# XVII. *On the Measurement of the Chemical Intensity of Total Daylight made at Catania during the Total Eclipse of Dec. 22nd, 1870.* By HENRY E. ROSCOE, *F.R.S., Professor of Chemistry, Owens College, Manchester, and* T. E. THORPE, *F.R.S.E., Professor of Chemistry, Andersonian University, Glasgow.*

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THE following communication contains the results of a series of measurements of photochemical action made at Catania in Sicily, on Dec. 22nd, 1870, during the total solar eclipse of that date, with the primary object of determining experimentally the relation existing between this action and the changes of area in the exposed portion of the sun's disk. The attempt to establish this relation has already been made by one of us from the results of observations carried out by Captain JOHN HERSCHEL, R.E., F.R.S., at Jamkhandi, in India, during the total eclipse of August 18th, 1868*. Unfortunately the weather at Jamkhandi at the time of the eclipse was very unfavourable for observation; the estimated amount of cloud during the time of the eclipse amounted to about 7, the sun occasionally being even completely obscured.

In addition to the errors arising from the unsettled state of the weather, a further element of uncertainty was unavoidably introduced in the subsequent calculation in allowing for the variation in chemical intensity caused by the alteration in the sun's altitude during the progress of the eclipse. It has been shown that the relation between the sun's altitude and the chemical intensity at any given place is represented by the equation

$$CI_a = CI_0 + \text{const.} \times a,$$

where $CI_a$ signifies the chemical intensity at any altitude ($a$) in circular measure, $CI_0$ the chemical intensity at 0°, and const. $a$ a number derived from the observations†. Since no special series of observations were made at Jamkhandi (lat. 16° 30′ N.) in order to determine the constant, its approximate value could only be obtained from observations made at Pará, in Brazil (lat. 1° 25′ S.), during a different season of the year.

It appeared from these observations that, as might be expected, the rate of diminution of the chemical intensity of total daylight during the first portion of the eclipse up to the point at which the disk is half obscured is greater than corresponds to the area of darkened solar disk, whilst from this point up to totality the rate of diminution of chemical action is much less than that of the exposed portion of the disk.

The occasion of the recent solar eclipse presented a favourable opportunity for rede-

* ROSCOE, Mem. Lit. and Phil. Soc. of Manchester, 1868–69, vol. iv. [3] p. 202.

† Philosophical Transactions, 1867, p. 555; 1870, p. 315.

termining this point, and accordingly we undertook a fresh series of observations at Catania in connexion with the Government Eclipse Expedition. The method of measurement employed in this, as in the above-mentioned series, was that already described by one of us*. It consists in exactly estimating the tint which uniformly sensitive paper coated with a thin film of silver chloride acquires on exposure to the action of daylight for a given time. The observations were made in the Garden of the Benedictine Monastery of San Nicola, at Catania. The position of the observatory was

Lat. 37° 30′ 12″ N.
Long. $1^{h}$ $0^{m}$ $18^{s}$ E.,

as determined by Mr. SCHOTT, of the United States' Coast Survey. By barometric measurements it was found to be about 170 feet above the sea-level, a result confirmed by the independent observations of Mr. SCHOTT. In order to secure as clear an horizon as possible, the insolating instruments were mounted on the roof of a portico in the garden overlooking the bay to the south and west. The place was well adapted to the work, the only intervening object of consideration being the Monastery itself, distant about 100 paces to the east, the dome of which subtended an angle of about 10° with the plane of the paper. To the north lay Etna, about twenty miles distant, the summit of which subtended an angle of rather more than 4°. The influence exerted by these objects in cutting off the diffused solar radiation is far too inconsiderable to affect the results. The sensitive paper was exposed in the plane of the horizon, the insolating instruments being placed upon a tripod stand about 4 feet 6 inches in height. This stand was carefully levelled at the commencement of each series of observations, and the insolators were firmly clamped down after being adjusted due east and west, in which position they remained throughout the entire course of the observations. As we contemplated making consecutive exposures for direct and diffused chemical intensity every ten minutes during the progress of the eclipse from first to last contact, it was necessary to employ greater lengths of sensitive chloride-of-silver paper than we had hitherto used. The brass insolators were therefore proportionately increased in length, so as to allow of at least twenty-five observations to be made on a single strip. We assured ourselves, in the first place, that the paper could be kept for hours in the insolator exposed to the bright sunshine without darkening in the slightest degree, so long, of course, as the moveable brass slide covered the hole. This was doubtless in part due to the good radiating surface of the polished brass insolator, whereby the paper remained unheated even under the influence of direct sunshine; for we have observed that the blackening which silver chloride paper containing excess of silver nitrate suffers in time, however carefully it may be protected from the light, is promoted by increased temperature; thus a strip of sensitive paper kept in the dark more rapidly undergoes alteration in the tropics than in England.

Two insolating instruments were employed placed side by side; by means of one the chemical action of total daylight was first observed in the ordinary manner, and imme-

* ROSCOE, Bakerian Lecture, Philosophical Transactions, 1865, Part II. p. 605.

diately afterwards the chemical action of the diffused daylight was determined by the other by projecting on the exposed portion of the sensitive paper the shadow of a small blackened ball, so placed that its apparent diameter seen from the surface of the paper was slightly larger than the sun's disk. As the instruments were clamped in a constant position, it was necessary to vary from time to time the position of the blackened ball with reference to the plane of the paper in order to bring its shadow upon the exposed portion. We have, however, shown in a former communication that the height of the blackened ball from the sensitive paper may safely vary between 140 and 200 millimetres without producing any appreciable difference, and in the present experiments its height was maintained between these limits.

The experiments were commenced on Dec. 19th, with the object of determining the value of the constant before referred to. As an example of these observations, 65 in number, we give the first one of the series:—

Observed time $11^h\ 15^m$ A.M.

Duration of exposure for total daylight $5^s$.

Duration of exposure for diffused daylight $7^s$.

| | Readings on calibrated strip. | Mean. |
|---|---|---|
| I. | 100, 97, 100, 97, 104, 96, 97, 96 | =98·3 |
| II. | 93, 93, 97, 94, 95, 92, 93, 94, 95 | =94·0 |

The duration of exposures divided into the values in the Table accompanying the graduated fixed strip give:—

| | |
|---|---|
| Direct Chemical Intensity . . . . . . | 0·037 |
| Diffused Chemical Intensity . . . . | 0·101 |
| Total Chemical Intensity . . . . . . | 0·138 |

The following Tables contain the results of this preliminary series of observations:—

TABLE I. (*a*).

| December 19th, 1870. | | | | |
|---|---|---|---|---|
| Hour. | Diffused. | Direct. | Total. | Remarks. |
| h m | | | | |
| 11 15 | 0·101 | 0·037 | 0·138 | Sky throughout the day perfectly cloudless and of a pure blue. Gentle breeze from E. Barometer 29·97 inches. |
| 11 45 | 0·112 | 0·032 | 0·144 | |
| 12 0 | 0·113 | 0·037 | 0.150 | |
| 12 15 | 0·120 | 0·026 | 0·146 | |
| 12 30 | 0·108 | 0·042 | 0·150 | |
| 12 47 | 0·106 | 0·039 | 0·145 | |
| 1 5 | 0·115 | 0·025 | 0·140 | |
| 1 15 | 0·096 | 0·036 | 0·132 | |
| 1 57 | 0·091 | 0·023 | 0·114 | |
| 2 6 | 0·082 | 0·028 | 0·110 | |
| 2 22 | 0·075 | 0·020 | 0·095 | |
| 2 36 | 0·062 | 0·019 | 0·081 | |
| 2 57 | 0·060 | 0·022 | 0·082 | |
| 3 6 | 0·060 | 0·017 | 0·077 | |
| 3 21 | 0·050 | 0·012 | 0·062 | |
| 3 36 | 0·049 | 0·011 | 0·060 | |

TABLE I. (*b*).

| December 20th, 1870. | | | | |
|---|---|---|---|---|
| Hour. | Diffused. | Direct. | Total. | Remarks. |
| h m | | | | |
| 9 22 | 0·070 | 0·034 | 0·104 | In the early part of the morning the sky was slightly cloudy, particularly on the horizon to the S. and S.W. Strong W. breeze. Bar. at 9 A.M. 29·87 inches. Thin haze throughout the day, but the blue colour of the sky was not much diminished. Bar. at noon 29·81 inches, at 5.30 29·74 inches. |
| 9 52 | 0·085 | 0·052 | 0·137 | |
| 10 23 | 0·096 | 0·078 | 0·174 | |
| 10 52 | 0·097 | 0·077 | 0·174 | |
| 11 37 | 0·104 | 0·074 | 0·178 | |
| 11 52 | ......... | ......... | 0·172 | |
| 12 7 | 0·106 | 0·066 | 0·172 | |
| 12 52 | 0·106 | 0·078 | 0·184 | |
| 1 23 | 0·096 | 0·058 | 0·154 | |
| 1 55 | 0·086 | 0·038 | 0·124 | |
| 2 24 | 0·075 | 0·028 | 0·103 | |
| 2 54 | 0·073 | 0·016 | 0·089 | |
| 3 24 | 0·057 | 0·008 | 0·065 | |
| 3 55 | 0·042 | 0·005 | 0·047 | |
| 4 34 | ......... | ......... | 0·009 | Sun just above horizon; low bank of clouds above S. horizon. Less haze. |

TABLE I. (*c*).

| December 21st, 1870. | | | | | |
|---|---|---|---|---|---|
| Hour. | Diffused. | Direct. | Total. | Cloud. | Remarks. |
| h m | | | | | |
| 8 24 | 0·036 | 0·011 | 0·047 | ...... | This day was by no means so favourable for observation as the two preceding days; the sky was cloudy throughout the day, particularly to the S. and S.W. W. breeze. Bar. at 8.54, 29·69 inches. do. 11.54, 29·61 „ do. 4.30, 29·50 „ |
| 8 54 | 0·050 | 0·018 | 0·068 | ...... | |
| 9 24 | 0·067 | 0·020 | 0·087 | ...... | |
| 9 54 | 0·075 | 0·032 | 0·107 | 3 | |
| 10 24 | 0·094 | 0·044 | 0·138 | 3 | |
| 10 54 | 0·091 | 0·028 | 0·119 | 6 | |
| 11 24 | 0·115 | 0·053 | 0·168 | 8 | |
| 11 54 | 0·124 | 0·056 | 0·175 ? | 8 | |
| 12 24 | Sun obscured. | | | 9 | |
| 12 44 | 0·119 | 0·038 | 0·157 | 9 | |
| 1 24 | 0·109 | 0·043 | 0·152 | 7 | |
| 1 54 | 0·086 | 0·051 | 0·137 | 5 | |
| 2 24 | 0·083 | 0·036 | 0·119 | 4 | |
| 2 54 | Sun obscured. | | 0·072 | 4–5 | |
| 3 24 | do. | | 0·058 | 8 | |
| 3 54 | do. | | 0·042 | 5 | |

On grouping together the observations taken at about the same hours on the three days, the following mean values are obtained:—

TABLE II.

| Hour. | Altitude. | No. of experiments. | Chemical intensity. | | |
|---|---|---|---|---|---|
| | | | Diffused. | Direct. | Total. |
| h m | ° ′ ″ | | | | |
| 8 24 | 11 4 13 | 1 | ·036 | ·011 | ·047 |
| 8 54 | 15 9 39 | 1 | ·050 | ·018 | ·068 |
| 9 23 | 19 9 35 | 2 | ·068 | ·027 | ·095 |
| 9 53 | 22 22 15 | 2 | ·080 | ·042 | ·122 |
| 10 24 | 25 8 21 | 2 | ·095 | ·061 | ·156 |
| 10 52 | 26 28 12 | 1 | ·097 | ·077 | ·174 |
| 11 30 | 28 43 46 | 4 | ·108 | ·050 | ·158 |
| 11 57 | 29 5 40 | 2 | ·118 | ·044 | ·162 |
| 12 11 | 29 0 12 | 2 | ·113 | ·046 | ·159 |
| 12 30 | 28 37 4 | 1 | ·108 | ·042 | ·150 |
| 12 44 | 28 7 31 | 2 | ·110 | ·039 | ·149 |
| 1 10 | 26 46 42 | 2 | ·105 | ·031 | ·136 |
| 1 24 | 25 48 54 | 2 | ·103 | ·050 | ·153 |
| 1 53 | 23 21 20 | 3 | ·088 | ·037 | ·125 |
| 2 6 | 22 3 46 | 1 | ·082 | ·028 | ·110 |
| 2 24 | 20 5 30 | 3 | ·078 | ·028 | ·106 |
| 2 44 | 17 40 44 | 4 | ·062 | ·018 | ·080 |
| 3 6 | 14 46 51 | 1 | ·060 | ·017 | ·077 |
| 3 22 | 12 32 0 | 3 | ·053 | ·010 | ·063 |
| 3 36 | 10 28 46 | 1 | ·049 | ·011 | ·060 |
| 3 55 | 7 34 41 | 2 | ·042 | ·005 | ·047 |
| 4 34 | 1 30 28 | 1 | ·009 | ·000 | ·009 |

On again grouping the observations made at hours equidistant from noon, we obtain the mean numbers contained in the following Table:—

TABLE III.

| Mean altitude. | No. of observations. | Diffused. | Direct. | Total. |
|---|---|---|---|---|
| ° ′ ″ | | | | |
| 1 30 28 | 1 | 0·009 | 0·000 | 0·009 |
| 9 28 10 | 7 | 0·044 | 0·008 | 0·052 |
| 13 9 57 | 7 | 0·050 | 0·014 | 0·064 |
| 19 57 49 | 12 | 0·072 | 0·028 | 0·100 |
| 24 46 12 | 7 | 0·095 | 0·049 | 0·144 |
| 28 24 10 | 14 | 0·108 | 0·047 | 0·155 |

These results are graphically represented in Plate XXII. figs. 1, 2 & 3.

The observations on the day of the eclipse (the 22nd) were commenced shortly after 9 o'clock, and up to the time of first contact were made regularly at intervals of about an hour. It will be seen from the remarks contained in the last columns of Table I. that the fine weather we had experienced up to the 19th was gradually drawing to a close; the barometer gradually fell from 29·97 inches at noon on the 19th to 29·50 inches at 4.30 P.M. on the 21st; the wind, too, had veered round, and clouds were slowly accumulating. During the night of the 21st much rain fell; but shortly after sunrise on the 22nd the clouds in great part disappeared, every trace of haze was dissipated, and the sky was of the purest blue: it will be seen that the measurements of photochemical action made up to the time of first contact are almost absolutely coincident with the mean numbers derived from the observations of the three preceding days. As the eclipse progressed, and the temperature of the air fell, clouds were again formed, and from $1^{h}\ 40^{m}$ up to the time of totality it was impossible to make any observations, as the sun was never unclouded for more than a few seconds at a time; indeed just before totality a slight shower of rain fell. As the illuminated portion of the solar disk gradually increased after totality, the clouds rapidly disappeared, the estimated amount falling from 9 (overcast=10) to 3 in about fifteen minutes. The observations were then regularly continued to within a few minutes of last contact.

Although the disk and by far the greater portion of the heavens were completely obscured by clouds during the period of totality, rendering any determination of the photochemical action perfectly valueless in view of our special object, it was yet thought worth while to attempt to estimate the chemical intensity of the feebly diffused light at this time. That it has a certain degree of actinism is of course evident from the fact that photographs can be taken during totality. Immediately, therefore, after the supposed commencement of totality the slit was opened, and the sensitive paper exposed for ninety-five seconds; as the end of totality was very plainly indicated about two or three seconds after the slit had been again closed, it was clear that the paper had been exposed only during the period of totality. Not the slightest action, however, could be detected on the paper; on comparing them in the dark room it appeared considerably lighter than the extreme light end of the graduated strip. The calibration of the fixed strip employed in our measurements was not carried out to the extreme limits of the tinted portion, but on the supposition that it decreased uniformly in shade from end to end; or, in other words, assuming that the curve representing the decrement in intensity of tint maintained its symmetrical character throughout, which is a perfectly legitimate assumption to make when we bear in mind the manner in which these tinted strips are made, it follows that the amount of chemical action during the totality could not exceed 0·003 of the unit which we adopt, and in all probability it is much less.

The results of the day's observations are contained in Table IV.

TABLE IV.

| Hour. | Altitude. | Sky. | Sun. | Total. | Cloud. | Remarks. |
|---|---|---|---|---|---|---|
| h m | ° ′ | | | | | |
| 9 3 | 16 31 | 0·085 | 0·011 | 0·096 | 2 | Bar. 29·27 inches. |
| 9 54 | 22 33 | 0·096 | 0·027 | 0·123 | 3 | |
| 10 54 | 26 44 | 0·105 | 0·055 | 0·160 | 2 | Pure blue sky. |
| 12 0 | 29 09 | 0·107 | 0·066 | 0·173 | 3–4 | |
| 12 24 | 28 45 | 0·105 | 0·070 | 0·175 | 3 | Large cumuli over Etna and on horizon. |
| 12 34 | 28 29 | 0·090 | 0·050 | 0·140 | — | |
| 12 44 | 28 08 | 0·090 | 0·044 | 0·134 | 4 | |
| 12 54 | 27 34 | 0·077 | 0·066 | 0·143 | 4 | Sun close to clouds. |
| 1 4 | 27 00 | …… | …… | [0·084] | 6 | Sun overcast. |
| 1 16 | 26 17 | 0·053 | 0·045 | 0·098 | 6 | Sun unclouded. |
| 1 24 | 25 49 | 0·043 | 0·051 | 0·094 | 7 | Yellow light strongly marked. |
| 1 40 | 24 25 | …… | …… | …… | …… | No exposure: sun overcast. |
| The disk was overcast during the time of totality by clouds; the paper, however, was exposed for the entire time of totality, but not the slightest action was evident, Alt. 22° 41′–22° 31′. | | | | | | |
| 2 9 | 21 43 | …… | …… | 0·024 | | |
| 2 25 | 20 03 | 0·023 | 0·010 | 0·033 | 3 | Sun unclouded. |
| 2 34 | 18 56 | 0·028 | 0·019 | 0·047 | 2–3 | " |
| 2 44 | 17 42 | 0·035 | 0·022 | 0·057 | 2–3 | " |
| 2 54 | 16 33 | 0·041 | 0·023 | 0·064 | 2–3 | " |
| 3 4 | 15 14 | …… | …… | 0·062 | 3 | " |
| 3 20 | …… | …… | …… | …… | …… | Sun clouded over. |

These results are graphically represented in figs. 4 and 4 *a*.

Table V. shows the relation of the total chemical intensity to the area of the solar disk obscured. The following approximate method, which we have employed for determining the relative area of the sun eclipsed at the times of observation, is sufficiently accurate for our purpose. Three large disks were cut from a stout and uniformly thick sheet of paper, two to represent the solar, the third the lunar disk, their radii being in the ratio of the apparent semidiameters of the sun and moon on the day of the eclipse. Each of the sun-cards was accurately weighed on a chemical balance; and on one the ratios of the intervals elapsing between first contact and the various times of observation before totality were pointed off along a diameter, and the edge of the lunar disk advanced successively to these points, and the segments cut off and weighed. The total weight of the solar disk into the weights of the various segments gives approximately the area of the sun covered at the corresponding time of observation. In a similar manner the approximate areas after totality were obtained. This method of procedure, which neglects the influence of the moon's motion and of the earth's motion of rotation, is of course crude; but as the commencement of the eclipse occurred near noon, the error thus introduced may certainly be disregarded for areas covered up to $1^h$ $24^m$, the time of the last observation taken before totality. To the areas thus obtained for the times of observation after totality we have applied the necessary corrections, for which we are indebted to Mr. SEABROKE.

Column I. gives the apparent solar times of observation; column II. the corresponding altitude of the sun. Column III. shows the corresponding total chemical intensity of the uneclipsed sun calculated from the mean curve in fig. 2. Column IV. shows the relation of this intensity to the sun's altitude, the chemical intensity immediately before first contact being taken as unity. Column V. gives the immediate results of the photochemical observations during the eclipse. Column VI. shows these results calculated from the mean curve in fig. 4; column VII. the same corrected for variation in the sun's altitude; column VIII. the same referred to the total chemical intensity immediately before first contact as unity. Lastly, Column IX. shows the magnitude of the eclipse at the times of observation, the unobscured sun being regarded as unity.

Table V.

| I. | II. | III. | IV. | V. | VI. | VII. | VIII. | IX. |
|---|---|---|---|---|---|---|---|---|
| h m | ° ′ | | | | | | | |
| 12 44 | 28 08 | 0·153 | 0·998 | 0·134 | 0·140 | 0·140 | 0·915 | 0·961 |
| 12 54 | 27 34 | 0·151 | 0·987 | 0·143 | 0·132 | 0·134 | 0·876 | 0·880 |
| 1 16 | 26 17 | 0·143 | 0·935 | 0·098 | 0·098 | 0·105 | 0·686 | 0·637 |
| 1 24 | 25 49 | 0·140 | 0·915 | 0·094 | 0·078 | 0·085 | 0·555 | 0·534 |
| 2 2 | 22 35 | 0·121 | 0·791 | 0·000 | 0·000 | 0·000 | 0·000 | 0·000 |
| 2 9 | 21 43 | 0·115 | 0·752 | 0·024 | 0·019 | 0·025 | 0·165 | 0·127 |
| 2 25 | 20 03 | 0·107 | 0·699 | 0·033 | 0·033 | 0·047 | 0·307 | 0·338 |
| 2 34 | 18 56 | 0·101 | 0·660 | 0·047 | 0·047 | 0·071 | 0·464 | 0·498 |
| 2 44 | 17 42 | 0·095 | 0·621 | 0·057 | 0·057 | 0·092 | 0·601 | 0·602 |
| 2 54 | 16 33 | 0·088 | 0·575 | 0·064 | 0·064 | 0·111 | 0·725 | 0·736 |
| 3 4 | 15 14 | 0·081 | 0·529 | 0·062 | 0·071 | 0·134 | 0·876 | 0·861 |

The relation of columns VIII. and IX. is graphically represented in fig. 5, the unbroken line representing the magnitude of the eclipse, the abscissæ represent the time, and the ordinates the corresponding chemical intensity and area of exposed disk.

*From these observations we deduce the law that the diminution in the total chemical intensity of the sun's light during an eclipse is directly proportional to the magnitude of the obscuration.*

We now proceed to investigate the influence respectively exerted by the (1) diffused and (2) direct radiation.

Table VI. contains the results of the determinations of chemical intensity of diffused light.

Column I. gives the apparent solar times of observations; column II. the corresponding solar altitude; column III. the chemical intensity of diffused light calculated from the mean curve in fig. 3 obtained from the observations of Dec. 19, 20, 21. Column IV. gives the relation of this intensity to the sun's altitude, the chemical intensity of the diffused light immediately before first contact being taken as unity. Column V. gives the immediate results of the determinations of chemical intensity of the diffused light during the eclipse. Column VI. shows these results calculated from the mean curve in fig. 5; column VII. the same corrected for variation in altitude; column VIII. the same referred to the chemical intensity of diffused light immediately before first contact as unity. Column IX. shows the magnitude of the eclipse at the time of observation, the unobscured sun being regarded as unity.

TABLE VI.

| I. | II. | III. | IV. | V. | VI. | VII. | VIII. | IX. |
|---|---|---|---|---|---|---|---|---|
| h m | ° ′ | | | | | | | |
| 12 44 | 28 08 | 0·100 | 0·980 | 0·090 | 0·090 | 0·092 | 0·900 | 0·961 |
| 12 54 | 27 34 | 0·098 | 0·961 | 0·077 | 0·077 | 0·080 | 0·786 | 0·880 |
| 1 16 | 26 17 | 0·095 | 0·931 | 0·053 | 0·053 | 0·057 | 0·558 | 0·637 |
| 1 24 | 25 49 | 0·093 | 0·912 | 0·043 | 0·043 | 0·047 | 0·462 | 0·534 |
| 2 2 | 22 35 | 0·083 | 0·814 | 0·000 | 0·000 | 0·000 | 0·000 | 0·000 |
| 2 9 | 21 43 | 0·080 | 0·784 | ...... | 0·012 | 0·015 | 0·151 | 0·127 |
| 2 25 | 20 03 | 0·074 | 0·725 | 0·023 | 0·023 | 0·032 | 0·311 | 0·338 |
| 2 34 | 18 56 | 0·072 | 0·706 | 0·028 | 0·028 | 0·040 | 0·389 | 0·498 |
| 2 44 | 17 42 | 0·067 | 0·657 | 0·035 | 0·035 | 0·053 | 0·522 | 0·602 |
| 2 54 | 16 33 | 0·064 | 0·626 | 0·041 | 0·041 | 0·065 | 0·642 | 0·736 |

TABLE VI. (*a*).

| I. | II. | III. | IV. | V. | VI. | VII. | VIII. | IX. |
|---|---|---|---|---|---|---|---|---|
| h m | ° ′ | | | | | | | |
| 12 44 | 28 08 | 0·053 | 0·982 | 0·044 | 0·056 | 0·057 | 0·966 | 0·961 |
| 12 54 | 27 34 | 0·052 | 0·963 | 0·066 | 0·051 | 0·053 | 0·898 | 0·880 |
| 1 16 | 26 17 | 0·048 | 0·889 | 0·045 | 0·045 | 0·051 | 0·864 | 0·637 |
| 1 24 | 25 49 | 0·047 | 0·870 | 0·051 | 0·037 | 0·043 | 0·730 | 0·534 |
| 2 2 | 22 35 | 0·038 | 0·704 | 0·000 | 0·000 | 0·000 | 0·000 | 0·000 |
| 2 9 | 21 43 | 0·035 | 0·648 | ...... | 0·007 | 0·011 | 0·186 | 0·127 |
| 2 25 | 20 03 | 0·033 | 0·611 | 0·010 | 0·012 | 0·020 | 0·339 | 0·338 |
| 2 34 | 18 56 | 0·029 | 0·537 | 0·019 | 0·020 | 0·037 | 0·627 | 0·498 |
| 2 44 | 17 42 | 0·027 | 0·500 | 0·022 | 0·022 | 0·044 | 0·745 | 0·602 |
| 2 54 | 16 33 | 0·024 | 0·444 | 0·023 | 0·023 | 0·052 | 0·881 | 0·736 |

The relation of columns VIII. and IX. is graphically represented in fig. 6, the abscissæ and ordinates having the same signification as in fig. 5.

On comparing the curve A, representing the chemical intensity of diffused light, with the curve of the solar obscuration, it is seen that the rate of diminution in the chemical action exerted by the diffused light is up to a certain point greater than corresponds to the portion of sun eclipsed, whilst from this point up to totality the rate of diminution becomes less than that corresponding to the progress of the eclipse. As a consequence of this fact, and of the law that the diminution in the total photochemical action exerted during an eclipse is proportional to the magnitude of the obscuration, it follows that the rate of diminution and increase of intensity of the chemically active rays in direct sunlight is much slower and quicker than corresponds to the changes of area in the exposed portion of the solar disk. This is graphically shown in curve B, fig. 6. The same rapid diminution of the chemical action of the diffused daylight during the former part of the eclipse was observed at Jamkhandi. It is doubtless due to the dark body of the moon cutting off the light from the highly luminous portion of sky lying on one side of the sun's disk.

That peculiar change of colour which it has long been noticed terrestrial objects assume during an eclipse was very strongly marked on the present occasion. Outside the garden of the Monastery, and just below our place of observation, was a profusion of a variety of *Opuntia*, on the flat broad leaves of which the change in colour was admirably depicted. When the obscuration of the solar disk amounted to about one half it was observed that they acquired a bright olive-green tinge, producing an effect as if they had been seen through yellow glass. This effect, it was remarked at the time, reached its maximum about $1^h\ 30^m$, at which time it will be seen that the curves representing the diminution of the direct and diffused chemical intensity are most widely separated from the mean curve representing the total chemical action.

On a former occasion we communicated to the Royal Society the results of a series of Observations on the Chemical Intensity of Daylight, made at Moita, near Lisbon, at the level of the sea, during August 1867, from which we deduced the relation between the sun's Altitude and the Photochemical Action of Total Daylight in a Cloudless Sky*. As Catania (lat. 37° 30′) and Moita (lat. 38° 40′) are nearly in the same latitude, it becomes interesting to compare the results obtained in December at the former place with those obtained for similar altitudes in August at the latter. The results of this comparison are seen in the following Table:—

TABLE VII.

| Mean altitude. | | Number of observations. | | Chemical intensity. | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Sun. | | Sky. | | Total. | |
| Lisbon. | Catania. | L. | C. | L. | C. | L. | C. | L. | C. |
| ° ′ | ° ′ | | | | | | | | |
| | 1 30 | ...... | 1 | ...... | 0·000 | ...... | 0·009 | ...... | 0·009 |
| | 9 28 | ...... | 7 | ...... | 0·008 | ...... | 0·044 | ...... | 0·052 |
| 9 51 | ...... | 15 | ...... | 0·000 | ...... | 0·038 | ...... | 0·038 | |
| | 13 10 | ...... | 7 | ...... | 0·014 | ...... | 0·050 | ...... | 0·064 |
| 19 41 | ...... | 18 | ...... | 0·023 | ...... | 0·062 | ...... | 0·085 | |
| | 19 58 | ...... | 12 | ...... | 0·028 | ...... | 0·072 | ...... | 0·100 |
| | 24 46 | ...... | 7 | ...... | 0·049 | ...... | 0·095 | ...... | 0·144 |
| | 28 29 | ...... | 14 | ...... | 0·047 | ...... | 0·108 | ...... | 0·155 |
| 31 14 | ...... | 22 | ...... | 0·052 | ...... | 0·100 | ...... | 0·152 | |

Figs. 2 & 3 give a graphical representation of these relations of chemical intensity as ordinates to the sun's altitude as abscissæ. The unbroken curve in fig. 2 shows the Catania observations, the dotted curve those made at Lisbon. In fig. 3 the observations of direct chemical intensity are represented by the broad lines, those made at Catania being distinguished by the unbroken curve. In all cases the positions of the experimentally determined points are given to show how closely they lie to the curves. In both cases it is evident that the relation between the solar altitude and the total chemical intensity is represented by a straight line, although the Catania observations slightly exceed by a constant difference those made at Moita, in conformity with the slight difference in latitude, and with the fact that the former determinations were made at a greater elevation above the sea-level.

The Catania observations further confirm the fact which we then announced, that for altitudes below 50° the amount of chemical action effected by diffused daylight on a surface placed in the plane of the horizon is greater than that exerted by direct radiation, and also that at low altitudes (9° or 10°) direct sunlight is almost completely robbed of its chemically active rays.

* Philosophical Transactions, 1870, p. 309.

FIG. 1.

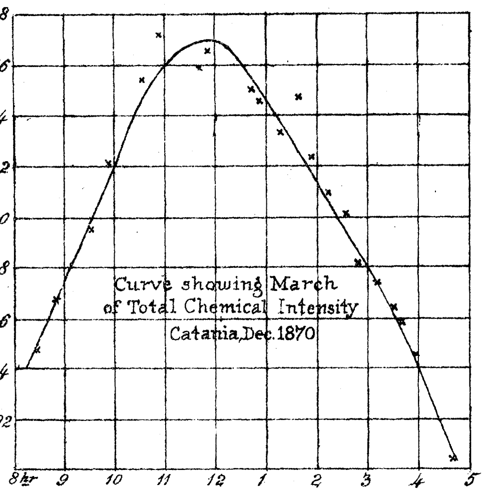


FIG. 2.

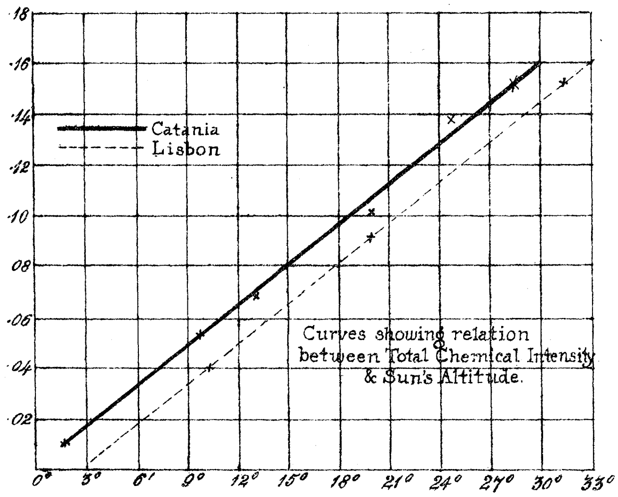


FIG. 3.

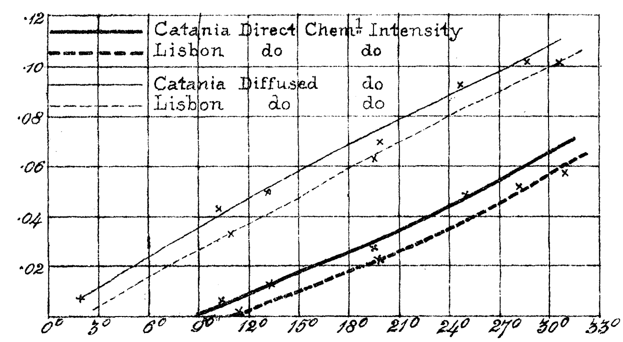


FIG. 5.

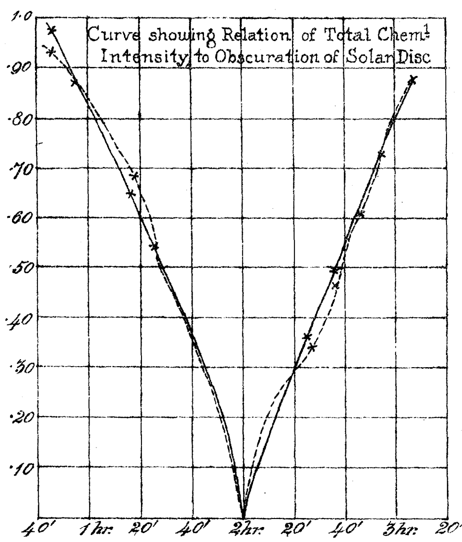


FIG. 4.

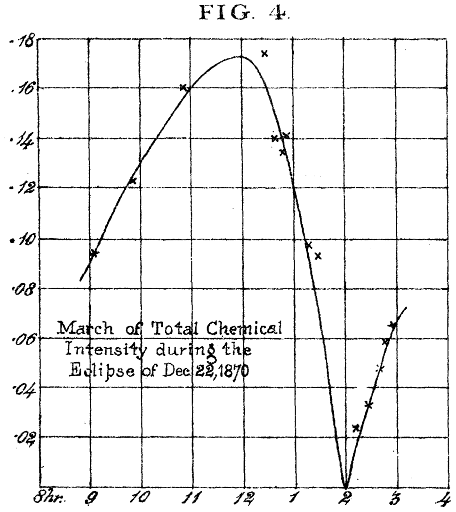


FIG. 4a.

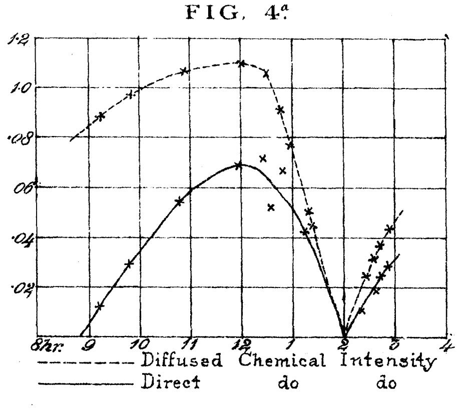


FIG. 6.