

PROCEEDINGS

OF

THE ROYAL SOCIETY.

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*January 10, 1878.*

Sir JOSEPH HOOKER, K.C.S.I., President, in the Chair.

The Presents received were laid on the table, and thanks ordered for them.

The following papers were read :—

- I. “Magnetic Observations taken during the Transit of Venus Expedition to and from Kerguelen Island.” By the Rev. S. J. PERRY, S.J., F.R.S. Received October 13, 1877.

In a previous paper, on the elements of terrestrial magnetism observed at Kerguelen, the reason is mentioned why it was not deemed advisable to take magnetic observations at sea during the voyage; the results, therefore, in this paper are entirely confined to the determinations of the Dip, Intensity, and Declination of the earth's magnetic force at the several places at which we landed. On our outward journey we had no opportunity of using our instruments, except at the Cape of Good Hope, but on our return we were much more fortunate, as H.M.S. “*Volage*” made a stay of at least two days at Point de Galle, at Bombay, Aden, Port Said, and Malta, and we utilised all these opportunities except the first. From Malta, the Rev. W. Sidgreaves and myself returned to England by Sicily, Italy, and France, and, taking our magnetic instruments with us, we were able to observe at Palermo, Naples, Rome, Florence, and Moncalieri. As we had previously made a complete survey of France in 1868 and 1869, we thought it too early to repeat the observations. The instrumental corrections and constants have already been given in the former paper on Kerguelen, it will, therefore, suffice to refer to that communication for any necessary details.

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TABLE I.

| Station.   | Place of Observation.                              | Latitude.     | Longitude.  | Authority.   |
|------------|----------------------------------------------------|---------------|-------------|--------------|
| Cape Town  | Observatory .....                                  | 33° 56' 3" S. | 1 13 55.0 E | N.A.         |
| Bombay..   | Colaba Observatory.....                            | 18 54 25 N.   | 4 51 39.63  | C. des Temps |
|            | The College .....                                  | 18 56 7       | 4 51 43.63  | "            |
| Aden ....  | Near Church at entrance<br>to town .....           | 12 46 15      | 3 0 40.63   | "            |
| Port Saïd  | Garden of Monastery....                            | 31 13 0       | 2 9 12      | Atlas.       |
| Malta....  | Garden of Governor's Pa-<br>lace, S. Antonio ..... | 35 53 50      | 0 58 4.63   | C. des Temps |
| Palermo..  | Botanical Gardens .....                            | 38 6 44       | 0 53 24.17  | N.A.         |
| Naples ..  | Observatory .....                                  | 40 51 46.6    | 0 56 58.86  | "            |
| Rome....   | Observatory Coll. Rom...                           | 41 53 52.2    | 0 49 54.7   | "            |
| Florence.. | Garden .....                                       | 43 46 4.1     | 0 45 1.46   | "            |
| Moncalieri | Garden of Palace.....                              | 44 59 53      | 0 30 48.77  | Observatory. |

*The Magnetic Dip.*

The long sea voyage, with its great variation of temperature, was very trying for the delicate portions of the instruments, and as we found that No. 1 Needle had been slightly injured by rust, it was never used during our home journey. In the last column of Table II the daily mean values of the dip are entered, but it was only at Cape Town and at Bombay that observations could be taken on more than a single day. Needle No. 2 seems to read about 30" higher than No. 3, but no correction has been applied to either, as the amount is considerably less than the usual errors of observations.

TABLE II.

| Station.             | Date.         | Needle<br>No. 1. | Needle<br>No. 2. | Needle<br>No. 3. | Daily<br>Means. |
|----------------------|---------------|------------------|------------------|------------------|-----------------|
| Cape Town .          | 1874. July 27 | -56° 6' 7"       | -55° 57' 47"     | -56° 3' 30"      | -56° 2' 28"     |
|                      | August 19     | ..               | -56 4 0          | -56 0 30         | -56 2 15        |
| Bombay Coll.         | 1875. April 7 | ..               | ..               | 20 4 16          | ..              |
| " Ob-<br>servatory.. | " 10          | ..               | ..               | 20 9 15          | 20 6 46         |
|                      | " 18          | ..               | 19 15 15         | 19 14 5          | 19 15 15        |
| Aden .....           | " 27          | ..               | 5 28 9           | ..               | 5 28 9          |
| Port Saïd ..         | May 15        | ..               | 42 33 35         | 42 30 12         | 42 31 54        |
| Malta ....           | " 24          | ..               | ..               | 51 36 42         | 51 36 42        |
| Palermo....          | " 29          | ..               | 54 17 47         | 54 18 28         | 54 18 8         |
| Naples ....          | June 3        | ..               | 57 0 13          | 57 0 33          | 57 0 23         |
| Rome.....            | " 8           | ..               | 58 51 53         | 58 49 56         | 58 50 55        |
| Florence....         | " 19          | ..               | 60 13 0          | ..               | 60 13 0         |
| Moncalieri..         | " 21          | ..               | 62 55 1          | 62 56 23         | 62 55 42        |

As previous observations of the magnetic dip, taken at different times at several of the above stations, have been collected and reduced

to the epoch 1840–45, by Sir Edward Sabine (Cf. *Phil. Trans.*, 1868), it may be well to compare the values for the two epochs, in order to ascertain the secular variation.

TABLE III.

| Station.          | 1842–5.     | 1875.        | Annual change. |
|-------------------|-------------|--------------|----------------|
| Cape Town ....    | — 53° 5     | — 56° 2' 22" | — 4' 69        |
| Bombay.....       | 18 4        | 19 14 40     | + 1 56         |
| Aden.....         | 5 1         | 5 28 9       | + 0 68         |
| Malta .....       | 53 5        | 51 36 42     | — 3 49         |
| Naples (1845) ..  | 58° 43' 45" | 57 0 23      | — 3 45         |
| Rome (1847) ..    | 59 49 4     | 58 50 55     | — 2 09         |
| Florence (1844) . | 61 54 30    | 60 13 0      | — 3 28         |

The values of the dip at the Cape of Good Hope, from 1751 to 1851, have been collected in vol. i of the *Cape Magnetic Observations*, and these give, for the yearly increase in the south dip of the needle, — 6'·94 from 1751 to 1840, — 5'·45 from 1841 to 1846, and — 5'·58 from 1843 to 1851. The quantity in Table III shows that this decrease in the acceleration is still continuing.

The inclination observed at the College in Bombay is very extraordinary, and would at first sight appear to have been entered incorrectly. The result, however, agrees perfectly with the observed angles, and as two complete observations were taken with Needle No. 3, and these fairly agree, it may be supposed that the instrument was standing at the time over an unsuspected mass of iron capable of deflecting the suspended needle, through an angle of nearly a degree. The paper by Mr. C. Chambers, in the *Phil. Trans.* for last year, gives 19° 8'·5 as the most probable value of the dip for January 1st, 1871, at the Colaba Observatory, with a secular change of + 1'·9. This magnetic element would, therefore, appear to be altering more rapidly at present than its mean rate of change during the last 30 years. The angle observed in 1875 is very slightly in excess of that computed for the same epoch from the data of Mr. Chambers.

The low value of the secular change at Rome is quite exceptional, but if we compute this quantity for the epoch 1849 from the figures given in Sir E. Sabine's report, we again obtain — 2'·09, showing that, if there be an error, it is due to local causes.

#### *The Magnetic Intensity.*

At each station the horizontal component of the magnetic force was determined absolutely by vibrations and deflections, and the total intensity deduced from the horizontal force combined with the dip. The magnets employed throughout were the same as those used at Kerguelen, and no departure from the usual methods was ever found necessary.

TABLE IV.

| Station.             | Date.         | Temperature.<br>° Fahr. | Time of one<br>vibration. | Log $m \ x.$ | Distances<br>of centres<br>of magnets | Temperature.<br>° | Observed<br>Deflection.<br>° ' " | Log $\frac{m}{x}$ . |
|----------------------|---------------|-------------------------|---------------------------|--------------|---------------------------------------|-------------------|----------------------------------|---------------------|
| Blackheath .....     | 1874. May 1   | 51·8                    | 5·14838                   | 0·25146      | 1·0                                   | 51·8              | 13 22 36                         | 9·06691             |
| Cape Town .....      | July 28       | 55·5                    | 4·90230                   | 0·29368      | 1·3                                   | 51·8              | 6 3 41                           | 9·06700             |
|                      |               |                         |                           |              | 1·0                                   | 60·0              | 12 4 52                          | 9·02414             |
|                      | August 8      | 62·7                    | 4·90700                   | 0·29347      | 1·3                                   | 59·3              | 5 28 55                          | 9·02418             |
| " 18                 |               | 64·2                    | 4·92380                   | 0·29162      | 1·0                                   | 61·5              | 12 4 53                          | 9·02429             |
|                      |               |                         |                           |              | 1·0                                   | 62·0              | 12 3 34                          | 9·02356             |
| Bombay College ..... | 1875. April 8 | 80·4                    | 3·60950                   | 0·56212      | 1·3                                   | 62·4              | 5 28 13                          | 9·02355             |
| " 9                  |               | ..                      | ..                        | ..           | 1·0                                   | 82·8              | 6 23 28                          | 8·75212             |
| " 8                  |               | 85·7                    | 3·59850                   | 0·56526      | 1·3                                   | 83·4              | 2 54 40                          | 8·75209             |
| " 10                 |               | 85·7                    | 3·59883                   | 0·56518      |                                       |                   |                                  |                     |
| " 27                 |               | 85·8                    | 3·59617                   | 0·56553      |                                       |                   |                                  |                     |
| Aden .....           | " 27          | 89·6                    | 3·70630                   | 0·53974      | 1·0                                   | 85·1              | 6 20 59                          | 8·74954             |
| Port Said .....      | May 15        | 89·7                    | 3·70992                   | 0·53890      | 1·3                                   | 85·1              | 2 53 39                          | 8·75029             |
| Malta .....          | " 24          | 75·8                    | 4·03929                   | 0·46381      | 1·0                                   | 89·9              | 6 43 39                          | 8·77484             |
|                      |               | 83·1                    | 4·31417                   | 0·40758      | 1·0                                   | 89·1              | 3 3 50                           | 8·77479             |
|                      |               |                         |                           |              | 1·0                                   | 74·8              | 8 2 51                           | 8·85070             |
| Palermo .....        | " 29          | 101·2                   | 4·41500                   | 0·38939      | 1·3                                   | 80·8              | 9 7 9                            | 8·90518             |
| Naples .....         | June 3        | 81·7                    | 4·51458                   | 0·36735      | 1·0                                   | 80·3              | 4 8 51                           | 8·90523             |
|                      |               |                         |                           |              | 1·0                                   | 88·2              | 9 31 4                           | 8·92453             |
| Rome .....           | " 8           | 87·2                    | 4·62927                   | 0·34652      | 1·0                                   | 77·2              | 10 0 50                          | 8·94523             |
|                      |               | 87·2                    | 4·61750                   | 0·34873      | 1·3                                   | 77·6              | 4 32 46                          | 8·94483             |
| Florence .....       | " 19          | 72·2                    | 4·67625                   | 0·33654      | 1·0                                   | 81·1              | 10 26 17                         | 8·96371             |
| Moncalieri .....     | " 21          | 73·2                    | 4·83625                   | 0·30756      | 1·0                                   | 79·2              | 4 44 48                          | 8·96314             |
|                      |               |                         |                           |              |                                       | 72·2              | 10 49 20                         | 8·97814             |
|                      |               |                         |                           |              |                                       | 72·3              | 11 32 42                         | 9·00587             |

TABLE V.

| Station.            | $m$ = magnetic<br>moment of<br>magnet. | $x$ = horizontal<br>force. | $y$ = vertical<br>force. | $z$ = total<br>force. |
|---------------------|----------------------------------------|----------------------------|--------------------------|-----------------------|
| Blackheath.....     | 0·45626                                | 3·9107                     | 9·5361                   | 10·3068               |
| Cape Town.....      | 0·45595                                | 4·3128                     | 6·4039                   | 7·7208                |
|                     | 0·45591                                | 4·3111                     | 6·4005                   | 7·7170                |
|                     | 0·45456                                | 4·3056                     | 6·3930                   | 7·7077                |
| Bombay College..... | 0·45406                                | 8·0354                     | 2·9425                   | 8·5572                |
| „ Observatory....   | 0·45456                                | 8·0849                     | 2·8210                   | 8·5629                |
|                     | 0·45452                                | 8·0841                     | 2·8207                   | 8·5621                |
|                     | 0·45465                                | 8·0869                     | 2·8217                   | 8·5650                |
| Aden .....          | 0·45423                                | 7·6289                     | 0·7304                   | 7·6638                |
|                     | 0·45380                                | 7·6216                     | 0·7297                   | 7·6565                |
| Port Said.....      | 0·45421                                | 6·4056                     | 5·8762                   | 8·6926                |
| Malta .....         | 0·45331                                | 5·6389                     | 7·1175                   | 9·0805                |
| Palermo .....       | 0·45390                                | 5·4005                     | 7·5161                   | 9·2551                |
| Naples.....         | 0·45337                                | 5·1451                     | 7·9247                   | 9·4484                |
| Rome .....          | 0·45192                                | 4·9144                     | 8·1435                   | 9·5114                |
|                     | 0·45307                                | 4·9269                     | 8·1642                   | 9·5356                |
| Florence .....      | 0·45430                                | 4·7775                     | 8·3476                   | 9·6181                |
| Moncalieri .....    | 0·45364                                | 4·4755                     | 8·7566                   | 9·8340                |

The tables of Sir Edward Sabine (Phil. Trans., 1868) furnish very few details from which to deduce the secular variation of the intensity at the above stations.

The total force at the Cape Observatory in 1845 was 7·58, and this combined with 7·7152, the value for 1874, will give + 0·0047 as the annual change. In the Cape Magnetic Observations, vol. i, we find + 0·0066 as the corresponding value for 1848.

Taking the mean of the observations at Bombay in 1845 and 1847, and also the mean for 1856 and 1867, we find 8·285 and 8·505 as the values of the intensity for the epochs 1846 and 1861·5. Comparing this last value with 8·5633 of 1875, gives a yearly change of + 0·0043, whilst the apparent change in 1854 was + 0·0142. Turning now to the Colaba results from 1867 to 1873 we see that, for January 1st, 1871, the absolute value of the total force was 8·5391, with an annual change of + 0·0064. This would make the magnetic intensity 8·5663 for April, 1875, which agrees well with the observed value. The mean annual acceleration from 1861 to 1875 is considerably less than the value deduced from the observations of the last few years.

The intensity, 9·27, observed by Caligny at Malta in 1839, combined with that of 1875, makes the annual variation — 0·0052.

At Rome, 9·6575 in 1849 gives also an annual variation of — 0·0052; but at Naples, 9·55 in 1845, makes the yearly change only — 0·0033.

#### *The Magnetic Declination.*

The observations, on which the determination of this element depend,

are necessarily affected by many possible sources of error, when the work has to be done in the course of a long and difficult journey. The carriage of the instruments by land and sea; the frequent packing and unpacking; the great variations of temperature; the shortness of time at each station, scarcely allowing sufficient attention to be paid to choice of locality or examination of instruments; all tell more against the magnetic declination than against the other elements of terrestrial magnetism.

As we were detained a considerable time at the Cape of Good Hope, it was thought advisable to examine thoroughly all the instruments, and to take a very complete set of observations at the Cape Observatory, in order to make this well-known station the point of departure for all our work in Kerguelen and elsewhere. It was fortunate that this could be done leisurely, as we found on examination that the declination magnet was useless, the bar not being magnetic, nor capable of retaining a sufficient amount of magnetism to secure accurate results. On July 30th the bar was magnetised by aid of large permanent magnets, and then subsequent declination observations led to most unsatisfactory results. On August the 19th a coil was made use of to magnetise the same bar, but two series of readings then taken with the needle, and with the Observatory magnet, shewed the utter untrustworthiness of our needle. As the Rev. W. Sidgreaves, though most kindly assisted by the Government Astronomer, Mr. E. J. Stone, was unable to magnetise satisfactorily our reversible declination needle, we were forced to substitute in its place the vibration magnet. The latter not being arranged for rapid reversal, the zero of the scale was very carefully determined both at the Cape Observatory and afterwards at Kerguelen, and the scale value accurately tested.

The method of observation usually adopted, was to fix the position of a well defined distant mark, by aid of sun or star transits, with the Simms' theodolite, and then to note the bearing of the magnetic needle with respect to the same mark with the Jones' unifilar. At Florence the confined space, and still more the badness of the weather, made it advisable to trust wholly to the unifilar, and therefore no fixed mark was used, but the position of the magnet was referred directly to that of the sun, observed by aid of the mirror attached to the instrument. The same method was used at Moncalieri, and the corrections for the displacement of the mirror, deduced from the latter observations, served to correct the single reading at Florence. The necessary correction for any error in the mirror is explained in a former paper on the magnetic survey of the west of France (Phil. Trans. 1869, p. 43).

The chronometer made use of throughout the whole series of observations was a good pocket instrument from Greenwich Observatory, Maurice 6144. It was compared on every possible occasion with the

standard clocks of fixed observatories, and at other times with the chronometers kept on board H.M.S. "Volage." No direct observations were taken with the transit theodolite to check the error and rate of the chronometer, but these depend entirely on the comparisons. It will not be necessary to give in full the details of each comparison, but all the requisite information is contained in the following table.

TABLE VI.

| Station.            | 1875.   | Chronometer time. | Fast on G. M. T. | Daily rate. |
|---------------------|---------|-------------------|------------------|-------------|
|                     |         | h. m. s.          | h. m. s.         | s.          |
| Bombay Observatory  | April 8 | 4 52 33·0 p.m.    | 6 58 7·23        |             |
|                     | " 10    | 4 46 40·6         | 6 58 14·23       | + 3·50      |
|                     | " 12    | 10 37 0           | 6 58 22·43       | + 3·64      |
| Aden, H.M.S. Volage | " 27    | 3 0 0             | 6 59 16·90       | + 3·56      |
|                     |         | 9 0 0             | 6 59 17·88       | + 3·92      |
| Port Said.....      | May 15  | 5 1 0             | 7 0 33·20        | + 4·31      |
| Malta .....         | " 24    | 5 38 0            | 7 1 11·00        | + 4·20      |
| Palermo Observatory | " 29    | Noon.             | 0 50 17·74       |             |
| Naples .....        | June 3  | 4 0 0             | 0 50 29·53       | + 2·30      |
| Rome .....          | " 8     | 4 0 0             | 0 50 56·91       | + 5·48      |
| Florence .....      | " 19    | 2 0 0             | 0 51 18·26       | + 1·94      |
| Moncalieri .....    | " 20    | 7 6 0             | 0 50 0·67        |             |
|                     | " 21    | 9 46 0            | 0 49 59·27       | - 1·24      |

When the journey through Sicily was commenced, the chronometer was altered to approximate local times. The great change in the daily rate between Naples and Rome will not affect the results at Rome, as the declination was measured from the standard mark at the Roman College Observatory. Before reaching Moncalieri the chronometer appears to have met with an accident which entirely altered its rate, but the double comparison at this station renders this change of less moment.

TABLE VII.

| Station.               | Date.         | Chronometer.   | Circle reading<br>for sun or<br>star. | Circle reading<br>for mark. | Circle<br>reading for<br>magnet. | Scale<br>correction. | Declination. |
|------------------------|---------------|----------------|---------------------------------------|-----------------------------|----------------------------------|----------------------|--------------|
| Cape Observatory ..... | 1874. Aug. 20 | h. m. s.<br>.. | ° ' "                                 | ° ' "                       | ° ' "                            | ' "                  | ° ' "        |
|                        |               | 1 15 0 p.m.    | ..                                    | 162 38 35                   | 132 28 55                        | -22 45               | * 30 0 34 W. |
|                        |               | 1 42 0         | ..                                    | 162 38 25                   | 132 40 50                        | -32 36               | 29 58 20     |
|                        |               | 1 47 0         | ..                                    | " "                         | 132 8 40                         | 0 0                  | * 29 57 54   |
|                        |               | 1 55 0         | ..                                    | " "                         | 132 42 30                        | -22 17               | 29 56 21     |
|                        |               | 2 2 0          | ..                                    | " "                         | 132 7 10                         | 0 0                  | * 29 59 24   |
|                        |               | 2 9 0          | ..                                    | " "                         | 132 42 25                        | -32 17               | 29 56 26     |
|                        | 22            | 3 55 0         | ..                                    | " "                         | 132 7 0                          | 0 0                  | * 29 59 34   |
|                        | "             | 3 30 0         | ..                                    | 233 55 50                   | 203 56 20                        | -32 7                | 29 59 46     |
| Bombay Observatory.... | 1875. April 8 | 5 5 0          | ..                                    | 221 51 40                   | 222 54 40                        | -32 21               | 0 57 5 E.    |
|                        |               | 5 13 0         | ..                                    | 226 8 20                    | 227 10 30                        | "                    | 0 56 15      |
|                        |               | 5 30 0         | ..                                    | 226 8 35                    | 227 9 55                         | "                    | 0 55 25      |
|                        |               |                | ..                                    | 224 42 5                    | 225 43 15                        | "                    | 0 55 15      |
| " College.....         | 12            | 11 3 23.5      | 141 30 7.5                            | 262 28 30                   | ..                               | ..                   | 0 57 16.5    |
|                        |               |                |                                       | 203 36 45                   | 159 29 0                         | "                    | "            |
|                        |               | 11 14 26.5     | 169 57 37.5                           | 262 28 15                   | ..                               | "                    | 0 53 55.5    |
| Aden .....             | 27            | 9 6 22.2       | 111 45 0                              | 117 45 15                   | ..                               | ..                   | 2 19 39.4 W. |
|                        |               |                |                                       | 230 14 25                   | 126 21 20                        | "                    | "            |



| Station.         | Date.  | Chronometer.               | Circle reading<br>for sun or<br>star. | Circle reading<br>for mark. | Circle<br>reading for<br>magnet. | Scale<br>correction. | Declination.      |
|------------------|--------|----------------------------|---------------------------------------|-----------------------------|----------------------------------|----------------------|-------------------|
| Port Said.....   | May 15 | h. m. s.<br>9 51 40.3 p.m. | ° ' " 129 6 22.5                      | ° ' " 108 23 15             | ° ' " ..                         | ' "                  | ° ' " 5 9 48.8 W. |
| Malta .....      | " 24   | 10 37 10.1                 | 197 50 15.0                           | 89 59 45                    | 192 4 25                         | "                    | 12 8 40.2 "       |
| Palermo .....    | " 29   | 10 49 22.7                 | 199 28 30.0                           | 177 4 0                     | 178 25 10                        | "                    | 12 8 8.9          |
|                  |        | 10 13 12.5 a.m.            | 220 56 37.5                           | 89 59 45                    | ..                               | "                    | 11 15 20.2 "      |
| Naples.....      | June 3 | 10 21 35.7                 | 223 59 22.5                           | 160 2 0                     | 187 15 0                         | "                    | 11 15 45.6        |
|                  |        | 3 44 23.2 p.m.             | 182 56 30.0                           | 257 13 30                   | ..                               | "                    | 11 31 57.8 "      |
|                  |        | 3 51 58.4                  | 184 12 0.0                            | 163 2 0                     | ..                               | "                    | 11 31 5.9         |
|                  |        | 3 59 58.0                  | 185 30 52.5                           | 201 20 7.5                  | 172 17 30                        | "                    | 11 31 9.8         |
|                  |        | 4 13 17.3                  | 187 39 22.5                           | 109 27 55                   | 172 18 50                        | -32 1                | 11 31 15.9        |
| Rome .....       | 8      | 11 40 0 a.m.               | 212 15 25                             | 201 20 7.5                  | 202 2 20                         | -32 21               | 12 17 20 "        |
| Florence .....   | " 19   | 1 55 39.4 p.m.             | 159 46 25                             | 192 20 25                   | 203 3 10                         | "                    | 12 15 45          |
| Moncalieri ..... | " 21   | 11 1 1.8 a.m.              | 162 32 40                             | 192 19 40                   | 143 48 0                         | "                    | 13 22 26.2 "      |
|                  |        | 11 7 25.3                  | 165 14 50                             | ..                          | 191 1 10                         | "                    | 13 45 15.9 "      |
|                  |        | 11 13 25.5                 | ..                                    | ..                          | ..                               | "                    | 13 45 51.9        |
|                  |        | ..                         | ..                                    | ..                          | ..                               | "                    | 13 45 15.9        |

At the Observatories of the Cape, of Colaba at Bombay, and of Rome, it was only necessary to enter the approximate local mean time under the heading, "Chronometer," as the declination at these stations was measured from the standard marks. The bearing of these magnetic marks is respectively  $0^{\circ} 31' 51''$ ,  $0^{\circ} 26' 26''$ , and  $21^{\circ} 26' 54''$  E. of the Astronomical North Point. At the remaining stations the sun's azimuth was computed for the hour angle of the sun given by the chronometer, except at the college of Bombay, where it was found more convenient to observe the stars Aldebaran and Capella, instead of the sun. The observations marked with an asterisk were taken with the needle of the Cape Observatory. The computed altitudes of the sun for the three observations at Moncalieri, were  $63^{\circ} 3' 33''\cdot60$ ,  $63^{\circ} 48' 57''\cdot69$ , and  $64^{\circ} 29' 17''\cdot78$ . This difference of altitude being so slight makes the correction for the perpendicularity of the mirror much less reliable than it might otherwise have been.

The declination observations at the Cape of Good Hope date back as far as 1600, and the mean yearly amount of the secular variation for the first 240 years was found to be  $+7'\cdot66$  W. It then diminished, and was  $+0'\cdot49$  from 1841 to 1846,  $+1'\cdot41$  from 1843 to 1848, and  $2'\cdot16$  from 1846 to 1850. The renewed acceleration in the annual variation seems to have lasted but for a short period, as a comparison of the mean value for 1874, with  $29^{\circ} 14'\cdot62$ , the mean for 1848, gives only  $1'\cdot68$  as the annual change.

From observations of this magnetic element at Bombay in 1845, 1856, 1867, and 1875, we notice a gradual easterly motion of the needle, it being at the above dates  $0^{\circ} 13'$  W.,  $0^{\circ} 19'$  E.,  $0^{\circ} 42'$  E., and  $0^{\circ} 56'$  E., shewing a decreasing yearly change of  $2'\cdot91$ ,  $2'\cdot09$ , and  $1'\cdot75$ . The amount of the mean annual variation given by the series of monthly observations at the Colaba Observatory from 1867 to 1873 is  $1'\cdot77$ , which may be considered identical with the above.

At Aden the heat of the sun was so great that it was imprudent to remain long near the theodolite whilst taking the solar observation, the declination was therefore obtained under very disadvantageous circumstances, and consequently less weight can be attached to the result. This is apparent also from the abnormal increase in the secular acceleration. Thus the declination which was  $5^{\circ} 2'$  W. in 1834, became  $4^{\circ} 15'$  W. in 1857, the annual variation being, therefore,  $-2'\cdot04$ ; whilst in 1875 the angle observed was  $2^{\circ} 19' 39''$  W., which increases the yearly change to  $-6'\cdot41$ .

The declination in 1875 at Malta, combined with the value  $15^{\circ} 20'$  W., obtained in 1834, gives a yearly change of  $-4'\cdot76$ ; and the angle  $13^{\circ} 49'$  measured at Rome in 1852-5, along with the value found in 1875, makes the annual variation  $-5'\cdot95$ . For the remaining stations I am unacquainted with any published values of this element of the earth's magnetic force, but the careful series of

measures taken at Moncalieri, by P. Denza, will most probably appear shortly in the publications of that Observatory.

In conclusion I will subjoin in a single table the mean results for all the elements of terrestrial magnetism at the different stations.

TABLE VIII.

| Station.     | Dip.      | Annual<br>amount<br>of<br>Sec. var. | Hori-<br>zontal<br>force. | Total<br>force. | Annual<br>amount<br>of<br>Sec. var. | Declination. | Annual<br>amount<br>of<br>Sec. var. |
|--------------|-----------|-------------------------------------|---------------------------|-----------------|-------------------------------------|--------------|-------------------------------------|
|              | ° / "     | /                                   |                           |                 |                                     | ° / "        | /                                   |
| Cape Town.   | -56 2 22  | -4·69                               | 4·3098                    | 7·7152          | +0·0047                             | 29 58 33 W.  | +1·68                               |
| Colaba ....  | +19 14 40 | +1·56                               | 8·0853                    | 8·5633          | +0·0043                             | 0 56 0 E.    | +1·75                               |
| Bombay....   | +20 6 46  | ..                                  | 8·0354                    | 8·5572          | ..                                  | 0 55 36 E.   |                                     |
| Aden.....    | + 5 28 9  | +0·68                               | 7·6253                    | 7·6602          | ..                                  | 2 19 39 W.   |                                     |
| Port Said .. | +42 31 54 | ..                                  | 6·4056                    | 8·6926          | ..                                  | 5 9 49 "     |                                     |
| Malta.....   | +51 36 42 | -3·49                               | 5·6389                    | 9·0805          | -0·0052                             | 12 8 25 "    | -4·76                               |
| Palermo....  | +54 18 8  | ..                                  | 5·4005                    | 9·2551          | ..                                  | 11 15 33 "   |                                     |
| Naples ....  | +57 0 23  | -3·45                               | 5·1451                    | 9·4484          | -0·0033                             | 11 31 22 "   |                                     |
| Rome.....    | +58 50 55 | -2·09                               | 4·9207                    | 9·5235          | -0·0052                             | 12 16 33 "   | -5·95                               |
| Florence ..  | +60 13 0  | -3·28                               | 4·7775                    | 9·6181          | ..                                  | 13 22 26 "   |                                     |
| Moncalieri . | +62 55 42 | ..                                  | 4·4755                    | 9·8340          | ..                                  | 13 45 28 "   |                                     |

II. "On the Limits to the Order and Degree of the Fundamental Invariants of Binary Quantics." By J. J. SYLVESTER, M.A., LL.D., F.R.S., Professor in the Johns Hopkins University, Baltimore, U.S. Received December 26, 1877.

The developments which I have recently given to Professor Cayley's second method of dealing with invariants (the first method being that which has been exclusively used by Professor Gordan), has led me through the theory of the Canonical Generating Fraction to the following results, showing that the degree and order of the fundamental invariants and covariants to a quantic or system of quantics are subject to algebraical limits of a very simple kind, and I think it right that these results should not be withheld from the knowledge of those who are pursuing another and, as it seems to me, much more arduous and less promising direction of inquiry into the same subject.

By order I mean the dimensions of a derived form in the coefficients of its primitive (Clebsch and Gordan's *grad*), and by degree the dimensions in the variables (Clebsch and Gordan's *ordnung*).

First as to degree.

If there be a system of  $n, n', n'' \dots$  odd degreed quantics and  $\nu, \nu', \dots$  &c., even ones, then (with the exception of the case when the system reduces to a single linear function or a single quadratic) the degree of