	
18.75		23.65		46.58		22.35	
20.80		25.68		48.65		24.38	
11338	12598	15431	17.146	36378	40420	14597	16.219
24.90		29.90		52.80		29.57	
27.25		31.95		54.88		30.67	
29.30		34.04		57.00		32.71	
31.28		36.06		59.00		34.70	
33.37		38.28		1.00		36.85	
14610	29220	17023	34046	28468	56936	16350	32700
	12.710		17.177		40.475		16.175
	-0.112		-0.031		-0.055		+0.044
	<i>H</i>		<i>H</i>		<i>H</i>		<i>H</i>
	<i>a</i>		<i>a</i>		<i>a</i>		<i>a</i>



6.25	48.62	6.27	2.40	6.28	32.00	6.34	37.70
	50.67		4.58		34.24		40.00
	52.79		6.75		36.26		42.00
	54.90		8.85		38.30		44.05
	57.00		11.00		40.45		46.20
26398	52796	3358	6.716	18125	36.250	995	41.990
1.00		15.33		44.68		50.30	
3.00		17.40		46.75		52.30	
5.18		19.50		48.75		54.45	
7.27		21.65		50.80		56.55	
9.38		23.78		52.80		58.60	
11.40		25.87		54.98		0.80	
13.55		28.05		57.00		2.83	
15.58		30.05		59.30		4.90	
17.70		32.35		1.40		7.00	
8406	9.340	21398	23.776	47646	52.938 <sup>40</sup>	52793	58.637
21.85		36.46		5.36		11.29	
24.05		38.60		7.38		13.30	
25.90		40.75		9.50		15.48	
27.50		42.85		11.67		17.47	
30.05		45.25		13.70		19.62	
12935	25.870	20391	40.782	4761	9.522	2716	15.432
	9.333		23749		52.886		58.711
	+0.007		+0.027		+0.057 <sup>4</sup>		-0.074
<i>Handwritten marks</i>							





## Summary of Mr. 74-83

Before means were corrected to red.

	Off	On
	+063	-118
Mar 9d	-26	-60
	+31	-46
	+37	-21
	<u>+105</u>	<u>245</u>
	+026	-061

Mar 10	<del>+82</del>	-88
	+36	
	+43	+16
	+41	-4
	+47	-73
	<u>17</u>	<u>-165</u>
	.044	<u>155</u>

Mar 11	+79	+73
	+39	-59
	+94	-39
	+57	-14
	<u>263</u>	<u>116</u>
	66	<u>113</u>
		28

16	+17	+32
	+109	-25
	+25	-35
	+62	-70
	<u>213</u>	<u>98</u>
	53	25

	Off	On
Mar 18	-31	-112
	+44	-55
	+27	+7
	-74	+52
	+76	59
	+71	108
	<u>-105</u>	<u>34</u>

	Off.	On	Off-On
9	+026	-061	+087
10	+044	-039	+083
11	+066	-028	+094
16	+053	-025	+078
18	-008	-027	+019
	+0187	-0180	+0361

## Corrected Summary.

Date 1879.	Full apertures in		Difference
	Group 183	Group 2	
March 9.	+024	-061	+085
10	+042	-039	+081
11	+066	-028	+094
16	+053	-024	+077
18	-008	-024	+016
Sum	+177	-176	+353
Means	+0354	-0352	+0706







June 3, 1879. Division of circle into two parts.





June 3, 1879. *Through down* R 12, 78, 79.

Calc.	C	E	F	G	H	
-0.2	52.1	0.10	57.75	2.80	3.80	
-0.0	<del>49.7</del> 55.8	59.85	56.70	2.80	4.25	
0.0	56.8	59.40	56.65	2.75	4.40	
0.0	57.2	59.70	57.30	2.50	3.60	
0.0	52.6	59.85	57.40	2.75	4.55	
-0.04	54.90	59.78	57.15	2.72	4.12	2.94

*Through down*

-0.4	48.5	2.10	5.40	3.20	57.85	
-0.4	49.9	1.85	5.30	3.30	58.00	
-0.4	51.2	1.90	5.75	3.05	57.70	
-0.4	49.7	1.85	5.30	2.35	58.20	
-0.4	49.6	1.60	5.30	3.10	58.20	
-0.40	49.78	1.86	5.29	3.00	57.99	1.14

$$+ .36 \quad + 5.12 \quad | \quad - 2.08 \quad - 8.12 \quad - .28 \quad + 6.13 \quad -$$

".88

".59

+ ".74

- 1.34 - 7.38

- 1.02 ~~+ 6.87~~  
+ 5.39

$$\Sigma + \Sigma' \quad 1.64 \quad 2.44 \quad 5.72 \quad 2.11$$

$$.82 \quad 1.22 \quad 2.86 \quad 1.06$$

$$+ .40 \quad + 2.04 \quad + .24$$

$$\Sigma + \Sigma' \quad 2.78 \quad 55.14 \quad 4.58 \quad 9.41$$

$$+ 1.39 \quad - 2.40 \quad + 2.29 \quad + 4.70$$

$$- 3.82 \quad + .90 \quad + 3.31$$



1879 June		Telescope up.		R 12.50 -		
E at.	b	E	H	G	H.	
-0.8	1 38.8	0 0 0.20	57.85	3.10	5.65	
-0.6	1 39.8	0.15	58.15	2.90	5.20	
-0.5	1.41.8	0.15	58.10	2.65	5.20	
-0.6	1 43.8	0.10	57.75	2.85	5.15	
-0.5	1 45.2	59.90	57.90	2.50	4.90	
-0.60	41.88	0.10	57.95	2.80	5.22	270

## Telescope down.

+0.2	1 60.8	0 0 0.75	5.05	2.15	57.55	
00	58.0	1.35	5.30	2.45	58.10	
00	58.8	1.15	5.45	2.35	58.15	
0.0	55.2	1.50	5.65	2.70	58.60	
00	56.3	1.55	5.45	2.30	58.10	
+0.04	57.82	1.26	5.38	2.39	58.10	1.13

$$\begin{array}{rcl}
 -0.64 - 15.94 & | & -1.16 - 7.43 + .41 + 7.12 \quad 1.57 \\
 1.36 \quad 1.83 & & 0.78 \\
 -1.70 & & -2.86 \\
 & & +2.11
 \end{array}$$

$$\begin{array}{rcl}
 1.36 & 3.33 & 5.19 & 3.34 \\
 .68 & 1.66 & 2.60 & 1.67 \\
 +.98 & +1.92 & +.99 & \\
 \hline
 2.49 & 56.05 & +4.06 & +10.60 \\
 1.24 & -2.98 & 2.03 & 5.30 \\
 -3.22 & +.79 & 4.06 &
 \end{array}$$

Telescope up.							R 12, 84-5,
Est.	l.	E	F	G	H		
0.0	5 42.2	0 0 0.65	58.45	2.75	6.70		
0.0	5 43.0	0.50	58.50	2.70	6.55		
+0.1	5 43.8	0.35	58.60	2.10	6.45		
+0.25	5 47.0	0.15	58.10	2.25	6.15		
0.0	5 43.3	0.30	58.65	2.50	6.30		
+0.07	43.86	0.39	58.46	2.46	6.43	2.07	

Telescope down							
+0.3	5 50.5	0 0 1.75	6.15	2.30	59.45		
+0.3	5 48.8	1.90	6.85	2.35	58.90		
+0.1	5 45.9	2.30	7.15	2.35	59.65		
+0.2	5 48.4	1.85	6.85	2.30	59.60		
+0.1	5 48.3	2.50	7.55	2.70	59.80		
+0.20	48.38	2.06	6.91	2.40	59.48	.34	

- .13	-4.52	-1.67	-7.45	+ .06	+6.95	1.73
"32	"52					0".86
- .42		-2.09				
		+ .36				

2.45	55.37	5.00	5.91
1.32	-2.32	2.50	29.6
-3.54	+1.28	+1.74	
3.79	57.94	4.52	13.34
+1.90	-1.03	+2.26	+6.67
-2.93	+3.86	4.77	5.27



1879, June 4. R 12, 82

$\epsilon$	$\zeta$	$\eta$	$\theta$	
22.87	2183	24.50	28.33	$\Sigma \epsilon = 82.80$
18.33	2493	25.93	23.77	$\Sigma \zeta = 93.10$
22.00	28.07	21.93	18.77	$\eta = 85.33$
19.60	18.27	12.97	19.70	$\theta = 90.57$
20.700	23.275	21.332	22.642	85.180
	+ 2.575	+ .632	+ 1.042	

1.63      -1.16  
 .07      +1.43  
 +1.70

	$0^\circ$	$90^\circ$	$180^\circ$	$270^\circ$	
$\eta$	22.87	21.83	24.50	28.33	86.84
	23.77	18.33	24.93	25.93	71.90
	21.93	18.77	22.00	28.07	91.13
	18.27	12.97	19.70	19.60	101.93
	86.84	71.90	91.13	101.93	351.80
	21.710	17.98	22.78	25.48	
		-3.73	+1.07	+3.77	3.2

R 12.83

E	F	G	H	
12.67	12.23	14.93	18.23	$\Sigma E$ 4850
10.23	17.20	17.40	15.40	F 6036
15.20	21.90	16.23	13.80	G 5116
10.40	9.03	2.60	9.73	H 5716
12.125	15.090	<del>12.79</del>	14.290	21718
		<del>12.79</del>		
		+ .67		
	+ 2.97	<del>- .83</del>	+ 2.17	

$$\begin{array}{r}
 + 2.26 \\
 + 1.03 \\
 \hline
 3.29 \quad 1.26 \\
 \hline
 4.55 + .63
 \end{array}$$

0°	90°	180°	270°	
12.67	12.23	14.93	18.23	53.33
15.40	10.23	17.20	17.40	38.86
16.23	13.80	15.20	21.90	57.06
<u>9.03</u>	<u>2.60</u>	<u>9.73</u>	<u>10.40</u>	<u>67.93</u>
53.33	38.86	57.06	67.93	21718
13.33	9.72	14.27	16.98	
	- 3.61	<del>9.6</del>	+ 3.65	
		+ .94		



June 5 R. 12.70

E	F	G	H	
3.97	5.50	4.87	8.97	$\Sigma E$ 60.61
16.20	25.90	25.00	23.82	F 83.87
19.27	27.97	22.27	19.07	G 68.21
21.17	24.50	16.07	22.20	H 74.06
15.152	20.967	17.052	18.015	
15.15	20.97	17.05	18.02	286.75

+ 5.82 + 1.90 + 2.87

+ .90  
 + 3.00  
 - 2.10  
 - 2.05

0°	90°	180°	270°	
3.97	5.50	4.87	8.97	74.56
23.82	16.20	25.90	25.00	56.84
22.27	19.07	19.27	27.97	72.24
24.50	16.07	22.20	21.17	83.41
74.56	56.84	72.24	83.41	<del>186.75</del>
18.64	14.21	18.06	<del>20.95</del>	286.75
			20.78	
	- 4.43	+ .58	+ 2.14	

R 12.90

$\mathcal{E}$	$\mathcal{F}$	$\mathcal{G}$	$\mathcal{H}$	
10.93	13.57	14.37	17.97	$\Sigma \mathcal{E} = 72.53$
12.70	22.67	21.70	20.93	$\mathcal{F} = 96.17$
22.90	31.70	25.40	23.07	$\mathcal{G} = 82.44$
26.00	28.23	20.97	28.20	$\mathcal{H} = 90.17$
18.132	24.042	20.610	22.542	341.31
		21		

+ 5.910 + 2.478 + 4.410

+ 3.44  
+ 2.50  
+ 94  
+ .47

$0^\circ$	$90^\circ$	$180^\circ$	$270^\circ$	$\Sigma \mathcal{E}$
10.93	13.57	14.37	17.97	$\mathcal{F} 70.31$
20.93	12.70	22.67	21.70	$\mathcal{G} 89.14$
25.40	23.07	22.90	31.70	$\mathcal{H} 97.37$
28.23	20.97	28.20	26.00	361.31
<del>5.49</del>	70.31	<del>81.4</del>	<del>97.37</del>	
23.87	17.58	<del>24.53</del>	24.34	
21.37		22.04		
	- 4.21 3.79	+ 0.67	+ 2.97	



$\lambda$	S	H				
+2.58	+63	+194	+584	+18	+65	
2.97	.67	2.17	+563	+16	+50	
5.82	1.90	2.87	+557	-10	+57	
5.91	2.48	4.41	+570	-07	+61	
.40	2.08 <sup>4</sup>	.24	+562	-13	+78	
98	1.92	.99	531	+50	1.04	
354	1.28	1.74	5.28	56	126	
90°	180°	270°				90+270
-373	+1.07	+377	-3.83	+30	+3.53	-30
-3.61	-.94	+3.65	4.06	50	3.48	-58
-4.43	+55	+2.14	3.84	71	3.33	-57
-4.21	+67	+2.97	3.60	90	3.76	+16
3.79			3.74	90	3.70	-.04
-3.82	+90	+3.31	3.66	88	3.25	-.41
-3.22	+79	+4.06	3.62	108	3.47	-.15
-2.93	+36	+4.77				

R12.98-9

E	F	G	H	
4.72	7.34	5.16	9.26	E 3252
7.98	18.00	15.08	12.30	F 5590 + 2338
10.14	19.24	10.88	6.46	G 3324 + .72
9.68	11.32	2.12	7.10	H 3512 + 2.60
3252	5590	3324	3512	15678
8.130	13.975	8.310	8.780	
				+ 5.84
+ .44				+ .18
+ .74				+ .65
- .30				
- .15				
0°	90°	180°	270°	
4.72	7.34	5.16	9.26	8922
12.30	7.98	18.00	15.08	2390 - 15.32
10.88	6.46	10.14	19.24	4040 + 1.18
1132	2.12	7.10	9.68	5326 + 1.43
3922	2390	4040	5326	156.78
9.805	5.975	10.100	13.315	
				- 3.83
				+ .30
				+ 3.58



RA 106-7

E	F	G	H	
480	670	554	906	E 3250
776	17.92	14.88	11.90	F 5502 + 22.52
10.20	19.10	10.88	6.34	G 3312 + .62
9.74	11.30	1.82	7.22	H 3452 + 2.02
3250	5502	3312	3452	155.16
8125	13.755	8.230	8.630	
				+ 5.63
+ .74				+ .16
+ .68				+ .50
+ .06				
+ .03				

0°	90°	180°	270°	
480	670	554	906	3888
11.90	776	17.92	14.88	2262 - 16.26
10.88	6.34	10.20	19.10	4088 + 2.00
11.30	1.82	7.22	9.74	5278 + 13.90
3888	22.62	4088	5278	155.16
9720	56.55	10.220	13.195	
				- 4.06
				+ .50
				+ 3.48

R12, 108.9

E	F	G	H	E	
320	524	422	734	2020	
-116	898	542	334	4248	2238
828	1672	796	440	9	1980 - 40
988	1154	220	740	H	2248 + 228
2136					
2020	4248	1980	2248		10496
5050	10620	4950	5620		

$$\begin{array}{r}
 +1.02 \\
 -32 \\
 \hline
 +1.34 \\
 +.67
 \end{array}$$

$$\begin{array}{r}
 +5.57 \\
 -10 \\
 \hline
 +.57
 \end{array}$$

0°	90°	180°	270°	
320	524	422	734	2604
334	-116	898	542	1068 - 1536
796	440	828	1672	2888 + 284
1154	220	740	988	3936 + 1232
2604	1184	2888	3936	10496
6510	1068	7220	9840	

$$\begin{array}{r}
 -3.84 \\
 +.71 \\
 \hline
 +3.33
 \end{array}$$



R 22, 4, 10 - 1

	E	F	G	H	
	3.00	5.34	4.18	7.30	E 1982
	- 1.24	8.96	5.66	3.50	F 4262 + 22.80
	7.96	16.96	7.14	3.94	G 1954 - .28
	10.10	11.36	2.56	7.52	H 2226 + 2.44
	21.06				
	1.24				
	1982	4262	1954	2226	10424
	4.955	10.655	4.885	5.565	
	+ 1.18				+ 5.70
	- .82				- .07
	+ .36	200			+ .61
	+ .18	1.00			

	0°	90°	180°	270°	
	3.00	5.34	4.18	7.30	2500
	3.50	- 1.24	8.96	5.66	10.60 - 14.40
	7.14	3.94	7.96	16.96	2862 + 3.62
	11.36	2.56	7.52	10.10	4002 + 15.02
	2500	11.84 1060	2862	4002	10424
	6.250	2.650	7.155	10.005	
					- 3.60
					+ .90
					+ 3.76

R 12.112.3

E	F	G	H	
3.12	5.10	4.20	7.66	E 1964
-1.42	8.82	5.40	3.50	F 4210 22.46
7.88	16.74	6.98	3.88	G 1912 - 52
10.06	11.44	2.54	7.74	H 2278 + 314
21.06				
19.64	4210	1912	2278	103.64
4.910	10525	4.780	5.695	

$$\begin{array}{r}
 +108 \\
 -90 \\
 \hline
 +18
 \end{array}$$

$$+09 \quad 99$$

$$+ 5.62$$

$$- .13$$

$$+ .78$$

0°	90°	180°	270°	
3.12	5.10	4.20	7.66	25024
3.50	-1.42	8.82	5.40	1010 -1494
6.98	3.88	7.88	16.74	2864 + 3.60
11.424	2.54	7.74	10.06	3986 + 14.82
25024	11.52	2864	3986	103.64
6.260	10.10	7.160	9.965	
	2.525			

$$- 3.74$$

$$+ 90$$

$$+ 3.70$$



R 114-5

	E	F	G	H	
	2.42	4.20	4.26	7.04	E 1234
	-0.04	+9.84	6.62	4.58	F 3360 + 212.6
	4.02	12.14	4.30	0.74	G 1434 + 200
	594	742	-0.84	4.12	H 1648 + 4.4
	1238	2376	1588		
	0.04	3360	64	1648	7676
	1234		1434		
	3.085	8.400	3.585	4.120	

$$\begin{array}{r}
 +1.84 \\
 - .28 \\
 \hline
 1.56 \\
 + .78 \\
 \hline
 \end{array}$$

+ 5.31

+ .50

+ 4.04

	0°	90°	180°	270°	
	2.42	4.20	4.26	7.04	1872
	4.58	-0.04	9.84	6.62	1406 - 4.66
	4.30	0.74	4.02	12.14	2224 + 3.52
	7.42	-0.84	4.12	594	3174 + 13.02
	1872	496	1240	3174	7676
	4.680	1.015	5.560	7.935	

- 3.66

+ .88

+ 3.25

R12, 116-7

E	F	G	H	
226	410	426	722	E 1174
000	980	684	480	F 3288 +2144
382	1208	396	040	G 1400 +226
566	690	-106	436	H 1678 +504
		1506		
1174	3288	1400	1678	7540
2935	8220	3500	4195	
				+ 528
				+ .56
				+ 1.26

$$\begin{array}{r}
 +200 \\
 - .14 \\
 \hline
 1.86 \\
 .93
 \end{array}$$

0°	90°	180°	270°	
226	410	426	722	1792
480	000	980	684	344 - 1448
396	040	382	1208	2224 + 432
690	-106	436	566	3180 + 1388
	480			
1792	344	2224	3180	7540
4480	0860	5560	7950	

$$\begin{array}{r}
 -362 \\
 +108 \\
 +3.47
 \end{array}$$



# Division of Circle into two parts $0^\circ - 180^\circ$

R 12

78-9	90	0.90
80-1	91	0.78
82-5	92	0.86
82	93	0.85
83	94	0.63
90	95	1.05
91	96	0.47
98-9	98	-0.15
106-7	99	+0.03
108-9	100	0.67
110-1	101	0.18 *
112-3	102	0.09 *
114-5	103	0.78
116-7	104	0.93

## Eccentricity of circle of Meridian circle-

	$F$	$FH$	$Fh$	$Fh$	$Hh$	$H$	$h$				$n$
$\epsilon = 45^\circ$	2.82	24.88	2.88	5.12	3.16	5.14	2.06	2.24	1.98	6.28	+2.093
" = $35^\circ$	3.24	5.24	4.92	7.06	5.16	6.94	2.00	2.14	1.88	6.02	+2.007
" = $25^\circ$	6.98	6.14	6.90	6.76	7.26	6.86	-0.84	-0.14	-0.40	13.8	-0.460
" = $15^\circ$	7.80	6.58	8.98	8.00	9.82	8.02	-1.22	-.98	-1.80	4.00	-1.333
" = $5^\circ$	7.82	6.88	8.30	7.18	8.18	6.88	-.94	-1.12	-1.30	336	-1.120
$355^\circ$	6.30	5.18	7.96	6.80	6.66	5.76	-1.12	-1.16	-0.90	318	-1.060
$345^\circ$	11.26	8.24	11.98	9.28	12.72	9.70	-3.02	-2.70	-3.02	874	-2.913
$335^\circ$	11.28	8.76	11.76	9.06	11.80	8.98	-2.52	-2.70	-2.82	804	-2.680
$325^\circ$	9.86	5.28	10.04	5.24	10.12	5.84	-4.58	-4.80	-4.28	1366	-4.553
$315^\circ$	10.80	4.84	11.58	5.40	12.10	6.16	-5.96	-6.18	-5.94	1808	-6.027
$305^\circ$	10.92	5.24	10.76	5.36	11.44	5.10	-5.68	-5.40	-6.34	1742	-5.807
$295^\circ$	7.54	3.88	8.16	4.12	8.80	4.16	-3.66	-4.04	-4.64	1234	-4.113
$285^\circ$	10.34	1.98	10.64	2.74	11.02	3.16	-8.36	-7.90	-7.86	2412	-8.040
$275^\circ$	8.50	0.56	8.96	0.52	9.94	1.36	-7.94	-8.44	-8.38	2496	-8.320
$265^\circ$	12.88	2.48	14.04	2.98	14.28	3.12	-10.40	-11.06	-11.16	3262	-10.873
$255^\circ$	13.24	0.22	18.04	5.24	12.76	0.62	-13.02	-12.80	-12.14	3796	-12.653
$245^\circ$	10.06	-1.90	11.18	-1.04	11.46	-0.54	-11.96	-12.22	-12.00	3618	-12.060
$235^\circ$	11.00	-0.02	11.74	0.54	12.38	1.00	-11.02	-11.28	-11.38	3368	-11.207
											+4.100
											-93.239
											-89.139



by Chauvenet's Method - v. Chauv. Astron. II. pp. 37-46

$z$	$\sin z$	$\cos z$	$m \sin z$	$n \cos z$
0	.00	1.00	+ .00	+ 2.09
10	.174	.985	+ .35	+ 1.98
20	.342	.940	- .16	- .43
30	.500	.866	- .67	- 1.15
40	.643	.766	- .72	- .86
50	.766	.643	- .81	- .68
60	.866	.500	- 2.52	- 1.46
70	.940	.342	- 2.52	- .92
80	.985	.174	- 4.48	- .79
90	1.00	.00	- 6.03	+ .00
100	.985	-.174	- 5.72	+ 1.01
110	.940	-.342	- 3.87	+ 1.41
120	.866	-.500	- 6.96	+ 4.02
130	.766	-.643	- 6.37	+ 5.35
140	.643	-.766	- 6.99	+ 8.33
150	.500	-.866	- 6.33	+ 10.96
160	.342	-.940	- 4.12	+ 11.34
170	.174	-.985	- 1.95	+ 11.06
			+ .35	+ 57.58
			- 60.22	- 6.29
			- 59.87	+ 51.26

	F	H	F	H	F	H						n
$\zeta = 225^\circ$	11.14	-1.24	12.55	-0.49	12.42	-0.24	-12.38	-13.04	-12.66	3808	-	12.693
215°	10.06	-3.32	11.68	-1.56	12.28	-0.56	-13.38	-13.24	-12.84	<sup>9</sup> 3846	-	<sup>13.153</sup> <del>12.820</del>
205°	13.30	+2.98	15.56	+3.99	15.56	+4.86	-10.32	-11.57	-10.70	3259	-	10.863
195°	7.28	-3.14	7.74	-2.24	8.02	-2.18	-10.42	-9.98	-10.20	3060	-	10.200
185°	7.74	-2.38	8.36	-2.22	8.24	-1.88	-10.12	-10.58	-10.12	3082	-	10.273
175°	6.32	-3.86	6.96	-3.06	6.30	-3.70	-10.18	-10.02	-10.00	3020	-	10.067
165°	5.14	-3.60	5.30	-3.96	5.00	-3.62	-8.74	-9.26	-8.62	2662	-	8.873
155°	5.70	-2.54	4.42	-4.02	5.26	-3.04	-8.24	-8.44	-8.30	2498	-	8.327
145°	4.98	-1.72	5.04	-1.54	5.63	-2.09	-6.70	-6.58	-7.72	2100	-	7.000
135°	5.30	+1.78	5.98	+1.44	5.80	+2.04	-3.52	-4.54	-3.76	1182	-	3.940
125°	3.08	-0.78	3.34	+0.20	3.15	-0.59	-3.86	-3.14	-3.74	1074	-	3.580
115°	2.78	-1.96	3.74	-1.00	4.20	-0.78	-4.74	-4.74	-4.98	1446	-	4.820
105°	2.06	+1.70	3.43	+2.65	3.23	+3.07	-0.36	-0.78	-0.16	130	-	0.483
95°	2.14	1.18	2.36	1.16	3.24	2.16	-0.96	-1.20	-1.08	324	-	1.0800
85°	3.62	5.30	3.52	5.50	4.24	5.86	+1.68	+1.98	+1.62	528	-	1.760
75°	4.08	7.04	4.66	8.10	0.74	4.20	+2.96	+3.44	+3.46	986	-	3.287
65°	2.21	5.57	3.04	5.10	3.44	5.68	3.36	2.06	2.24	766	-	2.553
55°	5.29	6.20	6.98	8.38	6.08	6.50	0.91	1.40	0.42	273	-	0.910
45°	3.60	4.94	4.48	5.46	3.84	5.30	1.34	0.98	1.46	378	-	1.260

+ 8.510

- 105.300

- 96.790

- 89.130

36) - 185.93

= - 5.160



term. II, 46.

$$3.11 \log = 2.09030$$

$$2.65 = 0.42325w$$

$$\log \sin \delta = 9.99990$$

$$\tan P = 1.66705w$$

$$P = 178^\circ 46'$$

$$36e = 2.09040$$

$$36 = 1.55630$$

$$e = 0.53410$$

$$e = 3.42$$

lts.

$$-5.165$$

requires the cor-  
centricity of

$$(z + 178^\circ 46')$$

reckoned from zenith  
south.



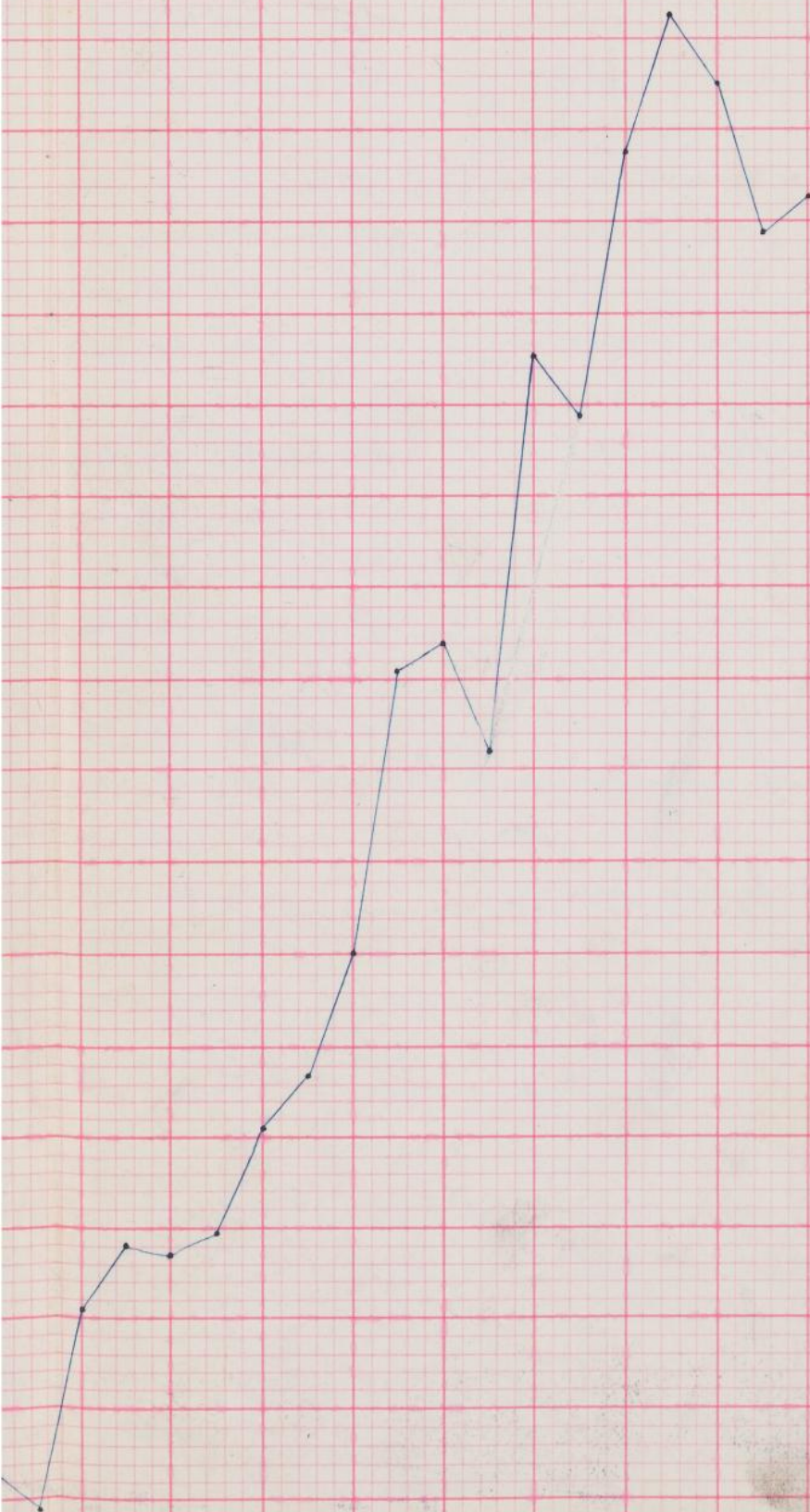
$\zeta$	$H$	$H_0$
$\zeta = 225^\circ$	11.14	-1.24
$215^\circ$	10.06	-3.32
$205^\circ$	13.30	+2.98
$195^\circ$	7.28	-3.14
$185^\circ$	7.74	-2.38
$175^\circ$	6.32	-3.86
$165^\circ$	5.14	-3.60
$155^\circ$	5.70	-2.54
$145^\circ$	4.98	-1.72
$135^\circ$	5.30	+1.78
$125^\circ$	3.08	-0.78
$115^\circ$	2.78	-1.96
$105^\circ$	2.06	+1.70
$95^\circ$	2.14	1.18
$85^\circ$	3.62	5.30
$75^\circ$	4.08	7.04
$65^\circ$	2.21	5.57
$55^\circ$	5.29	6.20
$45^\circ$	3.60	4.94





of  $n$ .

215 205 195 185 175 165 155 145 135 125 115 105 95 85 75 65 55 45°



from II, 46.

$$3.11 \log 2.09030$$

$$2.65 = 0.42325n$$

$$\log \sin \theta = 9.99990$$

$$\tan P = 1.66705n$$

$$P = 178^\circ 46'$$

$$36e = 2.09040$$

$$36 = 1.55630$$

$$e = 0.53410$$

$$e = 3.42$$

lts.

$$= -5.165$$

requires the cor-  
centricity of  
( $z + 178^\circ 46'$ )

reckoned from zenith  
south.

	$\mathcal{H}$	$\mathcal{H}$
$\zeta = 225^\circ$	11.14	-1.24
215°	10.06	-3.32
205°	13.30	+2.98
195°	7.28	-3.14
185°	7.74	-2.38
175°	6.32	-3.86
165°	5.14	-3.60
155°	5.70	-2.54
145°	4.98	-1.72
135°	5.30	+1.78
125°	3.08	-0.78
115°	2.78	-1.96
105°	2.06	+1.70
95°	2.14	1.18
85°	3.62	5.30
75°	4.08	7.04
65°	2.21	5.57
55°	5.29	6.20
45°	3.60	4.94

$z$
180
190
200
210
220
230
240
250
260
270
280
290
300
310
320
330
340
350



For nomenclature v. Chauv. Astron. II, 46.

$z$	$\sin z$	$\cos z$	$n \sin z$	$n \cos z$
180	.00	-1.000	+ .00	+ 12.69
190	-.174	.985	+ 2.29	+ 12.95
200	.342	.940	+ 3.71	+ 10.21
210	.500	.866	+ 5.10	+ 8.83
220	.643	.766	+ 6.60	+ 7.87
230	.766	.643	+ 7.71	+ 6.47
240	.866	.500	+ 7.68	+ 4.44
250	.940	.342	+ 7.83	+ 2.85
260	.985	-.174	+ 6.90	+ 1.22
270	1.000	.000	+ 3.94	- .00
280	.985	+.174	+ 3.53	- .62
290	.940	.342	+ 4.53	- 1.65
300	.866	.500	+ .37	- .22
310	.766	.643	+ .83	- .69
320	.643	.766	- 1.13	+ 1.35
330	.500	.866	- 1.64	+ 2.85
340	.342	.940	- .87	+ 2.40
350	-.174	+.985	- .16	+ .90
			+ 51.02	+ 75.03
			- 3.80	- 3.18
			+ 57.22	+ 71.85
			- 59.87	+ 51.26
			- 2.65	+ 123.11

$$36 \sin P = +123.11 \quad \log = 2.09030$$

$$36 \cos P = -2.65 \quad = 0.42325 n$$

$$\log \sin P = 9.99990$$

$$\tan P = 1.66705 n$$

$$P = 178^\circ 46'$$

$$36 e = 2.09040$$

$$36 = 1.55630$$

$$e = 0.53410$$

$$e = 3.42$$

Results.

$$\alpha = -5''.165$$

Microscope  $F$  requires the correction for eccentricity of

$$+ 3.42 \sin(z + 178^\circ 46')$$

where  $z$  is reckoned from zenith towards the south.

# Ellipticity of Pivot —

$Z$	$\sin 2z$	$\cos 2z$	$\sin 4z$	$\cos 4z$	$B-A$	$B'-A'$	$n'$
0	+ .000	+ 1.000	+ .000	+ 1.000	+ 2.093	- 12.693	- 5.300
10	.342	.940	.643	.766	+ 2.007	- 13.153	- 5.573
20	.643	.766	.985	+ .174	- 0.460	- 10.863	- 5.662
30	.866	.500	.866	- .500	- 1.333	- 10.200	- 5.766
40	.985	+ .174	+ .342	.940	- 1.120	- 10.273	- 5.696
50	.985	- .174	- .342	.940	- 1.060	- 10.067	- 5.564
60	.866	.500	.866	- .500	- 2.913	- 8.873	- 5.893
70	.643	.766	.985	+ .174	- 2.680	- 8.327	- 5.504
80	+ .342	.940	- .643	.766	- 4.553	- 7.000	- 5.776
90	- .000	1.000	+ .000	1.000	- 6.027	- 3.940	- 4.984
100	.342	.940	.643	.766	- 5.807	- 3.580	- 4.694
110	.643	.766	.985	+ .174	- 4.113	- 4.820	- 4.466
120	.866	.500	.866	- .500	- 8.040	- 0.433	- 4.236
130	.985	- .174	+ .342	.940	- 8.320	- 1.080	- 4.700
140	.985	+ .174	- .342	.940	- 10.873	+ 1.760	- 4.556
150	.866	.500	.866	- .500	- 12.653	+ 3.287	- 4.683
160	.643	.766	.985	+ .174	- 12.060	+ 2.583	- 4.754
170	- .342	+ .940	- .643	+ .766	- 11.227	+ 0.910	- 5.158

18) - 92.965

$\alpha - 5.165$

as before



By Chauvenet's Method - v. Chauv. Astron. II pp. 47-51

$n \sin 2z$	$n \cos 2z$	$n \sin 4z$	$n \cos 4z$		
.000	- 5.300	- .000	- 5.300	$18f'' \sin F'' - 1.056$	$\log = 0.02366n$
- 1.906	- 5.239	- 3.583	- 4.269		$\log \sin 9.99361$
- 3.641	- 4.337	- 5.577	- 0.985	$18f'' \cos F'' - 6.110$	$\log = 0.78604n$
- 4.993	- 2.883	- 4.993	+ 2.883		$\log \tan F'' 9.23762$
- 5.611	- 0.991	- 1.948	+ 5.3 <sup>54</sup> <del>47</del>		$F'' 189^\circ 48'$
- 5.481	+ 0.968	+ 1.903	+ 5.230	" $18f''$	0.79243
- 5.103	+ 2.946	+ 5.103	+ 2.946	" 18	1.25527
- 3.539	+ 4.223	+ 5.421	- 0.964	" $f''$	9.53716
- 1.975	+ 5.429	+ 3.714	- 4.425	$f''$	0".34
+ .000	+ 4.984	- .000	- 4.984		
+ 1.605	+ 4.412	- 3.018	- 3.595		
+ 2.872	+ 3.421	- 4.399	- 0.777	$18f''' \sin F''' - 0.503$	$\log = 9.70157n$
+ 3.668	+ 2.118	- 3.668	+ 2.118		$\log \sin 9.94734$
+ 4.630	+ 0.818	- 1.607	+ 4.418	$18f''' \cos F''' + 0.960$	$\log = 9.98227$
+ 4.458	- 0.793	+ 1.558	+ 4.283		$\log \tan F''' 9.71930n$
+ 4.055	- 2.342	+ 4.055	+ 2.342		$F''' 332^\circ 21'$
+ 3.057	- 3.641	+ 4.682	- 0.827	" $18f'''$	0.03493
+ 1.764	- 4.849	+ 3.317	- 3.951	" 18	1.25527
+ 26.139	+ 29.319	+ 29.753	+ 29.574	" $f'''$	8.77966
- 32.249	- 30.375	- 28.793	- 30.077	$f'''$	0".06
- 6.110	- 1.056	+ 0.960	- 0.503		

$$f(z) + f(180^\circ + z) = +0".68 \sin(2z + 189^\circ 48') + 0".06 \sin(4z + 332^\circ 21')$$

$$n' = -5''.165 + 0''.68 \sin(22 + 189^\circ 48')$$

Z	$22 + 189^\circ 48'$	$\sin(22 + 189^\circ 48')$	$.68X -$	C	0	$0 - C = v$	$vv$
0	189 48	-.170	-.116	-5.281	-5.300	-.02	.0004
10	209 48	-.497	-.338	5.503	5.573	-.07	.0049
20	229 48	-.764	-.520	5.685	5.662	+.02	.0004
30	249 48	-.938	-.637	5.802	5.766	+.04	.0016
40	269 48	-1.000	-.680	5.845	5.696	+.15	.0225
50	289 48	-.941	-.640	5.805	5.564	+.24	.0576
60	309 48	-.768	-.522	5.687	5.893	-.21	.0441
70	329 48	-.503	-.342	5.507	5.504	.00	.0000
80	349 48	-.177	-.120	5.285	5.776	-.49	.2401
90	9 48	+.170	+.116	5.049	4.984	+.06	.0036
100	29 48	+.497	+.338	4.827	4.694	+.13	.0169
110	49 48	+.764	+.520	4.645	4.466	+.18	.0324
120	69 48	+.938	+.637	4.528	4.236	+.29	.0841
130	89 48	+1.000	+.680	4.485	4.700	-.22	.0484
140	109 48	+.941	+.640	4.525	4.556	-.03	.0009
150	129 48	+.768	+.522	4.643	4.683	-.04	.0016
160	149 48	+.503	+.342	4.823	4.754	+.07	.0049
170	169 48	+.177	+.120	-5.045	-5.158	-.11	.0121
						+.118	.5765

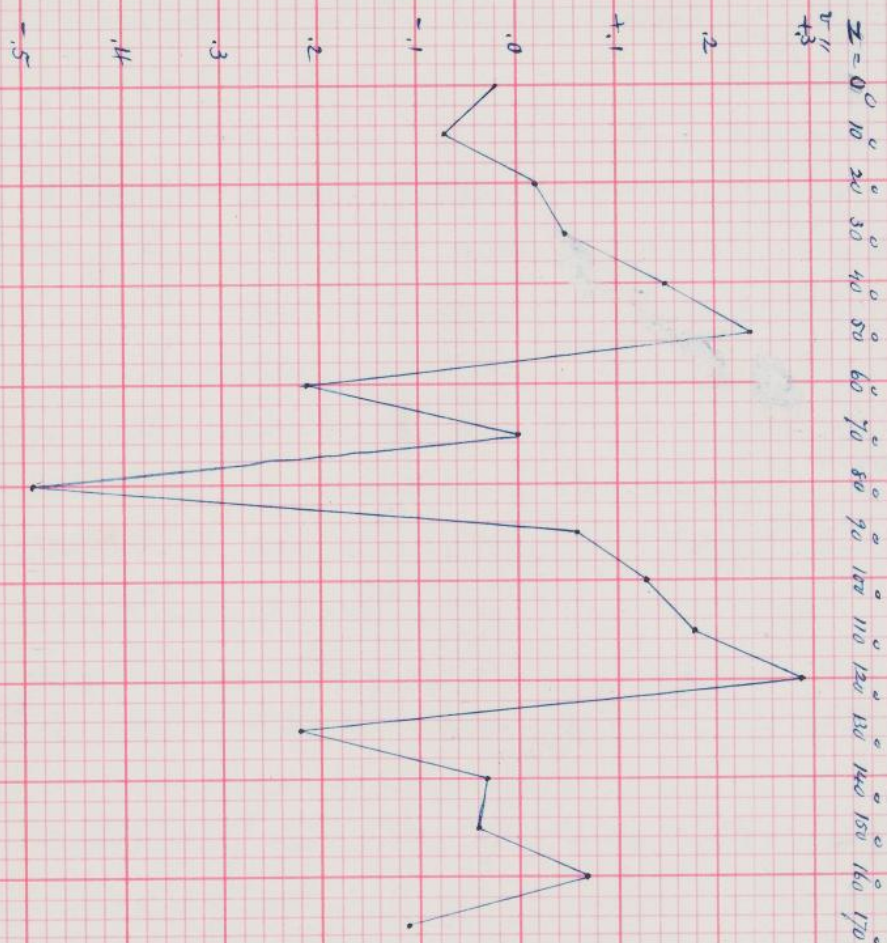
$$e = \sqrt{\frac{.5765}{17}} = 0''.18$$

-1.19

-.01



Errors in position of microscopes and of certain lines  
mild.



Residual curve

is at three points  
of microscopes  
of telescope at

$$+ e + b$$

$$+ f + b$$

$$+ g + b$$

$$+ h + b$$

$$+ e + d$$

$$+ f + d$$

$$+ g + d$$

$$+ h + d$$

$$[a + b + c + d]$$

"

"

"

(e-h) whence

$$[a + b + c + d]$$

"

"

"

(225°) 4(135°) whence

$$v' = -5''.165 + 0''.68 \sin(2z + 189^\circ 48')$$

z	$2z + 189^\circ 48'$	si
0	189 48	-
10	209 48	-
20	229 48	-
30	249 48	-
40	269 48	-
50	289 48	-
60	309 48	-
70	329 48	-
80	349 48	-
90	9 48	-
100	29 48	-
110	49 48	-
120	69 48	-
130	89 48	-
140	109 48	-
150	129 48	-
160	149 48	-
170	169 48	-



Errors in position of microscopes and of certain lines in the circle obtained by the following formulae.

Let  $45^\circ, 315^\circ$  &c denote errors of the lines at three points

$e, f, g, h$  " " in positions of microscopes.

$a, b, c, d$  " " in setting of telescope at

different times, then —

$$\mathcal{E} = 45^\circ \quad \mathcal{E} = 45^\circ + e + a \quad \mathcal{E} = 315^\circ \quad \mathcal{E}' = 315^\circ + e + b$$

$$\mathcal{F} = 315^\circ + f + a \quad \mathcal{F}' = 225^\circ + f + b$$

$$\mathcal{G} = 225^\circ + g + a \quad \mathcal{G}' = 135^\circ + g + b$$

$$\mathcal{H} = 135^\circ + h + a \quad \mathcal{H}' = 45^\circ + h + b$$

$$\mathcal{E} = 225^\circ \quad \mathcal{E}'' = 225^\circ + e + c \quad \mathcal{E} = 135^\circ \quad \mathcal{E}''' = 135^\circ + e + d$$

$$\mathcal{F}'' = 135^\circ + f + c \quad \mathcal{F}''' = 45^\circ + f + d$$

$$\mathcal{G}'' = 45^\circ + g + c \quad \mathcal{G}''' = 315^\circ + g + d$$

$$\mathcal{H}'' = 315^\circ + h + c \quad \mathcal{H}''' = 225^\circ + h + d$$

$$(1) \text{ Then } \mathcal{E} + \mathcal{E}' + \mathcal{E}'' + \mathcal{E}''' = [45^\circ + 315^\circ + 225^\circ + 135^\circ] + 4e + [a + b + c + d]$$

$$(2) \quad \mathcal{F} + \mathcal{F}' + \mathcal{F}'' + \mathcal{F}''' = \quad \quad \quad + 4f + \quad \quad \quad "$$

$$(3) \quad \mathcal{G} + \mathcal{G}' + \mathcal{G}'' + \mathcal{G}''' = \quad \quad \quad + 4g + \quad \quad \quad "$$

$$(4) \quad \mathcal{H} + \mathcal{H}' + \mathcal{H}'' + \mathcal{H}''' = \quad \quad \quad + 4h + \quad \quad \quad "$$

(1)-(2), (1)-(3), (1)-(4) will give  $4(e-f)$ ,  $4(e-g)$ ,  $4(e-h)$  whence can be obtained  $e-f$ ,  $e-g$ ,  $e-h$ .

$$(5) \text{ Again } \mathcal{E} + \mathcal{H}' + \mathcal{G}'' + \mathcal{F}''' = 4(45^\circ) + [e + h + g + f] + [a + b + c + d]$$

$$(6) \quad \mathcal{E}' + \mathcal{H}'' + \mathcal{G}''' + \mathcal{F} = 4(315^\circ) + \quad \quad \quad + \quad \quad \quad "$$

$$(7) \quad \mathcal{E}'' + \mathcal{H}''' + \mathcal{E} + \mathcal{F}' = 4(225^\circ) + \quad \quad \quad + \quad \quad \quad "$$

$$(8) \quad \mathcal{E}''' + \mathcal{H} + \mathcal{G}' + \mathcal{F}'' = 4(135^\circ) + \quad \quad \quad + \quad \quad \quad "$$

(5)-(6), (5)-(7), (5)-(8) will give  $4(45^\circ)$ ,  $4(315^\circ)$ ,  $4(225^\circ)$ ,  $4(135^\circ)$  whence can be obtained  $45^\circ, 315^\circ, 225^\circ, 135^\circ$

I.

45°, 315°, 225°, 135°

	-5'				0'				+5'			
	E	F	G	H	E	F	G	H	E	F	G	H
45°	0.06	2.82	-0.52	4.88	0.18	2.88	-0.70	5.12	0.54	3.16	-0.82	5.14
		-2.76	+3.34	-0.70+4.82		-2.90	+3.58	-5.82+4.99		-2.62	+3.98	-5.96+4.60
315°	0.66	10.80	4.56	4.84	0.90	11.58	4.98	5.40	1.20	12.10	5.08	6.16
		-10.14	+6.24	-0.28+4.18		-10.68	+6.60	-0.42+4.50		-10.90	+7.02	-1.08+4.96
225°	2.90	11.14	0.66	-1.24	2.86	13.00	1.20	0.04	3.70	12.42	1.96	-0.24
		-8.24	+10.98	+1.50-4.14		-10.14	+11.80	+1.16-2.82		-8.92	+10.46	+2.20-3.94
135°	3.82	5.30	-5.98	1.78	3.64	5.98	-5.82	1.44	4.12	5.80	-5.06	2.04
		-1.48	+11.28	-9.96-2.04		-2.34	+11.80	-7.26-2.20		-1.68	+10.86	-7.10-2.08

$\Sigma$	7.44	30.06	-0.28	10.26	7.58	33.44	-0.34	12.00	9.56	33.48	1.16	12.10
				46.48				52.68				57.30
4(e-f) 4(e-g) 4(e-h)	-22.62	+8.72	-2.82		-25.86	+7.24	-4.42		-23.92	+8.40	-3.54	
k-f) k-g) k-h)	-5.66	+2.18	-0.70		-6.46	+1.81	-1.10		-5.98	+2.10	-0.88	

0.06	2.82	-0.52	4.88	0.18	2.88	-0.70	5.12	0.54	3.16	-0.82	5.14
4.84	0.66	10.80	4.56	5.40	0.90	11.58	4.98	6.16	1.20	12.10	5.08
0.66	-1.24	2.90	11.14	1.20	0.04	2.86	13.00	1.96	-0.24	3.70	12.42
5.30	-5.98	1.78	3.82	5.98	-5.82	1.44	3.64	5.80	-5.06	2.04	4.12

$\Sigma$	10.86	-3.74	18.96	24.40	12.76	-2.00	15.18	26.74	14.46	-0.94	17.02	26.76
				46.48				52.68				57.30
4(45-315) 4(45-225) 4(45-135)	14.60	-4.10	-13.54		14.76	-2.42	-13.98		15.40	-2.56	-12.30	
4(45-315) 4(45-225) 4(45-135)	3.65	-1.02	-3.38		3.69	-0.60	-3.50		3.85	-0.64	-3.08	



II 15°, 285°, 195°, 105°

-5'					0'					+5'				
E	E	F	G	H	E	F	G	H		E	F	G	H	
15°	1.90	7.80	3.82	6.58	2.70	8.98	4.94	8.00	3.22	9.82	4.78	8.02		
		-5.90	+3.98	-2.96+4.68		-6.28	+4.04	-3.06+5.30		-6.60	+5.04	-3.24+4.80		
285°	0.76	10.34	2.90	1.98	1.12	10.64	3.32	2.74	1.60	11.02	3.66	3.16		
		-9.58	+7.44	+0.92+1.22		+9.52	+7.32	+5.8+1.62		-9.42	+7.36	+0.50+1.56		
195°	1.14	7.28	-3.78	-3.14	+1.68*	7.74	-3.24	-2.24	1.46	8.02	-3.02	-2.18		
		-6.14	+1.06	-0.64-4.28		-6.08	+1.098	-1.00+3.92		-6.56	+1.04	-0.84-3.64		
105°	1.48	2.06	-4.42	1.70	1.76	3.43	-3.96	2.65	2.22	3.23	-3.46	3.07		
		-0.58	+6.48	-6.12+0.22		+8.19	+7.39	-6.61+0.89		-1.01	+6.69	-6.58+0.85		
						-1.67								
Σ	5.28	27.48	-1.36 <sup>48</sup>	7.12 <sub>38.40</sub>	3.90	30.79	1.06	11.15 <sub>46.80</sub>	8.50	32.09	1.96	12.07 <sub>54.62</sub>		
4(e-f)	4(e-g)	4(e-h)	-22.20	6.76	-1.84	-26.89	2.84	-7.25	-23.59	6.54	-3.57			
(e-f)	(e-g)	(e-h)	-5.55	1.69	-0.46	-6.72	0.71	-1.81	-5.90	1.64	-.89			
								v. below						
	1.90	7.80	3.82	6.58	2.70	8.98	4.94	8.00	3.22	9.82	4.78	8.02		
	1.98	0.76	10.34	2.90	2.74	1.12	10.64	3.32	3.16	1.60	11.02	3.66		
	-3.78	-3.14	1.14	7.28	-3.24	-2.24	-1.68*	7.74	-3.02	-2.18	1.46	8.02		
	2.06	-4.42	1.70	1.48	3.43	-3.96	2.65	1.76	3.23	-3.46	3.07	2.22		
Σ	2.16	<del>7.84</del> <sup>1.00</sup>	17.00	18.24 <sub>38.40</sub>	5.63	3.90	16.55	20.82 <sub>46.80</sub>	6.59	5.78	20.33	21.92 <sub>54.62</sub>		
4(15°-285°)	4(15°-195°)	4(15°-105°)	1.16	-14.84	-16.08	+1.732	-10.92	-15.19	0.81	-13.74	-15.33			
(15-285)	(15-195)	(15-105)	0.29	-3.71	-4.02	0.43	-2.73	-3.80	0.20	-3.44	-3.83			
								v. below						

This should probably be +1.68. A comparison of the lines -5° 0' +5' with E made June 28 confirms this supposition. The results obtained by making this alteration are -

$\Sigma$	7.26	30.79	1.06	11.15
4(e-f)lc	-23.53	6.20	-3.89	
e-f lc	-5.88	1.55	-.97	

1991

-14.28

-3.57

(15-195)



1877phaa

					III					345°, 255°, 165°, 75°				



## Summary. Errors in Position of Microscopes -

Using correction mentioned on page 115 we have -

		-5'	0'	+5'	Mean	-5'	0'	+5'	Mean
I	e-f	-5.66	-6.46	-5.98	-6.03	-5.66	-6.46	-5.98	-6.03
II		-5.55	-6.72	-5.90	-6.05	-5.55	-5.88	-5.90	-5.78
III		-4.86	-5.24	-4.88	-4.99	-4.86	-5.24	-4.88	-4.99
	Mean	-5.36	-6.14	-5.58	-5.69	5.36	-5.86	-5.59	-5.60

I	e-g	+2.18	+1.81	+2.10	+2.03	+2.18	+1.81	+2.10	+2.03
II		+1.69	+ .71	+1.64	+1.35	+1.69	+1.55	+1.64	+1.63
III		+1.94	+1.46	+1.54	+1.65	+1.94	+1.46	+1.54	+1.65
		+1.94	+1.33	+1.76	+1.68	+1.94	+1.61	+1.76	+1.77

I	e-h	-0.70	-1.10	-0.88	-0.89	-0.70	-1.10	-0.88	-0.89
II		-0.46	-1.81	-0.89	-1.05	-0.46	-0.97	-0.89	-0.77
III		+0.59	+0.10	+0.20	+0.30	+0.59	+0.10	+0.20	+0.30
		-0.19	-0.94	-0.52	-0.55	-0.19	-0.66	-0.52	-0.45

$$e-f - (e-h) = h-f = -5''.15$$

$$= \alpha(p_{108}) = -5''.165$$

# Summary - Errors in lines of circle.

	-5'	0'	+5'
45° - 315°	+3.65	+3.69	+3.85
225	-1.02	-0.60	-0.64
135	-3.38	-3.50	-3.08
15 - 285	+0.29	+0.43	+0.20
195	-3.71	-3.57* -2.73	-3.44
105	-4.02	-3.80	-3.83
-3.57 is value using correction given on p. 115.			
345 - 255	-2.46	-2.56	-2.73
165	-7.54	-7.83	-7.60
75	-5.24	-5.56	-5.42



On pages 90-104 are results obtained in the same way on different dates. Combining all the separate results, we have —

	e-f	e-g	e-h	
June 4	- 2.58	- 0.63	- 1.94	
4	2.97	- 0.67	2.17	
5	5.82	- 1.90	2.87	
5	5.91	- 2.48	4.41 ✓	
	5.84	- 0.18	0.65	
	5.63	- 0.16	0.50	p. 97
	5.57	+ 0.10	0.57	
	5.70	+ 0.07	0.61	
	5.62	+ 0.13	0.78	
	5.31	- 0.50	1.04	
	5.28	- 0.56	1.26	
	5.66	+ 2.18	- 0.70	
	5.55	+ 1.69	- 0.46	
	4.86	+ 1.94	+ 0.59	
	6.46	+ 1.81	- 1.10	
June 16, 17	5.88	+ 1.55	- 0.97	p. 117
	5.24	+ 1.46	+ 0.10	
	5.98	+ 2.10	- 0.88	
	5.90	+ 1.64	- 0.89	
	4.88	+ 1.54	+ 0.20	

Summary of results of errors of lines at  
 $45^\circ$ ,  $315^\circ$ ,  $225^\circ$ ,  $135^\circ$ , from determinations on different  
 days

	$45^\circ - 315^\circ$	$45^\circ - 225^\circ$	$45^\circ - 135^\circ$	
June 24	+3."73	-1."07	-3."77	
4	3.61	.94	3.65	
5	4.43	.58	2.14 ✓	
5	4.21	.67	2.97	
	3.83	.30	3.53	
	4.06	.50	3.48	< p. 97
	3.84	.71	3.33	
	3.60	.90	3.76	
	3.74	.90	3.70	
	3.66	.88	3.25	
	3.62	1.08	3.47	
	3.69 Mean = +3."84	0.60 Mean = -0."76	3.50 Mean = -3.38	
16, 17	3.65 -5'	1.02 -5'	3.38 -5'	< p. 118
	3.85 +5'	0.64 +5'	3.08 +5'	



## Computation of eccentricity &amp; ellipticity for

45°, 315°, 225°, 135°

$$\text{Prp. 109} \quad \text{Eccentricity} = 3.42 \text{ em} (2 + 178^\circ 46')$$

$$111 \quad \text{Ellipticity} = 0.68 \text{ em} (22 + 189^\circ 48')$$

~~45°~~

Z		2+178° 46'	em(2+178° 46')	Eccentricity	22 (22+189° 48')	em	—	Ellip.
45°	0	178 46	+0.02	+0.07	0	189 48	-.17	-.12
315	90	268 46	-1.00	-3.42	180	9 48	+.17	+.12
225	180	358 46	-.02	-0.07	0	189 48	-.17	-.12
135	270	88 46	+1.00	+3.42	180	9 48	+.17	+.12

## Eccen. + Ellip.

$$45^\circ \quad -".05$$

$$315 \quad -3.30$$

$$225 \quad -0.19$$

$$135 \quad +3.54$$

$$45^\circ - 315^\circ \quad +3.25$$

$$45^\circ - 225^\circ \quad +.14$$

$$45^\circ - 135^\circ \quad -3.59$$

Reduction of Observations made June 23, 1879 in the  
with respect to all four microscopes -

$\theta$	$\epsilon$	$F$	$g$	$H$
$0^\circ$	0.00	3.26	1.54	3.92
90	0.00	9.92	6.70	5.20
180	0.00	8.88	0.88	-2.98
270	0.00	1.58	-6.72	-1.10
$\Sigma$	0.00	23.64	2.40	5.04

31.08

4(e-f)/4(e-g)/4(e-h)

e-f, e-g, e-h

-5.91 -0.60 -1.26

0.00	3.26	1.54	3.92
5.20	0.00	9.92	6.70
0.88	-2.98	0.00	8.88
1.58	-6.72	-1.10	0.00

$\Sigma$	7.66	-6.44	10.36	19.50
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31.08

4(0-90)/4(0-180)/4(0-270)

14.10 -2.70 -11.84

(0-90)/(0-180)/(0-270)

3.52 -0.68 -2.96



manner explained on p. 113, the errors being investigated  
 $\epsilon, F, G, H.$

$F$	$F$	$G$	$H$	$\epsilon$
$90^\circ$	0.00	-1.64	-1.08	-2.40
$180$	0.00	-3.06	-5.34	-10.10
$270$	0.00	-8.20	-12.26	-8.36
$360$	0.00	-10.24	-4.38	-2.06

$$\Sigma \quad 0.00 \quad -23.14 \quad -23.06 \quad -22.92 \quad 69.12$$

$$\begin{aligned} &4(f-g)4(f-h)4(f-e) \\ &(f-g)(f-h)(f-e) \end{aligned} \quad +5.78 \quad +5.76 \quad +5.73$$

0.00	-1.64	-1.08	-2.40	0.00	-10.24	-4.38	-2.06
-10.10	0.00	-3.06	-5.34	-2.40	0.00	-1.64	-1.08
-12.26	-8.36	0.00	-8.20	-5.34	-10.10	0.00	-3.06
-10.24	-4.38	-2.06	0.00	-8.20	-12.26	-8.36	0.00

$$\Sigma \quad -32.60 \quad -14.38 \quad -6.20 \quad -15.94 \quad 69.12 \quad -15.94 \quad -32.60 \quad -14.38 \quad -6.20$$

$$\begin{aligned} &4(0-\frac{90}{180})4(0-\frac{180}{180})4(0-\frac{270}{180}) \\ &(0-\frac{90}{180})(0-\frac{180}{180})(0-\frac{270}{180}) \end{aligned} \quad -18.22 \quad -26.40 \quad -16.66 \quad 16.66 \quad -11.56 \quad -9.74$$

$$\begin{aligned} &(90-\frac{180}{180})(90-\frac{270}{180})(90-\frac{360}{180}) \\ &(-1)(-1)(-1) \end{aligned} \quad -4.55 \quad -6.60 \quad -4.16 \quad 4.16 \quad -0.39 \quad -2.44$$

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$\theta$	$g$	$H$	$E$	$F$
$180^\circ 0^\circ$	0.00	2.72	-0.88	1.58
$270 90$	0.00	-2.74	-7.22	3.58
$0 180$	0.00	-3.94	0.20	9.28
$90 270$	0.00	4.90	8.34	10.90

$\Sigma$  0.00 0.94 0.44 25.34 26.72

$4(g-h)4(g-e)4g-f$   
 $g-h, g-e, g-f$

-0.24 -0.11 -6.34

0.00 -3.94 0.20 9.28  
 10.90 0.00 4.90 8.34  
 -0.88 1.58 0.00 2.72  
 -2.74 -7.22 3.58 0.00

0.00 2.72 -0.88 1.58  
 3.58 0.00 -2.74 -7.22  
 0.20 9.28 0.00 -3.94  
 4.90 8.34 10.90 0.00

$\Sigma$  7.28 -9.58 8.68 20.34 26.72

$4(0-\frac{90}{270})4(0-180)4(0-\frac{270}{90})$   
 $(0-\frac{90}{270})(0-180)(0-\frac{270}{90})$

16.86 -1.40 -13.06  
 4.22 -0.35 -3.26

8.68 20.34 7.28 -9.58 26.72  
 -11.66 1.40 18.26

$(180-\frac{270}{90})(180-360)(180-\frac{90}{270})$

-2.92 0.35 4.56



$H$	$H$	$E$	$F$	$G$
$27^\circ \quad 9^\circ$	0.00	-3.58	-0.54	-2.30
$0 \quad 90$	0.00	-4.26	6.70	2.90
$90 \quad 180$	0.00	4.66	13.88	4.28
$180 \quad 270$	0.00	3.62	6.16	-4.66

$\Sigma$	0.00	0.44	26.20	0.22	26.86
$4(l-e)4(l-f)4(l-g)$					
$l-e, l-f, l-g$		-0.21	-6.55	-0.06	

0.00	-4.26	6.70	2.90	0.00	-3.58	-0.54	-2.30
4.28	0.00	4.66	13.88	2.90	0.00	-4.26	6.70
6.16	-4.66	0.00	3.62	13.88	4.28	0.00	4.66
-3.58	-0.54	-2.30	0.00	3.62	6.16	-4.66	0.00

$\Sigma$	6.86	-9.46	9.06	20.40	26.86	20.40	6.86	-9.46	9.06	26.86
$4(0-90)4(0-180)4(0-270)$	16.32	-2.20	-13.54			13.54	29.86	11.34		
$(0-90)(0-180)(0-270)$	4.08	-0.55	-3.38							

$(270-360)(270-90)(270-180)$	3.38	7.46	2.84
------------------------------	------	------	------

## Summary.

e-f	e-g	e-h	f-g	f-h	g-h
$-5.91^I$	$-0.60^I$	$-1.26^I$	$+5.78^I$	$+5.76^I$	$-0.24^I$
$5.73^{II}$	$+0.11^{III}$	$+0.11^{IV}$	$5.31^I$	$4.65^I$	$-0.66^I$
$6.23^{III}$	$+0.05^{II}$	$+0.03^{II}$	$6.34^{III}$	$6.55^{IV}$	$+0.06^{IV}$
$6.44^{IV}$	$+0.05^{IV}$	$-0.13^{III}$	$6.49^{IV}$	$6.10^{III}$	$-0.02^{II}$

Mean    6.08    -0.10    -0.31    +5.98    +5.76    -0.22

	$0^\circ - 90^\circ$	$0^\circ - 180^\circ$	$0^\circ - 270^\circ$
E	$+3.52$	$-0.68$	$-2.96$
F	4.16	0.39	2.44
G	4.22	0.35	3.26
H	4.08	0.55	3.38

	E-F	E-G	E-H	F-G	F-H	G-H
$0^\circ - 90^\circ$	$-.64$	$-.70$	$-.56$	$-.06$	$+.08$	$+.14$
$0^\circ - 180^\circ$	$-.29$	$-.83$	$-.13$	$-.04$	$+.16$	$+.20$
$0^\circ - 270^\circ$	$-.52$	$+.30$	$+.42$	$+.82$	$+.94$	$+.12$

The  $0^\circ, 90^\circ, 180^\circ, 270^\circ$  lines are the same ones as those designated pp 113-121 as  $45^\circ, 315^\circ, 225^\circ, 135^\circ$ .



Summary of errors of different quarters  
of the circle as shown by the different microscopes  
for the same setting of the telescope.

$$\begin{array}{cccc} \cancel{C=0} & \cancel{C-F} & \cancel{F-G} & \cancel{G-H} \\ & -2.96 & & \end{array}$$

$$\begin{array}{cccccc} \cancel{C=0} & \cancel{C-F=0-90} & \cancel{F-G=90-180} & \cancel{G-H=180-270} & \cancel{H-C=270-360} \\ & -2.96 & -4.16 & 4.56 & 2.84 \end{array}$$

$$\begin{array}{cccccc} C=90 & C-F=90-180 & F-G=180-270 & G-H=270-360 & H-C=0-90 \end{array}$$

C	F	G	H		C	F	G	H
+3.52	-4.55	-2.92	+3.38		0-90	90-180	180-270	270-0
-0.68	-6.60	+0.35	+7.46	where	0-180	90-270	180-0	270-90
-2.96	-4.16	+4.56	+2.84		0-270	90-0	180-90	270-180

Investigation of error  $0^\circ-90^\circ$  in positions  
 $\delta-F$ ,  $H-E$ ,  $g-H$ ,  $F-g$

	$\delta-F$	$H-E$	$g-H$	$F-g$
I				
$\delta-F, H-E$ etc	-3.26	+5.20	+3.86	+8.30
cf, h-e, etc	-5.91	+1.26	-0.66	+5.31
$\Delta$		+2.65	+3.94	+4.52
			+2.99	
II				
	-2.40	+4.76	+4.06	+10.24
	-5.73	-0.03	-0.02	+5.78
		+3.33	+4.79	+4.08
			+4.46	
III				
	-2.46	+4.48	+3.94	+10.90
	-6.23	+0.13	+0.24	+6.34
		+3.77	+4.35	+3.70
			+4.56	
IV				
	-3.04	+4.26	+4.28	+10.82
	-6.44	-0.11	+0.06	+6.49
		+3.40	+4.37	+4.22
			+4.33	
Mean	+3.29	+4.36	+4.13	+4.08
Mean		3.96		
$\delta-F$ to Mean		+0.67		



# Investigation of error $90^\circ - 180^\circ$ in positions — E-F, H-E, G-H, F-G

		E-F	H-E	G-H	F-G
I	-9.92	-2.98	-5.62	+1.72	
	-5.91	+1.26	-0.66	+5.31	
		-4.01	-4.24	-4.96	-3.59
II	-10.10	-3.90	-5.86	+1.64	
	-5.73	-0.03	-0.02	+5.78	
		-4.37	-3.87	-5.84	-4.14
III	-10.80	-4.14	-4.90	+1.58	
	-6.23	+0.13	+0.24	+6.34	
		-4.57	-4.27	-5.14	-4.76
IV	-10.96	-4.66	-4.66	+1.76	
	-6.44	-0.11	+0.06	+6.49	
		-4.52	-4.55	-4.72	-4.73
	Mean	-4.37	-4.23	-5.16	-4.30
	Mean		-4.52		
	F-G to Mean			- .22	

Investigation of error  $180^\circ - 270^\circ$  in position  
 $\delta - F$ ,  $H - \delta$ ,  $G - H$ ,  $F - G$ .

$\delta - F$      $H - \delta$      $G - H$      $F - G$

I    -8.88    -1.10    -2.38    +3.22  
      -5.91    +1.26    -0.66    +5.31

-2.97    -2.36    -1.72    -2.09

II    -8.36    -2.32    -0.56    +3.06  
      -5.73    -0.03    -0.02    +6.78

~~x~~    -2.63    -2.29    -0.54    -2.72

III    -9.08    -3.44    -2.72    +3.58  
      -6.23    +0.13    -0.24    +6.34

-2.85    -3.57    -2.48    -2.76

IV    -9.22    -3.62    -2.30    +3.80  
      -6.44    -0.11    +0.06    +6.49

-2.78    -3.51    -2.36    -2.69

Mean    -2.81    -2.93    -1.78    -2.56

Mean    -2.52

G-H Mean    - .74



Investigation of error  $270^{\circ}$ - $360^{\circ}$  in positions  
 G-F, H-G, G-H, F-G

	G-F	H-G	G-H	F-G
I	-1.58	+3.92	+1.50	+8.00
	-5.91	+1.26	-0.66	+5.31
	+4.33	+2.66	+2.16	+2.69
II	-2.06	+1.32	+2.28	+8.20
	-5.73	-0.03	-0.02	+5.78
	+3.67	+1.35	+2.30	+2.42
III	-2.56	+3.60	+2.74	+9.28
	-6.23	+0.13	-0.24	+6.34
	+3.67	+3.47	+2.98	+2.94
IV	-2.54	+3.58	+2.90	+9.60
	-6.44	-0.11	+0.06	+6.49
	+3.90	+3.69	+2.84	+3.11
Mean	+3.89	+2.79	+2.57	+2.79
Mean		+3.01		
H-G to Mean		+2.22		





















