

KG  
11366  
152

WHP

No. 45

DETERMINATIONS OF PARALLAX BY PHTG. MEANS.

Mar. 30, 1882.





KG11366, 152

*Note Book E.*

KG 11366.152



# Determinations of Parallax by Photographic Means.

Mar 30, 1882.

At the focus of the East Equatorial  
 $75.0'' = 1 \text{ inch} \therefore 1'' = .00133 \text{ inches} + 1' = \frac{1}{12.5} = \frac{2}{25} = .08 \text{ in.}$

$15'$  traversed in 1 min. = 1.2 inches  $\therefore 15''$  in 1 sec =  $\frac{1}{50} = .02 \text{ in.}$

A parallax of  $1''$  = a displacement in 6 mos. of  $.000267 = \frac{1}{3750}$  inches.

The focus for the G line (mag. actinic effect) is 63 divisions of the head of the <sup>focusing</sup> screw less than the visual focus, i.e. tube longer for former.

In one square degree there are on the average 15 stars of the 10th mag and brighter, divided as follows:-

|           |      |                                                               |
|-----------|------|---------------------------------------------------------------|
| 8         | 10th | Radius in secs. = 206265 $\therefore$ if                      |
| 4         | 9th  | 92300000 miles appears as $1''$ the distance                  |
| 2         | 8th  | must be $206265 \times 92300000 = 19040000000000$             |
| 1         | 7th  | $\therefore 1''$ parallax = $19000000000000$ miles = distance |
| <u>15</u> |      | on photo. of $.000267 = \frac{1}{3750}$ inch                  |

Settings with the Dividing Engine can be made at the rate of about 1 per minute

+ Asterope

+ Taygeta

+ Maia

+ Celaeno

+ Electra

## Magnitudes

|            |     |
|------------|-----|
| Asterope b | 5.7 |
| " a        | 6.3 |
| Maia       | 4.0 |
| Taygeta    | 4.4 |
| Celaeno    | 5.2 |
| Electra    | 3.8 |

Took two photos of the Moon and two of a portion of the Pleiades, here represented. To the former I gave 60 sec. & 10 sec. both overexposed. 6 sec & 2 sec would have been better. Plate 1 of the Pleiades gave the following effect ... — with exposures of 60, 15, 5, and 600. Plate 2 gave — with exposures of 180, and 180.

- The Errors I shall find with in the determinations of parallaxes will be of 34 classes
- a 1 Different positions on diff. plates.
  - b 2 Diff. meas. on same image at diff. times caused by uncertainty in deciding on center, as O, and
  - § Diff. meas. on same image at same time caused by uncertainty in setting on center, as O.
  - 3 Diff. meas. on a distinctly vis. point, caused by ~~error~~ inaccuracy in construction of apparatus.

## Measurements of Pleiades Plate 2.

Selected the two stars at the beginning & end of the second exposure. The Unit is  $\frac{1}{10}$  inch.

| Name                        | R.A.        | diff. | S           | diff. |
|-----------------------------|-------------|-------|-------------|-------|
| Asterops b                  | 37.762      |       | 88.033      |       |
|                             | <u>773</u>  | 11    | <u>033</u>  | 0     |
|                             | 37.768      |       | 88.033      |       |
| "                           | 38.856      |       | 88.046      |       |
|                             | <u>851</u>  | 5     | <u>046</u>  | 2     |
|                             | 38.854      |       | 88.045      |       |
| Asterops d                  | 40.898      |       | 85.676      |       |
|                             | <u>.905</u> | 7     | <u>.679</u> | 5     |
|                             | 40.902      |       | 85.678      |       |
| "                           | 41.971      |       | 85.667      |       |
|                             | <u>971</u>  | 0     | <u>673</u>  | 6     |
|                             | 41.971      |       | 85.670      |       |
| <sup>Maria</sup><br>Taygeta | 36.906      |       | 70.413      |       |
|                             | <u>901</u>  | 5     | <u>410</u>  | 3     |
|                             | 36.904      |       | 70.412      |       |
| "                           | 38.021      |       | 70.440      |       |
|                             | <u>.019</u> | 2     | <u>432</u>  | 8     |
|                             | 38.020      |       | 70.436      |       |

| Name                          | P.A.        | diff | S           | diff. |
|-------------------------------|-------------|------|-------------|-------|
| <i>Maia</i> <sup>Toggia</sup> | 23.234      |      | 79.157      |       |
|                               | <u>.238</u> | 4    | <u>160</u>  | 3     |
|                               | 23.236      |      | 79.158      |       |
| "                             | 24.350      |      | 79.180      |       |
|                               | <u>350</u>  | 0    | <u>178</u>  | 2     |
|                               | 24.350      |      | 79.179      |       |
| <i>Celaeno</i>                | 15.397      |      | 62.063      |       |
|                               | <u>.400</u> | 3    | <u>067</u>  | 5     |
|                               | 15.398      |      | 62.065      |       |
| "                             | 16.485-     |      | 62.093      |       |
|                               | <u>485-</u> | 0    | <u>.100</u> | 7     |
|                               | 16.485-     |      | 62.096      |       |
| c (exceedingly faint)         | 32.926      |      | 68.230      |       |
|                               | <u>.920</u> | 6    | <u>232</u>  | 2     |
|                               | 32.923      |      | 68.231      |       |
| "                             | 33.606      |      |             |       |
|                               | <u>596</u>  | 10   | invisible.  |       |
|                               | 33.601      |      |             |       |

## Measurement of Pleiades. Plate 1.

Mar. 31, '82.

Measured 60, 15, and 5.

| <sup>10.25</sup> Name | B. A                                    | diff             | S           | diff. |
|-----------------------|-----------------------------------------|------------------|-------------|-------|
| Asterope b            | 39.148                                  |                  | 86.084      |       |
|                       | <u>144</u>                              | 4                | <u>016</u>  | 2     |
| 60 sec                | 39.146                                  |                  | 88.015      |       |
| "                     | " <sup>best</sup> found 38.268          |                  | 88.020      |       |
|                       | <u>271</u>                              | 3                | <u>022</u>  | 2     |
| 15 sec                | 38.270                                  |                  | 88.021      |       |
| "                     | " 37.251                                |                  | 88.019      |       |
|                       | <u>.249</u>                             | 2                | <u>.021</u> | 2     |
| 5 sec                 | 37.250                                  |                  | 88.020      |       |
| Asterope              | <sup>best</sup> <sub>found</sub> 42.260 |                  | 85.620      |       |
|                       | <u>256</u>                              | 4                | <u>628</u>  | 8     |
| 80                    | 42.258                                  |                  | 85.624      |       |
| "                     | " 41.401                                | <sup>found</sup> | 85.617      |       |
|                       | <u>.975</u>                             | 26               | <u>621</u>  | 4     |
| 15                    | 41.388                                  |                  | 85.619      |       |
| "                     | " 40.364                                | <sup>found</sup> | 85.607      |       |
|                       | <u>.349</u>                             | 15               | <u>615</u>  | 8     |
| 5                     | 40.356                                  |                  | 85.611      |       |

|    | Names   | P.A.        | diff. | $\delta$    | diff. |
|----|---------|-------------|-------|-------------|-------|
|    | Maia    | 38.117      |       | 70.422      |       |
|    |         | <u>.104</u> | 13    | <u>.416</u> | 6     |
| 60 |         | 38.110      |       | 70.419      |       |
|    | "       | 37.266      |       | 70.430      |       |
|    |         | <u>269</u>  | 5     | <u>427</u>  | 3     |
| 15 |         | 37.268      |       | 70.428      |       |
|    | " best  | 36.234      |       | 70.420      |       |
|    | good    | <u>232</u>  | 2     | <u>.427</u> | 7     |
| 5  |         | 36.233      |       | 70.424      |       |
|    | Taygeta | 24.510      |       | 79.279      |       |
|    | fine    | <u>512</u>  | 2     | <u>.291</u> | 12    |
| 60 |         | 24.511      |       | 79.285      |       |
|    | " good  | 23.681      |       | 79.297      |       |
|    | best?   | <u>684</u>  | 3     | <u>300</u>  | 3     |
| 15 |         | 23.682      |       | 79.298      |       |
|    | " best? | 22.629      |       | 79.276      |       |
|    | good    | <u>625</u>  | 4     | <u>281</u>  | 5     |
| 5  |         | 22.627      |       | 79.278      |       |

| Names                               | B.A.   | diff. | $\delta$ | diff. |
|-------------------------------------|--------|-------|----------|-------|
| Caetano                             | 16.521 |       | 62.283   |       |
| <i>best fit not as good as fair</i> | 520    | 1     | .286     | 3     |
| 60                                  | 16.520 |       | 62.284   |       |
| "                                   | 15.655 |       | 62.276   |       |
|                                     | 643    | 12    | .286     | 10    |
| 15                                  | 15.649 |       | 62.281   |       |
| <i>good</i>                         | 14.600 |       | 62.268   |       |
|                                     | 596    | 4     | .271     | 3     |
| 5                                   | 14.598 |       | 62.270   |       |
| <i>Electra</i>                      | 18.705 |       | 45.780   |       |
| <i>fair</i>                         | .699   | 6     | .792     | 12    |
| 60                                  | 18.702 |       | 45.786   |       |
| <i>fair</i>                         | 17.859 |       | 45.786   |       |
|                                     | .855   | 4     | .777     | 9     |
| 10                                  | 17.857 |       | 45.782   |       |
| <i>best fit good</i>                | 16.793 |       | 45.780   |       |
|                                     | 800    | 7     | .785     | 5     |
| 5/1.39                              | 16.796 |       | 45.782   |       |

| Names | Ab A          | diff | S             | diff. |
|-------|---------------|------|---------------|-------|
| c     | 29.700 ?      |      | 66.778        |       |
|       | <u>.700</u>   | 0    | <u>.786</u>   | 8     |
| 60    | 29.700        |      | 66.782        |       |
| "     | 28.793        |      | 66.820        |       |
| best  | <u>.800</u> ? | 7    | <u>.826</u> ? | 6     |
| 15-   | 28.796        |      | 66.823        |       |
| "     | 28.030        |      | 66.867        |       |
|       | <u>.034</u> ? | 4    | <u>.869</u> ? | 2     |
| 5-    | 28.032        |      | 66.868        |       |
| d     |               |      |               |       |
| "     | 51.675 ?      |      | 60.626        |       |
|       | <u>.661</u>   | 14   | <u>.624</u>   | 2     |
| 15-   | 51.668        |      | 60.625        |       |

| Names           | PA          | diff | 8          | diff |
|-----------------|-------------|------|------------|------|
| Maia (repeated) | 38.090      |      | 70.421     |      |
|                 | <u>.076</u> | 14   | <u>423</u> | 2    |
| 60              | 38.083      |      | 70.422     |      |
| " poor          | 37.267      |      | 70.440     |      |
|                 | <u>252</u>  | 15   | <u>440</u> | 0    |
| 15-             | 37.260      |      | 70.440     |      |
| " best          | 36.200      |      | 70.441     |      |
|                 | <u>222</u>  | 22   | <u>437</u> | 4    |
| 5-              | 36.211      |      | 70.439     |      |
| Taygeta         | 24.521      |      | 79.290     |      |
|                 | <u>.577</u> | 4    | <u>293</u> | 3    |
| 60              | 24.519      |      | 79.292     |      |
| poor            | 23.669      |      | 79.304     |      |
|                 | <u>670</u>  | 1    | <u>309</u> | 5-   |
| 15-             | 23.670      |      | 79.306     |      |
|                 | 22.624      |      | 79.296     |      |
| best            | <u>616</u>  | 8    | <u>295</u> | 1    |
| 5-              | 22.620      |      | 79.296     |      |

|               |               |                   |               |               |
|---------------|---------------|-------------------|---------------|---------------|
| 39.146        | 42.258        | 24.511            | 16.520        | 18.702        |
| <u>38.110</u> | <u>38.110</u> | <u>38.110</u>     | <u>38.110</u> | <u>38.110</u> |
| + 1.036       | + 4.148       | - 13.599          | - 21.590      | - 19.408      |
| 29.700        | 24.519        |                   |               |               |
| <u>38.110</u> | <u>38.083</u> |                   |               |               |
| - 8.410       | - 13.564      |                   |               |               |
| 38.270        | 41.388        | 23.682            | 15.649        | 17.857        |
| <u>37.268</u> | <u>37.268</u> | <u>37.268</u>     | <u>37.268</u> | <u>37.268</u> |
| + 1.002       | + 4.120       | - 13.586          | - 21.619      | - 19.411      |
| 28.796        | 51.668        | 23.670            |               |               |
| <u>37.268</u> | <u>37.268</u> | <u>37.260</u>     |               |               |
| - 8.472       | + 14.400      | - 13.590          |               |               |
| 37.250        | 40.356        | <del>36.233</del> | 22.627        | 14.598        |
| <u>36.233</u> | <u>36.233</u> |                   | <u>36.233</u> | <u>36.233</u> |
| 1.017         | 4.123         |                   | - 13.606      | 21.635        |
| 16.796        | 28.032        | 22.620            |               |               |
| <u>36.233</u> | <u>36.233</u> | <u>36.211</u>     |               |               |
| <u>19.437</u> | <u>8.201</u>  | <u>13.591</u>     |               |               |
| 88.015        | 85.624        | 79.285            | 62.284        | 45.786        |
| <u>70.419</u> | <u>70.419</u> | <u>70.419</u>     | <u>70.419</u> | <u>70.419</u> |
| + 17.596      | + 15.205      | + 8.866           | - 8.135       | - 25.633      |
| 66.782        | 79.292        |                   |               |               |
| <u>70.419</u> | <u>70.422</u> |                   |               |               |
| - 3.637       | + 8.870       |                   |               |               |
| 88.021        | 85.619        | 79.298            | 62.281        | 45.782        |
| <u>70.428</u> | <u>70.428</u> | <u>70.428</u>     | <u>70.428</u> | <u>70.428</u> |
| + 17.593      | + 15.191      | + 8.870           | - 8.147       | - 24.646      |
| 66.823        | 60.625        | 79.306            |               |               |
| <u>70.428</u> | <u>70.428</u> | <u>70.440</u>     |               |               |
| - 3.605       | - 9.803       | + 8.866           |               |               |

R. A.

| Names      | 60 sec  | 15 sec. | 5 sec   |
|------------|---------|---------|---------|
| Asterope b | + 1.036 | +1.002  | + 1.017 |
| " a        | 4.148   | 4.120   | 4.123   |
| Maia       | 0.000   | 0.000   | 0.000   |
| Taygeta    | -13.599 | -13.585 | -13.606 |
| Caclano    | -21.590 | -21.619 | 21.635  |
| Electra    | -19.408 | -19.411 | 19.437  |
| c          | - 8.410 | - 8.472 | 8.201   |
| d          | —       | +14.200 | —       |
| Maia       | 0.000   | 0.000   | 0.000   |
| Taygeta    | -13.564 | -13.590 | -13.591 |

S

|            |         |         |         |
|------------|---------|---------|---------|
| Asterope b | +17.596 | +17.593 | +17.596 |
| " a        | 15.205  | 15.191  | 15.187  |
| Maia       | 0.000   | 8.890   | 0.000   |
| Taygeta    | 8.866   | 8.870   | 8.854   |
| Caclano    | - 8.125 | - 8.147 | - 8.154 |
| Electra    | 24.633  | -24.646 | 24.642  |
| c          | 3.637   | - 3.605 | 3.556   |
| d          | —       | -9.803  | —       |
| Maia       | 0.000   | 0.000   | 0.000   |
| Taygeta    | + 8.870 | + 8.866 | + 8.857 |

|               |               |                   |               |               |               |
|---------------|---------------|-------------------|---------------|---------------|---------------|
| 88.020        | 85.611        | <del>70.424</del> | 79.278        | 62.270        | 45.782        |
| <u>70.424</u> | <u>70.424</u> |                   | <u>70.424</u> | <u>70.424</u> | <u>70.424</u> |
| 17.596        | 15.187        |                   | 8.854         | -8.154        | 24.642        |
| 66.868        | 79.296        |                   |               |               |               |
| <u>70.424</u> | <u>70.439</u> |                   |               |               |               |
| 3.556         | +8.857        |                   |               |               |               |
| 37.768        | 40.902        | 23.236            | 15.398        | 32.923        |               |
| <u>36.904</u> | <u>36.904</u> | <u>36.904</u>     | <u>36.904</u> | <u>36.904</u> |               |
| + .864        | + 3.998       | -13.668           | -21.506       | - 3.981       |               |
| 38.854        | 41.921        | 24.350            | 16.485        | 33.601        |               |
| <u>38.020</u> | <u>38.020</u> | <u>38.020</u>     | <u>38.020</u> | <u>38.020</u> |               |
| + .834        | + 3.951       | -13.670           | -21.535       | - 4.419       |               |
| 88.033        | 85.678        | 79.158            | 62.065        | 68.231        |               |
| <u>70.412</u> | <u>70.412</u> | <u>70.412</u>     | <u>70.412</u> | <u>70.412</u> |               |
| +17.621       | +15.266       | +8.746            | -8.347        | - 2.181       |               |
| 88.045        | 85.670        | 79.179            | 62.096        |               |               |
| <u>70.436</u> | <u>70.436</u> | <u>70.436</u>     | <u>70.436</u> |               |               |
| +17.609       | +15.234       | + 8.743           | -8.340        |               |               |

Readings on two points: Apr. 1, '82.

| Reading              | Error                | Reading              | Error                | Diff. E.             |
|----------------------|----------------------|----------------------|----------------------|----------------------|
| .204                 | -1                   | .038                 | +1                   | 2                    |
| .205                 | 0                    | .035                 | -2                   | 2                    |
| .201                 | -4                   | .036                 | -1                   | 3                    |
| .206                 | +1                   | .036                 | -1                   | 2                    |
| .204                 | -1                   | .041                 | +4                   | 5                    |
| .210                 | +5                   | .029                 | +2                   | 3                    |
| .206                 | +1                   | .044                 | +7                   | 6                    |
| .204                 | -1                   | .032                 | -5                   | 4                    |
| .204                 | -1                   | .035                 | -2                   | 1                    |
| .205                 | 0                    | .036                 | -1                   | 1                    |
| $10 \overline{) 49}$ | $10 \overline{) 15}$ | $10 \overline{) 72}$ | $10 \overline{) 26}$ | $10 \overline{) 29}$ |
| 205                  | 1.5                  | .037                 | 2.6                  | 2.9 = Av. dev. betw. |

means of measurements between two points.

Taking the readings two & two as will be done in future we obtain the following means

| Reading             | Error                 | Reading               | Error  | Diff. of Errors  |
|---------------------|-----------------------|-----------------------|--------|------------------|
| .2045               | -.0005                | .0365                 | -.0005 | .0000            |
| .2035               | -.0015                | .0360                 | - 10   | .0005            |
| .2070               | +.0020                | .0400                 | + 30   | .0010            |
| .2050               | .0000                 | .0380                 | + 10   | .0010            |
| .2045               | -.0005                | .0355                 | - 15   | .0010            |
| $5 \overline{) 45}$ | $5 \overline{) 0070}$ | $5 \overline{) 0035}$ |        |                  |
| .205                | .0009                 | .0370                 | .0014  | .0007 = Av. dev. |

of measurements between two points. It is I think more accident that this result comes out so small. Probably the figure should be about doubled.

# Readings on two Stars. Maia and Targeta

| P.A.         | E.         |             | E.         |
|--------------|------------|-------------|------------|
| 13.599       | + .010     | 8.866       | + 2        |
| .586         | - 3        | .870        | + 6        |
| .606         | + 17       | .854        | - 10       |
| .564         | - 25       | .870        | + 6        |
| .590         | + 1        | .866        | + 2        |
| .591         | + 2        | .857        | - 7        |
| <u>63536</u> | <u>658</u> | <u>6383</u> | <u>633</u> |
| 13.589       | .0097      | 8.864       | .0055      |

## Maia and Asterope b

|              |             |             |            |
|--------------|-------------|-------------|------------|
| 1.036        | 18          | 17.596      | 1          |
| 1.002        | 16          | .593        | 2          |
| <u>1.017</u> | <u>1</u>    | <u>.596</u> | <u>1</u>   |
| 3 <u>55</u>  | 3 <u>35</u> | 3 <u>15</u> | 3 <u>4</u> |
| 1.018        | .0117       | 17.595      | .0013      |

## Maia and Asterope a

|             |             |              |             |
|-------------|-------------|--------------|-------------|
| 4.148       | 18          | 15.205       | 11          |
| .120        | 10          | .191         | 3           |
| <u>.123</u> | <u>7</u>    | <u>.187</u>  | <u>7</u>    |
| 3 <u>91</u> | 3 <u>35</u> | 3 <u>583</u> | 3 <u>21</u> |
| 4.1303      | .0117       | 15.194       | .0070       |

## Maia and Cassiopeia

|                |             |             |          |
|----------------|-------------|-------------|----------|
| 21.590         |             | 8.135       | 10       |
| 21.619         | 4           | .147        | 2        |
| .590           | 25          | .154        | 9        |
| <u>.635</u>    | <u>20</u>   | <u>.136</u> | <u>9</u> |
| 3 <u>1.844</u> | 3 <u>49</u> | 3 <u>21</u> |          |
| 21.615         | .0163       | 8.145       | .0070    |

## Maia and Electra.

| P.A.              | e                 | S                  | e                 |
|-------------------|-------------------|--------------------|-------------------|
| 19.408            | 11                | 24.633             | 7                 |
| .411              | 8                 | .646               | 6                 |
| .437              | 18                | .642               | 2                 |
| 3 $\overline{56}$ | 3 $\overline{37}$ | 3 $\overline{121}$ | 3 $\overline{15}$ |
| 19.419            | .0123             | 24.640             | .0050             |

## Maia and c

|                   |                   |                   |                   |
|-------------------|-------------------|-------------------|-------------------|
| 8.410             | 31                | 3.637             | 16                |
| .472              | 31                | .605              | 16                |
| 2 $\overline{82}$ | 2 $\overline{62}$ | 2 $\overline{42}$ | 2 $\overline{32}$ |
| 8.441             | .0310             | 3.621             | .0160             |

This last is evidently too faint for comparison, and will not be included with the others.

## Average deviations

| Name     | P.A.                 | S                    |
|----------|----------------------|----------------------|
| Taygeta  | .0097                | .0055                |
| Asterops | .0117                | .0013                |
| "        | .0117                | .0070                |
| Caetano  | .0163                | .0070                |
| Electra  | .0123                | .0050                |
|          | 5 $\overline{.0724}$ | 5 $\overline{.0313}$ |
|          | .0128                | .0052                |

Average deviations to be expected. The greater size of the P.A. is evidently due to the fact that the clock does not follow closely for as much as 60 sec., & that a double image is sometimes obtained due probably to ~~close~~ the jar incident to closing

the slide, and so to the images being <sup>possibly</sup>  
too near together. From the above facts  
it is safe I think to use the av. obs.  
of the declinations as a fair test for  
determining the errors of this method.  
Including the 60<sup>sec</sup> & the 5-sec. exposures both,  
this plate contains an unfavorable condition  
for the six stars as are likely to occur  
in practice.

## Plate 2.

P.A.

| Names.     | beginning to 180 sec. | end 180 sec. |
|------------|-----------------------|--------------|
| Asterope b | +0.864                | +0.834       |
| " a        | 3.998                 | 3.951        |
| Maria      | 0.000                 | 0.000        |
| Taygeta    | -13.668               | -13.670      |
| Celaeno    | 21.506                | 21.535       |
| c          | 3.981                 | 4.419        |

8

|            |         |         |
|------------|---------|---------|
| Asterope b | +17.621 | +17.609 |
| " a        | 15.266  | 15.234  |
| Maria      | 0.000   | 0.000   |
| Taygeta    | 8.746   | 8.743   |
| Celaeno    | -8.347  | -8.340  |
| c          | 2.181   | —       |

Readings on two Stars.  
Maria and Taygeta

| P.A.         | 2     | 8     | 2     |
|--------------|-------|-------|-------|
| 13.668       |       | 8.746 |       |
| .670         |       | 743   |       |
| 2 <u>138</u> |       | 8.744 | .0015 |
| 13.669       | .0010 |       |       |

## Maria &amp; Asterope b

|             |       |        |       |
|-------------|-------|--------|-------|
| 0.864       |       | 17.621 |       |
| .834        |       | .609   |       |
| <u>.849</u> | .0150 | 17.615 | .0060 |

## Maia + Asterope a

| P.A.        | $\alpha$ | $\delta$      | $\alpha$ |
|-------------|----------|---------------|----------|
| 3.998       |          | 15.266        |          |
| <u>.951</u> |          | <u>15.234</u> |          |
| 3.974       | .0235    | 15.250        | .0160    |

## Maia + Celano

|              |       |              |       |
|--------------|-------|--------------|-------|
| 21.506       |       | 8.340        |       |
| <u>15.35</u> |       | <u>8.347</u> |       |
| 21.520       | .0145 | 8.344        | .0035 |

## Maia + c

|       |                 |       |  |
|-------|-----------------|-------|--|
| 3.981 |                 | 2.181 |  |
| 4.419 | something wrong |       |  |

## Average deviations

| Name       | P.A.           | $\delta$       |
|------------|----------------|----------------|
| Taygeta    | .0010          | .0015          |
| Asterope b | .0150          | .0060          |
| " a        | .0235          | .0160          |
| Celano     | .0145          | .0035          |
|            | 4 <u>.0540</u> | 4 <u>.0270</u> |
|            | .0135          | .0068          |

As the stars on this plate are indistinct I did not expect them to come out as well as the other, and use it merely to corroborate the others accuracy in some measure.

As no especial pains was taken to orient the plates before measurement, the P.A. &  $\delta$  are only approximate, the distances between the stars however should come out the same on both plates.

Distances bet. the Stars meas. on diff. Plates.  
 Plate 1.  
 Maia and Targeta

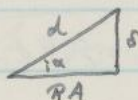
$$\log 13.589 = 1.132900$$

$$\begin{array}{r} 289 \\ \hline 1.133189 \end{array}$$

$$\begin{array}{r} 2 \\ \hline 2.266378 \\ 184.66 \\ \hline 184.66 \\ 146 \\ \hline 184.66 \end{array}$$

$$\log 8.864 = 0.947630$$

$$\begin{array}{r} 2 \\ \hline 1.895260 \\ 78.578 \\ \hline 184.66 \\ 263.23 \end{array}$$



$$\tan \alpha = \frac{s}{RA} \quad \sin \alpha = \frac{s}{d} \quad d = \frac{s}{\sin \alpha}$$

$$\begin{array}{r} 0.947630 \\ 1.133189 \\ \hline 9.814441 = \tan \alpha \\ 4406 \\ \hline 35 \end{array}$$

$$\alpha = 23^\circ 6' 58''$$

$$\begin{array}{r} \sin \alpha = 9.737435 \\ 24 \\ \hline 9.737459 \\ \log d = 1.210171 \\ d = 0051 \end{array}$$

$$d = 16.224$$

Maia and Antares

$$\log 1.018 = 0.007748$$

$$\begin{array}{r} \log s = 1.245390 \\ \log \sin \alpha = 9.999274 \\ \hline \log d = 1.246116 \\ 6006 \\ \hline 110 \end{array}$$

$$d = 17.625$$

$$\log 17.595 = 1.245266$$

$$\begin{array}{r} 124 \\ \hline 1.245390 \\ 0.007748 \\ \hline \log \tan \alpha = 1.237642 \\ 7300 \\ \hline 342 \end{array}$$

$$\alpha = 26^\circ 41' 20''$$

$$\log \sin \alpha = 9.999274$$

Maia and Asterope  $\alpha$ 

$$\lg 4.130 \quad 0.615950 \quad \lg 15.194 \quad 2.181558$$

$$\lg \delta = 1.181672$$

$$\lg \sin \alpha = 9.984521$$

$$\lg d = 1.197151$$

$$\underline{7005}$$

$$146$$

$$\alpha = 15.745$$

$$\underline{714}$$

$$1.181672$$

$$\underline{0.615950}$$

$$\lg \tan \alpha = 0.565722$$

$$\alpha = \underline{5670}$$

$$52$$

$$\alpha = 74 \quad 47 \quad 36$$

$$\lg \sin \alpha = 9.984518$$

$$\underline{3}$$

$$\lg \sin \alpha = 9.984521$$

## Maia and Carlsena

$$\lg 21.615 \quad 1.334655 \quad \lg 8.145 \quad 0.910891$$

$$\underline{100}$$

$$1.334755$$

$$\lg \delta = 0.910891$$

$$\lg \sin \alpha = 9.547304$$

$$\lg d = 1.363587$$

$$\underline{3424}$$

$$163$$

$$\alpha = 23.099$$

$$\lg \tan \alpha = 9.576136$$

$$\alpha = 20 \quad 38 \quad 51$$

$$\lg \sin \alpha = 9.547304$$

## Maia and Electra.

$$\log 19.419 \quad 1.288026$$

201

$$1.288227$$

$$\log \delta = 1.391641$$

$$\log \sin \alpha = 9.895093$$

$$\log d = 1.496548$$

$$65.15$$

33

$$\log 24.640 \quad 1.391641$$

$$1.288227$$

$$\log \tan \alpha = 0.103414$$

$$\alpha = 51 \quad 45 \quad 29$$

$$\log \sin \alpha = 9.895093$$

$$\alpha = 31.372$$

## Plate 2

## Maia and Targeta.

$$\log 13.669 \quad 1.135451$$

286

$$1.135737$$

$$\log \delta = 0.941710$$

$$\log \sin \alpha = 9.731487$$

$$\log d = 1.210223$$

$$0051$$

8172

$$\log 8.744 \quad 0.941710$$

$$1.135737$$

$$\log \tan \alpha = 9.805973$$

$$5951$$

22

$$\alpha = 32 \quad 36 \quad 25$$

$$\log \sin \alpha = 9.731487$$

$$\alpha = 16.226$$

## Maia and Asterops.

$$\log 0.849 \quad 9.928908$$

$$\log 17.615 \quad 1.245759$$

123

$$\log \delta = 1.245822$$

$$1.245882$$

$$\log \sin \alpha = 9.999497$$

$$9.928908$$

$$\log d = 1.246385$$

$$\log \tan \alpha = 1.316974$$

$$6252$$

$$6702$$

133

272

$$\alpha = 17.635$$

$$87 \quad 14 \quad 26$$

$$\log \sin \alpha = 9.999497$$

## Meria and Asterope a

$$\begin{array}{rcll}
 \log 3.974 & 0.599228 & \log 15.250 & 1.183270 \\
 \log \delta = 1.183270 & & & 0.599228 \\
 \sin \alpha = 9.985733 & & \log \tan \alpha & 0.584042 \\
 \log \alpha = 1.197537 & & \alpha = 75 & 23 & 39 \\
 & 7281 & \sin \alpha = 9.985733 & & \\
 & 256 & \alpha = 15.759 & & 
 \end{array}$$

## Meria and Celacno

$$\begin{array}{rcll}
 \log 21.520 & 1.332842 & \log 8.344 & 0.921374 \\
 & & & 1.332842 \\
 \log \delta = 0.921374 & & \log \tan \alpha & 9.588532 \\
 \sin \alpha = 9.558119 & & & 8504 \\
 \log \alpha = 1.363255 & & & 28 \\
 & 3236 & & \\
 & 19 & \alpha = 21 & 11 & 34 \\
 \alpha = 23.081 & & & 9.558095 & \\
 & & & 24 & \\
 & & \sin \alpha = 9.558119 & & 
 \end{array}$$

## Comparison of the two Plates

| Plates  | Targeta | Asterope b | Asterope a | Celacno | Electra |
|---------|---------|------------|------------|---------|---------|
| 1st     | 16.224  | 17.625     | 16.745     | 23.099  | 31.372  |
| 2d      | 16.226  | 17.635     | 15.759     | 23.081  | —       |
|         | 16.225  | 17.630     | 15.752     | 23.090  | 31.372  |
| Av. dev | -.0010  | -.0050     | -.0070     | +.0090  |         |

Av. dev. of all.

.0010

.0050

.0070

.0090

4 | 0220

## Results of Work.

## Average Deviations.

## Measurement of two Points.

Let  $n$  be the number of observations coupled in sets of  $m$  each, of which the means are taken.

Let  $r$  be the number of different points compared, in the present case always 2. Let  $d$  = av. dev. found

Then the average deviation of each separate observation will be  $\frac{d \sqrt{m}}{\sqrt{r}}$  and the number of results in the column compared  $\frac{\sqrt{r} m}{m r}$ .

The av. dev. of each set  $m$  will be  $\frac{d}{\sqrt{r}}$ .

## Measurement of the Dist. bet. two Points

$$d = .0007 \quad m = 2 \quad r = 2 \quad n = 20.$$

av. dev. of each obs. = .0007, of each set .0005

Probably  $d$  should equal .0014 making the others .0004 & .0010 respectively.

## Measurement of the Dist. bet. two Stars on the same Plate.

$$d = .0052 \quad m = 2 \quad r = 2 \quad n = \cancel{54} 72 \text{ or would}$$

be if Maia had been observed 36 times instead of 9, as it ought to have been.

av. dev. of each obs. = .0052, of each set .0037

Measurement of the Dist. bet. two Stars on diff. Plates.  
 $d = .0055$   $m = 42$   $k = 2$   $n = 120$  or would if  
 each plate had been observed on 3 points instead  
 of one 3 and the other 2 and if Maia had  
 been observed 60 times instead of 12., and Tay-  
 geta 12 times instead of 9.

Av. dev. of each obs.  $.0055$  of each set  $.0039$

Each obs. here so called really involves 2 made  
 at right angles. The ~~max~~ error of each one  
 of these is a minimum when the diff  
 of  $RA =$  the diff of  $S$  & is a max  
 when either reaches 0 therefore the average  
 places are ~~at~~  $22.5^\circ$  &  $67.5^\circ$ ,  $\cos 22.5 = \sin 67.5 = .924$   
 $.924 \times .0055 = .0051$  which is nearly the same  
 as that found for two stars on the same  
 plate. Hence the conclusion is that errors  
 no 1 (page 2) would appear to be of no account  
 on these two particular plates.

The Average Deviation of two settings <sup>each</sup>,  
 in either  $RA$  or  $S$  (supposing errors equal), on two  
 stars, either on the same or different plates  
 is  $.0052 \times \frac{1}{2}$  inches.  $= .00026$  inches  $.00026 \div .000267$   
 (see p. 1)  $= 1$  And therefore this average dev. corresponds  
 to a parallax of  $.1''$ . The Prob. Error of 20 such  
 settings  $= \frac{.83 \times \text{av. dev.}}{\sqrt{10}} = .26 \times \text{av. dev.} = \frac{\text{av. dev.}}{4} = .025''$  or  
 an error in  $\frac{1}{10} = 3.16$  the setting of  $.05''$

Most probable values of the distances from  
Maia to the other stars observed.

The first plate has 3 objects observed to 2 on  
the second & as the points are better defined  
I give it double weight excepting for Taygeta  
where these points were observed twice & therefore  
it has 4 times the weight. I am inclined  
to think the first plate ~~and last~~ <sup>I suppose also</sup>  
the second moved a little during the observations.

1st Plate.

|                              |        |        |        |
|------------------------------|--------|--------|--------|
| 1st settings on Maia in R.A. | 38.110 | 37.268 | 36.233 |
| 2d " " " "                   | 38.083 | 37.260 | 36.211 |
|                              | + .027 | + .008 | + .022 |

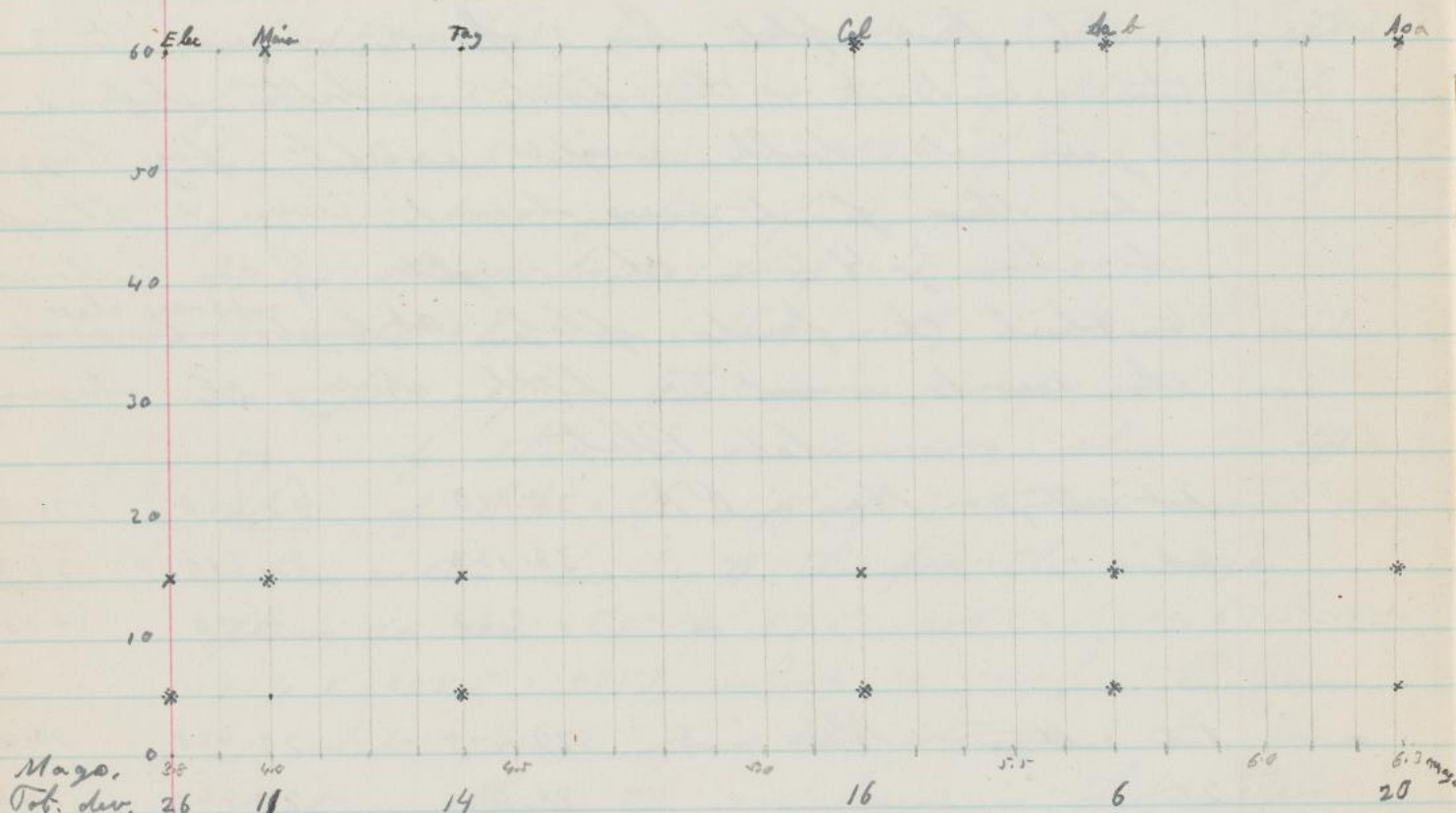
|                                  |        |        |        |
|----------------------------------|--------|--------|--------|
| 1st settings on Maia in $\delta$ | 70.419 | 70.428 | 70.429 |
| 2d " " " "                       | 70.422 | 70.440 | 70.439 |
|                                  | - .003 | - .012 | - .015 |

|                                 |        |        |        |
|---------------------------------|--------|--------|--------|
| 1st settings on Taygeta in R.A. | 24.511 | 23.682 | 22.627 |
| 2d " " " "                      | 24.519 | 23.670 | 22.620 |
|                                 | - .008 | + .012 | + .007 |

|                                     |        |        |        |
|-------------------------------------|--------|--------|--------|
| 1st settings on Taygeta in $\delta$ | 79.285 | 79.298 | 79.278 |
| 2d " " " "                          | 79.292 | 79.306 | 79.296 |
|                                     | - .007 | - .008 | - .018 |

|            | $\frac{1}{100}$ | inches             |                                                                          |
|------------|-----------------|--------------------|--------------------------------------------------------------------------|
| Taygeta    | 16.224          | .8112 $\pm .0002$  | The prob.<br>errors, all<br>taken roughly from<br>the no. obs. on p. 15. |
| Asterope b | 17.628          | .8814 $\pm .0003$  |                                                                          |
| " a        | 15.749          | .7874 $\pm .0003$  |                                                                          |
| Celaeno    | 23.093          | 1.1546 $\pm .0004$ |                                                                          |
| Electra    | 31.372          | 1.5686 $\pm .0004$ |                                                                          |

Av. dev. in S of the stars on Plate 1  
 placed in the order of magnitude.



\* Means least av. dev. x next smallest • largest.

Probably the best exposure is about 5 sec.

for mag. 4th mag. star. On these lists of times  
 give the best exposure, the least visible <sup>and measurable</sup> time, and the longest that can be conveniently used for measurement. This latter is not mag. vis. well determined. Inclosed is a table of times necessary for the fainter mags, particularly for stars near the pole.

| Mag. | best time | vis.  | can use |
|------|-----------|-------|---------|
| -1   | .1        |       | .8      |
| 0    | .2        |       | 2       |
| +1   | .3        |       | 5       |
| 2    | .8        | .2    | 12      |
| 3    | 2         | .3    | 30      |
| 4    | 5 sec     | .8    | 80      |
| 5    | 12        | 2     | 3 min   |
| 6    | 30        | 5     | 8       |
| 7    | 80        | 12    | 20      |
| 8    | 3 min     | 30    | 50      |
| 9    | 8         | 80    | 2 h     |
| 10   | 20        | 3 min | 5 h     |
| 11   |           |       | 12 h    |
| 12   |           |       | 20 h    |
| 13   |           |       | 50 h    |
| 14   |           |       | 2 h     |
| 15   |           |       | 5 h     |
| 16   |           |       | 12 h    |







## Spectrum Photography.

Apr. 24, '83.

Record of photographs of the Spectrum.

Mar. 16. Found that one could photograph red end spectrum by taking photo. through red glass. Used Elliott spectroscope with  $60^\circ$  prism & 1 piece red glass. Made notch on head of screw of slit which when closed was  $\ominus$  in this position. Moved screw  $\ominus$  through  $10^\circ$ .

No 1. From 2.5-0. exp. 10 min. Reached A

Set up an apparatus in the lecture room using a lecture room prism & a cheap burning lens of about 7 inches focus. No spectroscope at all. Used slit of Portulanium.

No. 7. Mar. 22. 1.05-1.20 slit  $\frac{1}{8}$  inch 3 pieces glass. Dev. 14 minutes.

No 8. 1.30-1.45 slit  $\frac{1}{8}$  bisulphide prism.

No 9. 2.30 for 2 m 30 s slit  $\frac{1}{16}$  1 curtain of room up. Bisulphide prism. dev. 10

No. 10. 2.5-0 for 2 m 30 s slit  $\frac{1}{8}$  glass prism dev. 10. (As far as 112), As far as

No 11 3.30 3 m slit  $\frac{1}{8}$  glass prism dev. 15-

" 12 3.50 10 m " " " " bisulph + iodine instead of 3 red glasses.

No 13 5.00 4 m slit  $\frac{1}{8}$  & 2 m slit  $\frac{1}{4}$  Bisulph + iodine & for 2 m slit  $\frac{1}{4}$  also 3 red glasses.

No 14 Mar. 24 slit  $\frac{1}{16}$  1.15 30 sec. 2 glasses (lightest) dev. 15- focus  $3\frac{5}{16}$  inches from end of camera (99 faintly) slit same.

No 15 1.15 3 min 3 glasses focus  $3\frac{5}{16}$  slit same.

|         |      |        |                                    |                        |
|---------|------|--------|------------------------------------|------------------------|
| ✓ No 16 | 1.27 | 3 min  | focus $3\frac{5}{16}$              | 15 min obs. (94 faint) |
| ✓ 17    | 1.31 | "      | " $3\frac{5}{16}$                  | " "                    |
| 18      | 1.45 | "      | " $3\frac{3}{16}$                  | " "                    |
| 19      | 1.49 | "      | " $3\frac{0}{16}$                  | " "                    |
| 20      | 2.15 | 5 sec. | slit $\frac{1}{8}$ $3\frac{8}{16}$ | 8 der 1 glass          |
| 21      | 2.17 | 10 "   | " $\frac{1}{16}$ "                 | " "                    |

G in focus at  $3\frac{14}{16}$  F at  $3\frac{7}{16}$  H 4(?) B  $3\frac{8}{16}$  (?)

|       |      |        |                                      |                      |
|-------|------|--------|--------------------------------------|----------------------|
| No 22 | 2.50 | 3 sec  | slit $\frac{1}{32}$ $3\frac{10}{16}$ | 15 der 1 glass       |
| 23    | 2.50 | 12 min | " $3\frac{6}{16}$                    | " "                  |
| ✓ 24  | 3.15 | 15 min | " $3\frac{6}{16}$                    | " 3 (94+112)         |
| 25    | 4.18 | 15 "   | $\frac{1}{16}$ $3\frac{6}{16}$       | " 3 Spill-           |
| ✓ 26  | 4.43 | 15 "   | $\frac{1}{16}$ $3\frac{6}{16}$       | " 6 glasses (94+112) |

Date unknown Used other lens.

|      |      |        |                                          |                 |
|------|------|--------|------------------------------------------|-----------------|
| ✓ 27 | 2.05 | 15 "   | $\frac{1}{32}$ $1\frac{1}{4}$            | " 3 best of all |
| 28   | 2.25 | ditto  | absorbed by yellow flint glass [6 in (?) |                 |
| 29   | 2.45 | "      | " white crown "                          | [5 in (?)       |
| 30   | 3.15 | 30 min | $\frac{1}{32}$ $1\frac{7}{8}$ 15 "       | 3               |

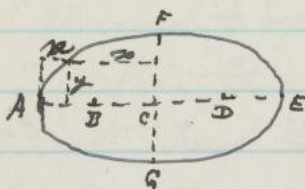
Date unknown

|    |      |        |                                  |               |
|----|------|--------|----------------------------------|---------------|
| 31 | 1.30 | 1 sec  | $\frac{1}{32}$ $1\frac{7}{8}$ 10 | 3 East. Spec. |
| 32 | "    | "      | " " 15                           | " Rich. Inst. |
| 33 | 1.38 | 15 min | " " 3                            | " East. Spec. |
| 34 | 1.55 | "      | " " 15                           | " Rich. Inst. |

Used spectrocope 1 red glass (lightest) with condenser lens.  
 Apr 18 37 3.00 5 min position screw 18° Rich Inst.  
 Reached past A.  
 38 3.30 15 min 1 red glass (deepest) screw 90°  
 i.e. notch at top. Rich Inst.

# Curves for Spectroscope Lenses.

May 1, '83.

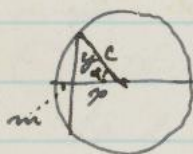


$$AC = a \quad FC = b \quad BC = f$$

When  $AE : BD = N : 1$  there is no spherical aberration. Brewster p. 54

$$h^2 = a^2 - f^2 \quad (1) \quad p = a \sqrt{1 - \frac{f^2}{h^2}} \quad \underline{m = a - p = a(1 - \sqrt{1 - \frac{f^2}{h^2}})} \quad (2)$$

$N = \text{index refraction} = 1.6$



$$p + m = c \quad p^2 + y^2 = c^2$$

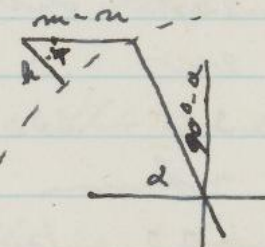
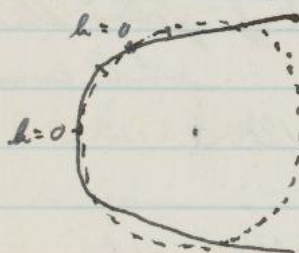
$$p^2 + 2mp + m^2 = c^2 = p^2 + y^2 \therefore$$

$$2mp + m^2 = y^2 \therefore p = \frac{y^2 - m^2}{2m}$$

$$c = p + m = \frac{y^2 - m^2}{2m} + \frac{2m^2}{2m} = \frac{y^2 + m^2}{2m} \quad (3)$$

$$(4a) \sin \alpha = \frac{y}{c}$$

$$\underline{m = c - c \cos \alpha = c(1 - \cos \alpha)} \quad (4)$$



$$h = (m - p) \cos \alpha$$

$$(5) \underline{h = \cos \alpha (m - p) = \cos \alpha [c(1 - \cos \alpha) - a(1 - \sqrt{1 - \frac{f^2}{h^2}})]}$$

$h$  is assumed = 0 when  $y = 0 + 1.7$ . To find  $h$  when  $y = 1.4 + 2.0$ .

$$y_1 = 1.0 \quad y_2 = 1.4 \quad y_3 = 1.7 \quad y_4 = 2.0$$

$$\underline{y_1 = 1.0 \quad y_2 = 1.5 \quad y_3 = 2.0}$$

$$a = 8. \quad \therefore \quad \therefore \quad \therefore \quad b^2 = 64 - 25 = \underline{39} \quad f(1) \quad y=1$$

$$Q(2) \quad u_1 = 8 \left( 1 - \sqrt{1 - \frac{1}{39}} \right) = 8 \left( 1 - \sqrt{\frac{38}{39}} \right) \quad y_1^2 = 1.0^2 = 1.00$$

$$u_2 = 8 \left( 1 - \sqrt{\frac{37.04}{39}} \right) \quad y_2^2 = 1.4^2 = 1.96$$

$$u_3 = 8 \left( 1 - \sqrt{\frac{36.11}{39}} \right) \quad y_3^2 = 1.7^2 = 2.89$$

$$u_4 = 8 \left( 1 - \sqrt{\frac{35}{39}} \right) \quad y_4^2 = 2.0^2 = 4.00$$

$$f_{38} = 1.579784 \quad f_{37.04} = 1.568671$$

$$f_{39} = 1.591065 \quad f_{39} = 1.591065$$

$$\begin{array}{r} 2 \overline{) 19.988719} \\ 9.994350 \\ \hline .98710 \\ 1.00000 \\ \hline .01290 \\ \hline 8 \\ \hline u_1 = .10328 \end{array}$$

$$\begin{array}{r} 2 \overline{) 19.977606} \\ 9.988803 \\ \hline .87822 \\ .974539 \\ \hline 1.00000 \\ \hline .02545 \\ \hline 8 \\ \hline u_2 = .20360 \end{array}$$

$$f_{36.11} = 1.557627 \quad f_{35} = 1.544068$$

$$f_{39} = 1.591065 \quad f_{39} = 1.591065$$

$$\begin{array}{r} 2 \overline{) 19.966562} \\ 9.983281 \\ \hline .65 \\ .962246 \\ \hline 1.00000 \\ \hline .03786 \\ \hline 8 \\ \hline u_3 = .30208 \end{array}$$

$$\begin{array}{r} 2 \overline{) 19.953003} \\ 9.976502 \\ \hline .64888 \\ .94733 \\ \hline 1.00000 \\ \hline .05267 \\ \hline 8 \\ \hline u_4 = .42136 \end{array}$$

$$O_3(3) \quad c = \frac{y^2 + m^2}{2m}$$

$$\text{Scaling } m = m_3 = .30208 + j_3 = 1.7$$

$$f y m = 9.480007$$

115-

$$9.480122$$

2

$$8.960244$$

$$m^2 = .09125$$

$$y_3^2 = 2.89000$$

$$2.98125$$

$$f(y^2 + m^2)$$

$$f y^2 + m^2 = 0.474362$$

36

$$0.474398$$

$$f(2m = .60416) = 9.781152$$

$$9.781109$$

43

$$9.781152$$

$$0.693246$$

$$3199$$

47

$$4.9345 = c$$

$$O_3(4) \quad m = c(1 - \cos \alpha) \quad + f(4a) \quad \sin \alpha = \frac{z}{c}$$

$$f y_1 = 0.000000$$

$$f c = 0.693243$$

$$9.306757$$

$$\alpha_1 = 11^\circ 41' 30''$$

$$f c = 0.693199$$

44

$$0.693243$$

$$f y_2 = 0.146128$$

$$f c = 0.693243$$

$$9.452885$$

$$\alpha_2 = 16^\circ 29' 00''$$

$$f y_4 = 0.301030$$

$$f c = 0.693243$$

$$9.607797$$

$$\alpha_4 = 23^\circ 54' 40''$$

$$f y_3 = 0.230449$$

$$f c = 0.693243$$

$$9.537206$$

$$\alpha_3 = 20^\circ 9' 10''$$

$$1.000000$$

$$\cos \alpha_1 = .97922$$

$$(1 - \cos \alpha_1) = .02078$$

$$f(1 - \cos \alpha_1) = 8.317646$$

$$f c = 0.693243$$

$$9.010889$$

$$9.010889$$

$$1.000000$$

$$.95890$$

$$.04110$$

$$8.613842$$

$$0.693243$$

$$9.307085$$

$$9.307085$$

$$1.000000$$

$$.93879$$

$$.06121$$

$$8.786822$$

$$0.693243$$

$$9.480065$$

$$9.480065$$

$$1.000000$$

$$.91414$$

$$.08586$$

$$8.933791$$

$$0.693243$$

$$9.627034$$

$$9.627034$$

$$D_z(5) h = \cos \alpha (m-n)$$

|                           |                      |                      |                      |
|---------------------------|----------------------|----------------------|----------------------|
| $m_1 = .10254$            | $-.20281$            | $.30204$             | $.42368$             |
| $m_1 = \underline{10320}$ | $\underline{.20360}$ | $\underline{.30208}$ | $\underline{.42136}$ |
| $-.00066$                 | $-.00079$            | $-.00004$            | $+ .00232$           |
|                           |                      |                      | $\underline{.914}$   |
|                           |                      |                      | $928$                |
|                           |                      |                      | $232$                |
|                           |                      |                      | $\underline{2088}$   |

.0021215 inches

$$y_r^2 = 1.85^2 = 3.4225$$

$$m_5 = 8 \left( 1 - \sqrt{\frac{30.5775}{39}} \right)$$

|                                                                                        |                                                                                                                                                                                          |
|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $\begin{array}{r} 185 \\ 185 \\ \hline 925 \\ 1480 \\ 185 \\ \hline 34225 \end{array}$ | $\begin{array}{r} 30.5775 = 1.551169 \\ \hline 1.551175 \\ \hline 39 = 1.591065 \\ \hline 2 \overline{) 19.960110} \\ 9.980055 \\ \hline .95511 \\ 1.00000 \\ \hline .04489 \end{array}$ |
|----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

$$m_r = .35912$$

$$m_r = .39160$$

$$m_r = .35912$$

$$.03248$$

$$m_r = .35992$$

$$m_r = .35912$$

$$.00080$$

$$\sin \alpha = \frac{z}{c}$$

$$z = 0.267172$$

$$c = 0.693243$$

$$9.573929$$

$$\alpha_r = 22^\circ 1' 10''$$

$$\cos \alpha_r = 9.967106$$

$$\text{nat } \cos \alpha_r = .92706$$

$$1.00000$$

$$(1 - \cos \alpha_r) = .07294$$

$$8.862966$$

$$c = 0.693243$$

$$9.556209$$

$$.39160 \quad .35992$$

m-n

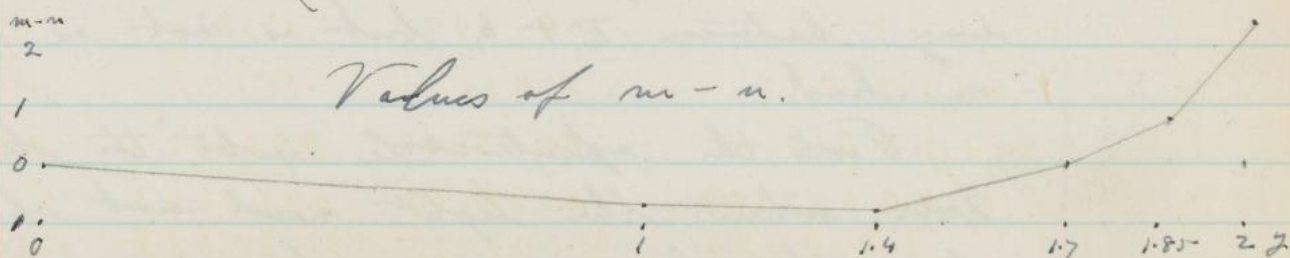
2

1

0

0

Values of m-n.



# Measurements of Slit.

Position of notch on head of screw of slit

| Position notch | Aperture | Difference in general 80°<br>for 90° |
|----------------|----------|--------------------------------------|
| 0°             | 15"      |                                      |
| 30°            | 1' 0"    |                                      |
| 90°            | 1' 40"   |                                      |
| 180°           | 3' 0"    |                                      |
| 360°           | 5' 40"   |                                      |

Placed the rear edge of the back frame of the camera 5 inches from the end of the base board.

Apr. 26, '83.

| No | Hour | Exp. | Placed before slit | Position of notch | Dev. | Col.         | Deviation |
|----|------|------|--------------------|-------------------|------|--------------|-----------|
| 39 | 1.25 | 5 m  | 30° prism          | 90°               | 10 m | Red          |           |
| 40 | 1.32 | 5    | Slight red glass   | "                 | "    | "            |           |
| 41 | 2.07 | 10   | "                  | 360               | "    | "            |           |
| 42 | 2.40 | 15 s | prism              | 30                | 2    | Yellow green |           |

Apr 27, '83

|    |       |       |              |    |       |               |  |
|----|-------|-------|--------------|----|-------|---------------|--|
| 43 | 12.20 | 15 s  | Yellow glass | 30 | 5     | 2 + 8         |  |
| 44 | 12.30 | 4     | "            | "  | "     | "             |  |
| 45 | 1.10  | 10    | Nothing      | "  | 2 1/2 | violet + blue |  |
| 46 | 1.20  | 5 min | red          | "  |       | 205° "        |  |

Spectra transmitted through red glass stops at D line. Through yellow glass stops at half way between F + b, but is not as sharply marked.

Took the spectroscope into the lecture room where the light need not have to pass through 1 window glass + 2 mirror glasses

May 1st '83

| No | Hour | Exp             | Before Shift | Ang. notch | Dev.            | Deviation    |
|----|------|-----------------|--------------|------------|-----------------|--------------|
| 47 | 3.00 | 15 <sup>m</sup> | red glass    | 720°       | 15 <sup>m</sup> | 214° 15' red |

May 2d.

|    |      |                |                  |      |    |          |
|----|------|----------------|------------------|------|----|----------|
| 48 | 3.45 | 15             | red glass        | 180° | 15 | 215° 15' |
| 49 | 4.10 | "              | shut hard rubber | "    | "  | "        |
| 50 | 4.40 | 3 <sup>m</sup> | red glass        | "    | "  | "        |

May 3d

|    |      |                 |             |      |    |          |
|----|------|-----------------|-------------|------|----|----------|
| 51 | 1.25 | 10 <sup>m</sup> | red glass   | 180° | 10 | 213° 20' |
| 52 | 5.06 | 15              | hard rubber | "    | 15 | "        |

Spectrum Work in New Photographic Laboratory,  
with large 4 in. prism & lens made by the  
Clarks & using the 4 in. Bowditch (?) Comet Lens  
as a collimator.

Dec. 22, 1883.

Plate 1 Glib screw  $45^\circ$  Prism about 43 on scale Dev 5 min  
Focus at 72  
Medium 2 red glasses. Hour 12.35 to 12.45.

The condensing lens is only half covered by  
the mirror.

| Focus | Exp. | Focus | Exp. | Focus | Exp. |
|-------|------|-------|------|-------|------|
| 72    | 6 s  | 73    | 6 s  | 74    | 6 s  |
| "     | 60 s | "     | 60 s | "     | 60 s |

All out of focus.

Plate 2 Glib  $45^\circ$  Prism 43 Medium 2 r Hour 1.20 to 1.27.

| Focus | Exp. | Focus | Exp. | Focus | Exp. |
|-------|------|-------|------|-------|------|
| 60    | 15 s | 61    | 60 s | 63    | 60 s |
| "     | 60 s | 62    | "    | 64    | 15 s |

Plate 3 ~~45~~ Prism 40 2 r 1.50 - 2.07

| Glib        | Focus | Exp. | Glib    | Focus | Exp. | Glib    | Focus | Exp. |
|-------------|-------|------|---------|-------|------|---------|-------|------|
| $45^\circ$  | 64    | 1 m  | 2 turns | 61    | 1 m  | 4 turns | 61    | 8 m  |
| $180^\circ$ | 61    | "    | 4 "     | "     | 2 m  |         |       |      |

Dec. 28, '83.

Plate 4 Glib 5 turns Prism 40 2 r 11.55 - 12.15

| Focus | Exp.  | Focus | Exp.  | Focus | Exp.  |
|-------|-------|-------|-------|-------|-------|
| 61    | .4 s  | 62    | 125 s | 64    | 120 s |
| "     | 150 s | 63    | 170 s |       |       |

Plate 5 Glib 5 Prism 40 Focus 62.5 12.40 - 1.10

Swing-back inclined about  $20^\circ$   Exp. 2 m.

Sun for 10 min. from 12.53 - 1.03 behind Trinity

Focus Medium. (1) 2 r. (2)  $CS_2$  & I 4 times dil. (3) Hard rubber  
1/100 in. thick in motion (4) smoked glass (5) 1 r.

Plate 6 Slit 2 r. Exp. 2 m Hour 1.55

Rubber in contact with film

" " " " [Rubber ground thin?]

Dec. 29, '83.

Plate 7 Swing-back  $15^\circ \approx 1/4$  inch as above. 1.05-1.30

|     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|
| Exp | Med | Exp | Med | Exp | Med |
|-----|-----|-----|-----|-----|-----|

|     |             |     |     |     |       |
|-----|-------------|-----|-----|-----|-------|
| 2 m | hard rubber | 2 m | 2 r | 3 s | 2 g r |
|-----|-------------|-----|-----|-----|-------|

|   |               |   |                     |  |  |
|---|---------------|---|---------------------|--|--|
| 2 | smoked glass* | 2 | $CS_2$ dil 4 times† |  |  |
|---|---------------|---|---------------------|--|--|

\* Buildings faintly outlined against blue sky

† Could see window frames

Plate 8 Focus 61 2.00-2.15

|     |     |     |     |     |     |
|-----|-----|-----|-----|-----|-----|
| Exp | Med | Exp | Med | Exp | Med |
|-----|-----|-----|-----|-----|-----|

|     |     |     |     |     |               |
|-----|-----|-----|-----|-----|---------------|
| 2 m | 2 r | 3 s | 2 r | 2 m | $CS_2$ + 1 r. |
|-----|-----|-----|-----|-----|---------------|

|   |             |     |        |  |  |
|---|-------------|-----|--------|--|--|
| 2 | hard rubber | 2 m | $CS_2$ |  |  |
|---|-------------|-----|--------|--|--|

Observations by J. H. Hutchings.

Feb. 29, '84.

Plate 9 Focus 61.5 Exp 2 m Slit 4 Prism 45 11.30-12.15

Hazy with passing clouds.

thick asphalt med. asphalt. thin asphalt

2 r r. blue. thin asphalt = or slightly  
lighter than r. b.

Condensing lens is  $3/4$  covered by mirror.

Mar. 10, '84.

Plate 11 Focus 60 Slit 4 12-12.35 Bright & Sunny

See next page.

| Exp  | Med  | Slit | Source | Exp | Med | Slit | Slit |
|------|------|------|--------|-----|-----|------|------|
| 2 m  | none | 4    | Candl  | 2 m | 2 r | 2    | Jun  |
| 2    | 2 r  | 4    | Jun    | 2   | 2 r | 1    | "    |
| 20 m | none | 4    | Candl  |     |     |      |      |

Plate 12 Focus 61.5 - Slit 1 10. - 11. Hazy

| Exp | Med | Exp | Med       | Exp | Med     |
|-----|-----|-----|-----------|-----|---------|
| 4 m | 2 r | 4 m | r b       | 4   | rubber, |
| 2   | 1 r | 4   | asp. thin |     |         |

Plate 10 Focus 61.5 - Slit 4 Exp. 2 m Hazy 12.50 -  
 yellowish green r bluish green r r y b y. yel g.

Plate Mar 31, '84.

| Plate  | 13    | 61.5 - | red red & | Juny | Dec 10. | 10 - |
|--------|-------|--------|-----------|------|---------|------|
| 240 s  | 240 s | 60 s   | 15 - 5    | 4 s  |         |      |
| slit 4 | 1     | 1      | 1         | 1    |         |      |

Plate 14 61.5 slit 1 11.30  
 2d 24 s red blue 3d 60 s hard rubber 4th 240 s hard rubber  
 rubber .01 inch thick.

April, 14, '84.

Plate 14 11.30 61.5 slit 1 Juny Rubber .005 in  
 1st 300 sec h.r. 2d 60 sec h.r. 3d 300 sec h.r. 4th 60 sec r r  
 spoiled. screen off side of film

Plate 15 61.5 12.30

60 sec. slit 1 r r. 1200 sec slit 4 rubber.

Apr. 16, '84.

Plate 16 61.5- 11.30- slit 1 Cloudy. Prism moved

120 sec stop 10 medium red

30 .1 —

120 10 yg

120.5- .1 —

120 10 rr

Plate 17 61.5- 12.50 slit 1 Cloudy prism 50

120 10 red Sunny.

10 .1 — Cloudy

30 10 yg

60 10 rr

15- .1 rr

Apr. 29, 84 N.H.P.

Trans 61.5- Prism 45- 10.45-

Plate 18

rr 2 min. slit 1

rubber 8 min 4

r b 2 1

rubber " "

rubber 2 1

rrrr 4 1

} same spectra by mistake

Plate 19

rr 2 m 1

" 30 s "

" 7 1/2 s "

Plate 20

Inglis Plate rr 2 m slit 1

May 3, '84. Sunny

Plate 21 Ingle Sun as independently deter-  
 r b 2 m slit 1 mined not much more than  
 rubber 8 4 half as active as usual,  
 r r 2 1 when equally clear.  
 rubber 2 1  
 r r 8  $\frac{1}{3}$

## Notes + Remarks May 5, '84.

Plate 1 Out of focus.

Plate 2 One mm. is enough to vary focus  
 slit  $\frac{1}{8}$  exp. 1 m. reaches .9 calling A O.

Plate 3 No Yellow end. A reverse direct ends.

|   |      |   |                |                |     |
|---|------|---|----------------|----------------|-----|
| 1 | -4.  | 0 | <del>1.2</del> | <del>1.7</del> | 2.0 |
| 2 | -4.  | 0 | 1.3            | 1.7            | 2.3 |
| 3 | -4.7 | 0 | 0.8            | 2.0            | 2.3 |
| 4 | -5.0 | 0 | 0.4            | 2.7            | 3.2 |
| 5 | -5.1 | 0 | 0.3            | 3.0            | 3.6 |

Taken through r r. The equivalent exposures  
 with the alb. set at 1 would be,

8 s    30 s    2 m    8 m    32 m

In the last two the alb. was really  
 set at 4 yet the A line comes out  
 very distinctly in each.

Prism should be set at 40. The length of the  
 exp.

Although A is distinct the other lines do not  
 appear.

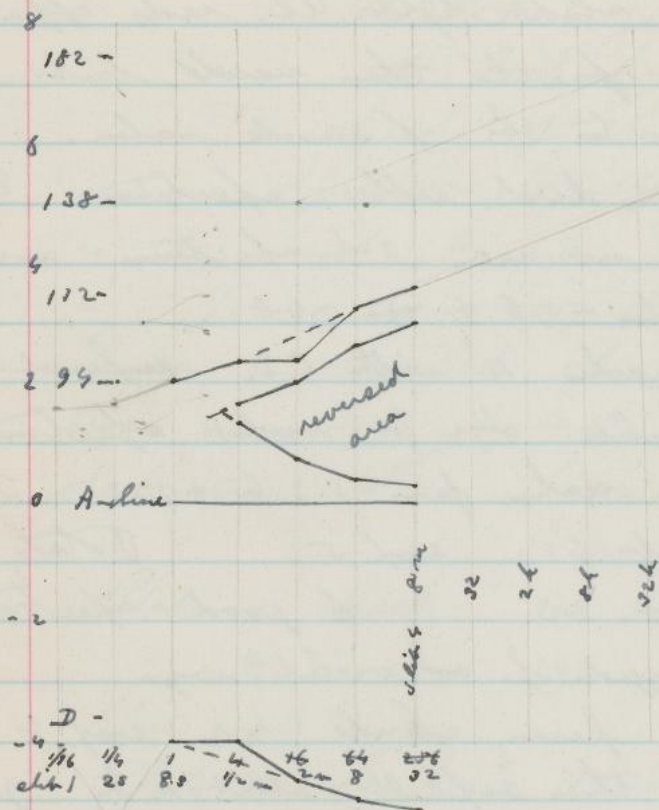


Plate 4 The focus is not <sup>near</sup> so good though set at from 61 to 64. 62 is perhaps the best. slit 5 instead of 4. The first was taken with exp. 14 sec + slit 5. Plotting on above curve the reading (1.7) it falls in line with the others from plate 3. But the other <sup>and extends to 5.3</sup> Plate 5 First spectrum with exp. 10 min slit 1 reaches 5! 2d with C.S. + I reaches 2 3d with rubber two inch thick about 4 (1) 4th did not appear 5th with 1 red also about 5. but fogged badly so that 2 is the best of these media. This must have been a remarkably good day or a most uncommon plate. Reverses from 13 to 2.6 as usual. First spectrum reaches other way to -5.8. Latest Dec. 20, '23. 12.15. No other lines.

Plate 6 Exposed to white light, the reds apparently not carried further than usual but results too uncertain to be of much value.

Plate 7 Characteristic hard rubber spectrum. Smoked glass is of no use. 3rd spectrum with exp. 5- reaches  $-5.6$  &  $+5.7$  &  $+4.8$   
4th spect reaches 4. with  $CS_2$  exposed I think to white light due to violet spectrum.

Plate 8 1st r.r. reaches from  $-5.3$  to  $+5.3$  In good focus again at 61 exp 5- Total length rubber spect. 3.3 A good spectrum with  $CS_2$  but fogged by violet rays.

Plate 9 Hazy with passing clouds r.r. exp 8 ready 3 r.b. and thin asphalt - about r.b. gave about same values <sup>(2.5)</sup> but A line not so distinct. A line poor again in r.r. No reversals

Plate 10 The yellow-green & yellow glasses transmit at least 4 times the  $\delta$  actinic effects of the r.r.

Plate 11 The 5th spectrum was in pretty good focus <sup>(60)</sup> The candle spectrum did not go beyond the A line.

Plate 12 Focus poor (61.5) This plate was a for one.

Plate 13 A line clearest on least exposed ( $1/6$ ). Spect. reaches 1.6 and  $-4.0$  - about the same as with 4 times the exposure.

Plate 14 The red blue combination goes 1.6 either way. exp. 4 The rubber gives faint spect at exp 4 reaching about 1.3 roughly. At exp 1 no satisfactory spect. is visible.

Plate 15 Spoiled

Continued on page 81

## Photomicrography.

Dr. B. Richards.

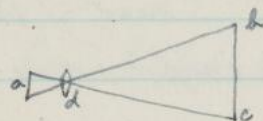
The object of this investigation is to compare various objectives together, and determine which is the best to use for the various magnifying powers employed. It is planned to use it as a method of comparison of their relative excellency, and at the same time to determine their foci.

Mar 19, '84.

Plate 1 Beck 1" 4s Proboscis of *Oryz. Powell.* <sup>P<sub>max</sub> .50.</sup>  
 " 2 " 14s " " " "

Blue solution

Plate 3 Beck 1" 40 diam Reading 79.3 Cor. 68.0 Exp 4s  
 Henderson Plate Mar 21 Stage Micrometer Focus 1.66 cm <sup>.65</sup>  
 Plate 4 Unknown 1" 40 112.4 101.1 1s  
 Henderson Mar 21 Stage Micrometer 2.46 cm = <sup>.96</sup>  
 Plate 5 Unknown 8/10 40 92.3 81.0 1s  
 Henderson Mar 21 Stage Microm. 1.97 = <sup>.77</sup> in



$$a : bc = ad : dc \therefore a + bc : a = ad + dc : ad$$

$$41 : 1 = 68 : ad$$

$$\therefore ad = 1.66 \text{ cm} \times .394 (= \times .40 + \text{then subtract } \frac{1}{10} \times .02)$$

Correction of millimeter scale = -11.3 cm

Plate 6 Mar 24 Powell in future unless otherwise stated.

Hartnack #2 40 diam. 1s *Pleurosigma formosum*

Reading 120 Cor. 108.7 Focus 2.65 cm = 1.04 in. Bazy.

Plate 7 Mar 24 Hart #2 40 d. Blue sol. 60s *Pleu. form.*

Pls

Plate 8 " " " " 20s " "

Plate 9 Darb single full spectrum no. mag. negative 4x5-

Cloudy 15-min.

Plate 10 Apr. 11 Hartnack #2 Cloudy Cotton fiber dry.

Distance 105. Exp. 3 sec

Plate 11 Ditto Exp. 5 sec.

Plate 12 Apr 14 Sunny Pleurosigma formosum

Beck 1 in. 5 sec. 79.8 Chem focus 2.2 cms outside.

Plate 13 Ditto 8/10 inch 1 sec dish 92.3

Chem focus 3 cms. outside.

Plate 14 Apr. 21 Cloudy Beck 1 in Cotton fiber

web. 5 sec. 79.8 focused at 77.0 with argand lamp  
& mirror. Exp. by daylight.

Plate 15 Ditto exp. 15-sec.

Plate 16 Ditto Linen fiber web 30 sec.

82.0 same focus at microscope. Good.

Apr. 23, '84.

Plate 17 Sunny Beck 1 in 100 diam = reading 175.5

gave correction  $\frac{50}{100} = 6$  cms. Exp. 30 s daylight

Overexposed bad focus.

Plate 18 Sunny Beck 1 in ready 185-

correction 20 cms  $\frac{1}{4}$  exp. 15-sec. Sun

off 7°

Apr 25, '84.

Cloudy Beck 1" 40 diam

Plate 19 Woollen dish 79.3 exp 30

focus back over exposed.

Plate 20 Woollen fiber dish 84 exp 15 excellent.

Plate 21 silk dish 84 exp 15

Apr. 28, '24.

Sunny Hartnack #2 100 diam reading 280.  
*Plenusigma formosum*.

Plate 22 focused at 250 exp 4 sec.  
 Indistinct

Plate 23 focused 265 exp 5 sec.  
 Indistinct but better.

Apr 30, '24.

Same conditions. Taken by W. H. S.  
 Plate 24 focused 272 exp 5 sec.  
 Indistinct. Not so clear.

May 1, '24.

Sunny Beck 1/4" 100 diam. focused 66.  
*Plenusigma formosum* (D.B. Richards)

Plate 25 ~~focused~~ set 61 exp 15 sec.

Plate 26 57.5 10

Plate 27 57.5 10 refocused at 61.

Concluded that the reading should be 61.

25 & 27 are equally well focused

Plate 28 Beck 1/4" 250 diam *Plenus. formos.*

|         |     |        |            |
|---------|-----|--------|------------|
| focused | set | exp    |            |
| 143     | 134 | 60 sec | Sun 3° off |

|          |     |     |    |     |
|----------|-----|-----|----|-----|
| Plate 29 | 148 | 134 | 30 | " " |
|----------|-----|-----|----|-----|

This was the best. It was a sharper view. Concluded that for the center of the field the opt light focus was 8 cms outside & that for the edges it was 9 cms inside. Hence practically light + active







# Colored Media for the Light in the Dark Room.

Mar. 25, '84.

The object of this investigation is to determine which of several media will give the least fog for an equal distinctness of vision, using both gas and daylight as sources. Then to measure the relative light transmitted and the spectra of the lights. Also to try the effect on different makes of plate & ~~to~~ have the light observed by different persons.

Tried a Rowell plate and covered it with a paper having 21 holes.

Daylight ~~4 ft. from~~ <sup>High trail</sup> ~~light~~ <sup>light</sup>

Daylight (cloudy sky)

Mar 25

Mar 26

| No                                      | Hour  | Dist    | Corrected | Exp. | Medium.              | No | Hour  | Dist | Exp. |
|-----------------------------------------|-------|---------|-----------|------|----------------------|----|-------|------|------|
| 1                                       | 12.30 | 130 cms | 164       | 4 m  | red glass            | 21 | 11.08 | 221  | 4 m  |
| 2                                       | .45   | 90      | 124       | "    | red + ground         | 20 | .00   | 91   | "    |
| 3                                       | .56   | 33      | 67        | "    | red red              | 19 | 10.53 | 74   | "    |
| 4                                       | 1.18  | 120     | 154       | "    | red gel              | 18 | .46   | 115  | "    |
| 5                                       | 1.40  | 162     | 196       | "    | gel gel <sup>x</sup> | 17 | .38   | 198  | "    |
| 6                                       | .49   | 48      | 82        | "    | gel green            | 16 | .24   | 182  | "    |
| 7                                       | .56   | 104     | 138       | "    | gel violet           | 15 | .10   | 92   | "    |
| 8                                       | 2.09  | 30      | 64        | "    | Cashett paper        | 14 | 9.5-4 | 13   | "    |
| 9                                       | .17   | 56      | 90        | "    | gel paper            | 13 | .45   | 24   | "    |
| 10                                      | .25   | 66      | 100       | 15   | nothing              | 12 | .35   | 100  | 15   |
| Unprotected from diffused light of room |       |         |           |      |                      | 11 | 11.16 | 221  | 4 m  |

<sup>x</sup> This particular yellow was a brown orange the other were ~~be~~

The window used with the gaslight measured  $18 \times 15$  cms and was situated 34 cms from the gas flame. The third column in the preceding table gives the distance from the window, and the fourth, from the gas flame. It is possible that for the colored papers the situation of the screen may make a difference.

The window used with daylight measured  $13 \times 13$  cms. Direct light of the clouds was used.

The plate was developed in fresh developer for 10 min.

The distances ~~denoted~~ given were those at which some very light pencil lines drawn about ~~4.0~~<sup>1 mm.</sup> apart could just be distinguished. In cases 10 and 12 100 cms was selected.

Mar 26 '84.

Exposed a plate through red gel. to gas light and dev. 10 min in developer 50 min. old.  
Exposed 2 squares at a time

1 s. 2 4 8 15 30 s 1 m. 2 4 min.

Dist plate from gas 50 cms or 16 cms from window.

May 9, '24.

The yellow green + violet glasses were unfortunately broken but have been matched as nearly as possible. The <sup>new</sup> violet is a trifle bluer + lighter, the yellow a little darker + the green a little lighter, but all the

|              |         |      |      |      |     |                           |
|--------------|---------|------|------|------|-----|---------------------------|
| the old      | yy      | 1.43 | 1.77 | 3240 | 254 |                           |
| Higgins (201 | y gd    | 1.09 | 1.43 | 286  |     |                           |
| ments with   | r       | .59  | .93  | 186  | 149 | below.                    |
|              | r gd    | .38  | .72  | 143  | 123 | right W.H.P.              |
|              | y fch   | .25  | .59  | 108  | 82  | Medium                    |
|              | r y     | .185 | .525 | 105  | 144 | +10. red                  |
|              | r y y   | .153 | .493 | 99   |     | +1. red green             |
|              | y y     | .135 | .475 | 95   | 108 | -20. red red              |
|              | r y gd  | .111 | .451 | 90   | 88  | +7. red yel               |
|              | r r     | .098 | .438 | 88   | 86  | -23. yel yel              |
|              | r fch   | .071 | .411 | 82   | 61  | -24. yel gre              |
|              | r y fch | .030 | .370 | 75   | 44  | +3. yel viol              |
|              |         |      |      |      |     | +5. Carbutt spec.         |
|              |         |      |      |      |     | +10 yel fch.              |
|              |         |      |      |      |     | -31 red yel fch           |
|              |         |      |      |      |     | range } red yel green     |
|              |         |      |      |      |     | than his } gre + yel fch. |

Mr. Higgins figures are probably the most reliable as he took two settings for each, to my one, + he remained in the dark room all the time, while I had frequently to go out into the bright light.

May 9, '24.

The yellow green + violet glasses were unfortunately broken but have been matched as nearly as possible. The new violet is a trifle bluer + lighter, the yellow a little darker + the green a little lighter, but all the differences are small. Before the old glasses were broken Mr. E. E. Higgins (201 Gean) made a series of measurements with the gas flame on Apr. 20, as given below.

| No | Dist     | Dist | Mean | Corrected Higgins | Corrected W.H.P. <del>Higgins</del>      | % Medium |                |
|----|----------|------|------|-------------------|------------------------------------------|----------|----------------|
| 1  | 115      | 115  | 115  | 149               | 164                                      | +10.     | red            |
| 2  | 90       | 88   | 89   | 123               | 124                                      | +1.      | red green      |
| 3  | 51       | 52   | 52.5 | 86                | 67                                       | -20.     | red red        |
| 4  | 111      | 108  | 110  | 144               | 154                                      | +7.      | red yel        |
| 5  | 220      | 221  | 220  | 254               | 196                                      | -23.     | yel yel        |
| 6  | 72       | 75   | 74   | 108               | 82                                       | -24.     | yel gre        |
| 7  | 98       | 102  | 98   | 134               | 138                                      | +3.      | yel viol       |
| 8  | 27       | 27   | 27   | 61                | 64                                       | +5.      | Carburetor gas |
| 9  | 47       | 50   | 48   | 82                | 90                                       | +10      | yel fox.       |
| 10 | 10       | 9.5  | 10   | 44                |                                          | -31      | red yel fox    |
| 11 | 55       | 54   | 54   | 88                | {On the average}                         |          | red yel green  |
| 12 | too dark |      |      |                   | {my readings were 3.4% smaller than his} |          | gre + yel fox. |

Mr. Higgins figures are probably the most reliable as he took two settings for each, to my one, + he remained in the dark room all the time, while I had frequently to go out into the bright light.

May 9<sup>th</sup> 14.

Mr Higgins on a cloudy afternoon May 8 made the following readings with the new glasses by the light of the sky. He used the same sized window as before.

|              | ready | ready | corrected | W.H.P. |
|--------------|-------|-------|-----------|--------|
| red          | 103   | 105.5 | 106       | 221    |
| ground + red | 27.5  | 27.   | 27        | 91     |
| yel yel      | 196   | 223   | 218       | 198    |
| yel green    | 104   | 97.   | 100       | 182    |

These readings are so utterly discordant as to be entirely untrustworthy. Probably mine are the best as they were made under more favorable circumstances than those I made with the gas flame.

It will be noticed that the effect of the ground glass is much more pronounced than with the gas flame. With the latter the light was cut down as follows:-

|        | W.H.P. | Higgins | Though the two      |
|--------|--------|---------|---------------------|
| Sun    | 25     | 23      | last figures do     |
| Clouds | 59     | 74      | not agree, still    |
|        |        |         | the effect produced |

is very marked.

The above discordance may be due to varying light from the clouds.













## Sensitometer Experiments.

Apr. 21, '24.

Have been experimenting since about April 1st  
of Ag Cl. Finally placed it in a paper  
cell between two slides of glass & half  
covered with piece of black paper. De-  
cided to use a scale made of tissue paper  
instead of glass.

1st Exp. Dried impure Ag Cl 10 min. <sup>Glass scale</sup> Ready 5-  
" pure Ag Cl " " 10

Hence Ag Cl C.P. must be used.

2d Exp. Exp. 5 min. Glass scale. Ready 7  
" 10 " 10

3d " 5 " 10  
" 2 1/2 " 5

4th " 3 " 4  
" 1 1/2 " 1

5th Apr. 12 " 2 " Tissue paper scale 0  
" 4 " 3

No 1 <sup>Powell</sup> Powell plate 8 " 7-8  
No 2 <sup>Powell</sup> Powell plate 2 " 10  
" 5-7

Apr. 14.

|                   |       |                                                                                         |
|-------------------|-------|-----------------------------------------------------------------------------------------|
| Ag Cl             | 6     | 4                                                                                       |
| No 3 Powell       | 100 3 | { without black paper on<br>wrong side of<br>glass.<br>Developer fresh.<br>Dev. 13 min. |
| " Carb. spec      | "     |                                                                                         |
| " Rich stand      | "     |                                                                                         |
| " Blair tri       | "     |                                                                                         |
| " Carb. exp. ref. | "     |                                                                                         |
| Ag Cl             | 8     | 6                                                                                       |

Apr. 21, '84.

Cloudy, tried the plates by lamp light exposing them to the brightest part of an alcohol lamp flame burning about 5-ft. per hour.

|    |                                          |      |        |                |       |
|----|------------------------------------------|------|--------|----------------|-------|
| 6  | Rowell                                   | 2 m. | Dev 7  | Remarks Ready  | 4     |
| 8  | Blair <sup>Apr. 19 '83</sup> (small box) | "    | " 10   |                | 4     |
| 9  | Blair Jan 83                             | "    | "      | imperfect      | 3     |
| 10 | Rich stem 83                             | "    | "      |                | 3 (?) |
| 11 | Carb. spec. '81                          | "    | "      |                | 1 (?) |
| 12 | Carb. spec. 83                           | "    | "      | half of it bad | 0     |
| 13 | Inglis Jan 84                            | 1 m  | Dev 10 |                | 6     |
| 14 | East spec. 83 Mon?                       | "    | "      |                | 0     |
| 15 | Cramer '83                               | "    | "      |                | 1 (?) |
| 16 | Monroe '83                               | "    | "      |                | 0     |
| 17 | Whit + Wain '82                          | "    | "      |                | 0     |
| 18 | Beebe '82                                | 2 m  | 10     | bad.           | 0     |
| 19 | Monckhousen '82                          | "    | "      | rather bad     | 3     |
| 20 | Rich Inst May 82                         | "    | "      | rather bad     | 0     |
| 21 | Beebe '83                                | "    | "      |                | 0     |
| 22 | Edwards '82                              | "    | "      | bad            | 0     |
| 23 | Inglis                                   | 4 m  |        |                | 10    |
| 24 | East spec '83 Mon?                       | "    |        |                | 10    |
| 25 | Cramer                                   | "    |        |                | 7     |
| 26 | Monroe                                   | "    |        |                | 5 (?) |
| 27 | Whit + Wain                              | "    |        |                | 3     |

These plates bet. 8 and 22 which were most sensi-

time to <sup>gas</sup> candle light took the longest time to dry. ~~Ready~~ Every 0 plate, and ~~most~~ all the subtletest plates save #9 & 15, dried 15 or 20 min. before these two, or any of the certain plates did which showed markings. No 13 which was much the most sensitive plate, took at least an hour longer than the others to dry.

Apr. 28, '84. Gas flame.

|    |                         |           |        |                           |
|----|-------------------------|-----------|--------|---------------------------|
| 28 | Powell                  | 3 m. 10.5 | Dev 10 | Remarks: Dark box Ready 6 |
| 29 | Blair Jan 83            |           |        | Sparked                   |
| 30 | Monckhoven              |           |        | Hazy 5-                   |
| 31 | Cramer                  |           |        | Hazy 5-                   |
| 32 | Carbutt Trans. '84 Apr. |           |        | poor 0 (?)                |
| 33 | Rich Land '83           | 6 min     | 5- 10  | 0                         |
| 34 | Carb. Exp. '81          |           |        | 0                         |
| 35 | Carb. Spec. Dec '83     |           |        | 0 - 7.5                   |
| 36 | Carb. Spec. Apr '84     |           |        | 0                         |
| 37 | Monroe                  |           |        | 0                         |
| 38 | Webb & Wain '82 (?)     | 12 min    | 5- 10  | 0                         |
| 39 | Rich Inst. May '82      |           |        | 0                         |
| 40 | Beebe '83               |           |        | 0                         |
| 41 | Edwards                 |           |        | 0                         |

May 2, 84 Exposed to Gas flame of  
W. H. P.

| No | Plate           | Exp | Wt      | Dev.  | Reading |
|----|-----------------|-----|---------|-------|---------|
| 42 | Rich. H. Stand. | 30s | 3.16 mm | 15-in | 0       |
| 43 | Carb. Spec.     |     |         |       | 3       |
| 44 | Monroe          |     |         |       | 7       |
| 45 | Wiat & Wain     |     |         |       | 0       |
| 46 | East Spec.      |     |         |       | 8       |

|    |              |    |      |    |         |
|----|--------------|----|------|----|---------|
| 47 | Rich. Instr  | 30 | 3.16 | 10 | spoiled |
| 48 | Beebe        |    |      |    | 3       |
| 49 | Edwards      |    |      |    | spoiled |
| 50 | Carb. Trans. |    |      |    | 0       |

~~51~~

| 10.00 May 3, 84. Campbell. Blue Sky. Reading |              |    |    |    |        |     |
|----------------------------------------------|--------------|----|----|----|--------|-----|
|                                              |              |    |    |    | Water  | Dry |
| 51                                           | Rowell       | 3m | 5- | 10 | 0      | 0   |
| 52                                           | Marshall     |    |    |    | 4      | 3   |
| 53                                           | Carb. Trans. |    |    |    | 0      | 0   |
| 54                                           | Blair        |    |    |    | poor 3 | 4   |
| 55                                           | Rich. Stand  |    |    |    | 0      | 0   |

10.15

|    |              |    |    |    |        |    |
|----|--------------|----|----|----|--------|----|
| 56 | Carb. Spec.  | 2m | 5- | 10 | 2      | 4  |
| 57 | Monroe       |    |    |    | poor 3 | 4  |
| 58 | East Spec.   |    |    |    | 7      | 7  |
| 59 | Wiat & Wain. |    |    |    | 4      | 4  |
| 60 | Inglis       |    |    |    | 10 (?) | 10 |

| 10.30          |            |       |      |       |               |     |
|----------------|------------|-------|------|-------|---------------|-----|
| No.            | Plate      | Exp.  | Stk  | Dev.  | Reading       |     |
|                |            |       |      |       | web           | dry |
| 61             | Monckhoven | 90s   | J-   | 10    | bad           | bad |
| 62             | Cramer     |       |      |       | 9             | 10  |
| 63             | Beebe      |       |      |       | 10            | 10  |
| 64             | Rich Inst. |       |      |       | 5             | 4   |
| 65             | Edwards    |       |      |       | bad           | 1   |
| W.H.P.         | Tried      | Ag Cl | 16 m | 8 (?) | 10.55 - 11.10 |     |
| "              | "          | "     | 8    | J-    | 11.25 -       |     |
| 12.45 - W.H.P. |            |       |      |       |               |     |
| 66             | Inghis     | 410s  | J-   | 10    | 3             | 3   |
| 67             | Cramer     |       |      |       | 6             | 7   |
| 68             | Beebe      |       |      |       | 7             | 6   |
| 69             | Monck.     |       |      |       | J-            | 7   |
| 70             | Edwards    |       |      |       | bad 2         | 3   |











# On the Speed of Falling Bodies.

Nov. 8, 1884.

Took four photos yesterday numbered 1 2 3 & 4  
 & measured one <sup>(photo 1)</sup> today on Dividing Engine. Found  
 afterwards that measurements were very incorrect  
 owing to defective construction and placing of in-  
 strument. 1st, means 1st measurement of upper  
 front thread. 2nd, " 3d " " second  
 rear " " " "

Under "curve" 1<sup>st</sup> means mid-  
 dle of upper ~~see~~ distinctly separate vibrations  
 photographed. The plate was turned so that  
 the direction of fall was nearly parallel  
 to the <sup>very</sup> screw of engine & then corrections  
 made for the middle of the curves by  
 the transverse screw. Half vibrations are

counted thus under curve "4" is ~~not~~ 1/2 double vib.  
 later than "3". The "(?)" means there was some  
 difficulty in making the measurement accurate,  
 usually due to superposition of image of scale.

|                  | 1            | 2            | 3            | 4            | 5            |
|------------------|--------------|--------------|--------------|--------------|--------------|
| 1 <sub>a</sub> , | 55.764       | 56.799       | .779         | 783          | 762          |
| 1 <sub>f</sub> , | 55.286       | 55.390       | .381         | 374          | 354          |
|                  | <u>1.478</u> | <u>1.409</u> | <u>1.398</u> | <u>1.409</u> | <u>1.408</u> |

|                     |      |                       |      |
|---------------------|------|-----------------------|------|
| 1 <sub>f</sub> to 0 | .674 | 0 to 1 <sub>a</sub> , | .804 |
| 1 <sub>f</sub> " "  | .593 | " " 1 <sub>a</sub> ,  | .816 |
| 1 <sub>f</sub> " "  | .602 | " " 1 <sub>a</sub> ,  | .806 |

From above consideration I shall assume 55.354 as the correct reading for instead of 1<sub>f</sub>, & insert it instead below. After making the complete set which will follow later

| I include the following readings. |         |       |          |              |           |
|-----------------------------------|---------|-------|----------|--------------|-----------|
| each reading                      | reading | diff  | 1/2 diff | mean reading | 1st diff. |
| 1 <sub>f</sub>                    | 55.390  | 1.409 | .704     | 56.094       |           |
| 2                                 | 56.799  |       |          |              | 4.007     |
| 2 <sub>f</sub>                    | 59.570  | 1.062 | .531     | 60.101       |           |
| 2                                 | 60.632  |       |          |              | 3.929     |
| 3 <sub>f</sub>                    | 63.685- | .690  | .345-    | 64.030       |           |
| 2                                 | 64.375- |       |          |              | 4.005-    |
| 4 <sub>f</sub>                    | 67.85-1 | .367  | .184     | 68.035-      |           |
| 4                                 | 68.218  |       |          |              | 3.981     |
| 5 <sub>f</sub>                    | 72.016  | .000  | .000     | 72.016       |           |
| 5                                 | 72.016  |       |          |              | 4.027     |
| 6 <sub>a</sub>                    | 75.857  | .371  | .186     | 76.043       |           |
| 6 <sub>f</sub>                    | 76.228  |       |          |              | 3.994     |
| 7 <sub>a</sub>                    | 79.695  | .686  | .343     | 80.037       |           |
| 7 <sub>f</sub>                    | 80.320  |       |          |              | 3.982     |
| 8 <sub>a</sub>                    | 83.477  | 1.084 | .542     | 84.019       |           |
| 8 <sub>f</sub>                    | 84.561  |       |          |              | 4.072     |
| 9 <sub>a</sub>                    | 87.365- | 1.433 | .716     | 88.081       |           |
| 9 <sub>f</sub>                    | 88.798  |       |          |              |           |

| Scale reading | reading | diff  | 1/2 diff | mean reading | lat diff |
|---------------|---------|-------|----------|--------------|----------|
| 10 r          | 91.235  | 1.792 | .896     | 92.131       | 4.050    |
| +<br>+        | 93.027  |       |          |              |          |

## Complete set of Readings.

| Scale | Curve | Reading | diff + + r                  | 1/2 diff       | mean reading (curve - no. reading) | Curve at each          |
|-------|-------|---------|-----------------------------|----------------|------------------------------------|------------------------|
| 1 +   |       | 55.354  | <del>+410</del>             | <del>705</del> | <del>56.059</del>                  |                        |
|       | top   | .960 ?  | reading - top reading in cm | 1 + r = 9.1    | 3.94                               | -.094                  |
|       | 1     | 56.275  | 67                          |                |                                    |                        |
|       | 2     | 342     | 13.382                      |                | 477                                | 10 92.131              |
|       | 3     | 422     | 80 9.5                      |                | 578                                | 1 56.094               |
|       | 4     | 523     | 101 116                     |                | 45                                 | 36.037 801             |
|       | 5     | 636     | 113 9.676                   |                | 360                                | 37                     |
|       | 6     | 758 ?   | 122 1.88                    | 5 + r = 13.1   | .844                               |                        |
| 12    |       | 764     | 133                         |                |                                    |                        |
|       | 7     | 891     | 33 931                      |                | 1.163                              | measures on scale .801 |
|       | 8     | 57.057  | 166 232                     |                |                                    | ∴ .001 division on     |
|       | 9     | 207     | 150 38                      |                |                                    | scale = 1.249 cms.     |
|       | 10    | 395     | 188 141.435                 |                |                                    |                        |
|       | 11    | 569     | 174 359                     | 10 + r = 23.1  | 1.792                              |                        |
|       | 12    | 765     | 196 12                      |                |                                    |                        |
|       | 13    | 949     | 185 32                      |                |                                    |                        |
|       | 14    | 58.165  | 216 5                       |                |                                    |                        |
|       | 15    | 376     | 211 2.416                   | 15 + r = 23.1  | 3.018                              |                        |
|       | 16    | 609     | 602                         |                |                                    |                        |
|       | 17    | 848     |                             |                |                                    |                        |
|       | 18    | 59.088  |                             |                |                                    |                        |
|       | 19    | 366     |                             |                |                                    |                        |
| 2 +   |       | 541     | +064                        | .502           | 60.073                             |                        |
|       | 20    | 627     | 3.667                       | 20 + r = 23.1  | 4.581                              |                        |
|       | 21    | 935     | 914                         |                |                                    |                        |
|       |       |         |                             |                | .138                               | 21.45 + r              |

## Readings continued.

| Leah Curve Reading | diff + + +<br>reading - top reading | 2nd diff<br>reading - 1st reading | 3rd diff<br>reading - 2nd reading | corrected |
|--------------------|-------------------------------------|-----------------------------------|-----------------------------------|-----------|
| 22 60.240          |                                     |                                   |                                   |           |
| 23 570 ?           |                                     |                                   |                                   |           |
| 24 605-            |                                     |                                   |                                   |           |
| 29 900             |                                     |                                   |                                   |           |
| 30 63.187          | 7.227<br>11.809                     | 30 + 7 = 37.1                     | 9.028                             |           |
| 31 603 (?)         |                                     |                                   |                                   |           |
| 35 660             | -695                                | -548                              | 64.008                            |           |
| 32 64.027          |                                     |                                   |                                   |           |
| 32 355             |                                     |                                   |                                   |           |
| 33 461 ?           |                                     |                                   |                                   |           |
| 34 906             |                                     |                                   |                                   |           |
| 39 67.335          |                                     |                                   |                                   |           |
| 45 820             |                                     |                                   |                                   |           |
| 40 841 ?           | 11.881<br>2.895                     | 68.008<br>40 + 7 = 48.1           | 14.841                            |           |
| 42 68.195          |                                     |                                   |                                   |           |
| 41 .400            |                                     |                                   |                                   |           |
| 46 71.305          |                                     |                                   |                                   |           |
| 47 901             |                                     |                                   |                                   |           |
| 55+2 72.017        |                                     |                                   |                                   |           |
| 48 532             | 16.572<br>4.130                     | 48 + 7 = 55.1                     | 20.702                            |           |
| 52 75.155          |                                     |                                   |                                   |           |
| 53 785 ?           |                                     |                                   |                                   |           |
| 62 840             | -373                                | -486                              | 76.026                            |           |
| 65 76.213          |                                     |                                   |                                   |           |
| 56 501             |                                     |                                   |                                   |           |
| 58 79.414          |                                     |                                   |                                   |           |
| 72 686             | -691                                | -346                              | 80.032                            |           |
| 59 80.173          |                                     |                                   |                                   |           |
| 75 577             |                                     |                                   |                                   |           |



| Obs.<br>Dist in cm. | Obs.<br>Vibs. |    | Theoretical<br>Dist in cm. | Corrected<br>Dist in cm. | Corrected<br>Vibs. | Diff |
|---------------------|---------------|----|----------------------------|--------------------------|--------------------|------|
| .494                | 8.0           | 1  | .154                       | .094                     | 4.4                | .06  |
| .578                |               | 3  | .326                       | .178                     | 6.4                | .14  |
| .844                | 13.0          | 5  | .548                       | .444                     | 8.4                | .10  |
| 1.163               |               | 7  | .83                        | .763                     | 10.4               | .07  |
| 1.792               | 18.0          | 10 | 1.392                      | 1.392                    | 13.4               | .00  |
| 3.018               | 23.0          | 15 | 2.62                       | 2.618                    | 18.4               | .00  |
| 4.181               | 28.0          | 20 | 4.23                       | 4.181                    | 23.4               | .05  |
| 9.028               | 38.0          | 30 | 8.62                       | 8.628                    | 33.4               | -.01 |
| 14.841              | 48.0          | 40 | 14.56                      | 14.441                   | 43.4               | .12  |
| 20.702              | 56.0          | 48 | 20.40                      | 20.302                   | 51.4               | .10  |
| 31.179              | 68.0          | 60 | 31.03                      | 30.779                   | 63.4               | .25  |
| 36.241              | 73.0          | 65 | 36.12                      | 35.841                   | 68.4               | .28  |
| 41.662              | 78.0          | 70 | 41.61                      | 41.262                   | 73.4               | .35  |
| 47.481              | 83.0          | 75 | 47.45                      | 47.081                   | 78.4               | .37  |

$$s = \frac{gt^2}{2} \quad \text{For } \frac{1}{252} \text{ sec } g = \frac{980}{252} \therefore s = \frac{980}{60504 \times 2} = .007726^2$$

$$\begin{array}{r}
 504 \overline{) 980} \quad (1.944 \quad 12.7000) \quad 980.000 \quad (.00772 \\
 \underline{504} \phantom{000} \\
 4760 \phantom{00} \\
 \underline{4536} \phantom{00} \\
 2240 \phantom{00} \\
 \underline{2016} \phantom{00} \\
 2240
 \end{array}
 \quad
 \begin{array}{r}
 910 \\
 \underline{889} \\
 210
 \end{array}
 \quad
 .01544 = s$$

To determine the correct starting point in distance and the correct number of vibrations,  $y$  = unknown dist.  
 $s = \frac{gt^2}{2} \quad (y + s) = \frac{g}{2} (t + p)^2 \quad p = \text{vibs.}$

$$(y + s_2) = \frac{g}{2} (t_2 + p)^2$$

$$(y + s_1) = \frac{g}{2} (t_1 + p)^2$$

$$(s_2 - s_1) = \frac{g}{2} [(t_2 + p)^2 - (t_1 + p)^2] = \frac{g}{2} (t_2^2 + 2t_2p - t_1^2 - 2t_1p)$$

$$\frac{(s_2 - s_1) 2}{g (2(t_2 - t_1))} + \frac{t_1^2 - t_2^2}{2(t_2 - t_1)} = p$$

$$p = \frac{(s_2 - s_1)}{g(t_2 - t_1)} + \frac{t_1^2 - t_2^2}{2(t_2 - t_1)}$$

$$y = \frac{g}{2} (t_2 + p)^2 - s_2$$

$s$  = dist in cm from assumed top.

$t$  = assumed number of the vibration

Determination of  $\gamma$ 

$$s_1 = .494 \quad t_1 = 1$$

$$s_2 = .844 \quad t_2 = 5$$

$$s_3 = 1.792 \quad t_3 = 10$$

$$s_4 = 3.018 \quad t_4 = 15$$

$$s_5 = 4.581 \quad t_5 = 20$$

$$\gamma = \frac{(s_2 - s_1)}{g(t_2 - t_1)} - \frac{t_2^2 - t_1^2}{2(t_2 - t_1)}$$

$$g \Rightarrow s = \frac{gt^2}{2} \therefore g = \frac{2s}{t^2}$$

for  $s=1$  cm &  $t=1$  sec  
at Boston when  $s = 1$  cm &  $t = 1$  sec

$$g = \frac{2s}{t^2} = \frac{2 \times 490}{1^2} = 980 \text{ cm/sec}^2 \therefore g \approx \frac{1}{2}$$

$$g = \frac{980}{21-2^2} = \frac{980}{63504} = .01544 = g \therefore$$

$$\gamma = \frac{(s_2 - s_1) \times 64.8}{9264} = \frac{.350 \times 64.8}{9264} = \frac{22.68}{9264} = .00244$$

$$\gamma = \frac{s_2 - s_1}{4} + \frac{-24}{8} = \frac{.350 \times 64.8}{4} - 3 = 5.67 - 3 = 2.67$$

$$\begin{array}{r} .350 \\ 16.2 \\ \hline 21.600 \\ 350 \\ \hline 5.6700 \\ 64.8 \\ \hline .948 \\ 5184 \\ 2592 \\ \hline 518404 \\ 122966 \\ \hline 4854.8 \\ .245 \\ \hline 3240 \\ 2592 \\ \hline 1296 \\ 158760 \\ 125 \\ \hline 3.38 \end{array}$$

$$\gamma = \frac{s_2 - s_1}{5} = \frac{.948 \times 64.8}{5} - \frac{75}{10} = 4.38 - 7.5 = -3.12$$

$$\gamma = \frac{s_4 - s_3}{5} = \frac{1.225 \times 64.8}{5} - \frac{125}{10} = 3.38 - 12.5 = -9.12$$

$$\gamma = \frac{s_5 - s_4}{5} = \frac{1.563 \times 64.8}{5} - \frac{175}{10} = 2.78 - 17.5 = -14.72$$

$$\begin{array}{r} 64.8 \\ .313 \\ \hline 1944 \\ 648 \\ \hline 1944 \\ 202824 \\ 175 \\ \hline 2.78 \end{array}$$

$$y = \frac{g}{2} (10 + 3.4)^2 - 1.793$$

$$y = .00772 \times 179.56 - 1.793 = -.41$$

$$y = .00772 \times 338.56 - 3.018 = -.40$$

$$\begin{array}{r} .00772 \\ 180. \\ \hline 61760 \\ 772 \\ \hline 138960 \\ 179 \\ \hline -.41 \end{array} \quad \begin{array}{r} .00772 \\ 339. \\ \hline 6948 \\ 2316 \\ \hline 2316 \\ 261708 \\ 3.018 \\ \hline .401 \end{array}$$

Nov. 15-84.

The following observations were made on Plate 1a

| Vib      | 1       | 2   | 3   | 4   | 5   | 6   | 7   | 8       | 9 | 10   |
|----------|---------|-----|-----|-----|-----|-----|-----|---------|---|------|
| Readings | 109.066 | 149 | 246 | 365 | 625 | 780 | 920 | 110.099 |   | .280 |
| "        | .071    | 147 | 249 | 366 | 621 | 784 | 924 | 1103    |   | .285 |
| "        | .067    | 151 | 249 | 360 | 628 | 783 | 926 | 1104    |   | .287 |
| Average  | 109.068 | 149 | 248 | 364 | 625 | 782 | 923 | 110.102 |   | .284 |

| Vib | Reading | Diff. Reading | Diff. in ins. | Diff. vib. |
|-----|---------|---------------|---------------|------------|
|-----|---------|---------------|---------------|------------|

|    |         |                |       |    |
|----|---------|----------------|-------|----|
| 12 | 110.670 | 1.602<br>1.499 | 2.001 | 11 |
|----|---------|----------------|-------|----|

|    |         |                |       |    |
|----|---------|----------------|-------|----|
| 15 | 111.326 | 2.258<br>1.563 | 2.821 | 14 |
|----|---------|----------------|-------|----|

|    |         |                |       |    |
|----|---------|----------------|-------|----|
| 20 | 112.669 | 3.601<br>1.897 | 4.498 | 19 |
|----|---------|----------------|-------|----|

|    |         |                |       |    |
|----|---------|----------------|-------|----|
| 25 | 114.343 | 5.275<br>1.514 | 6.589 | 24 |
|----|---------|----------------|-------|----|

|    |        |                |       |    |
|----|--------|----------------|-------|----|
| 29 | 15.901 | 6.833<br>1.801 | 8.534 | 28 |
|----|--------|----------------|-------|----|

|    |        |                |       |    |
|----|--------|----------------|-------|----|
| 31 | 16.754 | 7.686<br>1.912 | 9.598 | 30 |
|----|--------|----------------|-------|----|

|    |        |                |        |    |
|----|--------|----------------|--------|----|
| 35 | 18.573 | 9.505<br>2.366 | 11.871 | 34 |
|----|--------|----------------|--------|----|

|    |        |                 |        |    |
|----|--------|-----------------|--------|----|
| 40 | 21.148 | 12.080<br>3.008 | 15.088 | 39 |
|----|--------|-----------------|--------|----|

|    |        |                 |        |    |
|----|--------|-----------------|--------|----|
| 50 | 27.193 | 18.125<br>4.513 | 22.638 | 49 |
|----|--------|-----------------|--------|----|

|    |        |                 |        |    |
|----|--------|-----------------|--------|----|
| 60 | 34.450 | 25.382<br>6.319 | 31.701 | 59 |
|----|--------|-----------------|--------|----|

|    |        |                 |        |    |
|----|--------|-----------------|--------|----|
| 70 | 42.943 | 33.875<br>8.434 | 42.309 | 69 |
|----|--------|-----------------|--------|----|

|    |        |                 |        |    |
|----|--------|-----------------|--------|----|
| 75 | 47.694 | 38.626<br>9.617 | 48.243 | 74 |
|----|--------|-----------------|--------|----|

|   |        |       |       |   |
|---|--------|-------|-------|---|
| 1 | 09.068 | 0.000 | 0.000 | 0 |
|---|--------|-------|-------|---|

|   |      |            |      |   |
|---|------|------------|------|---|
| 2 | .149 | .081<br>20 | .101 | 1 |
|---|------|------------|------|---|

|   |      |            |      |   |
|---|------|------------|------|---|
| 3 | .248 | .180<br>42 | .225 | 2 |
|---|------|------------|------|---|

|   |      |            |      |   |
|---|------|------------|------|---|
| 4 | .364 | .296<br>74 | .370 | 3 |
|---|------|------------|------|---|

|   |      |  |  |  |
|---|------|--|--|--|
| 5 | .625 |  |  |  |
|---|------|--|--|--|

|   |      |             |      |   |
|---|------|-------------|------|---|
| 6 | .625 | .557<br>134 | .696 | 5 |
|---|------|-------------|------|---|

|   |      |             |      |   |
|---|------|-------------|------|---|
| 7 | .782 | .714<br>178 | .892 | 6 |
|---|------|-------------|------|---|

|   |      |             |       |   |
|---|------|-------------|-------|---|
| 8 | .923 | .855<br>213 | 1.068 | 7 |
|---|------|-------------|-------|---|

|   |        |                |       |   |
|---|--------|----------------|-------|---|
| 9 | 10.102 | 1.034<br>1.258 | 1.292 | 8 |
|---|--------|----------------|-------|---|

|    |      |              |       |   |
|----|------|--------------|-------|---|
| 10 | .284 | 1.216<br>203 | 1.519 | 9 |
|----|------|--------------|-------|---|

$$x = \frac{s_2 - s_1}{2(t_2 - t_1)} + \frac{t_2^2 - t_1^2}{2(t_2 - t_1)}$$

$$y = \frac{2}{2}(t_1 + x)^2 - s_1$$

$$\frac{1}{2} = 64.8$$

$$g = .01544$$

No 1+2

$$p = \frac{.101 - .0}{1} (64.8) - \frac{1}{2} = 6.04 \checkmark$$

$$\begin{array}{r} 648 \\ 648 \\ \hline 6.5448 \\ .5 \end{array}$$

No 2+3

$$p = \frac{(225 - 101) 64.8}{1} - \frac{3}{2} = 6.53 \checkmark$$

$$\begin{array}{r} 64.8 \\ 1296 \\ \hline 2592 \\ 1296 \\ 648 \\ \hline 8.0352 \\ 150 \\ \hline 6.53 \end{array}$$

No 4+3

$$p = \frac{225 - 0}{2} (64.8) - \frac{4}{4} = 6.29$$

No 4+6

$$p = \frac{(696 - 370) 64.8}{2} - \frac{16}{4} = 6.56$$

No 1+10

$$p = \frac{(15 - 19 - 0) 64.8}{9} - \frac{81 - 0}{18} = 6.44 \checkmark$$

$$\begin{array}{r} 225 \\ 3240 \\ 1296 \\ 1296 \\ \hline 2 \overline{) 14.5800} \\ 7.29 \end{array}$$

$$\begin{array}{r} 326 \\ 3888 \\ 1296 \\ 1944 \\ \hline 2 \overline{) 21.1248} \\ 10.56 \end{array}$$

$$\begin{array}{r} 1519 \\ 5832 \\ 648 \\ 3240 \\ 648 \\ \hline 9 \overline{) 98.4312} \\ 10.94 \\ 4.50 \end{array}$$

No 6+8

$$p = \frac{(1068 - 696) 64.8}{2} - \frac{24}{4} = 6.05$$

No 10+8

$$p = \frac{(15 - 19 - 1.068) 64.8}{2} - \frac{32}{4} = 6.61$$

$$\begin{array}{r} 372 \\ 1296 \\ 4536 \\ 1944 \\ \hline 2 \overline{) 24.1056} \\ 12.05 \end{array}$$

$$\begin{array}{r} .451 \\ 648 \\ 3240 \\ 2592 \\ \hline 2 \overline{) 29.2248} \\ 14.61 \end{array}$$

No 3+7

$$p = \frac{(892 - 225) 64.8}{4} - \frac{32}{8} = 6.81$$

No 7+9

$$p = \frac{(1292 - 892) 64.8}{2} - \frac{28}{4} = 5.96$$

$$\begin{array}{r} .667 \\ 4536 \\ 3888 \\ 3888 \\ \hline 4 \overline{) 43.2216} \\ 10.80 \end{array}$$

$$\begin{array}{r} .400 \\ 2 \overline{) 25.92} \\ 12.96 \end{array}$$

No 2+4

$$p = \frac{(370 - 101) 64.8}{2} - \frac{8}{4} = 6.71$$

$$\begin{array}{r} .269 \\ 5832 \\ 3888 \\ 1296 \\ \hline 2 \overline{) 17.4312} \\ 8.71 \end{array}$$

|   |      |
|---|------|
| 1 | 648  |
| 2 | 1296 |
| 3 | 1944 |
| 4 | 2592 |
| 5 | 3240 |
| 6 | 3888 |
| 7 | 4536 |
| 8 | 5184 |
| 9 | 5832 |

No. Values of  $p$  Dev.

1 + 3 6.29 .14  $y = \frac{g}{2} (t_1 + p)^2 - s$   $g = .01544$

3 + 7 6.81 .38

7 + 9 5.96 .47  $y = .00772 (0 + 6.43)^2 - 0 = .00772 \times 41.3449 =$

2 + 4 6.71 .28  $41.34 \cdot 319 \text{ cm} = y.$

4 + 6 6.56 .13  $.00772$

6 + 8 6.05 .38  $8268$

8 + 10 6.61 .18  $28938$

$7 \overline{) 2.997196}$   $28938$

$p = 6.43$   $.28$   $3191448$   $.00772$

$238$

$6176$

$2316$

$1544$

$1.83736$

$1.519$

$.318$

$.28 = \text{dev. dev.}$

$p = 6.43$   $g = .319$

No 10 + 15

$p = \frac{(2.821 - 1.519) 64.8}{5} - \frac{125}{10} = 5.37$

$1.302$

$1296$

$1944$

$648$

$5 \overline{) 84.37}$

$16.87$

$11.50$

$5.37$

No 15 + 20

$p = \frac{(4.498 - 2.821) 64.8}{5} - \frac{165}{10} = 5.23$

$1.677$

$4536$

$4536$

$3888$

$648$

$5 \overline{) 108.67}$

$21.73$

$16.50$

$5.23$

Continued on p. 81.

70

70

69

68

67

66

65

64

63

62

61

60

59

# Spectrum observations

Continued from page 44. May 6, '84.

- Plate 16 A single red glass transmits more actinic ~~energy~~ effect in the region <sup>bet. F & G</sup> ~~about~~ ~~GF~~ than about C and as much as the ultra violet far as H. The 2d spectrum Plate 17 has about 1000 the exposure of the first, and should have about the 1000. On cloudy day with the slit 1 give exp for C about 8 min.
- Plate 17 The spectrum was in moderate focus from A to H, but nowhere very good. Prism 50. 45- would be better.
- A = 0. D = 4. F = 8. G = 12. H<sub>2</sub> = 16.
- These figures are not exact as A & D were not visible.

May 7, '84.

- Plate 18 With rr readings were 1.5 & -4.6  
With rrrr " " 1.4 & -3.9  
& no shading near the F & G lines.  
rr had 2 min exp. & rrrr 4 min exp.  
A very unactinic day. The rubbers did not come down at all, though one had 16 times the exposure.
- Plate 19 Equiv exp 2. yellowed A reverse direct and
- |     |      |   |     |     |     |
|-----|------|---|-----|-----|-----|
| 2   | -4.1 | 0 | 1.8 | 2.9 | 3.5 |
| 1/2 | -4.  | 0 | 1.2 | 3.0 | 3.0 |
| 1/8 | -3.9 | 0 |     |     | 1.2 |
- The difficulty with the second was that there was not enough general

fog to bring out the edges of the spectrum so that it was not noticeable at first beyond 1.4. There must be a certain amount of fog to get the best effect with a reversing spectrum. Lines at 2 + 3.4

Plate 20 Taken immediately after on Inglis plate, same exposure as first slit 1 exp 2 min.

yellow end A reverse direct end visible  
-4.1 0 1.1 3.0 4.5 5.0

Lines at 0 2 3.3 + 5.1 also at -9.0 <sup>13.7</sup>  
A 94 112 138 F 9

Other things being equal the Inglis seemed to reach 1 mm further in this case. It fogged about the same but was less intense in the red & more so about F, giving a much prettier spectrum. The visible spectrum & infra-red are just in the right position with prism 45° & the above measurements <sup>of the lines</sup> are accurate.

Plate 21 Inglis Plate. The developer was I think fresher which may have caused increased general discoloration of plate. Turn was not as active as usual.

r.b. end H<sub>2</sub> H<sub>1</sub> G end end end A change end  
exp. 2. -19.0 18.5 17.9 13.7 6.6 36 2.5 1.9 0. +1.3 3.2

rubber end change change min. A rev. dir end  
exp. 32. -4.0 3.0 1.2 .3 0. +2.0 3.0 3.2

red red exp 2 -4.1 0. +1.2 2.8 3.8

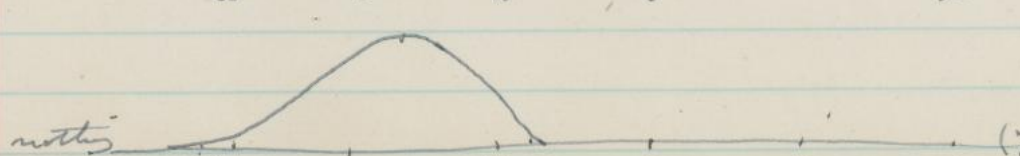
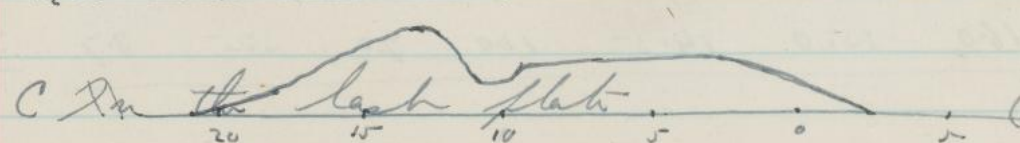
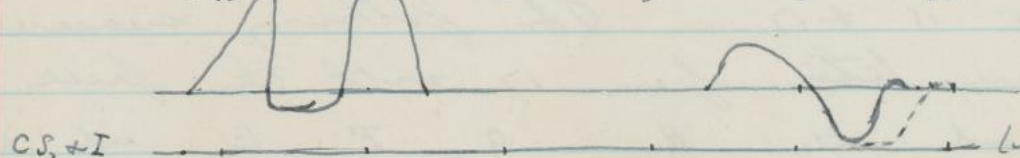
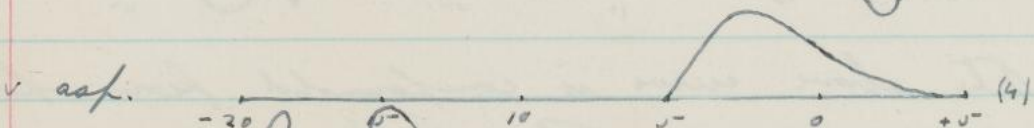
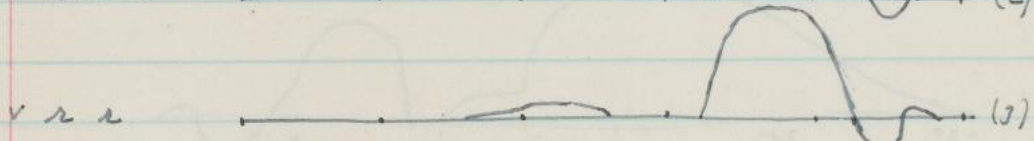
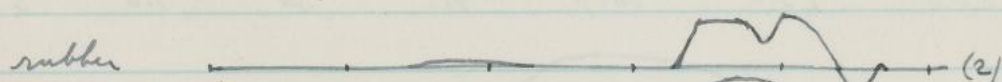
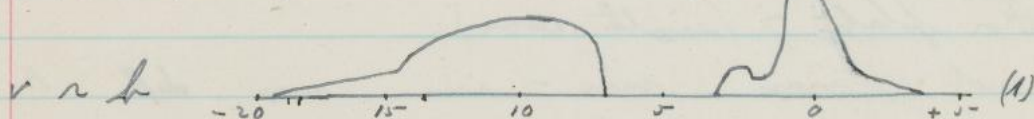
rubber exp 2 0 3.1

red red exp 2 4.1 0 +1.4 2.5 3.8

Red glass seems to go rather further than r h or rubber, but red blue gives no reversal either on this or on any other plate that I have tried. The following measurements were made on plate 9. The A line was exceedingly indistinct. Hazy with passing clouds.

| r r       | end  | A | end | The asphalt      |
|-----------|------|---|-----|------------------|
| exp 8     | -4.0 | 0 | 3.3 | would appear to  |
| r h exp 8 | -1.5 | 0 | 3.1 | go as far as     |
| asp exp 8 | -5.0 | 0 | 3.3 | the r r on this  |
|           |      |   |     | plate there were |

no reversals. Below are given sketches of absorption spectra. The first three are from plate 21. The fourth from plate 9. \* the fifth from plate 8. the sixth from plate 7 & the sixth from recol-



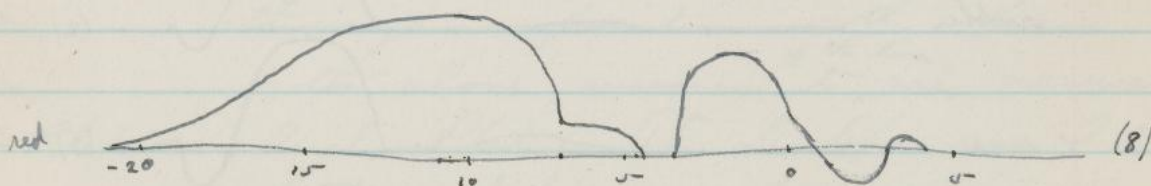
lection of one of the earlier plates last year. In the fifth above plate the upper line represent the general of fog produced by the blue light

transmitted & the hollow at the blue end is due to over exposure. At the red end the dotted line shows the actual result obtained on the plate & the full line the effect that probably would have been produced had the day been as poor as ~~poor~~ as that on which the other plates were taken. The next absorption spectrum is that of lampblack from plate 7, and the last the spectrum as photo'd through clear glass. The following are the readings for plate 8 (fifth curve).

| end   | rev. | dir. | end  | end | A | rev. | dir. | end |
|-------|------|------|------|-----|---|------|------|-----|
| -21.6 | 19.0 | 15.0 | 13.0 | 3.0 | 0 | +1.5 | 4.5  | 5.0 |

For plate 7 (sixth curve)

| end   | max  | min  | - min | max | defl. | A | end  |
|-------|------|------|-------|-----|-------|---|------|
| -21.0 | 13.0 | 10.7 | 9.5   | 30  | 7.0   | 0 | +2.5 |



The above curve is compounded from plates 5, 16 & 17. The following measurements are taken from 17 with the prism at 5.0.

| end   | H <sub>2</sub> | H <sub>1</sub> | G    | F   | E   | end | end | A | end  |
|-------|----------------|----------------|------|-----|-----|-----|-----|---|------|
| -16.0 | 15.0           | 14.5           | 11.0 | 7.0 | 5.5 | 3.7 | 3.0 | 0 | +1.3 |













Speed of Drop Gunther. Strong M forward from p. 80.  
 Corrected Diff. Observed vibs. Corrected vibs. Corrected dist. Throat. dist Diff. Diff. Plate 1a

|     |       |                           |        |                    |   |           |
|-----|-------|---------------------------|--------|--------------------|---|-----------|
| 0.  | 6.43  | .319                      | .319   | .000               | 1 | 772       |
| 5.  | 7.43  | .420                      | .426   | +.006              | 2 | 1544      |
| 2.  | 8.43  | .544                      | .549   | .005               | 3 | 2316      |
| 5.  | 11.43 | <del>1.015</del><br>1.015 | 1.008  | -.007              | 4 | 3088      |
| 9.  | 15.43 | 1.838                     | 1.838  | .000               | 5 | 3860      |
| 14. | 20.43 | 3.140                     | 3.222  | +.082              | 6 | 4632      |
| 19. | 25.43 | 4.817                     | 4.993  | .176               | 7 | 5404      |
| 28. | 34.43 | 8.853                     | 9.148  | .295               | 8 | 6176      |
| 39. | 45.43 | 15.407                    | 15.933 | .526               | 9 | 6948      |
| 49. | 55.43 | 22.957                    | 23.720 | .763               |   |           |
| 59. | 65.43 | 32.020                    | 33.050 | 1.030              |   | by .00772 |
| 69. | 75.43 | 42.628                    | 43.924 | 1.296              |   | 7.887617  |
|     |       |                           | 43.599 | .971 = error limit |   |           |

$$A = \frac{S}{2} = \frac{26}{2} = .007726^2$$

|          |          |          |                     |          |
|----------|----------|----------|---------------------|----------|
| 0        | 41.34    | 5-5-20   | 7106                | 1306     |
| 1018     | 3088     | 15-44    | 4632                | 4632     |
| 6176     | 2316     | 3860     | 772                 | 2316     |
| 772      | 772      | 3860     | 5-404               | 772      |
| 772      | 3088     | 4261     | 5485-8              | 10082    |
| 7859     | 31914    |          |                     |          |
| 2381     | 9860     | 41824    | 6468                | 1185-    |
| 772      | 4632     | 3088     | 6176                | 3860     |
| 6176     | 6176     | 5404     | 4632                | 6176     |
| 2316     | 6948     | 772      | 3088                | 772      |
| 1544     | 7612     | 3088     | 4632                | 772      |
| 18381    |          | 32223    | 49933               | 91482    |
| 2064     | by 45.43 | 1.657343 | by 55.43 = 1.743745 |          |
| 3088     |          | 1.657343 | 1.743745            |          |
| 4632     |          | 7.887617 | 7.887617            |          |
| 15-44    |          | 1.202303 | 1.375107            |          |
| 15934    |          | 2216     |                     |          |
| by 65.43 | 1.815777 | 87       | by 75.43            | 1.877544 |
|          | 1.815777 |          |                     | 1.877544 |
|          | 7.887617 |          |                     | 7.887617 |
|          | 1.519171 |          |                     | 1.639475 |
|          |          |          |                     | 43.599   |
|          |          |          |                     | 1.642705 |

# Measurements of Plate 2.a

## Calculated Nov. 26, 1884.

| Fils       | 0                  | 1     | 2     | 3     | 4     | 5     | 7       | 8      | 9      | 10     |
|------------|--------------------|-------|-------|-------|-------|-------|---------|--------|--------|--------|
| Readings 1 | 131.248            | .324  | .417  | .516  | .644  | .763  | 132.041 | .202   | .376   | .569   |
| 2          | 247                | 313   | 420   | 517   | .641  | .764  | .036    | 208    | .379   | .565   |
| 4          | 367                | 434   | 539   | 640   | 749   | 871   | 1355    | 313    | 485    | 678    |
| 3          | 367                | 430   | .533  | 640   | 750   | 872   | 157     | 314    | 488    | 680    |
| 5          | 354                | 430   | 521   | 630   | 732   | 855   | 138     | 303    | 480    | 663    |
| 5          | <del>131.583</del> | 6.931 | 7.430 | 7.943 | 8.516 | 9.125 | 10.527  | 11.340 | 12.208 | 13.155 |
| Average    | 131.317            | 1.386 | 1.486 | 1.589 | 1.703 | 1.825 | 2.105   | 2.268  | 2.442  | 2.631  |

The instrument was moved between the 2d + 3d & again between the 4th + 5th sets. The following readings were made in connection with the 3d + 4th sets. Correcting the average to the average of the 3d + 4th by ~~subtracting~~ adding 50 we get the average readings on the next page.

|                   |    |          |                  |    |          |
|-------------------|----|----------|------------------|----|----------|
| Front silk thread | 10 | 168.283  | Rear silk thread | 10 | 166.492  |
| " " "             | 1  | 130.669  | " " "            | 1  | 132.034  |
|                   | 9  | 37.614   |                  | 9  | 34.458   |
| average           |    | 4.179    | average          |    | 3.829    |
|                   |    | <u>4</u> |                  |    | <u>4</u> |
|                   |    | 16.716   |                  |    | 15.316   |
|                   |    | 130.669  |                  |    | 132.034  |
| reading 147.307   |    | 147.385  |                  |    | 147.350  |

$$\begin{array}{r}
 4.179 \\
 3.829 \\
 \hline
 8.008 \\
 \hline
 5- \\
 \hline
 40.040 = 50. \text{ cm} \therefore 1 \text{ in} = 1.249
 \end{array}$$

Vib Reading Diff. reading Diff. in cns. corrected

|    |         |                        |        |       |      |
|----|---------|------------------------|--------|-------|------|
| 0  | 131.367 | .000                   | .000   | 242   |      |
| 1  | 436     | .069 <sub>17</sub>     | .086   | 328   |      |
| 2  | 536     | .169 <sub>62</sub>     | .211   | 453   |      |
| 3  | 639     | .272 <sub>68</sub>     | .340   | 582   |      |
| 4  | 753     | .386 <sub>96</sub>     | .482   | 724   |      |
| 5  | 875     | .508 <sub>127</sub>    | .635   | 877   |      |
| 7  | 132.155 | .788 <sub>196</sub>    | .984   | 1226  |      |
| 8  | 318     | .951 <sub>237</sub>    | 1.188  | 1430  | 1205 |
| 9  | 492     | 1.125 <sub>250</sub>   | 1.405  | 1647  |      |
| 10 | 681     | 1.314 <sub>327</sub>   | 1.641  | 1883  | 1663 |
| 12 | 133.069 | 1.702 <sub>423</sub>   | 2.125  | 2367  |      |
| 15 | 786     | 2.419 <sub>602</sub>   | 3.021  | 3263  |      |
| 20 | 135.189 | 3.822 <sub>950</sub>   | 4.772  | 5014  |      |
| 25 | 136.900 | 5.533 <sub>1377</sub>  | 6.910  | 7152  |      |
| 29 | 138.486 | 7.119 <sub>1773</sub>  | 8.892  | 9134  |      |
| 31 | 139.345 | 7.978 <sub>1986</sub>  | 9.964  | 10206 |      |
| 40 | 143.843 | 12.476 <sub>3107</sub> | 15.583 | 15825 |      |
| 50 | 150.010 | 18.643 <sub>4641</sub> | 23.284 | 23526 |      |
| 60 | 157.415 | 26.048 <sub>6485</sub> | 32.533 | 32775 |      |
| 70 | 166.062 | 34.695 <sub>8637</sub> | 43.332 | 43574 |      |
| 75 | 169.819 | 38.452 <sub>9573</sub> | 48.025 | 48267 |      |

$$g = .01544$$

$$p = \frac{s_2 - s_1}{g(t_2 - t_1)} - \frac{t_2^2 - t_1^2}{2(t_2 - t_1)}$$

$$\frac{1}{g} = 64.8$$

Vibs 0 + 2

$$p = \frac{(1211 - 0)64.8}{2} - \frac{4}{4} = 5.84$$

1 648

2 1296

3 1944

4 2592

5 3240

6 3888

7 4536

8 5184

9 5832

$$\begin{array}{r} 211 \\ 648 \\ 648 \\ 1296 \\ \hline 2 \overline{) 13.6728} \\ 6.84 \end{array}$$

Vibs 2 + 4

$$p = \frac{(482 - 211)64.8}{2} - \frac{12}{4} = 5.78$$

$$\begin{array}{r} .271 \\ 648 \\ 4536 \\ 1296 \\ \hline 2 \overline{) 17.560} \\ 8.78 \end{array}$$

Vibs 4 + 8

$$p = \frac{(1188 - 482)64.8}{4} - \frac{48}{8} = 5.44$$

Vibs 8 + 10

$$p = \frac{(1641 - 1188)64.8}{2} - \frac{36}{4} = 5.68$$

$$\begin{array}{r} .706 \\ 3888 \\ 4536 \\ 4 \overline{) 45.7488} \\ 11.4372 \\ 6 \\ \hline 5.44 \end{array}$$

Vibs 1 + 3

$$p = \frac{(340 - 086)64.8}{2} - \frac{8}{4} = 6.23$$

$$\begin{array}{r} 129 \\ 5832 \\ 1296 \\ 648 \\ \hline 8.3592 \\ 2.50 \\ \hline 5.85 \end{array}$$

$$\begin{array}{r} 453 \\ 1944 \\ 3240 \\ 2592 \\ \hline 2 \overline{) 29.3544} \\ 14.68 \\ 9. \\ \hline 5.68 \end{array}$$

$$\begin{array}{r} 254 \\ 2592 \\ 3240 \\ 1296 \\ \hline 2 \overline{) 16.4592} \\ 8.23 \end{array}$$

Vibs 3 + 5

$$p = \frac{(635 - 340)64.8}{2} - \frac{16}{4} = 5.56$$

Vibs 5 + 7

$$p = \frac{(984 - 635)64.8}{2} - \frac{24}{4} = 5.31$$

Vibs 7 + 9

$$p = \frac{(1405 - 984)64.8}{2} - \frac{32}{4} = 5.64$$

$$\begin{array}{r} 349 \\ 5832 \\ 2592 \\ 1944 \\ \hline 2 \overline{) 22.6152} \\ 11.31 \end{array}$$

$$\begin{array}{r} 1296 \\ 19.1160 \\ 9.56 \end{array}$$

Vibs 1 + 2

$$p = \frac{(211 - 086)64.8}{2} - \frac{3}{2} = 6.60$$

$$\begin{array}{r} 125 \\ 3240 \\ 1296 \\ 648 \\ \hline 2 \overline{) 27.2808} \\ 13.64 \end{array}$$

Vibs 2 + 3

$$p = \frac{(340 - 211)64.8}{1} - \frac{5}{2} = 5.85$$

| $\nu_{00}$ | Value of $\nu$ | dev |
|------------|----------------|-----|
| 0 + 2      | 5.84           | 24  |
| 0 + 4      | 5.81           | 21  |
| 1 + 3      |                |     |
| 2 + 4      | 5.78           | 18  |
| 3 + 5      | 5.56           | 4   |
| 3 + 7      | 5.43           | 17  |
| 4 + 8      | 5.44           | 16  |
| 5 + 7      | 5.31           | 29  |
| 5 + 9      | 5.47           | 13  |
| 7 + 9      | 5.64           | 4   |
| 8 + 10     | 5.68           | 8   |

$$10 \overline{) 5.96} \quad 10 \overline{) 154}$$

$$5.60 = \nu \quad .15 = \text{av. dev.}$$

Vib 0 + 1

$$\nu = \frac{(.086 - 0) 64.8}{1} - \frac{1}{2} = 5.07$$

$$\begin{array}{r} 86 \\ 3888 \\ 5184 \\ 5.5728 \\ 5. \end{array}$$

$$1 + 3 \text{ give } \nu = 6.23$$

$$1 + 2 \text{ " } \nu = 6.60$$

$$0 + 1 \text{ " } \nu = 5.07$$

$$2 \overline{) 11.67} \\ 5.83$$

As all the equations containing vib 1 give evidently incorrect answers, this observation is omitted. The mean of 1 + 2 and 0 + 1 gives  $\nu = 5.83$

Vib 0 + 4

$$\nu = \frac{(482 - 0) 64.8}{4} - \frac{16}{8} = 5.81$$

$$\begin{array}{r} 482 \\ 1296 \\ 5184 \\ 2592 \\ 4 \overline{) 312336} \\ 7.81 \end{array}$$

Vib 3 + 7

$$\nu = \frac{(984 - 340) 64.8}{4} - \frac{40}{8} = 5.43$$

Vib 5 + 9

$$\nu = \frac{(1405 - 635) 64.8}{4} - \frac{56}{8} = 5.47$$

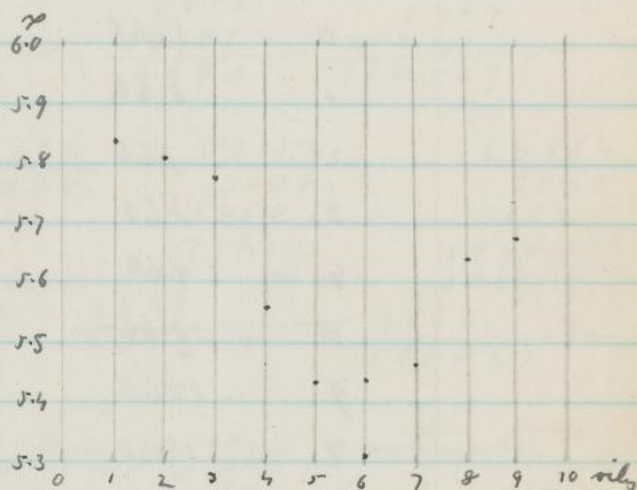
$$\begin{array}{r} 644 \\ 2592 \\ 2592 \\ 3888 \\ 4 \overline{) 41.7312} \\ 10.43 \end{array}$$

$$\begin{array}{r} 770 \\ 4536 \\ 4536 \\ 4 \overline{) 49.896} \\ 12.47 \end{array}$$

$$y = \frac{2}{2} (1 + \nu)^2 - 8$$

$$y = .00772 (0 + 5.60)^2 - 0 = .242$$

$$\nu = 5.60 \quad y = .242$$



*Fibs. Corrected vibs. Corrected dist. Theoret. dist. Diff.*

|    |       |        |        |        |                 |      |
|----|-------|--------|--------|--------|-----------------|------|
| 0  | 5.60  | .242   | .242   | .000   | 1               | 772  |
| 1  | 6.60  | .328   | .337   | +0.009 | 2               | 1544 |
| 2  | 7.60  | .453   | .446   | -0.007 | 3               | 2316 |
| 3  | 8.60  | .582   | .571   | -0.011 | 4               | 3088 |
| 4  | 9.60  | .724   | .712   | -0.012 | 5               | 3860 |
| 5  | 10.60 | .877   | .868   | -0.009 | 6               | 4632 |
| 7  | 12.60 | 1.226  | 1.226  | .000   | 7               | 5404 |
| 8  | 13.60 | 1.430  | 1.428  | -0.002 | 8               | 6176 |
| 9  | 14.60 | 1.647  | 1.646  | -0.001 | 9               | 6948 |
| 10 | 15.60 | 1.883  | 1.879  | -0.004 | $\log .00772 =$ |      |
| 12 | 17.60 | 2.367x | 2.392  | +0.025 | 7.887617        |      |
| 15 | 20.60 | 3.263  | 3.276  | +0.013 | $S = .007726^2$ |      |
| 20 | 25.60 | 5.014  | 5.060  | +0.046 |                 |      |
| 25 | 30.60 | 7.152  | 7.229  | .077   |                 |      |
| 31 | 36.60 | 10.206 | 10.344 | .138   |                 |      |
| 40 | 45.60 | 15.825 | 16.003 | .228   |                 |      |
| 50 | 55.60 | 23.526 | 23.866 | .340   |                 |      |
| 60 | 65.60 | 32.775 | 33.222 | .447   |                 |      |
| 70 | 75.60 | 43.574 | 44.123 | .549   |                 |      |
| 75 | 80.60 | 48.267 | 50.152 |        |                 |      |

|                                                                            |                                                                           |                                                                           |                                                                           |                                                                            |
|----------------------------------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------------------------------------|----------------------------------------------------------------------------|
| $\begin{array}{r} 31.48 \\ 3088 \\ 772 \\ 2316 \\ \hline 2424 \end{array}$ | $\begin{array}{r} 436 \\ 4632 \\ 2316 \\ 3088 \\ \hline 3366 \end{array}$ | $\begin{array}{r} 578 \\ 6176 \\ 5404 \\ 3860 \\ \hline 4462 \end{array}$ | $\begin{array}{r} 740 \\ 3088 \\ 5404 \\ \hline 5713 \end{array}$         | $\begin{array}{r} 922 \\ 1544 \\ 1544 \\ 6948 \\ \hline 71178 \end{array}$ |
| $\begin{array}{r} 1124 \\ 3088 \\ 1544 \\ 772 \\ \hline 772 \end{array}$   | $\begin{array}{r} 1588 \\ 6176 \\ 6176 \\ 3860 \\ \hline 772 \end{array}$ | $\begin{array}{r} 185- \\ 3860 \\ 6176 \\ 772 \\ \hline 1428 \end{array}$ | $\begin{array}{r} 2132 \\ 1544 \\ 2316 \\ 772 \\ \hline 1544 \end{array}$ | $\begin{array}{r} 2434 \\ 3088 \\ 2316 \\ 3088 \\ \hline 1544 \end{array}$ |
| 8677                                                                       | 12259                                                                     |                                                                           | 164590                                                                    | 18790                                                                      |

|                                                                                                 |                                                                                                  |                                                                                                   |                                                                                                           |                                                                                                            |
|-------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|
| $  \begin{array}{r}  3098 \\  6176 \\  6948 \\  2316 \\  \hline  23916  \end{array}  $          | $  \begin{array}{r}  4244 \\  3088 \\  3088 \\  1544 \\  \hline  32763  \end{array}  $           | $  \begin{array}{r}  6554 \\  3088 \\  3860 \\  3860 \\  4632 \\  \hline  50596  \end{array}  $   | $  \begin{array}{r}  9364 \\  3088 \\  4632 \\  2316 \\  6948 \\  \hline  72290  \end{array}  $           | $  \begin{array}{r}  20794 \\  3088 \\  6948 \\  5404 \\  1544 \\  \hline  1605296  \end{array}  $         |
| $  \begin{array}{r}  1340 \\  3088 \\  2316 \\  772 \\  \hline  10344  \end{array}  $           | $  \begin{array}{r}  30914 \\  3088 \\  772 \\  6948 \\  2316 \\  \hline  238650  \end{array}  $ | $  \begin{array}{r}  43034 \\  3088 \\  2316 \\  2316 \\  3088 \\  \hline  352222  \end{array}  $ | $  \begin{array}{r}  57154 \\  3088 \\  3860 \\  772 \\  5404 \\  3860 \\  \hline  441228  \end{array}  $ | $  \begin{array}{r}  64964 \\  3088 \\  4632 \\  6948 \\  3088 \\  4632 \\  \hline  501522  \end{array}  $ |
| $  \begin{array}{r}  5738 \\  6176 \\  2316 \\  5404 \\  3860 \\  \hline  44297  \end{array}  $ | <p>Result. For every centimeter that the body falls it is delayed .014 centimeters.</p>          |                                                                                                   |                                                                                                           |                                                                                                            |

Nov 27, '84

This calculation may be simplified & the coef. of delay obtained by the method of successive approximation, as follows:-

Measure the dist. bet. 2 vibs. Let  
 dist =  $s$  no. vibs =  $t$  no. vibs from start  
 to first observation =  $x$  dist traversed =  $y$   
 $g$  = value of gravity in terms of single vib.  
 $C$  = coef of delay roughly determined (.014)  
 $C_1$  = coef of delay accurately to be determined.

$$x = \frac{(C+1)s}{gt} - \frac{t}{2} \quad (\text{see p. 76}) \quad [C, \text{ here } + s, \text{ here become } 0.]$$

$$y = \frac{g}{2} x^2 = \frac{g}{2} \left( \frac{(C+1)s}{gt} - \frac{t}{2} \right)^2$$

$$\text{theor dist traversed} = \frac{g}{2} \left( x + \frac{t}{2} \right)^2 = \frac{g}{2} \left( \frac{(C+1)s}{gt} + \frac{t}{2} \right)^2$$

$$\text{corrected obs. dist. trav.} = s + y = s + \frac{g}{2} \left( \frac{(C+1)s}{gt} - \frac{t}{2} \right)^2$$

$$C_1 = \frac{\text{theor dist} - \text{cor. obs. dist.}}{\text{theor dist}} = 1 - \frac{\text{cor. obs. dist.}}{\text{theor dist}} =$$

$$1 - \left[ \frac{s}{\frac{g}{2} \left( \frac{(C+1)s}{gt} + \frac{t}{2} \right)^2} + \frac{\left( \frac{(C+1)s}{gt} - \frac{t}{2} \right)^2}{\left( \frac{(C+1)s}{gt} + \frac{t}{2} \right)^2} \right] = C_1, \quad \frac{\frac{2s}{2} + \left( \frac{(C+1)s}{gt} - \frac{t}{2} \right)^2}{\left( \frac{(C+1)s}{gt} + \frac{t}{2} \right)^2} + C_1 = 1$$

$$\frac{2s}{2} + \left[ \frac{(C+1)s}{gt} - \frac{t}{2} \right]^2 + C_1 \left[ \frac{(C+1)s}{gt} + \frac{t}{2} \right]^2 = \left[ \frac{(C+1)s}{gt} + \frac{t}{2} \right]^2$$

$$\frac{2s}{2} + \left( \frac{(C+1)s}{gt} \right)^2 - \frac{(C+1)s}{gt} + \frac{t^2}{4} + C_1 \left[ \frac{(C+1)s}{gt} + \frac{t}{2} \right]^2 = \left( \frac{(C+1)s}{gt} \right)^2 +$$

$$\frac{2(C+1)s}{gt} + \frac{t^2}{4} \quad \frac{2s}{2} - \frac{2s(C+1)}{2} + C_1 \left[ \frac{(C+1)s}{gt} + \frac{t}{2} \right]^2 = 0$$

$$C_1 = \frac{2s(C+1-1)}{\left[ \frac{(C+1)s}{gt} + \frac{t}{2} \right]^2} = \frac{2Cs}{2 \left[ \frac{(C+1)s}{gt} + \frac{t}{2} \right]^2} = \frac{2Cs}{2 \left[ \frac{2s(C+1)}{2gt} + \frac{gt^2}{2} \right]^2} = \frac{8Cs}{(2s(C+1) + gt^2)^2}$$

Dec. 15 '84.

This calculation may be simplified and the coef. of delay obtained by the observation of three points as follows:-

Let  $S_1$  = theor. dist. trav. in time  $t_1$ , let  $s_1$  be obs. dist. trav. in time  $t_1$

"  $S_2$  " " "  $t_2$  "  $s_2$  " " "  $t_2$

"  $S_3$  " " "  $t_3$  "  $s_3$  " " "  $t_3$

$$c = \text{coef. of delay} = \frac{S_1 - s_1}{S_1} \quad \left[ \begin{array}{l} s_1 \\ s_2 \\ s_3 \end{array} \right] \therefore c S_1 = S_1 - s_1 + s_1 = S_1 - c S_1$$

$$S_2 = \frac{g t_2^2}{2} \quad s_2 = \frac{g t_2^2}{2} - c \frac{g t_2^2}{2}$$

$$S_1 = \frac{g t_1^2}{2} \quad s_1 = \frac{g t_1^2}{2} - c \frac{g t_1^2}{2}$$

$$s_2 - s_1 = \frac{g}{2} (t_2^2 - t_1^2) + \frac{c g}{2} (t_1^2 - t_2^2) =$$

$$s_2 - s_1 = \frac{g}{2} (t_2 - t_1)(t_2 + t_1) + \frac{c g}{2} (t_1 - t_2)(t_2 + t_1)$$

$$s_2 - s_1 = \frac{g}{2} (t_2 - t_1)(t_2 + t_1) - \frac{c g}{2} (t_2 - t_1)(t_2 + t_1)$$

$$s_3 - s_2 = \frac{g}{2} (t_3 - t_2)(t_3 + t_2) - \frac{c g}{2} (t_3 - t_2)(t_3 + t_2)$$

$$\text{Let } s_2 - s_1 = a \quad s_3 - s_2 = b \quad t_2 - t_1 = m \quad t_3 - t_2 = n$$

$$a = \frac{g}{2} m (t_2 + t_1) - \frac{c g}{2} m (t_2 + t_1) = \frac{g}{2} m (t_2 + t_1) (1 - c)$$

$$\frac{g}{2} m (t_3 + t_2) (1 - c) = b \quad t_3 + t_2 = \frac{b}{\frac{g}{2} m (1 - c)}$$

$$t_2 + t_1 = \frac{a}{\frac{g}{2} m (1 - c)}$$

$$t_3 - t_1 = \frac{b}{\frac{g}{2} m (1 - c)} - \frac{a}{\frac{g}{2} m (1 - c)} = \frac{bm - am}{\frac{g}{2} m m (1 - c)} \therefore$$

$$1 - c = \frac{bm - am}{\frac{g}{2} m m (t_3 - t_1)} \therefore c = 1 - \frac{bm - am}{\frac{g}{2} m m (t_3 - t_1)} \therefore$$

$$c = 1 - \frac{(s_3 - s_2)(t_2 - t_1) - (s_2 - s_1)(t_3 - t_2)}{\frac{g}{2} (t_2 - t_1)(t_3 - t_2)(t_3 - t_1)}$$

~~Let  $s_2 - s_1 = d_1$ ,  $s_3 - s_2 = d_2$   $t_2 - t_1 = v_1$   $t_3 - t_2 = v_2$~~

~~then  $t_3 - t_1 = v_2 + v_1$   $\therefore$~~

~~$$C = \frac{d_2 v_1 - d_1 v_2}{\frac{1}{2} v_1 v_2 (v_2 + v_1)}$$~~

Using the above letters,

$$y_1 = \frac{gt_1^2}{2} \text{ for short distances practically } = s,$$

$$y_2 = \frac{gt_2^2}{2}$$

$$t_1^2 = \frac{2}{g} y_1 \quad t_1 = \left(\frac{2}{g}\right)^{1/2} y_1^{1/2}$$

$$t_2 = \left(\frac{2}{g}\right)^{1/2} y_2^{1/2}$$

$$t_2 - t_1 = \left(\frac{2}{g}\right)^{1/2} (y_2^{1/2} - y_1^{1/2}) = \left(\frac{2}{g}\right)^{1/2} (y_2^{1/2} - s^{1/2})$$

$$y_2^{1/2} = \frac{t_2 - t_1}{\left(\frac{2}{g}\right)^{1/2}} + s^{1/2}$$

$$y_2 = s + \frac{2(s)^{1/2} (t_2 - t_1) g^{1/2}}{(2)^{1/2}} + \frac{g(t_2 - t_1)^2}{2} =$$

$y_2 = s + (2sg)^{1/2}(t_2 - t_1) + \frac{g}{2}(t_2 - t_1)^2$  Having found the relation of  $y$  to  $s$  by successive approximation we substitute & obtain

$$y_2 = y_1 + (2y_1 g)^{1/2}(t_2 - t_1) + \frac{g}{2}(t_2 - t_1)^2$$

## Measured Plate 1 Dec 17, '84.

| meters | 1st readings | 2d readings | average | diff.  | Measured Dec. 19, '84 |
|--------|--------------|-------------|---------|--------|-----------------------|
| 0.     | 72.144       | 72.140      | 72.142  |        | 0 191.905             |
| 0.5-   | 94.134       | 94.135      | 94.134  | 21.992 | p 192.380             |
| 1.0    | 116.407      | 116.395     | 116.401 | 22.267 | .475                  |

| vibs  | 1st readings | diff | 2d readings | diff | average |
|-------|--------------|------|-------------|------|---------|
| 0     | 72.144       |      | 72.140      |      |         |
| p     | 94.134       |      | 94.135      |      |         |
| 70+p  | 116.407      |      | 116.395     |      |         |
| 100+p | 138.438      |      | 138.445     |      |         |

## Plate 2

| meters | 1st readings | 2d readings | average | diff   |
|--------|--------------|-------------|---------|--------|
| 0.     | 105.395      | 105.393     | 105.394 |        |
| .5-    | 127.340      | 127.339     | 127.340 | 21.946 |
| 1.0    | 149.770      | 149.769     | 149.770 | 22.430 |

| vibs  | 1st readings | 2d readings | average | diff        |
|-------|--------------|-------------|---------|-------------|
| 0     | 105.395      | 105.393     | 105.394 |             |
| p     | 105.937      | 105.940     | 105.938 | .559 = 5,   |
| 70+p  | 128.069      | 128.074     | 128.072 | 22.134      |
| 100+p | 147.745      | 147.750     | 147.748 | 22.678 = 5, |

Dec. 19, '84.

| vibs | reading | reading |
|------|---------|---------|
| 0    | 191.805 | .806    |
|      | 196.361 | .356    |
|      | 556     | .550    |

$$\frac{.5-4.4}{2 \times 21.946} =$$

$$\frac{22.678}{2 \times 21.946} =$$

$$\frac{42.354}{2 \times 22.430} =$$

## Plate 1

$$by .475 = 9.676694$$

$$ac by 21.992 = 8.657735$$

$$ac by 2. = 9.698970$$

$$\underline{8.033399}$$

$$.01080 \text{ meters}$$

$$1.08 \text{ cms.}$$

$$21.584 = 1.333125$$

$$8.657735$$

$$9.698970$$

$$\underline{9.689830}$$

$$48.959 \text{ cms.}$$

$$by 9.261 = 1.284679$$

$$ac by 22.267 = 8.652339$$

$$ac by 2. = 9.698970$$

$$\underline{9.635988}$$

$$43.25 \text{ cms.}$$

Results.

vibs

dist

0

0.00 cms.

$$t_1 = p$$

$$1.08 \text{ cms} = S_1$$

$$t_2 = 70 + p$$

$$50.04 \text{ " } = S_2$$

$$t_3 = 100 + p$$

$$93.29 \text{ " } = S_3$$

## Plate 2

$$by .555 = 9.742725$$

$$ac by 21.946 = 8.658644$$

$$ac by 2. = 9.698970$$

$$\underline{8.100339}$$

$$1.260$$

$$22.154 = 1.345059$$

$$21.946 = 8.658644$$

$$2. = 9.698970$$

$$\underline{9.702673}$$

$$50.43$$

Results.

vibs

dist

0

0.00 cms.

p

$$1.26 \text{ " } = S_1$$

$$70 + p$$

$$51.69 \text{ " } = S_2$$

$$100 + p$$

$$95.55 \text{ " } = S_3$$

$$g = .01544$$

## Plate 1

$$\begin{aligned}
 \lg 2 &= 0.301030 \\
 \lg 3 &= 0.046105 \\
 \lg 2 &= 8.188647 \\
 2 \overline{) 18.535782} \\
 &9.267891 \\
 &1853 \\
 &70 \\
 \hline
 &12.9710
 \end{aligned}$$

$$\begin{aligned}
 \frac{2}{2} &= .00772 \\
 (12-4)^2 &= 4900. \\
 &694800 \\
 &3088 \\
 \hline
 &37.82800 \\
 &12.971 \\
 &1.112 \\
 \hline
 &51.910 = S_2 \\
 &50.04 = S_2 \\
 \hline
 &1.87 = \text{diff.}
 \end{aligned}$$

$$\begin{aligned}
 S_1 &= 1.08 \\
 &1.03 \\
 \hline
 &324 \\
 &108 \\
 \hline
 &1.112
 \end{aligned}$$

$$\begin{aligned}
 &.1853 \\
 &100 \\
 \hline
 &18.53
 \end{aligned}$$

$$\begin{aligned}
 &.00772 \\
 &10000 \\
 \hline
 &77.20000 \\
 &18.53 \\
 &1.112 \\
 \hline
 &96.84 = S_3 \\
 &93.29 = S_3 \\
 \hline
 &3.55 = \text{diff.}
 \end{aligned}$$

## Plate 2

$$\begin{aligned}
 \lg 2 &= 0.301030 \\
 \lg 3 &= 0.103275 \\
 \lg 2 &= 8.188647 \\
 2 \overline{) 18.502952} \\
 &9.301476 \\
 &.2002 \quad 4972 \\
 &70 \quad 70 \\
 \hline
 &14.014 \quad 13.8040
 \end{aligned}$$

$$\begin{aligned}
 &.00772 \\
 &4900. \\
 \hline
 &48 \\
 &37.828 \\
 &14.014 \\
 &1298 \\
 \hline
 &53.140 = S_2 \\
 &51.690 = S_2 \\
 \hline
 &1.45 = \text{diff.}
 \end{aligned}$$

$$\begin{aligned}
 &.00772 \\
 &10000 \\
 \hline
 &77.20 \\
 &20.02 \\
 &1.30 \\
 \hline
 &98.52 = S_3 \\
 &95.55 = S_3 \\
 \hline
 &2.97 = \text{diff.}
 \end{aligned}$$

$$\begin{aligned}
 &.2002 \\
 &100 \\
 \hline
 &20.02
 \end{aligned}$$

$$\begin{aligned}
 &.1972 \\
 &100 \\
 \hline
 &19.72
 \end{aligned}$$

$$\begin{aligned}
 &.126 \\
 &1.03 \\
 \hline
 &378 \\
 &126 \\
 \hline
 &298
 \end{aligned}$$

$$C = 1 - \frac{d_2 v_1 - d_1 v_2}{\frac{g}{2} v_1 v_2 (v_1 + v_2)}$$

Plate 1

$$d_1 = 48.96$$

$$v_1 = 70$$

$$d_2 = 43.25$$

$$v_2 = 30$$

$$\frac{77.20000}{1544}$$

$$C = 1 - \frac{302.75 - 146.88}{.00772 \times 210000} = \frac{155.87}{1621.2}$$

$$\begin{aligned} \log &= 3.192763 \\ \log &= 3.209837 \\ \hline &9.982926 \\ &.9614 \end{aligned}$$

$$C = 0.386$$

Plate 2

$$d_1 = 50.43$$

$$v_1 = 70$$

$$d_2 = 43.86$$

$$v_2 = 30$$

$$C = 1 - \frac{3070.2 - 1512.9}{.00772 \times 210000} = \frac{1557.3}{1621.2}$$

$$\begin{aligned} \log &= 3.192372 \\ \log &= 3.209837 \\ \hline &6.402209 \\ &-.087465 \\ \hline &9.982535 \\ &.9606 \end{aligned}$$

$$C = 0.394$$

## Plate 4. Measured Dec. 20, 84.

| cms | readings | diff   | ribs   | before                      | after                   | change                  |
|-----|----------|--------|--------|-----------------------------|-------------------------|-------------------------|
| 0   | 80.147   | 9.824  | 0      | <del>79.634</del><br>79.634 | <del>.618</del><br>.618 | <del>.621</del><br>.621 |
| 25  | 89.971   | 10.889 | n      | 81.494                      | .492                    | .483                    |
| 50  | 100.860  | 11.016 | n + 4  | 82.175                      | .164                    | .160                    |
| 75  | 111.876  | 11.089 | n + 30 | 88.108                      |                         | .106                    |
| 100 | 122.965  |        | n + 60 | 102.8                       | .599                    | .602                    |
|     |          |        | n + 75 | 111.590                     |                         | .596                    |
|     |          |        | n + 92 | 123.621                     |                         | .619                    |

## Differences

|            |                        |                  |          |       |                 |
|------------|------------------------|------------------|----------|-------|-----------------|
| 1.866      | by 1.866 = 0.270912    | .676             | 9.829947 | 5.941 | 0.773860        |
| .676       | ac by 9.824 = 9.007712 |                  | 8.404752 |       | 8.404752        |
| 5.941      | ac by 4. = 9.397040    |                  | 8.234699 |       | 9.178612        |
| 14.493     |                        | 8.675664         |          |       |                 |
| 8.993      |                        |                  |          |       |                 |
| 12.027     |                        |                  |          |       |                 |
|            | 14.493 = 1.161158      | 8.993 = 0.953905 | 12.027   |       | 1.080155        |
| 1.036988   | 10.889 = 8.963012      | 8.958213         |          |       | 8.955106        |
| 1.041787   | 4. = 9.397040          | 9.397040         |          |       | 9.397040        |
| <u>236</u> | <u>9.521210</u>        | <u>9.309158</u>  |          |       | <u>9.432302</u> |
| 1.042022   |                        |                  |          |       |                 |
| 079904     |                        |                  |          |       |                 |
| <u>222</u> |                        |                  |          |       |                 |
| 080156     |                        |                  |          |       |                 |
| .044540    |                        |                  |          |       |                 |
| <u>354</u> |                        |                  |          |       |                 |
| .044894    |                        |                  |          |       |                 |

| Ribs   | Dist-      | Value s    | Theoretical value of $S_1 =$              |
|--------|------------|------------|-------------------------------------------|
| 0      | 0.000 cms. | 0.000      | $4.738 \times 1.03 = 4.88$                |
| n      | 4.738      | = 5. 4.738 | $\frac{14214}{103}$<br>by 4.88 = 0.688420 |
| n + 4  | 1.717      | 6.45       | $\frac{4738}{4880}$<br>by 2. = 0.301030   |
| n + 30 | 15.09      | 21.54      | by 0.01544 = 8.188647                     |
| n + 60 | 33.21      | 54.75      | $2 \sqrt{19.178097}$                      |
| n + 75 | 20.38      | 75.13      | 9.589048                                  |
| n + 92 | 27.06      | 102.19     | $S_1 = 4.88$<br>$\sqrt{29.5} = .3882$     |

$$y_2 = y_1 + (2g y_1)^{1/2} (t_2 - t_1) + \frac{g}{2} (t_2 - t_1)^2$$

$$\begin{array}{r} 4.88 \quad .388 \quad .00772 \\ \hline \quad \quad 4 \quad \quad 16 \\ 1.552 \quad 4632 \\ \hline \quad \quad 772 \\ \hline .12352 \end{array}$$

$$\begin{array}{r} 4.88 \\ 1.55 \\ \hline .12 \\ \hline 6.55 \text{ then} \\ 6.45 \text{ obs.} \\ \hline 6.55 \cdot 1.00 (.016) \\ \hline 65 \\ \hline 35 \end{array} \quad (x+4)$$

x + 30

$$\begin{array}{r} 4.88 \quad .388 \quad .00772 \\ \hline \quad \quad 30 \quad \quad 900 \\ 11.640 \quad 694800 \\ \hline \quad \quad 11.64 \\ \hline \quad \quad 4.88 \\ \hline 23.47 \text{ then} \\ 21.54 \\ \hline 1.93 \end{array}$$

x + 60

$$\begin{array}{r} 4.88 \quad .388 \quad .00772 \\ \hline \quad \quad 60 \quad \quad 3600 \\ 23.280 \quad 4632 \\ \hline \quad \quad 2316 \\ \hline 27.79200 \\ 23.28 \\ \hline 4.88 \\ \hline 55.95 \\ 54.75 \\ \hline 1.20 \end{array}$$

x + 75

$$\begin{array}{r} 4.88 \quad .388 \quad .00772 \\ \hline \quad \quad 75 \quad \quad 5625 \\ 1940 \quad 3860 \\ \hline 2716 \quad 1544 \\ \hline 29.100 \quad 4632 \\ \hline \quad \quad 3860 \\ \hline 43.42500 \\ 29.10 \\ \hline 4.88 \\ \hline 77.40 \\ 75.13 \\ \hline 2.27 \end{array}$$

x + 92

$$\begin{array}{r} 4.88 \quad .388 \quad .00772 \\ \hline \quad \quad 92 \quad \quad 8464 \\ 776 \quad 3088 \\ \hline 3492 \quad 4632 \\ \hline 35.696 \quad 3088 \\ \hline \quad \quad 6176 \\ \hline 65.34208 \\ 35.696 \\ \hline 4.88 \\ \hline 105.92 \\ 102.19 \\ \hline 106) 3.73 (.0352) \\ \hline \quad \quad 318 \\ \hline \quad \quad 550 \\ \hline \quad \quad 530 \\ \hline \quad \quad 200 \end{array}$$

## Plate 1 a

$$\begin{array}{r} .3-19 \\ 103 \\ \hline 957 \\ 319 \\ \hline 3.28 \end{array}$$

$$\begin{array}{r} .1006 \\ 49 \\ \hline 9054 \\ 4024 \\ \hline 4.929 \end{array}$$

$$\begin{array}{r} 69 \text{ vils.} \\ 1006 \\ 69 \\ \hline 9054 \\ 6036 \\ \hline 6.9414 \end{array}$$

$$\begin{array}{l} h .328 = 9.5115874 \\ h 2 = 0.301030 \\ h 2 = 8.188647 \\ 2 \sqrt{18.005551} \\ 9.002776 \\ \hline 15.5918 \end{array}$$

$$\begin{array}{r} .00772 \\ 2400. \\ \hline 3088 \\ 1544 \\ \hline 18.52800 \\ 4.929 \\ \hline 3.286 \\ 26.743 \end{array}$$

$$\begin{array}{r} 49 \text{ vils} \\ 18.528 \\ 4.929 \\ \hline .328 \\ 23.785 \\ 22.927 \\ \hline .828 \end{array}$$

$$\begin{array}{r} .00772 \\ 4761. \\ \hline 777 \\ 4632 \\ \hline 5404 \\ 3088 \\ \hline 36.75497 \end{array}$$

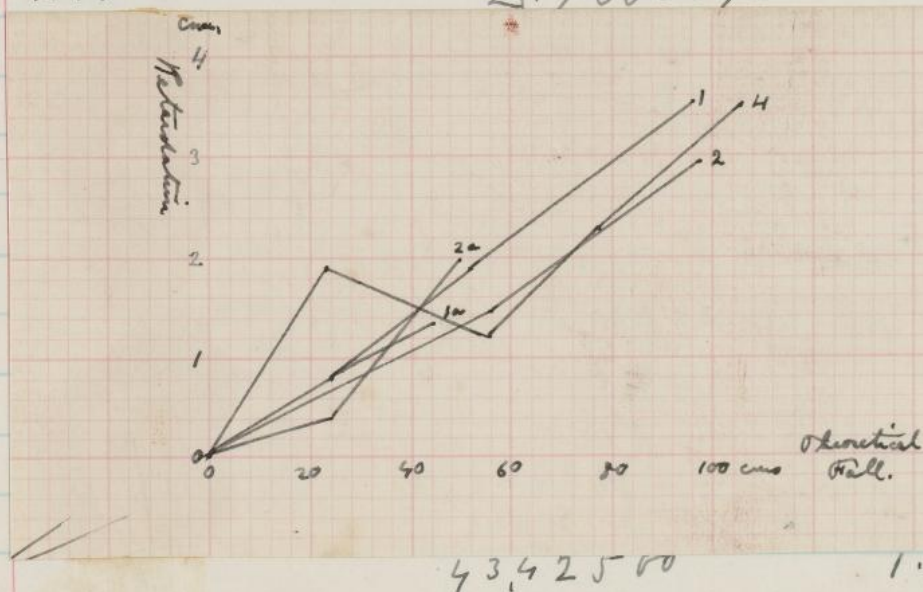
$$\begin{array}{r} 36.755 \\ 6.941 \\ \hline .328 \\ 44.024 \\ 42.628 \\ \hline 1.396 \end{array}$$

## Plate 2 a

$$\begin{array}{r} .242 \\ 1.03 \\ \hline 726 \\ 242 \\ \hline .2493 \end{array}$$

$$\begin{array}{l} h .249 = 9.396199 \\ 2. = 0.301030 \\ 2 = 8.188647 \\ 2 \sqrt{17.885876} \end{array}$$

$$\begin{array}{r} .00772 \\ 2500. \\ \hline 3860 \\ 1544 \\ \hline 19.30000 \end{array}$$



$$\begin{array}{r} 85- \\ 49 \\ \hline 34 \\ 28 \\ \hline 06 \end{array}$$

$$\begin{array}{r} 425- \\ 578 \\ \hline 249 \\ 52 \\ \hline 67 \\ 1.485 \end{array}$$

## Plate 1 a

$$\begin{array}{r} .3-19 \\ 103 \\ \hline 957 \\ 319 \\ \hline 3.28 \end{array}$$

$$\begin{array}{r} .1006 \\ 49 \\ \hline 9054 \\ 4024 \\ \hline 4.929 \end{array}$$

$$\begin{array}{r} 69 \text{ vils.} \\ .1006 \\ 69 \\ \hline 9054 \\ 6036 \\ \hline 6.9414 \end{array}$$

$$\begin{array}{l} h .328 = 9.511874 \\ h 2 = 0.301030 \\ h 2 = 8.188647 \\ 2 \boxed{18.005551} \\ 9.002776 \end{array}$$

$$\begin{array}{r} \cancel{8182} \\ \cancel{49} \\ \hline 28638 \\ 12728 \\ \hline 15.5918 \end{array}$$

$$\begin{array}{r} .00772 \\ 2400. \\ \hline 3088 \\ 1544 \\ \hline 18.52800 \\ \cancel{4.929} \\ 3.286 \\ \hline 26.743 \end{array}$$

$$\begin{array}{r} 49 \text{ vils} \\ 18.528 \\ 4.929 \\ \hline .328 \\ 23.785 \\ 22.957 \\ \hline .828 \end{array}$$

$$\begin{array}{r} .00772 \\ 4761. \\ \hline 777 \\ 4632 \\ \hline 5404 \\ 3088 \\ \hline 36.75497 \end{array}$$

$$\begin{array}{r} 36.755 \\ 6.941 \\ \hline .328 \\ 44.024 \\ 42.628 \\ \hline 1.396 \end{array}$$

## Plate 2 a

$$\begin{array}{r} .242 \\ 103 \\ \hline 726 \\ 242 \\ \hline .2493 \end{array}$$

$$\begin{array}{l} h .249 = 9.396199 \\ 2. = 0.301030 \\ 2 = 8.188647 \\ 2 \boxed{17.885876} \\ 8.942938 \end{array}$$

$$\begin{array}{r} 877 \\ 50 \\ \hline 785-0 \end{array}$$

$$.08769$$

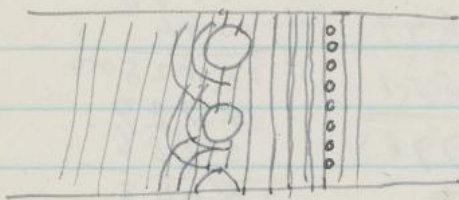
$$\begin{array}{r} .00772 \\ 2500. \\ \hline 3860 \\ 1544 \\ \hline 19.30000 \\ 4.385 \\ \hline .249 \\ 23.934 \\ 23.528 \\ \hline .406 \end{array}$$

$$\begin{array}{r} 877 \\ 75 \\ \hline 385 \\ 39 \\ \hline 775 \end{array}$$

$$\begin{array}{r} .00772 \\ 5625 \\ \hline 3860 \\ 1544 \\ \hline 4632 \\ 3860 \\ \hline 43.42500 \end{array}$$

$$\begin{array}{r} 43.425 \\ 6.578 \\ \hline .249 \\ 50.252 \\ 48.267 \\ \hline 1.985 \end{array}$$

Explanation why Microscopes cannot be indefinitely improved. Sept. 21, 1886.



Imagine an indefinite tank filled with water which is ~~infl-~~ flect of the wind so as to produce ripples 1 inch apart. This represents a beam of sunlight. In the tank insert a transverse row of stakes 6 in. in diam. & 6 in. apart. These will reflect the ripples, which may be made to pass through a small hole separating (the lens of the eye), separating the images on a screen.

If the ripples strike instead a row of small stakes  $\frac{1}{8}$  in. in diam. and  $\frac{1}{8}$  in. apart, we shall not have a series of distinct & separate ripples but a flat reflected wave front which of course cannot be separated.

## Actinometry

Mar. 17, '86.

Plate 100 <sup>Yach Reading</sup> Note Book (blue cover) <sup>Log Days</sup> 3 p 44 <sup>Days.</sup>

Ag.

Fish.

Hera.

Plate 101 p 46 + 47

G.F. 144.5 136 141 107

R.G. 156.5 135.5 128 109

Lows. 27 22

Plate 102 p 50

Plate 104

Plate 105

Gas 27 24

Thy 30.5

Plate 106

Thy 42 35 24 19

" 178.5 166.5 137.5 111 41 2.2 .26 days with 1.06 per year

Gas 238 164.5 135 120 8 4 2 1 out 40 times = 10.4 days =

Plate 107

290+ 257 244.5 222 +04 272 +26 -63

Plate 108 p 48

Candle 15-8 139 107 20 10.33 10.08 9.72? 2.14 1.20 .52? 1

Yuna 177 163.5 140.5 125 10.7 10.4 10.1 .98 5.02 2.57 1.26 .63

Gas 164.5 143.5 124 10.42 10.13 9.91 2.63 1.36 .81

Plate 109 p 44

Hera. 184 152 132 113 8.970 8.785 8.615? .093 .061 .041

Fish. 244 177.5 149 137 9.435 8.945 8.83 .27 .088 .068

Ag 261 231 155 123 9.6 9.2 9.0 8.7 1.40 .20 .10 .05



Mar. 26, '86.

| Scale Reading                 | Log Days                           | Days                 |
|-------------------------------|------------------------------------|----------------------|
| Plate 110 p. 47               |                                    |                      |
| G.P. 176 142.5- 131 121.5-    | 9.215- 8.95- 8.865- 8.810?         | .164 .089 .073 .065? |
| Lens. 265 226.5- 174 136.     | 9.80 9.50 9.20 8.90 <del>8.3</del> | .63 32 .16 .08       |
| R.G. 180 172 136 123          | 9.255? 9.18 8.90 8.82?             | .180 .157 .079 .066  |
| Plate 111 p. 47               | Manufacturing                      |                      |
| Plate 112 p. 52 Full Moon     |                                    |                      |
| Plate 113 p. 5-2              |                                    |                      |
| Moon                          |                                    |                      |
| Moon                          |                                    |                      |
| Plate 114 p. 5-2              |                                    |                      |
| Moon 248.5 234.5- 158. 139.5- | 10.8 10.54                         | 6.31 3.47            |
| Lens 179 150 120.5 126        | 11.0 10.7 10.4 10.1                | 10.00 5.00 2.50 1.25 |
| Moon 181 157.5 144 127.5-     | 11.1(?) 10.795- 10.605- 10.20      | 12.6 6.24 4.03 1.58  |
| Plate 115- p. 5-3             |                                    |                      |
| Lens 131.5- 119.5 115.5 112.  |                                    |                      |
| Lens. 177.5- 159 144.5 139.   |                                    |                      |
| Mg. 186.5- 162 154.5- 127.    |                                    |                      |
| Plate 116 p. 5-3              |                                    |                      |
| Lens 255- 156. 144.5- 132.    |                                    |                      |
| Lens 257 184. 155. 145.       |                                    |                      |
| Mg 238 158. 134.5- 134.       |                                    |                      |
| Plate 117 p. 5-5-             |                                    |                      |
| Paper 143.5- 133 122 116      |                                    |                      |
| Lens 190. 146.5- 138.5- 126   |                                    |                      |
| Plate 118 p. 5-5-             |                                    |                      |
| Paper 156 141 135- 119        |                                    |                      |
| Lens 158 138 130 127          |                                    |                      |



Calculation of Curve representing amount of light transmitted by film after various exposures.  
 Carbutt D plate measured at Harvard Observatory.

Mar. 16, '86.

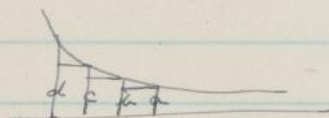
From 0 to 75 per cent transmitted.

$$y = mp + c = 100 \quad c = 100$$

$$0 = mp + 100 \quad mp = -100 \quad p = 41.5$$

$$y = -2.41 p + 100 \quad m = \frac{-100}{41.5} = -2.41$$

From 75 to 99 per cent transmitted.



ordinates are log times.  
 ordinates light trans.

$l = \text{dist. } a \text{ to } b = b - c = c - d \text{ etc.}$

$n = \text{no. of dists. employed.}$

$M = \text{dist. } a \text{ to origin.}$

$$\frac{b-a}{a} = \frac{c-b}{b} = \frac{d-c}{c} \text{ etc.} \quad \therefore C_1 = \frac{b}{a} - 1 = \frac{c}{b} - 1 = \frac{d}{c} - 1$$

$$\therefore C = \frac{b}{a} = \frac{c}{b} = \frac{d}{c} \text{ etc.} \quad b = aC \quad c = bC \quad d = cC$$

$$\therefore d = bC^2 = aC^3 \quad y = aC^m \quad X = M + ln$$

$$n = \frac{X-M}{l} \quad y = aC^{\frac{X-M}{l}} \quad C = \left(\frac{y}{a}\right)^{\frac{l}{X-M}}$$

$$l = \log \frac{p_2}{p_1} = \log \frac{p_2}{p_1} \text{ etc.} \quad X-M = \log \frac{p}{p_m} \quad \frac{l}{X-M} = \frac{\log \frac{p_2}{p_1}}{\log \frac{p}{p_m}}$$

$$y = aC^{\frac{l}{\log \frac{p}{p_m}}}$$

Numerical results

$$y = 167 \quad a = 7.5 \quad \frac{p_2}{p_1} = 1.26 \quad \frac{p}{p_m} = \frac{2.56}{40} = 6.4$$

$$C = \left(\frac{167}{7.5}\right)^{\frac{\log 1.26}{\log 6.4}} = \frac{1}{1.2} = 1.47 \quad y = 7.5 \times 1.47^{\frac{\log 2.56}{\log 1.26}} =$$

$$7.5 \times 1.47^{10 \log \frac{2.56}{p}} = 7.5 \times 1.47^{10(2.4 - \log p)} = 7.5 \times 48.5^{(2.4 - \log p)}$$

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