

# PROCEEDINGS

OF

## THE ROYAL SOCIETY.

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“Magnetic Observations in Egypt, 1893—1901.” By Captain  
H. G. LYONS, R.E. Communicated by Professor RÜCKER,  
Sec. R.S. Received June 6,—Read June 20, 1901.

The following Magnetic Observations have been made at various times during the years 1893 to 1899, at first with a Declinatorium, made by Bamberg, of Berlin, the property of the Egyptian Government, and later with a Kew Magnetometer, No. 73, and Dover's Dip Circle, No. 99, both kindly lent by the Council of the Royal Society on the recommendation of Professor A. W. Rücker, F.R.S. These observations are most conveniently divided into five groups, each of which includes observations made during a single period and with a single instrument—

I. Observations made with a Declinatorium by Bamberg, of Berlin :

- (a.) In the neighbourhood of Cairo, 1893—1894.
- (b.) In the Lybian Desert, near the Kharga and Dakhla Oases, in December, 1893, and January, 1894.
- (c.) In the Lybian Desert from the Wadi Natrun to the Baharia Oasis, April, 1894.

II. Observations taken with Kew Magnetometer, No. 73, and Dover's Dip Circle, No. 99, in the Nile Valley from Cairo to the 2nd Cataract, November, 1894, to June, 1896.

(a.) Declination. (b.) Dip and Horizontal Force.

III. Observations taken to determine the Diurnal Variation of the Declination.

IV. Observations taken at Helwan, near Cairo, in November and December, 1898.

V. Determination of the Annual Variation from the above observations and those of various observers in previous years.

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The declinatorium used at first consisted of a horizontal circle furnished with two verniers reading to  $30''$ , while the magnet was balanced on a vertical steel pivot, in a box which occupied the centre of the horizontal circle. Attached to the magnet was a mirror, in which the reflected image of the cross wires was observed with a small telescope placed excentrically. The same telescope also served to observe the sun or a meridian mark for determining the geographical meridian.

The geographical positions were taken from Maps Nos. 740, 662, published by the Intelligence Division, War Office, or from astronomical observations taken on the spot; the former are indicated by \* and the latter by †.

In each case the time of the observation is given as Cairo mean time, *i.e.*,  $2^h 5^m 8^s.9$  fast of Greenwich, since all the observations were made before the time of the  $30^\circ$  meridian E. of Greenwich was adopted as civil time for Egypt.

D'Abbadie's station, beside the Great Pyramid at Giza, was occupied on May 10, 1901, to obtain improved values of the secular variation. The observations were made between 1 P.M. and 4 P.M. when the electric tramway was not working.

Since there are, as yet, no self-registering magnetic instruments in Egypt, it is impossible to reduce the results obtained to a single epoch with any accuracy; they are, therefore, given as they were originally observed.

Helwan, 20 kiloms. south of Cairo, was chosen for the observations of 1898 and 1899, since the electric tramways of Cairo render observations impracticable even if the amount of iron in the present observatory building at Abbassia did not vitiate all observations taken there. For this reason the value of  $5^\circ 36'$  west for the declination, given in the 'Bulletin Mensuel' of the Abbassia Observatory for June, 1886, is wholly wrong.

In observing with the Declinatorium, the feet of the tripod were firmly pressed into the ground, and this was found sufficient for the precision obtainable with the instrument. With the Kew pattern magnetometer, however, wooden pickets were driven firmly into the ground, and the feet of the tripod rested on these, thus avoiding any errors due to the tripod sinking into soft or sandy soil.

All the observations which follow may be considered as satisfactory ones taken under favourable conditions, since all those which were interfered with by high winds, sand storms, &c., have been omitted. The stations where igneous rocks are known to be near enough to affect the results somewhat are marked with an asterisk on page 10.

At several places on the Bahr el Abyad granite masses, and occasionally basaltic rocks, rise through the sandstone, and the high value for declination obtained at Renk (page 23) is probably due to this.

The times given are those of the middle of the observation, *i.e.*, for Girga—

|                               |            | Mean. |
|-------------------------------|------------|-------|
| Declination observation ..... | 8.58—9.11  | 9.5   |
| First vibration .....         | 9.14—9.27  | 9.20  |
| Second vibration... ..        | 9.34—9.47  | 9.40  |
| Deflection .....              | 10.35—11.0 |       |

The time of the horizontal force value is given as the middle of the time of the vibration observation.

Where one value is given for the dip one needle was used ; where two values, the value obtained from each is given.

Deflection observations as well as the vibration observation were made on each occasion for the observations given in Table II(*b*) ; in the observations given on page 22 it is mentioned when it was not possible to take them.

I (a). Declination at Stations near Cairo determined with a Declinatorium.

| Place.                                           | Latitude<br>N.<br>° ' " | Longitude<br>E.<br>° ' " | Date.    | Cairo<br>mean time.<br>h. m. | Declination<br>West.<br>° |                                                              |
|--------------------------------------------------|-------------------------|--------------------------|----------|------------------------------|---------------------------|--------------------------------------------------------------|
| Mataria, site of ancient Temple<br>of Heliopolis | *30 7 40                | 31 8 53                  | 2-10-93  | 15 45                        | 4 26·9                    |                                                              |
| Abbassia, The Polygon Camp...                    | *30 4 13                | 31 18 8                  | 11-8-93  | 6 20                         | 4 17·7                    |                                                              |
| " " " " " "                                      | " "                     | " "                      | 11-10-93 | 16 10                        | 4 24·6                    |                                                              |
| " " " " " "                                      | " "                     | " "                      | 24-8-94  | 8 0                          | 4 11·7                    |                                                              |
| " " " " " "                                      | " "                     | " "                      | 26-10-94 | 7 0                          | 4 17·0                    |                                                              |
| Cairo, Gezira Hut Barracks, S.<br>end            | *30 3 25                | 31 13 3                  | 14-8-93  | 16 45                        | 4 27·3                    |                                                              |
| Cairo, Venus Station on Jebel<br>Moqattam        | *30 1 46                | 31 16 39                 | 17-8-93  | 18 20                        | 4 35·9                    | Position determined by Transit<br>of Venus Expedition, 1874. |
| Cairo, Moqattam Fort, south side                 | *30 1 31                | 31 16 6                  | 20-9-93  | 16 58                        | 4 24·6                    |                                                              |
| Mena House Hotel, Giza Pyra-<br>mids             | *29 59 30               | 31 7 46                  | 1-9-93   | 15 15                        | 4 30·4                    |                                                              |
| Saqqara, Mariette's House .....                  | *29 52 30               | 31 12 47                 | 25-8-93  | 12 45                        | 4 30·4                    |                                                              |
| Helwan, right bank of Nile.....                  | *29 51 32               | 31 20 16                 | 13-10-93 | 13 30                        | 4 27·7                    |                                                              |
| Mit Rahini Village, left bank of<br>Nile         | *29 50 57               | 31 15 3                  | 25-8-93  | 8 0                          | 4 19·5                    |                                                              |

## I (b). Declination at Stations in the Lybian Desert near Kharga and Dakha Oases, determined with a Declinatorium.

| Place.                                                                            | Latitude<br>N. | Longitude<br>E. | Date.    | Cairo<br>mean time. | Declination<br>West. |                                                                                                     |
|-----------------------------------------------------------------------------------|----------------|-----------------|----------|---------------------|----------------------|-----------------------------------------------------------------------------------------------------|
| Assiut, left bank of Nile .....                                                   | 27 11 0        | 31 12 0         | 15-12-93 | h. m.               | ° ' "                | Position given by Jordan, 1874.<br>Position fixed by compass traverse<br>between Assiut and Kharga. |
| On caravan road between Assiut<br>and Kharga Oasis .....                          | 26 50 0        | 30 53 15        | 18-12-93 | 9 40<br>13 30       | 4 47·5<br>4 52·7     |                                                                                                     |
| Kharga village .....                                                              | +25 26 20      | 30 32 50        | 22-12-93 | 10 0                | 5 1·5                | Position from compass traverse.                                                                     |
| Beris, Kharga Oasis .....                                                         | +24 42 33      | 30 36 0         | 27-12-93 | 17 0                | 4 54·8               |                                                                                                     |
| " " .....                                                                         | " "            | " "             | 11-1-94  | 16 0                | 4 55·7               |                                                                                                     |
| On caravan road between Beris<br>in Kharga Oasis and Mut in<br>Dakhla Oasis ..... | 25 10 20       | 29 47 20        | 31-12-93 | 9 20                | 5 23·9               |                                                                                                     |
| Mut, Dakhla Oasis .....                                                           | +25 29 4       | 29 4 40         | 2-1-94   | 17 0                | 5 22·8               | Position from compass traverse<br>from Mut to Beris.                                                |
| Point on caravan road south of<br>Mut .....                                       | 24 16 45       | 29 14 30        | 7-1-94   | 14 30               | 5 32·0               |                                                                                                     |
| Point in Desert west of Beris ....                                                | 24 37 30       | 30 20 40        | 9-1-94   | 15 10               | 4 56·2               |                                                                                                     |
| Point on Derb el Arbain caravan<br>road south of Beris .....                      | 23 52 30       | 30 27 40        | 13-1-94  | 15 30               | 5 14·2               |                                                                                                     |
| Bir Murr .....                                                                    | +23 19 30      | 30 11 40        | 15-1-94  | 9 5                 | 5 3·2                |                                                                                                     |

## I (c). Declination at Stations in Wadi Natrun and Baharia Oasis, determined with a Declinatorium.

|                               |           |          |         |       |        |  |
|-------------------------------|-----------|----------|---------|-------|--------|--|
| Wadi Natrun, Deir Anba Bishoi | +30 19 25 | 30 25 0  | 16-4-94 | 10 30 | 4 38·3 |  |
| " " Deir Baramus .....        | +30 21 18 | 30 16 24 | 17-4-94 | 16 0  | 4 54·0 |  |
| Baharia Oasis, Mandisha ..... | +28 21 00 | 28 58 0  | 24-4-94 | 8 30  | 5 8·9  |  |

## Description of Stations observed at with Declinatorium.

| Place.                            | Description.                                                                                                                     |
|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------|
| Mataria .....                     | On ruins of Temenos wall of Temple of Heliopolis ; S. of obelisk.                                                                |
| Abbassia .....                    | N. end of Polygon, E. of Suez road, E. end of row of trees behind battery.                                                       |
| Gezira.....                       | 100 metres north of Grotto, N.W. of Gezira.                                                                                      |
| Venus Station,<br>Jebel Moqattam. | Observation point of Transit of Venus Expedition, 1874.                                                                          |
| Moqattam Fort ...                 | 200 metres south of old fort on spur above Citadel, <i>not</i> the earthwork on the top of the hill by the Cholera Camp of 1883. |
| Mena House, Giza..                | Opposite Mena House Hotel, S. of road to Pyramids.                                                                               |
| Saqqara .....                     | 150 metres N.E. of Mariette's house.                                                                                             |
| Helwan .....                      | 20 kilom. S. of Cairo ; on a low hill E. of water reservoirs to N.E. of town.                                                    |
| Mit Rahini.....                   | 50 metres west of the larger Ramses Colossus on the site of Memphis.                                                             |
| Assiut .....                      | On bank 300 metres S. of railway station and 80 metres E. of main road to town.                                                  |
| Kharga .....                      | 50 metres S. of blockhouse S.E. corner of village.                                                                               |
| Beris .....                       | E. of village 100 metres E. of fort.                                                                                             |
| Mut.....                          | West end of the old Government buildings.                                                                                        |
| Bir Murr .....                    | Close to the well.                                                                                                               |
| Deir Anba Bishoi ..               | In garden between guest chamber and church.                                                                                      |
| Deir Baramus ....                 | On roof, east side of guest chamber.                                                                                             |
| Mandisha .....                    | In front of Omda's house.                                                                                                        |



## II (b). Dip and Horizontal Force in the Nile Valley.

| Place.                            | Date.      | Cairo mean time. | Dip.    | Cairo mean time. | Horizontal force. | Lat. 28° 38' 50" | No. of dip needle. |
|-----------------------------------|------------|------------------|---------|------------------|-------------------|------------------|--------------------|
| Abbassia, Polygon Camp.....       | 3-5-95     | h. m.<br>12 10   | °     ' | h. m.<br>10 20   | 0·30076           | —                | 2                  |
| " " ".....                        | 12-6-96    | 16 50            | 40 44·0 | 16 0             | 0·30038           | Lat. 28° 38' 50" | 2                  |
| Maghagha.....                     | 19-11-97   | 13 00            | 38 11·8 | —                | —                 | —                | 1                  |
| Girga, left bank of Nile.....     | 24-11-94   | 10 50            | 34 37·0 | 9 20             | 0·31608           | —                | 1                  |
| " " ".....                        | 6-11-95    | { 13 10          | 34 30·5 | 9 40             | 0·31622           | —                | 2                  |
| " " ".....                        | " " "..... | { 11 40          | 34 31·4 | —                | —                 | —                | 1                  |
| Dendera " " ".....                | 5-11-94    | { 11 40          | 34 18·5 | —                | —                 | —                | 2                  |
| " " ".....                        | " " "..... | { 12 10          | 34 19·0 | —                | —                 | —                | 2                  |
| " " ".....                        | 7-11-95    | —                | —       | 11 15            | 0·31874           | —                | —                  |
| Luxor, right " " ".....           | 15-3-95    | 16 40            | 33 38·1 | 11 45            | 0·31904           | —                | 2                  |
| Mualla " " ".....                 | 14-3-95    | 6 30             | 32 58·7 | 15 30            | 0·32070           | Lat. 25° 29' 0"  | 1                  |
| Edfu, left " " ".....             | 30-12-94   | 8 30             | 31 56·0 | —                | —                 | —                | 1                  |
| " " ".....                        | 13-3-95    | —                | —       | 8 30             | 0·32357           | —                | —                  |
| Assuan, Rest Camp.....            | 29-12-94   | 11 20            | 30 19·7 | 7 15             | 0·32364           | Lat. 24° 7' 0"   | 1                  |
| " " ".....                        | 11-3-95    | { 17 20          | 30 18·8 | —                | —                 | —                | 1                  |
| " " ".....                        | " " "..... | { 16 20          | 30 18·2 | —                | —                 | —                | 2                  |
| " " ".....                        | " " "..... | { 7 30           | 30 28·9 | 18 15            | 0·32440           | —                | 1                  |
| Philæ Island.....                 | 9-3-95     | { 8 5            | 30 29·1 | 16 40            | 0·32390           | —                | 2                  |
| " " ".....                        | " " "..... | —                | —       | —                | —                 | —                | —                  |
| Dabod, left bank of Nile.....     | 9-2-95     | { 7 10           | 30 16·5 | —                | —                 | —                | 1                  |
| " " ".....                        | 10-2-95    | { 7 45           | 30 16·3 | —                | —                 | —                | 2                  |
| Taifa " " ".....                  | 7-3-95     | { 10 25          | 29 46·7 | 13 30            | 0·32716           | —                | 1                  |
| " " ".....                        | " " "..... | { 9·50           | 29 46·7 | —                | —                 | —                | 2                  |
| Kalabsha " " ".....               | 11-2-95    | { 17 40          | 29 26·4 | 7 0              | 0·32926           | —                | 1                  |
| " " ".....                        | " " "..... | { 17 0           | 29 26·0 | —                | —                 | —                | 2                  |
| Abu Hor, right " " ".....         | 13-2-95    | { 17 30          | 29 34·2 | 15 40            | 0·32702           | —                | 1                  |
| Gerf Hussein, left bank of Nile.. | 15-2-95    | { 15 30          | 29 1·5  | 12 20            | 0·32815           | —                | 1                  |
| " " ".....                        | " " "..... | { 14 50          | 29 8·3  | —                | —                 | —                | 2                  |



II (b)—continued.

| Place.                             | Date.    | Cairo mean time. | Dip.        | Cairo mean time. | Horizontal force. | No of Dip Needle. |
|------------------------------------|----------|------------------|-------------|------------------|-------------------|-------------------|
| Dakka, left bank of Nile.....      | 16-2-95  | h. m.<br>{ 14 10 | ° ' 29 10.6 | h. m.<br>12 0    | 0.32795           | 1 }<br>2 }        |
| Uffeduni, " .....                  | 17-2-95  | { 13 40          | 29 10.6     | 12 0             | 0.32795           | 1 }<br>2 }        |
| Siala, right .....                 | 26-12-94 | { 16 0           | 28 35.2     | 12 40            | 0.32902           | 1 }<br>2 }        |
| Sebua, left .....                  | 19-2-95  | { 15 30          | 28 35.2     | 7 30             | 0.32747           | 1 }<br>2 }        |
| " .....                            | 20-2-95  | { 13 20          | 28 27.0     | —                | —                 | 1 }<br>2 }        |
| Korosko, right bank of Nile.....   | 1-12-94  | { 13 35          | 28 27.0     | 11 50            | 0.32932           | 1 }<br>2 }        |
| " .....                            | 21-2-95  | { 14 40          | 28 19.8     | 15 0             | 0.32692           | 1 }<br>2 }        |
| Amada, left .....                  | 5-3-95   | { 15 30          | 28 17.8     | 16 0             | 0.32638           | 1 }<br>2 }        |
| Abu Simbel, left bank of Nile...   | 23-2-95  | { 16 40          | 28 6.7      | 14 20            | 0.32903           | 1 }<br>2 }        |
| Akshi (Serra), left bank of Nile.. | 2-3-95   | { 17 10          | 27 47.7     | 17 0             | 0.32735           | 1 }<br>2 }        |
| Wadi Halfa, right ..               | 25-2-95  | { 6 40           | 27 15.4     | 10 0             | 0.33316           | 1 }<br>2 }        |
| " ..                               | 27-2-95  | { 7 10           | 27 16.5     | —                | —                 | 1 }<br>2 }        |
| Bir Ongat, Nubian Desert .....     | 20-12-94 | { 6 50           | 26 51.0     | 14 50            | 0.32939           | 1 }<br>2 }        |
| Wadi Mogharin ..                   | 14-12-94 | { 7 30           | 26 49.4     | 7 0              | 0.33148           | 1 }<br>2 }        |
| Murrat Wells .....                 | 11-12-94 | { 17 30          | 26 28.6     | 7 15             | 0.33149           | 1 }<br>2 }        |
| " ..                               | 12-12-94 | { 16 50          | 26 28.4     | —                | —                 | 1 }<br>2 }        |
| " ..                               | 12-12-94 | { 11 25          | 26 18.1     | 8 15             | 0.33695           | 1 }<br>2 }        |
| " ..                               | 12-12-94 | { 12 0           | 26 23.5     | —                | —                 | 1 }<br>2 }        |
| " ..                               | 12-12-94 | { 16 30          | 25 23.7     | —                | —                 | 1 }<br>2 }        |
| " ..                               | 12-12-94 | { 17 10          | 25 22.4     | —                | —                 | 1 }<br>2 }        |
| " ..                               | 12-12-94 | { 15 40          | 24 27.1     | —                | —                 | 1 }<br>2 }        |
| " ..                               | 12-12-94 | { 16 20          | 24 27.6     | —                | —                 | 1 }<br>2 }        |

Description of Stations observed at with Magnetometer and Dip Circle.

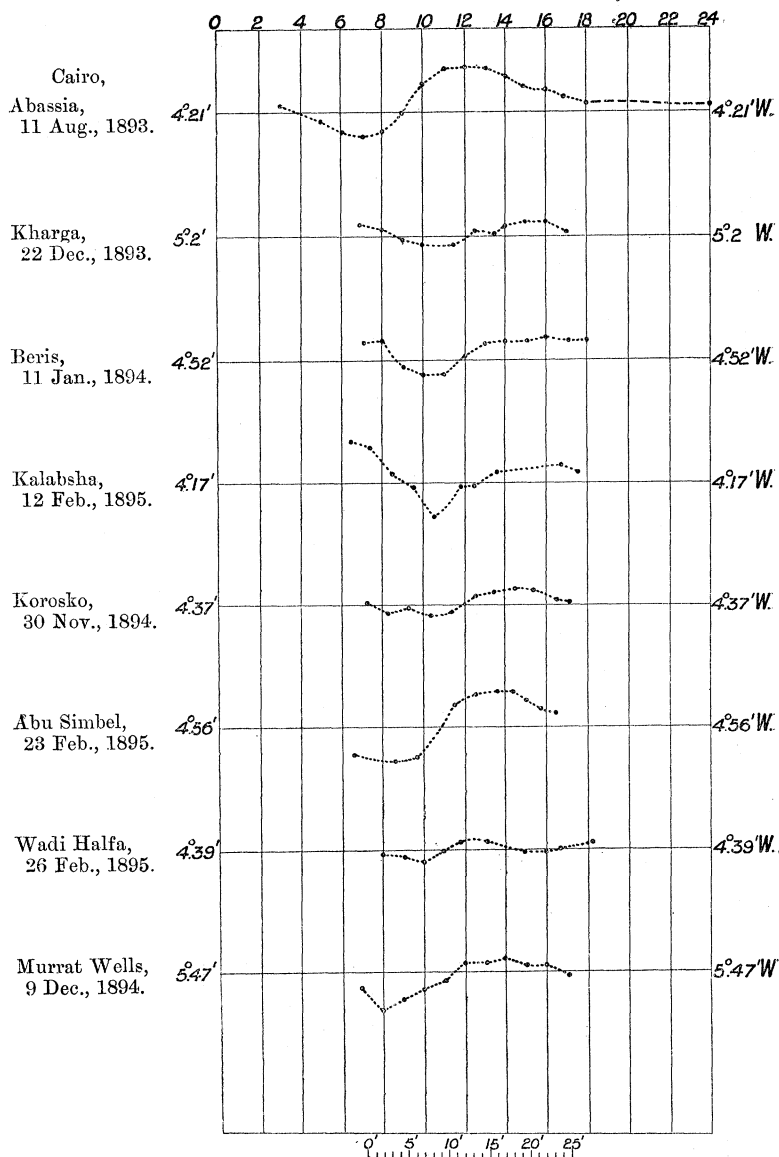
| Place.                             | Description.                                                                                                                |
|------------------------------------|-----------------------------------------------------------------------------------------------------------------------------|
| Abbassia .....                     | The same as for Declinatorium.                                                                                              |
| Girga .....                        | S.W. of huts, which are 150 metres west of canal head on N. side of steamer landing barge.                                  |
| Dendera .....                      | 100 metres E. of point where steamers stop.                                                                                 |
| Luxor .....                        | On river bank, 50 metres north of house painted red and white, on bank south of Luxor.                                      |
| Mualla .....                       | 2 kiloms. S. of irrigation resthouse.                                                                                       |
| Esna .....                         | 100 metres north of landing barge, and on river bank.                                                                       |
| Edfu .....                         | 40 metres from bank, and 120 metres S. of landing barge.                                                                    |
| Assuan* .....                      | Rest camp, S. side of 2nd hut from N.W. corner.                                                                             |
| Elephantine* .....                 | 25 metres S.E. from gateway of ancient temple.                                                                              |
| 1st Cataract* .....                | South side of the Bab el Gedid.                                                                                             |
| Phile* .....                       | Till 29 Nov. E. side of kiosk, on quay, after then on roof of Temple of Isis, N. end.                                       |
| Dabod .....                        | 200 metres N. of ancient masonry quay.                                                                                      |
| Taifa* .....                       | 100 metres from S.E. corner of village, on river bank.                                                                      |
| Kalabsha* .....                    | 30 metres from river bank, and 70 metres north of great temple.                                                             |
| Abu Hor* .....                     | On river bank, 100 metres S. of steamers' stopping place.                                                                   |
| Gerf Hussein .....                 | At entrance to temple.                                                                                                      |
| Dakka .....                        | S.E. angle of temple.                                                                                                       |
| Uffeduni .....                     | On eastern part of temple ruins.                                                                                            |
| Siala .....                        | On bank opposite N. end of village.                                                                                         |
| Sebua .....                        | On river bank 50 metres S. of line of temple axis.                                                                          |
| Bir Ongat* .....                   | Close to the well.                                                                                                          |
| Wadi Mogharin* .....               | At mouth of Wadi, to W. of Murrat Wells.                                                                                    |
| Murrat Wells,* Nubian Desert ..... | On rocky spur between the two blockhouses.                                                                                  |
| Korosko .....                      | On river bank, S.W. end of officers' quarters.                                                                              |
| Amada .....                        | 150 metres S.E. of temple, and on the foundation course of an ancient building.                                             |
| Abu Simbel .....                   | 50 metres S.E. of and slightly lower than great temple entrance.                                                            |
| Akshi (Serra) .....                | West bank, 200 metres S. of temple ruins.                                                                                   |
| Wadi Halfa .....                   | Under gamaiza tree, 60 metres S. of Commandant's house.                                                                     |
| Mirgissi Fort* .....               | In ancient Egyptian fort W. of remains of small temple in N.W. corner of the walled enclosure.                              |
| Great Pyramid, Giza                | 10.5.1901 occupied d'Abbadie's station close to pyramid, east of it; on ruins of the most northern of three small pyramids. |

\* Denotes crystalline rocks in the immediate neighbourhood.

### III. *Diurnal Variation of the Magnetic Declination.*

In the absence of any self-registering apparatus in Egypt, the diurnal variation of the declination has been observed hourly at a few places, and the results of some of these observations are here given graphically. Except in the case of Abbassia, a single day only was available.

## Curves of Diurnal Variation of Declination.



Scale of twenty-five minutes of arc.

Abbassia, Kharga, and Beris observed with Declinatorium, the rest with Kew pattern magnetometer.

W. 4° +. Mean Values of Diurnal Variation of  $\delta$  at Philæ.

| Period.                 | 7          | 8          | 9          | 10         | 11        | Noon.      | 1          | 2          | 3          | 4          | 5          |
|-------------------------|------------|------------|------------|------------|-----------|------------|------------|------------|------------|------------|------------|
| Dec. 23—Dec. 31 .....   | 26.1<br>'  | 24.9<br>'  | 25.4<br>'  | 25.8<br>'  | 27.4<br>' | 27.3<br>'  | —*<br>'    | 26.1<br>'  | 25.8<br>'  | 26.0<br>'  | 20.2<br>"  |
| Jan. 1—Jan. 10† .....   | 26.6<br>'  | 26.7<br>'  | 26.5<br>'  | 27.6<br>'  | 28.7<br>' | 28.6<br>'  | 27.4<br>'  | 27.1<br>'  | 26.9<br>'  | 26.6<br>'  | 27.2*<br>' |
| Jan. 11—Jan. 20.....    | 26.1<br>'  | 25.5*<br>' | 25.4<br>'  | 25.9<br>'  | 27.3<br>' | 27.7*<br>' | 26.2<br>'  | 25.5*<br>' | 25.2<br>'  | 25.9<br>'  | 25.8*<br>' |
| Jan. 21—Jan. 31‡ .....  | 25.5*<br>' | 26.0<br>'  | 24.9<br>'  | 24.8<br>'  | 25.1<br>' | 26.1<br>'  | 25.6*<br>' | 26.8*<br>' | 27.0<br>'  | 26.7<br>'  | 26.2*<br>' |
| Feb. 1—Feb. 10 .....    | 26.2*<br>' | 25.5<br>'  | 25.7<br>'  | 25.3<br>'  | 26.3<br>' | 26.6<br>'  | 26.1<br>'  | 26.2<br>'  | 25.8<br>'  | 25.5<br>'  | 26.4*<br>' |
| Feb. 11—Feb. 20§ .....  | 26.2*<br>' | 25.2<br>'  | 25.0<br>'  | 24.9<br>'  | 25.7<br>' | 26.5<br>'  | 26.6*<br>' | 26.6*<br>' | 25.6<br>'  | 24.9<br>'  | —          |
| Feb. 21—Feb. 29   ..... | —          | 24.0<br>'  | 23.4<br>'  | 23.2<br>'  | 23.9<br>' | 24.6<br>'  | 24.6<br>'  | —          | 24.4<br>'  | 23.5<br>'  | —          |
| March 1—March 10¶ ..... | —          | 24.9<br>'  | 25.8<br>'  | 26.7<br>'  | 27.6<br>' | 27.3<br>'  | 27.9<br>'  | 25.8*<br>' | —          | 25.1<br>'  | —          |
| March 11—March 20.....  | —          | 23.7<br>'  | 24.6<br>'  | 25.7*<br>' | 26.2<br>' | 27.7<br>'  | 27.6<br>'  | 26.3<br>'  | 25.3*<br>' | 25.6<br>'  | 24.7*<br>' |
| March 21—March 31.....  | 21.8<br>'  | 21.8<br>'  | 22.0<br>'  | 23.9<br>'  | 25.8<br>' | 27.4<br>'  | 26.5*<br>' | 26.4<br>'  | 24.4*<br>' | 24.4<br>'  | 23.4<br>'  |
| April 1—April 10 .....  | 22.8*<br>' | 21.0<br>'  | 23.3*<br>' | 23.0*<br>' | 24.9<br>' | 25.1<br>'  | —          | 25.2<br>'  | —          | 24.6*<br>' | 22.3<br>'  |

\* Too few readings to give a fair average.

† No observations 21st, 25th, 30th, and 31st Jan.

‡ No observations on 23rd and 25th Feb. only.

† No observations 8th and 9th Jan.

§ Observations few 11th—16th Feb.

¶ No observations on 1st, 2nd, 3rd, and 6th March.



|   | 18.  | 19.  | 20.  | 21.              | 22.  | 23.  | 24.  | 25.              | 26.  | 27.  | 28.  | 29.  | 30.              | 31.              |
|---|------|------|------|------------------|------|------|------|------------------|------|------|------|------|------------------|------------------|
| 6 | —    | 26·4 | 24·6 | No observations. | 25·5 | —    | —    | No observations. | —    | —    | —    | —    | No observations. | No observations. |
|   | 24·9 | —    | —    |                  | 25·1 | 26·2 | —    |                  | 26·2 | 26·2 | 26·2 | —    |                  |                  |
| 5 | 24·6 | 26·4 | 24·2 |                  | —    | 24·8 | 24·1 |                  | 24·6 | 24·9 | 25·1 | 25·7 |                  |                  |
| 6 | 26·4 | —    | 24·8 |                  | 25·1 | 24·6 | —    |                  | 24·4 | 24·6 | —    | 25·5 |                  |                  |
|   | 28·0 | 29·3 | 25·7 |                  | —    | 26·4 | 24·6 |                  | 24·6 | 24·6 | 25·1 | —    |                  |                  |
| 7 | —    | —    | —    | No observations. | 27·1 | 28·2 | 24·9 | No observations. | 26·2 | 24·8 | 25·1 | 26·6 | No observations. | No observations. |
|   | 26·4 | —    | 26·2 |                  | —    | —    | —    |                  | 25·5 | 26·4 | 24·8 | —    |                  |                  |
|   | 25·3 | —    | —    |                  | 26·2 | —    | —    |                  | —    | 26·6 | —    | 27·8 |                  |                  |
| 8 | —    | 24·6 | 24·6 |                  | —    | 27·8 | 26·2 |                  | 26·2 | —    | —    | 27·7 |                  |                  |
|   | 24·8 | —    | —    |                  | —    | 27·1 | —    |                  | 26·6 | 26·8 | 26·0 | 27·1 |                  |                  |
|   | —    | —    | 24·4 |                  | 26·2 | —    | 26·2 |                  | —    | —    | —    | —    |                  |                  |

| 4.               | 15.  | 16.              | 17.  | 18.  | 19.  | 20.  | 21. | 22. | 23.  | 24. | 25.  |
|------------------|------|------------------|------|------|------|------|-----|-----|------|-----|------|
| No observations. | —    | No observations. | 26·2 | —    | —    | —    | —   | —   | —    | —   | —    |
|                  | —    |                  | —    | 25·3 | 24·8 | 24·4 | —   | —   | 24·8 | —   | 23·3 |
|                  | 25·3 |                  | 24·8 | 24·6 | 24·8 | 24·9 | —   | —   | 23·2 | —   | 23·7 |
|                  | —    |                  | —    | 24·6 | 24·6 | 26·2 | —   | —   | 22·1 | —   | 24·4 |
|                  | 26·2 |                  | 24·9 | 25·1 | 26·6 | 27·5 | —   | —   | 23·0 | —   | 24·8 |
|                  | 26·4 |                  | —    | 26·6 | 27·7 | —    | —   | —   | 24·6 | —   | 24·6 |
|                  | —    |                  | 24·8 | 27·1 | 27·8 | —    | —   | —   | —    | —   | 24·6 |
|                  | —    |                  | 26·8 | —    | 26·6 | 26·4 | —   | —   | —    | —   | —    |
|                  | —    |                  | 26·4 | 26·4 | —    | 24·9 | —   | —   | —    | —   | 24·4 |
|                  | —    |                  | —    | 25·7 | 24·8 | 24·6 | —   | —   | —    | —   | 23·5 |
|                  | —    |                  | —    | —    | —    | —    | —   | —   | —    | —   | —    |

|  | 18.  | 19.  | 20. | 21.  | 22.  | 23. | 24. | 25.  | 26.  | 27.  | 28.  | 29.  | 30.  | 31.  |
|--|------|------|-----|------|------|-----|-----|------|------|------|------|------|------|------|
|  | —    | —    | —   | —    | 23·8 | —   | —   | 21·9 | 20·5 | —    | 21·2 | —    | —    | —    |
|  | 23·3 | 24·2 | —   | 21·7 | 22·8 | —   | —   | 22·1 | 22·4 | 22·6 | —    | 20·5 | 21·6 | 21·0 |
|  | 24·0 | 25·3 | —   | 21·9 | 21·7 | —   | —   | —    | 23·1 | —    | 21·9 | —    | 21·6 | —    |
|  | —    | —    | —   | —    | 22·3 | —   | —   | 26·2 | 23·1 | 25·3 | —    | 22·8 | 22·9 | 24·4 |
|  | 27·1 | 27·3 | —   | 27·1 | 23·7 | —   | —   | —    | 25·8 | 26·6 | 24·6 | —    | 24·6 | 26·4 |
|  | 28·2 | 28·2 | —   | 28·2 | 25·1 | —   | —   | 29·4 | 26·4 | 28·2 | 25·5 | 27·7 | 28·2 | 27·5 |
|  | —    | 27·3 | —   | —    | 26·4 | —   | —   | —    | 26·4 | —    | —    | —    | 26·8 | —    |
|  | 26·4 | 25·5 | —   | 26·4 | 25·8 | —   | —   | 27·7 | —    | 26·2 | 25·8 | 27·1 | —    | 26·0 |
|  | —    | —    | —   | —    | 24·6 | —   | —   | —    | —    | 24·2 | —    | —    | —    | —    |
|  | 25·7 | 25·1 | —   | 25·7 | 23·1 | —   | —   | 24·8 | 24·6 | 24·0 | —    | —    | —    | —    |
|  | 24·8 | —    | —   | 24·8 | 23·7 | —   | —   | —    | —    | —    | 23·1 | 22·6 | 23·5 | 22·8 |

*Diurnal Variation of Declination at Philæ, Assuan.*

Lat. N.  $24^{\circ} 1' 10''$ ; Long. E.  $32^{\circ} 51' 50''$ , from December, 1895, to April, 1896.

While employed on Philæ Island examining and restoring the ancient buildings on the island, magnetic observations in the neighbouring country could not be undertaken for want of time. A magnetometer was set up, therefore, in a small, empty chamber on the roof of the Great Isis Temple, and the declination observed hourly from 7 A.M. to 5 P.M., except when the work on the excavations prevented. The results are given in the following tables (see also p. 12):—

## December, 1895.

| Hours. | 20.  | 21.  | 22.  | 23.  | 24.  | 25.  | 26.  | 27.  | 28.              | 29.  | 30.  | 31.  |
|--------|------|------|------|------|------|------|------|------|------------------|------|------|------|
| 7      | —    | 26·9 | 26·0 | 26·4 | 26·4 | 25·7 | —    | 26·0 | No observations. | 25·5 | 26·8 | 26·2 |
| 8      | 24·6 | —    | —    | —    | 25·9 | 25·5 | —    | 24·4 |                  | 24·4 | 24·8 | —    |
| 9      | 24·1 | 25·1 | 25·3 | 25·9 | 25·9 | 26·8 | 24·8 | 23·7 |                  | 24·8 | 27·8 | 25·0 |
| 10     | 24·6 | 24·8 | 24·6 | 27·6 | —    | —    | 27·1 | 25·0 |                  | 26·6 | —    | —    |
| 11     | 25·1 | 25·0 | —    | 29·6 | 28·0 | 29·3 | 27·8 | 25·2 |                  | 27·7 | 27·8 | 28·4 |
| Noon   | 25·1 | —    | 26·0 | 29·4 | 28·2 | 28·8 | 27·6 | 24·1 |                  | 27·5 | —    | 28·6 |
| 1      | —    | 24·6 | —    | —    | —    | —    | —    | 23·7 |                  | —    | —    | —    |
| 2      | 24·6 | 25·1 | 24·8 | 27·7 | 26·0 | 26·4 | 26·2 | —    |                  | 26·2 | —    | 27·7 |
| 3      | 24·6 | —    | —    | 25·8 | 24·2 | 26·0 | 25·7 | 23·7 |                  | 26·6 | 27·7 | 28·1 |
| 4      | 26·9 | 24·6 | —    | 25·5 | —    | —    | 25·7 | 24·6 |                  | 26·8 | —    | 28·1 |
| 5      | 26·7 | 25·8 | 24·6 | 26·2 | 24·4 | —    | —    | —    |                  | 26·9 | 26·8 | 27·9 |

(See folding tables for months of January, February and March.)

W. 4° +

April, 1896.

| Hours. | 1.   | 2.   | 3.   | 4.   | 5.   | 6.   | 7.   | 8.   | 9.   |
|--------|------|------|------|------|------|------|------|------|------|
| 7      | —    | 22·8 | —    | —    | —    | —    | —    | —    | —    |
| 8      | 22·3 | —    | 22·8 | 21·5 | 21·0 | 19·9 | 20·5 | 20·8 | 19·2 |
| 9      | —    | 24·4 | —    | 22·3 | —    | —    | —    | —    | —    |
| 10     | —    | 26·6 | —    | —    | —    | —    | 21·5 | —    | 20·9 |
| 11     | 24·6 | 28·0 | 27·1 | —    | 23·7 | 23·5 | 24·6 | —    | 22·8 |
| Noon   | 25·5 | —    | —    | 25·5 | 24·9 | 24·8 | 26·0 | 24·6 | 24·6 |
| 1      | —    | —    | —    | —    | —    | —    | —    | —    | —    |
| 2      | 24·6 | 28·2 | 26·0 | 24·6 | 24·6 | 24·2 | 25·8 | 26·0 | 22·9 |
| 3      | —    | —    | —    | —    | —    | —    | —    | —    | —    |
| 4      | —    | 24·6 | —    | —    | —    | —    | —    | —    | —    |
| 5      | 22·9 | —    | 22·8 | 22·1 | 22·3 | 21·0 | 22·8 | 21·9 | 22·6 |

IV. *Magnetic Observations at Helwan, near Cairo.*

(See table on opposite page.)

V. *Secular Variation.*

As many early observations as it has been possible to find in various works have been collected in the following tables for the purpose of determining the average annual rate of change. Generally the declination appears to have been annually decreasing by about 6' to 7' in the first half of the century, becoming, however, 3' to 4' only in the second half. For the dip the available observations are very few; but from those at Alexandria and at the Great Pyramid, Giza, the rate of decrease appears to be about 1' to 1'·5 annually. For the horizontal force the observations are too few, and give results which are not very concordant.

The observations before June, 1894, were made with the declinatorium, so that those made at later dates are more reliable, since a Kew pattern magnetometer with a unifilar suspension was used.

The values obtained cannot be considered as laying claim to a high degree of accuracy, seeing that in most cases the hour of observation is not given in the older observations; still in most cases the number of years elapsed is sufficiently great to reduce the error thus introduced into the value for the annual change to small dimensions.

(Tables are printed on pp. 16, 17 and 18.)



## IV. Magnetic Observations at Helwan, near Cairo, 1898.

| Date.                          | Time.          | Dip.            | Time.      | Horizontal force. | Time.      | Declination. | Notes.                                                                       |
|--------------------------------|----------------|-----------------|------------|-------------------|------------|--------------|------------------------------------------------------------------------------|
| October 27 . . . . .           | h. m.<br>15 42 | ° ' 40 31·6(1)* | h. m.<br>— | —                 | h. m.<br>— | ° ' —        | (1) Dip needle 1.                                                            |
| November 1 . . . . .           | 14 50          | 0 31·2(1)*      | —          | —                 | —          | —            | (2) „ „ 3.                                                                   |
| December 9 . . . . .           | 13 37          | 0 32·6(1)       | —          | —                 | 12 35      | 4 15 45      | (3) Uncorrected for torsion. This correction was almost invariably positive. |
| „ 9 . . . . .                  | 14 17          | 0 27·8(2)       | —          | —                 | —          | —            |                                                                              |
| „ 14 . . . . .                 | 15 44          | 0 27·9(2)       | 14 21      | 0 30182           | 13 53      | 4 15 13      |                                                                              |
| „ 24 . . . . .                 | 15 33          | 0 28·1(2)       | 14 10      | 0 30211           | 13 54      | 4 14 46      |                                                                              |
| „ 29 . . . . .                 | 14 37          | 0 30·8(2)*      | —          | —                 | 16 52      | 4 13 23(3)   |                                                                              |
| Mean values for 1899 . . . . . | —              | 40 32·1         | —          | 0 30182           | —          | 4 11 17      |                                                                              |

The details of the above observations are given in the Meteorological Report of the Survey Department, Cairo, for 1898 and 1899.

\* Observed by Mr. J. J. Craig.

## V. Secular Variation of Declination.

| Place.                            | Observer.             | Date. | Declination<br>west. | Change<br>per<br>annum. |                                            |
|-----------------------------------|-----------------------|-------|----------------------|-------------------------|--------------------------------------------|
| Alexandria .....                  | Quesnot and<br>Nouet. | 1798  | 13   6   0           | —                       |                                            |
| „ .....                           | ?                     | 1842  | 8   24   0           | -6.4                    |                                            |
| „ .....                           | Güssfeldt.            | 1876  | 5   55   9           | -4.4                    |                                            |
| „ .....                           | Capt. Leslie,<br>R.E. | 1890  | 5   3   0            | -3.8                    |                                            |
| „ (Ramleh)                        | d'Abbadie.            | 1884  | 5   6   2            | —                       |                                            |
| Cairo .....                       | Russegger.            | 1839  | 9   2   0            | —                       |                                            |
| „ (Old Cairo) ..                  | d'Abbadie.            | 1885  | 5   15   9           | -4.8                    |                                            |
| „ Abbassia ....                   | H.G.L.                | 1895  | 4   5   0            | -7.7                    | '39-95 = 5'.3                              |
| „ J. Moqattam..                   | d'Abbadie.            | 1885  | 4   56   5           | —                       |                                            |
| „ „ „                             | H.G.L.                | 1893  | 4   36   0           | -2.5                    |                                            |
| „ Great Pyramid                   | d'Abbadie.            | 1885  | 4   48   9           | —                       |                                            |
| „ „ „                             | H.G.L.                | 1893  | 4   32   0           | -2.1                    |                                            |
| „ „ „                             | H.G.L.                | 1901  | 3   48   6           | -5.5                    | '85-01 = 3'.8                              |
| Helwan .....                      | H.G.L.                | 1893  | 4   27   7           | —                       |                                            |
| „ .....                           | Mean for<br>1899.     | 1899  | 4   11   3           | -2.7                    |                                            |
| Siwa Oasis .....                  | Cailliand.            | 1819  | 12   30   0          | —                       |                                            |
| „ „ .....                         | Jordan.               | 1874  | 7   33   0           | -5.4                    |                                            |
| Mandisha (Baharia<br>Oasis) ..... | Cailliand.            | 1819  | 12   11   0          | —                       | Village Zubbo                              |
|                                   | Jordan.               | 1874  | 6   34   8           | -6.1                    | „ Qasr                                     |
|                                   | H.G.L.                | 1894  | 5   8   9            | -4.3                    |                                            |
| Assiut .....                      | Cailliand.            | 1819  | 12   0   0           | —                       |                                            |
|                                   | Jordan.               | 1874  | 5   42   0           | -6.9                    |                                            |
|                                   | d'Abbadie.            | 1885  | 5   45   9           | —                       |                                            |
|                                   | H.G.L.                | 1893  | 4   49   0           | -2.7                    | 1874-93                                    |
| Kharga (Kharga<br>Oasis) .....    | Cailliand.            | 1819  | 12   10   0          | —                       |                                            |
|                                   | Jordan.               | 1874  | 6   24   0           | -6.4                    |                                            |
|                                   | H.G.L.                | 1894  | 5   3   0            | -4.0                    |                                            |
|                                   | *Dr. J. Ball.         | 1899  | 4   15   0           | -9.6                    |                                            |
| Mut (Dakhla Oasis)                | Cailliand.            | 1819  | 12   0   0           | —                       | Qasr Dakhel,<br>20 kiloms.<br>north of Mut |
|                                   | Jordan.               | 1874  | 6   33   0           | -6.0                    |                                            |
|                                   | H.G.L.                | 1894  | 5   24   0           | -3.4                    |                                            |
| Luxor .....                       | Cailliand.            | 1819  | 12   0   0           | —                       |                                            |
|                                   | d'Abbadie.            | 1885  | 4   25   0           | -6.5                    | At Gurna on<br>west bank                   |
|                                   |                       |       | 4   45   0           | -6.9                    |                                            |
|                                   | H.G.L.                |       | 4   27   0           | -6.0                    |                                            |

\* Used Bamberg's Declinatorium.

V. Secular Variation of Declination—*continued.*

| Place.             | Observer.  | Date. | Declination<br>west. | Change<br>per<br>annum. |                                      |
|--------------------|------------|-------|----------------------|-------------------------|--------------------------------------|
|                    |            |       | ° ' "                |                         |                                      |
| Assuan .....       | Cailliand. | 1819  | 12 0 0               | —                       |                                      |
|                    | d'Abbadie. | 1885  | 5 13 2               | −6·1                    |                                      |
|                    | H.G.L.     | 1895  | 4 26 0               | −4·7                    |                                      |
| Amada.....         | Cailliand. | 1819  | 11 13 0              | —                       | At Tomas, 6<br>kiloms. up-<br>stream |
|                    | H.G.L.     | 1895  | 4 38 0               | −5·2                    |                                      |
| Wadi Halfa .....   | Cailliand. | 1819  | 11 30 0              | —                       |                                      |
|                    | H.G.L.     | 1895  | 4 40 0               | −5·4                    |                                      |
| Mirgissi (Amka) .. | Cailliand. | 1819  | 13 0 0               | —                       | At Sarras, 20<br>kiloms. south       |
|                    | H.G.L.     | 1895  | 4 56 0               | −6·2                    |                                      |

The magnetic bearing of the walls or axes of certain temples is given in the "Description de l'Égypte," and from these an approximate value for the secular change in the declination may be deduced.

On Philæ—

|                                       | Magnetic<br>bearing,<br>1799. | True<br>bearing. | Declination,<br>1799. |
|---------------------------------------|-------------------------------|------------------|-----------------------|
| Great Isis Temple.....                | 44° E. of N.                  | 32° 5' E. of N.  | 11° 55'               |
| Nectanebo's Temple....                | 25° „                         | 13° 28' „        | 11° 32'               |
| The Kiosk (or Pharaoh's<br>Bed) ..... | 104° 30' „                    | 93° 25' „        | 11° 5'                |
|                                       |                               | Mean.....        | 11° 31'               |

The Declination in 1896 was 4° 23' W., which gives an average annual decrease of 4'·4.

Kom Ombo Temple—

|                                     |         |          |
|-------------------------------------|---------|----------|
| Magnetic bearing of axis, 1799..... | 55°     | E. of N. |
| „ „ 1892.....                       | 43° 55' | „        |
| Change in 93 years .....            | 11° 5'  |          |
| „ per annum .....                   | 7'·2    |          |

Edfu Temple—

|                                      |         |          |
|--------------------------------------|---------|----------|
| Magnetic bearing of axis, 1799 ..... | 15°     | E. of N. |
| „ „ 1892 .....                       | 3° 10'  | „        |
| Change in 93 years .....             | 11° 50' |          |
| „ per annum .....                    | 7'·7    |          |

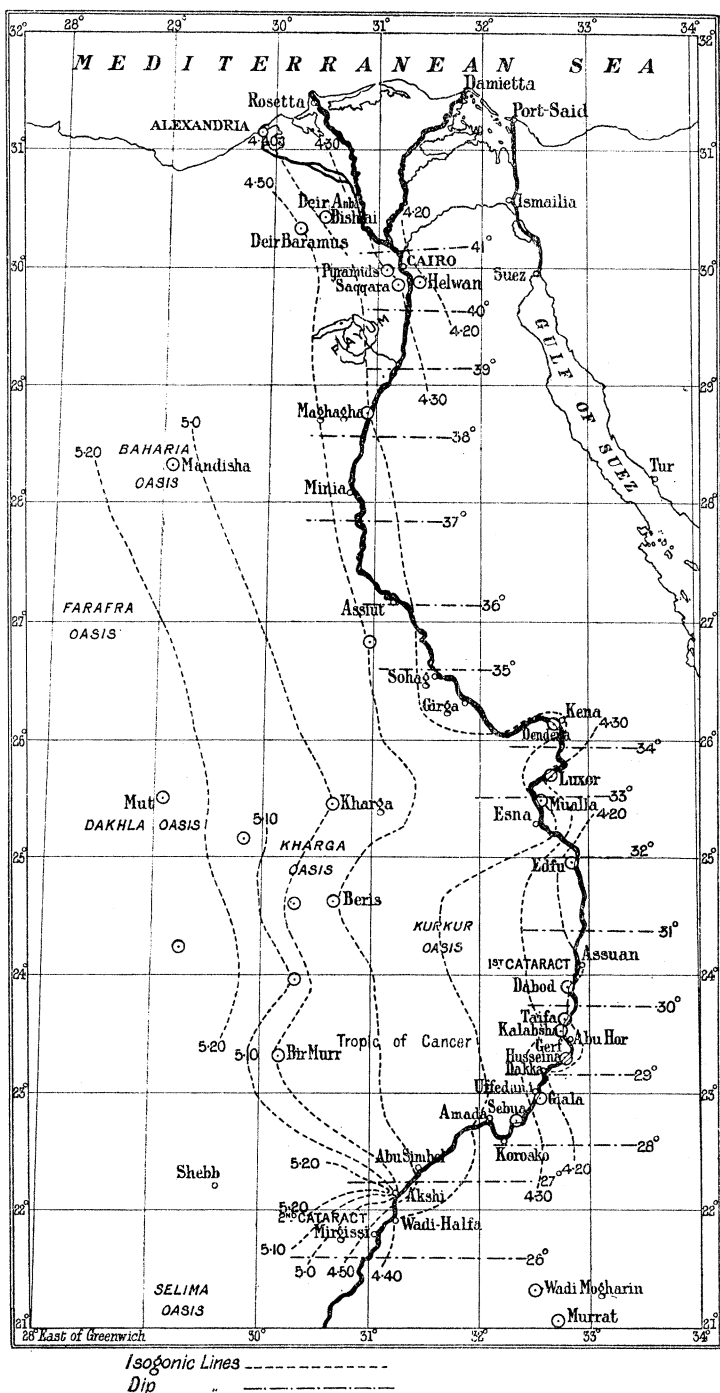
## Secular Variation of Dip.

| Place.            | Observer.          | Date. | Dip.         | Yearly change. |
|-------------------|--------------------|-------|--------------|----------------|
| Alexandria .....  | Quesnot and Nouet. | 1798  | ° /<br>47 30 | /<br>—         |
| „ .....           | ?                  | 1842  | 43 48        | —5·0           |
| „ .....           | Güssfeldt.         | 1876  | 42 52        | —1·6           |
| „ (Ramleh)        | d'Abbadie.         | 1884  | 42 47·7      | —0·7           |
| Cairo—            |                    |       |              |                |
| Great Pyramid.... | d'Abbadie.         | 1839  | 41 41·8      | —              |
| „ „ ....          | „                  | 1885  | 40 46·8      | —1·2           |
|                   | H.G.L.             | 1901  | 40 31·6      | —1·0           |
| Luxor .....       | d'Abbadie.         | 1885  | 33 7·7       |                |
|                   | H.G.L.             | 1895  | 33 38·1      | +3·0           |
| Assuan .....      | —                  | —     | —            | —              |

## Secular Variation of Horizontal Force.

| Place.               | Observer.  | Date.  | H. in C.G. S. units. | Annual change. |
|----------------------|------------|--------|----------------------|----------------|
| Alexandria .....     | —          | 1842–5 | 0·27955              | —              |
| „ .....              | Güssfeldt. | 1876   | 0·2914               | +0·00036       |
| „ (Ramleh)           | d'Abbadie. | 1884   | 0·2971               | +0·00067       |
| Cairo, Abbassia .... | d'Abbadie. | 1884   | 0·30159              | —              |
|                      | H.G.L.     | 1895   | 0·30076              | —0·00008       |
|                      | H.G.L.     | 1896   | 0·30038              | —0·00010       |
| Great Pyramid ....   | d'Abbadie. | 1885   | 0·3034               | —              |
|                      | H.G.L.     | 1901   | 0·2992               | —0·00026       |
| Luxor .....          | d'Abbadie. | 1885   | 0·3249               | —              |
|                      | H.G.L.     | 1895   | 0·32070              | —0·00042       |
| Assuan .....         | d'Abbadie. | 1885   | 0·3259               | —              |
|                      | H.G.L.     | 1895   | 0·32364              | —0·00023       |

As the observations for declination given in Tables Ia, b, c and IIa were all made between the autumn 1893 and the spring 1895, during which time the secular decrease would have been about 5', equal to about half the amount of the diurnal variation, no reduction to an epoch has been attempted. The values obtained by observation have been plotted on the accompanying map, and the isogonic lines drawn between them by hand.



These appear to show abnormally high values at Qena where the faulting of the Nile Valley is highly developed, and also at Esna and at Akshi (Serra) between Abu Simbel and Wadi Halfa. At this place, too, the horizontal force has a high value.

#### APPENDIX.

##### *Observations on the Upper Nile.*

The following observations were taken in March and April of the present year (1901) while accompanying Sir W. E. Garstin, K.C.M.G., Under-Secretary of State for Public Works, from Khartum through the region of the "Sadd" to Gondokoro and back, and are added here with his permission. As this journey was specially undertaken to see the upper reaches of the Bahr el Jebel, and to measure the discharge of the White Nile and its various tributaries in this district, magnetic observations had to be taken whenever opportunities occurred. It has consequently happened that the stations occupied cannot be described with sufficient accuracy for them to be re-occupied at a future date, since most of them were wooding-stations with no permanent building or other marks in the neighbourhood.

The latitudes given are taken from the map of the Bahrel Abiad (White Nile) made under the direction of General Gordon, when Governor-General of the Sudan, for the stations on that river; and those on the Bahr el Jebel from a compass survey of the river made on this occasion and adjusted to the latitudes of Gaba Shamba, Kenisa, Bor, Lado, and Gondokoro, which have been determined by observations at various times. (See map, p. 24.)

The station occupied at Omdurman was on the left bank of the Nile, half-way between the gunboat workshops and the angle of the old Omdurman wall, and about 100 metres from the river bank.

These observations, extending as they do from about  $16^{\circ}$  to  $5^{\circ}$  north latitude, and crossing the magnetic equator, form an interesting continuation to those from Cairo to Wadi Halfa,  $30^{\circ}$  N. to  $21^{\circ} 30'$  N., which have been given above.

No attempt has been made to reduce these southern results to the same epoch as the others, since no reliable data are as yet available for doing so. Hardly any observations exist, it seems, which can be utilised to determine the secular change. Pruyssenaere's results (quoted in the following short table taken from 'Petermann's Mittheilungen,' Ergänzt.-heft 51, 1877) in the desert east of the Bahr el Abyad (White Nile) appear to show too much local attraction to be of much use.

An observation of Russegger's in April, 1837, at Torra, on the Bahr el Abyad, gives  $9^{\circ}$  W. for the declination, which, taking the present value at  $5^{\circ} 20'$  W., gives  $3^{\circ} 4'$  of annual decrease.

| Place.                       | Lat. N. | Long. E. | Declination.<br>1863-64. |
|------------------------------|---------|----------|--------------------------|
| J. Abel .....                | 12° 42' | 34° 25'  | 9° 10'                   |
| J. Qerebin .....             | 12 8    | 34 15    | 20 01                    |
| Werkat (southern part) ..... | 12 8    | 34 10    | 6 30                     |
| Roro .....                   | 11 54   | 34 3     | 12 05                    |
| Gule .....                   | 11 43   | 33 57    | 8 40                     |

Also Captain A. W. Peel gives the West Declination at Khartum, as 8° 30' in October, 1851, and Lieut. Watson, R.E., gives 7° 30' West, for that of Rejaf (lat. 4° 40' ±), on 15th December, 1874.

The only other observation it has been possible to find in the books of travel, &c., available in Cairo, is a value of 7° 30' W. for the declination at Gondokoro on March 20, 1861,\* which with 6° 20' for the present values gives - 2' per annum.

Unfortunately the first rains were already threatening at Lado and Gondokoro, and the sky was usually too cloudy to admit of satisfactory observations for azimuth, Hellet el Nuer and El Kenisa were therefore the only two places where the declination could be determined on the Bahr el Jebel. Russegger also gives for El Obeid declination 8° 30' west and dip 18° for April, 1837, but neither of these can be utilised, being too far from the Nile.

The instruments used were Kew-pattern Magnetometer, No. 87, by Elliott, and a Dip Circle, No. 131, by Dover.

\* Peney, 'Bull. Soc. Géog. Paris,' 1863.

## Observations of Dip and Horizontal Force on Bahr el Abyrad and the Bahr el Jebel.

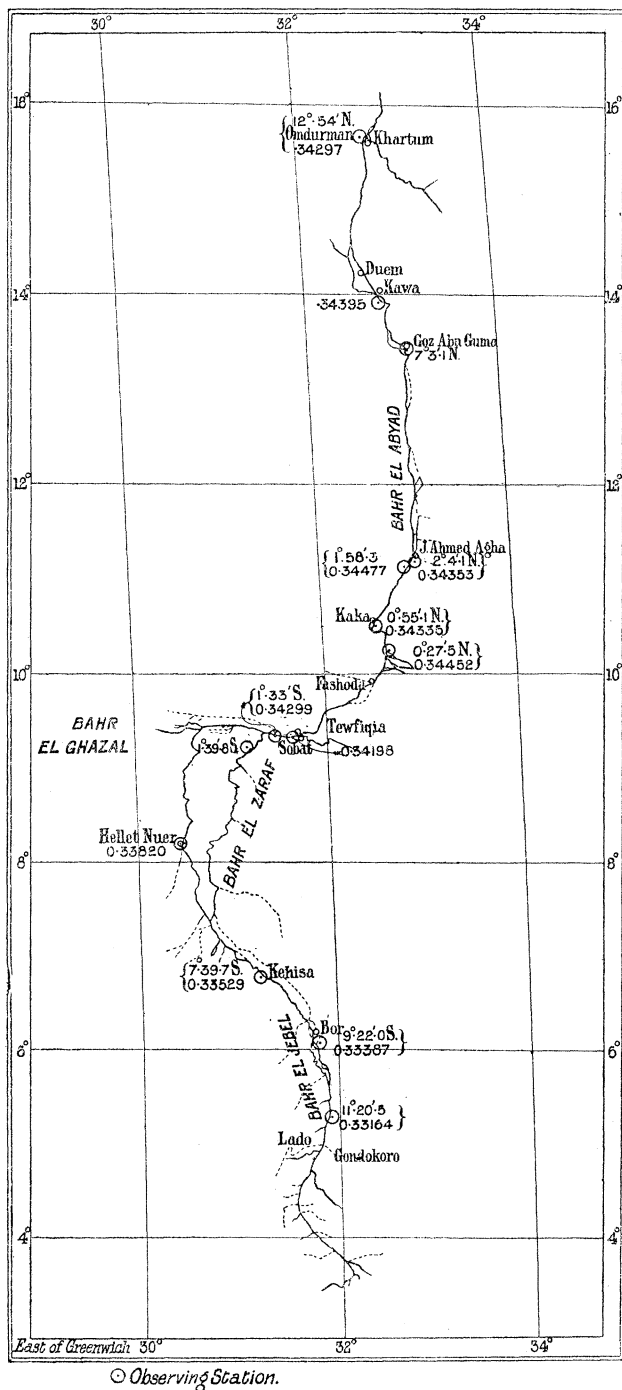
| Place.                                         | Date.     | Mean time<br>30° E. of<br>Greenwich. | Dip.                     | Mean time.<br>30° E. | Horizontal<br>force. |                                                                                 |
|------------------------------------------------|-----------|--------------------------------------|--------------------------|----------------------|----------------------|---------------------------------------------------------------------------------|
| Ondurman, left bank of Nile.....               | 12-4-1901 | h. m.<br>16 25                       | ° '<br>12 54·4 N.        | —                    | 0·34297              | 1° 34'·9 obtained from obs. 10° E.<br>and W. of meridian.<br>No deflection obs. |
| Kawa, left bank of Nile.....                   | 10-4-1901 | —                                    | —                        | —                    | 0·34395              |                                                                                 |
| Goz Abu Goma, right bank.....                  | 10-4-1901 | 8 25                                 | 7 3·1 N.                 | —                    | —                    |                                                                                 |
| Near J. Ahmed Agha, right bank..               | 8-4-1901  | 8 15                                 | 2 4·1 N.                 | —                    | 0·34353              |                                                                                 |
| " " left " ..                                  | 14-3-1901 | 11 40                                | 1 58·3 N.                | —                    | 0·344774             |                                                                                 |
| " Kaka .....                                   | 7-4-1901  | 12 20                                | 0 55·1 N.                | —                    | 0·34335              |                                                                                 |
| North of Fashoda, right bank.....              | 15-3-1901 | 10 15                                | 0 29·2 N.                | —                    | 0·34452              |                                                                                 |
| S.W. of Sobat mouth, " .....                   | 16-3-1901 | —                                    | 0 25·3 N.                | —                    | 0·34198              |                                                                                 |
| E. of Bahr el Zaraf mouth, right<br>bank ..... | 4-4-1901  | { 12 0<br>14 30                      | { 1 31·6 S.<br>1 32·6 S. | —                    | 0·34299              |                                                                                 |
| Bahr el Zaraf, left bank .....                 | 3-4-1901  | 17 20                                | 1 34·9 S.                | —                    | —                    |                                                                                 |
| Hellet el Nuer " .....                         | 20-3-1901 | —                                    | 1 39·8 S.                | —                    | 0·33820              | No deflection obs.                                                              |
| Kenisa, left bank .....                        | 23-3-1901 | 17 15                                | 7 42·0 S.                | —                    | 0·33529              |                                                                                 |
| " " " .....                                    | 31-3-1901 | —                                    | 7 37·4 S.                | —                    | 0·33506              |                                                                                 |
| S. of Bor, right bank .....                    | 25-3-1901 | 12 15                                | 9 22 0 S.                | —                    | 0·33387              |                                                                                 |
| S. of Kiro " .....                             | 26-3-1901 | 17 20                                | 11 20·5 S.               | —                    | 0·33164              |                                                                                 |



Magnetic Declination determined on White Nile and Bahr el Jebel with Kew-pattern Magnetometer No. 87.

| Place.                                                                 | Date.     | Latitude, N. |       | Mean time<br>30° E. |    | Declination<br>west. |      |
|------------------------------------------------------------------------|-----------|--------------|-------|---------------------|----|----------------------|------|
|                                                                        |           | °            | ' "   | h.                  | m. | °                    | ' "  |
| Omdurman, near steamer workshops.....                                  | 12-4-1901 | 15           | 39 40 | 17                  | 28 | 4                    | 39 5 |
| Renk.....                                                              | 13-3-1901 | 12           | 0 0   | 8                   | 0  | 6                    | 4 5  |
| East bank, 6 kiloms. south of Jebel Ahmed Agha.....                    | 8-4-1901  | 11           | 1 0   | 6                   | 45 | 5                    | 7 1  |
| West bank, south of Jebel Ahmed Agha.....                              | 14-3-1901 | 10           | 58 0  | 9                   | 20 | 4                    | 57 6 |
| Wood station, near Kaka, right bank.....                               | 17-4-1901 | 10           | 30 0  | 14                  | 5  | 4                    | 55 7 |
| Wood station, right bank, 48 kiloms. north of Fashoda..                | 15-3-1901 | 10           | 20 0  | 8                   | 30 | 5                    | 8 9  |
| Wood station, right bank, 8 kiloms. south of mouth of<br>R. Sobat..... | 16-3-1901 | 9            | 22 0  | 16                  | 10 | 5                    | 43 7 |
| Left bank of Bahr el Jebel, 10 kiloms. south of Hellet<br>Nuer.....    | 20-3-1901 | 8            | 9 30  | 17                  | 15 | 5                    | 49 6 |
| Kenisa, left bank of Bahr el Jebel.....                                | 23-3-1901 | 6            | 46 0  | 16                  | 20 | 6                    | 13 8 |

Probably local disturbance.



## Description of Stations.

| Place.                                                               | Bank of river. | Observations made.                  |
|----------------------------------------------------------------------|----------------|-------------------------------------|
| Omdurman, 200 metres south of steamer workshops                      | Left           | Declination. Dip. Horizontal force. |
| Kawa (lat. $13^{\circ} 55'$ ).....                                   | „              | Horizontal force.                   |
| Goz Abu Goma (lat. $13^{\circ} 23'$ ) .....                          | Right          | Dip.                                |
| Renk.....                                                            | „              | Declination.                        |
| 6 kilometres up stream of Jebel Ahmed Agha                           | „              | Declination. Dip. Horizontal force. |
| 16 „ „ „ „ „                                                         | Left           | „ „ „                               |
| Near Kaka (lat. $10^{\circ} 30'$ ) .....                             | Right          | „ „ „                               |
| 48 kilometres down stream of Fashoda (lat. $10^{\circ} 20'$ )        | „              | „ „ „                               |
| 8 kilometres up stream of mouth of River Sobat, on Bahr el Abyad     | „              | Declination. Horizontal force.      |
| Wood station on Bahr el Abyad, east of mouth of Bahr el Zaraf        | „              | Dip. Horizontal force.              |
| 12 kilometres                                                        |                |                                     |
| Bahr el Zaraf, 20 kilometres from mouth                              | Left           | Dip.                                |
| Bahr el Jebel, 10 kilometres.....                                    | „              | Declination. Horizontal force.      |
| South of Hellet Nuer (lat. $8^{\circ} 9' 30''$ )                     |                |                                     |
| Kenisa (lat. $6^{\circ} 46' 0''$ ) .....                             | „              | Declination. Dip. Horizontal force. |
| Wood station, south of Bor on Bahr el Jebel (lat. $6^{\circ} 5'$ )   | Right          | Dip. Horizontal force.              |
| Wood station, south of Kiro on Bahr el Jebel (lat. $5^{\circ} 15'$ ) | „              | „ „                                 |

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“Note on the Effect of Mercury Vapour on the Spectrum of Helium.” By Professor J. NORMAN COLLIE, F.R.S. Received June 3,—Read June 19, 1902.

Some years ago the author, in conjunction with Professor Ramsay, published the results of some experiments relating to the visibility of the spectrum of one gas in presence of another.\*

Since then some experiments have been made on the effect of mercury vapour (when present in considerable quantity) on the spectrum of helium in an ordinary Plücker's tube, under the influence of the electric discharge from an induction coil. When the spectrum of helium is examined in an ordinary Plücker's tube, it appears to be a simple one consisting of only eight lines—two red, one yellow, three green, one blue, and one violet.

The spectrum, however, of the negative glow is much more com-

\* ‘Roy. Soc. Proc.’ vol. 59, p. 262.

W. 4° +

January, 1896.

| Hours. | 1.   | 2.   | 3.   | 4.   | 5.   | 6.   | 7.   | 8.               | 9.               | 10.  | 11.  | 12.  | 13.  | 14. | 15. | 16.  | 17.  | 18.  | 19.  | 20.  | 21.  | 22.  | 23.  | 24.  | 25.  | 26.  | 27.  | 28.  | 29.  | 30.  | 31.              |                  |
|--------|------|------|------|------|------|------|------|------------------|------------------|------|------|------|------|-----|-----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------------------|------------------|
| 7      | 26.8 | 28.2 | —    | 27.1 | 25.5 | 26.4 | 25.7 |                  |                  |      | 26.4 | 26.2 |      |     |     | —    | 26.6 | —    | 26.4 | 24.6 |      | 25.5 | —    | —    | —    | —    | —    | —    | —    | —    | —                |                  |
| 8      | 25.3 | 28.0 | 27.8 | 26.9 | 25.7 | —    | —    |                  |                  | 26.4 | 26.2 | —    |      |     |     | —    | —    | 24.9 | 24.6 | 24.2 |      | 25.1 | 26.2 | —    | —    | —    | —    | —    | —    | —    | —                |                  |
| 9      | 24.6 | 26.2 | 26.8 | —    | —    | 26.6 | —    |                  |                  | —    | 26.2 | —    |      |     |     | 24.6 | 25.5 | 24.6 | 24.4 | 24.2 |      | —    | 24.8 | 24.1 | —    | —    | —    | —    | —    | —    | —                |                  |
| 10     | 26.6 | 27.7 | 26.8 | 28.6 | 28.4 | 28.0 | 28.4 |                  |                  | 26.2 | 27.7 | 25.3 |      |     |     | 24.6 | 25.6 | 26.4 | —    | 24.8 | 25.1 | 24.6 | —    | —    | —    | 24.4 | 24.6 | 25.1 | 25.5 | —    | —                |                  |
| 11     | 26.9 | 28.6 | —    | 28.4 | 30.0 | 29.6 | 30.0 |                  |                  | 28.4 | 28.2 | 26.0 |      |     |     | 26.6 | 27.5 | 28.0 | 29.3 | 25.7 |      | —    | —    | 24.6 | 24.6 | 24.6 | 24.6 | 25.1 | —    | —    | —                | —                |
| Noon   | 27.1 | 28.0 | 29.8 | 27.8 | 29.5 | —    | 28.4 |                  |                  | —    | 29.8 | 27.8 | 25.3 |     |     | —    | 27.7 | —    | —    | 29.3 | 27.1 | 28.2 | 24.9 | —    | —    | 24.6 | 24.8 | 25.1 | 26.6 | —    | —                | —                |
| 1      | —    | 27.7 | 28.2 | —    | 26.4 | 28.4 | —    | No observations. | No observations. | —    | —    | —    | 26.6 |     |     | —    | —    | 26.4 | —    | 26.2 |      | —    | —    | —    | —    | 25.5 | 26.4 | 24.8 | —    | —    | —                | —                |
| 2      | 27.1 | —    | 28.2 | 26.0 | —    | 27.3 | —    |                  |                  | 26.4 | —    | 26.6 | 24.6 |     |     | —    | —    | 25.3 | —    | —    | 26.2 |      | —    | —    | —    | 26.6 | —    | —    | 27.8 | —    | —                | —                |
| 3      | 28.0 | 27.5 | 27.1 | 26.2 | —    | —    | 26.4 |                  |                  | —    | 27.1 | 25.3 | —    |     |     | 24.6 | 24.6 | —    | 24.6 | 24.6 |      | —    | 27.8 | 26.2 | —    | —    | —    | —    | —    | 27.7 | —                | —                |
| 4      | 27.8 | —    | 28.0 | 24.6 | 26.0 | 26.6 | —    |                  |                  | —    | 26.0 | 25.4 | —    |     |     | 25.5 | —    | 24.8 | —    | 24.6 | 24.6 |      | 27.1 | —    | —    | 26.6 | 26.8 | 26.0 | 27.1 | —    | No observations. | No observations. |
| 5      | 27.5 | —    | —    | 27.8 | —    | 26.2 | —    |                  |                  | —    | 26.4 | —    |      |     |     | —    | —    | —    | —    | 24.4 | 26.2 |      | 26.2 | —    | 26.2 | —    | —    | —    | —    | —    | —                | —                |

W. 4° +

February, 1896.

| Hours. | 1.   | 2.   | 3. | 4.   | 5.   | 6.   | 7.   | 8.   | 9.   | 10.  | 11.  | 12. | 13.  | 14. | 15.  | 16. | 17.  | 18.  | 19.  | 20.  | 21. | 22. | 23.  | 24. | 25.  |
|--------|------|------|----|------|------|------|------|------|------|------|------|-----|------|-----|------|-----|------|------|------|------|-----|-----|------|-----|------|
| 7      | —    | —    | —  | 26.2 | —    | —    | —    | —    | —    | —    | —    | —   | —    | —   | —    | —   | 26.2 | —    | —    | —    | —   | —   | —    | —   | —    |
| 8      | —    | 27.7 | —  | 25.7 | 24.6 | 25.7 | 24.9 | 25.5 | 25.3 | 24.6 | 25.1 | —   | 26.4 | —   | —    | —   | —    | 25.3 | 24.8 | 24.4 | —   | —   | 24.8 | —   | 23.3 |
| 9      | 26.9 | 26.8 | —  | 25.7 | —    | 24.6 | 24.9 | 26.2 | 24.6 | —    | 24.4 | —   | 26.4 | —   | 25.3 | —   | 24.8 | 24.6 | 24.8 | 24.9 | —   | —   | 23.2 | —   | 23.7 |
| 10     | —    | —    | —  | 25.1 | 25.1 | 24.6 | 25.8 | 26.9 | 24.6 | 24.8 | 24.6 | —   | 24.6 | —   | —    | —   | —    | 24.6 | 24.6 | 26.2 | —   | —   | 23.1 | —   | 24.4 |
| 11     | 26.2 | 26.2 | —  | 25.1 | 26.2 | 25.3 | 27.7 | 27.3 | 26.4 | 26.2 | —    | —   | 24.1 | —   | —    | —   | 24.9 | 25.1 | 26.6 | 27.5 | —   | —   | 23.0 | —   | 24.8 |
| Noon   | —    | 26.4 | —  | 26.8 | 26.4 | 26.4 | 27.7 | 27.8 | 26.4 | 25.3 | —    | —   | 25.3 | —   | —    | —   | —    | 26.6 | 27.7 | —    | —   | —   | 24.6 | —   | 24.6 |
| 1      | 25.7 | —    | —  | 26.6 | 26.6 | 26.4 | —    | 26.6 | —    | 24.8 | —    | —   | —    | —   | —    | —   | 24.8 | 27.1 | 27.8 | —    | —   | —   | —    | —   | 24.6 |
| 2      | —    | —    | —  | 26.9 | 26.4 | 25.7 | 26.6 | 26.4 | —    | —    | —    | —   | —    | —   | —    | —   | 26.8 | —    | 26.6 | 26.4 | —   | —   | —    | —   | —    |
| 3      | 26.2 | —    | —  | —    | —    | 26.4 | —    | —    | 25.7 | 24.8 | —    | —   | 24.8 | —   | —    | —   | 26.4 | 26.4 | —    | 24.9 | —   | —   | —    | —   | 24.4 |
| 4      | 26.2 | —    | —  | 26.2 | 25.1 | 24.8 | 25.3 | 26.2 | 25.5 | 24.6 | —    | —   | 24.6 | —   | —    | —   | —    | 25.7 | 24.8 | 24.6 | —   | —   | —    | —   | 23.5 |
| 5      | —    | —    | —  | —    | —    | —    | —    | 26.4 | —    | —    | —    | —   | —    | —   | —    | —   | —    | —    | —    | —    | —   | —   | —    | —   | —    |

W. 4° +

March, 1896.

| Hours. | 1. | 2. | 3. | 4.   | 5.   | 6. | 7.   | 8.   | 9.   | 10.  | 11.  | 12.  | 13. | 14.  | 15.  | 16.  | 17.  | 18.  | 19.  | 20. | 21.  | 22.  | 23. | 24. | 25.  | 26.  | 27.  | 28.  | 29.  | 30.  | 31.  |
|--------|----|----|----|------|------|----|------|------|------|------|------|------|-----|------|------|------|------|------|------|-----|------|------|-----|-----|------|------|------|------|------|------|------|
| 7      | —  | —  | —  | —    | —    | —  | —    | —    | —    | —    | —    | —    | —   | —    | —    | —    | —    | —    | —    | —   | —    | 23.8 | —   | —   | 21.9 | 20.5 | —    | 21.2 | —    | —    | —    |
| 8      | —  | —  | —  | 24.6 | 24.4 | —  | 25.3 | 24.9 | 24.6 | 25.5 | 23.9 | 24.6 | —   | 22.8 | 23.7 | 23.3 | 23.5 | 23.3 | 24.2 | —   | 21.7 | 22.8 | —   | —   | 22.1 | 22.4 | 22.6 | —    | 20.5 | 21.6 | 21.0 |
| 9      | —  | —  | —  | 25.8 | 25.5 | —  | 25.5 | 26.2 | 25.7 | 26.4 | 24.6 | 24.9 | —   | 23.8 | 24.8 | —    | 24.6 | 24.0 | 25.3 | —   | 21.9 | 21.7 | —   | —   | —    | 23.1 | —    | 21.9 | —    | 21.6 | —    |
| 10     | —  | —  | —  | 27.3 | 26.8 | —  | —    | 26.2 | 26.2 | 26.9 | 25.7 | —    | —   | —    | —    | —    | —    | —    | —    | —   | —    | 22.3 | —   | —   | 26.2 | 23.1 | 25.3 | —    | 22.8 | 22.9 | 24.4 |
| 11     | —  | —  | —  | 28.2 | 27.7 | —  | 26.8 | 27.3 | —    | 28.2 | —    | 26.8 | —   | 24.6 | —    | 24.6 | 26.6 | 27.1 | 27.3 | —   | 27.1 | 23.7 | —   | —   | —    | 25.8 | 26.6 | 24.6 | —    | 24.6 | 26.4 |
| Noon   | —  | —  | —  | 27.8 | —    | —  | 26.6 | 27.7 | 26.4 | 28.0 | 28.2 | 27.5 | —   | 26.4 | 26.4 | —    | 27.7 | 28.2 | 28.2 | —   | 28.2 | 25.1 | —   | —   | 20.4 | 26.4 | 28.2 | 25.5 | 27.7 | 28.2 | 27.5 |
| 1      | —  | —  | —  | 29.3 | —    | —  | 27.5 | 26.4 | 28.2 | 28.2 | 27.3 | 27.5 | —   | —    | —    | —    | 28.2 | —    | —    | —   | —    | 26.4 | —   | —   | —    | —    | —    | —    | —    | 26.8 | —    |
| 2      | —  | —  | —  | —    | 25.8 | —  | —    | —    | —    | —    | —    | 26.6 | —   | —    | —    | —    | —    | —    | —    | —   | —    | —    | —   | —   | —    | —    | —    | —    | —    | —    | 26.0 |
| 3      | —  | —  | —  | —    | —    | —  | —    | —    | —    | —    | 26.2 | —    | —   | —    | —    | —    | —    | —    | —    | —   | —    | —    | —   | —   | —    | —    | —    | —    | —    | —    | —    |
| 4      | —  | —  | —  | 24.6 | 24.1 | —  | 24.6 | 24.6 | 26.4 | 26.4 | 26.2 | 25.7 | —   | 25.5 | —    | —    | —    | 25.7 | 25.1 | —   | 25.7 | 23.1 | —   | —   | 24.8 | 24.6 | 24.0 | —    | —    | —    | —    |
| 5      | —  | —  | —  | —    | —    | —  | —    | —    | —    | —    | —    | —    | —   | —    | —    | —    | 24.6 | 24.8 | —    | —   | 24.8 | 23.7 | —   | —   | —    | —    | —    | 23.1 | 22.6 | 23.5 | 22.8 |