Atmospheric Electric Potential Gradient at Bangalore.

By

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(Plate XXIX)

1. *Introduction.*

The determination of the Electric data of the atmosphere has passed into the ordinary routine of the most important observatories in Europe and other parts of the civilised world. In India, a consistent and continuous series of observations has not been made. G. C. Simpson published the results of observations at Simla covering a period December 1908—May 1910.[1] Only relative values are given, as it was not found feasible to obtain the factor of reduction to level. No other station appears to have taken up this work systematically since.[2] One of the difficulties which seems to have discouraged some observers is the difficulty of preserving insulation, especially during the extremely humid months of the South-West Monsoon. It was therefore thought desirable to obtain results continuously over a fairly long period at Bangalore.

[1] Memoirs of the Indian Meteorological Department, Vol. XXI, Pt. VI.
[2] Recently observations have been started at the Colaba Observatory, Bombay.

2. *Situation and Climatic Data.*

Bangalore is in Latitude 12°58′ N and Longitude 77°36′ E at a height of 3,000 feet above mean sea level. The standard time adopted for observation is $5\frac{1}{2}$ hours Greenwich time. The accompanying tables show the seasonal and climatic conditions.

The seasonal conditions may be described as below.

In January the N.E. monsoon prevails with occasional showers and fairly strong and steady winds. February and March are dry with little rain or cloudiness, showing, however, thin cirrus clouds at a high level on many days, generally towards noon and later. There is a tendency to dustiness and haze. April and May are hot summer months often alleviated by thunderstorms towards the end of the day. There is generally little steady wind except when there is a storm. With June the South-West monsoon with strong winds and cloudiness establishes itself. In the earlier part there is little rain, leading to dustiness. Later rains and drizzles occur. This state continues into July and August. In September the wind moderates and rain is more frequent. In fact September is the rainiest month of the year. In October there is a pause of the South-West monsoon before the North-East one begins. The wind is only slight and there is moderate rain. This continues into the earlier part of November. The North-East monsoon begins in November and continues through December into January. These are the cold months.

Months.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
Rainfall average of 1917 26.	·46"	·11"	·44"	1·89"	4·68"	2·71"	2·98"	4·66"	6·92"	3·95"	2·60	·45"	$\frac{31·85}{12}$
Cloudiness % at 8 A.M.	32	19	11	28	45	76	86	87	80	62	52	39	51
Wind Vel. daily miles.	133	125	120	110	129	192	192	170	129	102	113	126	136
Temperature ...	58·2°F.	60·7	65·1	69·5	69·3	67·1	66·2	65·9	65·7	65·3	62·3	58·6	64·5

Seasonal data for Bangalore.

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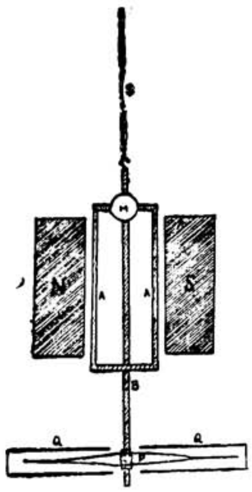
3. *Apparatus.*

The instrument for recording the potential gradient is a quadrant electrometer, rendered dead-beat by an electromagnetic device (Fig. 1). The reflection of a vertical

Fig. 1.

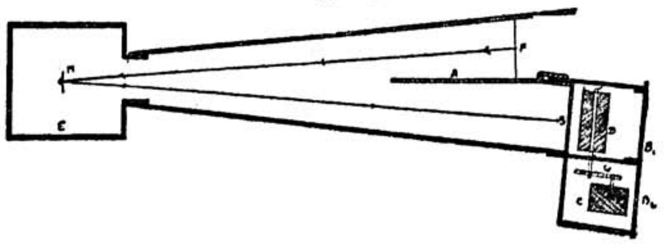


Dead beat arrangement for Electrometer.

S_r—Phosphor bronze suspension of electrometer needle. B—Spindle carrying the needle P. A, Aluminium rectangle fixed to the spindle whose rotation between poles N, S of permanent horse-shoe magnet causes the instrument to be dead-beat. M— Concave mirror. Q. Q—Quadrants.

incandescent filament falls on a fine horizontal slit in the recording camera, and so a spot of light travels about horizontally on a photographic paper wound on a drum inside the camera-box. This drum is rotated about a horizontal axis parallel to the slit by clockwork, so as to turn round once in one day or two days as required (Fig. 2). The collector

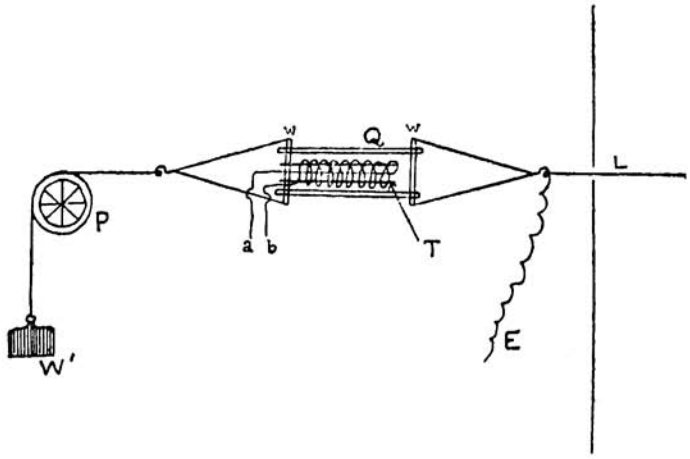
Fig. 2.



Recording Camera.

E—Electrometer, M—the concave mirror. A. A. is a box through which rays from a vertical glowing filament F pass, are reflected by M, and form an image just be hind S, a horizontal slit in the front of a box, B_1B_2 having two compartments, B_1 in which is mounted the drum D on horizontal spindle and B_2 in which is the clock C driving the drum by means of gear wheels G.

Fig. 3.

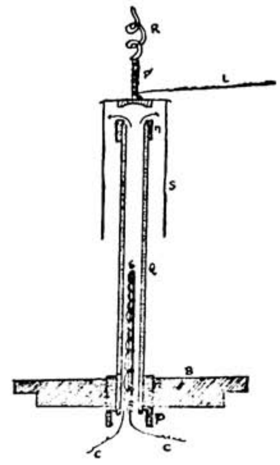


Insulating Shackle to keep line under tension.

Q is a tube of quartz inside which is introduced a glass tube, T, with a heating coil wound on it (terminals a, b). Q is grooved slightly about one centimeter from each end and a stout copper wire W is fixed on each groove. From W stretch loops of thinner wire keeping clear of the ends of the quartz tube. To the loop on one side is fixed the line L and on the other side a string passing over a pulley and carrying a weight W; this keeps the line L tight and level in spite of any elongation which may occur. The line passes on without tension to the electrometer.

is a spiral coated with a *radium salt*, and mounted on an insulating support at some particular position at some distance from the walls of the building (Fig. 4). A line, *i.e.* a copper

Fig. 4.



Insulating Support for Collector.

B is the block carrying the pulg P, which supports a quartz tube Q vertically. C-C. heating coil terminals, M metal cap on top of Q which carries S- a thin copper sleeve shielding the upper part of Q from the weather and P′ a pin which supports the collector R and the line wire L.

wire, runs from the collector to an insulated shackle inside the room to keep it under tension and thence to the needle of the electrometer (Fig. 3).

4. *Insulation.*

The insulation at the different parts, *viz.*, the electrometer head, the shackle, and the support of the collector, was specially attended to. Vulcanite was used, and was found fairly satisfactory with special devices for protection. As however this insulation was liable to break down during rain and to a certain extent in very moist weather, this method of insulation was given up in favour of quartz tube insulators kept warm, *i.e.*, maintained constantly some degrees above atmospheric temperature. The warming was carried out in one of two ways, *viz.*, a heating coil was kept within the quartz tube, or a concentric glass tube not touching the quartz was kept hot by means of an electric current through a coil wound on it (the glass tube). In the second case the quartz was kept warm by radiated heat. (Figs. 3 & 4.)

The heating current was from an 8-volt alternating current source, the conveying line being earthed at one point. The insulation obtained by these means is excellent in all kinds of weather, except for a short time in very heavy rain, as verified by frequent tests. In fact, daily tests were found quite unnecessary.

5. *Zero Changes and Calibration.*

One of the quadrants of the electrometer is earthed and the other connected to the positive terminal of a battery of cadmium cells of which the negative terminal is earthed. The sensitiveness of the instrument could be altered by varying the number of cells used. Two cells were ordinarily used. An automatic device was employed to disconnect the second quadrant from the positive terminal of the battery and earth it exactly at each hour for about two minutes. This marks the hours and gives the zero line on the record. It also helps to test the adjustment of the instrument continuously.[1]

[1] NOTE.—Before the above device was employed a different arrangement was tried, *i.e.*, to earth the line with the electrometer needle at the end of each hour. The present method is superior in that it gives automatic correction for want of exact adjustment of the instrument; thus :

If the instrument is slightly out of adjustment, the deflection $\delta = a.V + b\ V^2$ where V is the needle voltage, large in comparison with the quadrant potential to which 'a' is proportional while 'b' is independent of it. If now with the same volts on the needle, both the quadrants are earthed 'a' becomes zero and the present deflection $\delta' = bV^2$. Hence $\delta - \delta' \doteq aV$. This means that on measuring the ordinate $\delta - \delta'$ we get a quantity proportional to V, whence V can be calculated, since 'a' is constant and easily determined.

The calibration of the record for volts, *i.e.*, the determination of 'a' is carried out by charging the needle to some known voltage for about two minutes at the beginning and end of each record.

6. *Co-efficient of Reduction to Level.*

To obtain from the potential recorded by the instrument the potential gradient on the level, simultaneous observations were made with the recording instrument and a portable instrument. This latter was an instrument of the gold leaf type suitably calibrated. A collector similar to the one employed for records was mounted at a height of about four feet on a level plain near by and the potential measured with the abovementioned instrument. The co-efficient was found to be ·795.

7. *Results.*

From the records of each month were selected those for ten days on which there was no negative potential, nor any markedly violent oscillations of potential. It is difficult to find ten such days in certain months, usually in the period March-August, when either due to monsoon winds, thunder storms or dry dusty days, violent oscillations and frequent negative potentials prevail.[1] In such cases we have to be satisfied with a smaller number of days. If, in any month, the number of selected days available be less than five, no mean results are worked out for that month.

[1] See Figs. 3, 4 in Plate.

TABLE I.

1927

Hour of day.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Mean.
January ...	26·6	16·3	12·6	11·7	9·3	6·8	8·7	7·3	23·0	25·5	28·5	27·2	31·2	37·9	33·6	31·1	29·1	31·6	40·4	56·7	57·8	50·3	42·7	36·7	23·4
February ...	25·5	21·7	11·9	11·7	11·9	9·1	12·3	11·3	14·0	8·7	21·7	26·4	28·4	27·3	25·6	24·7	23·8	25·2	31·8	50·7	52·9	40·1	31·6	23·4	23·9
March ...																									
April ...	40·0	40·8	33·7	32·6	28·6	29·0	31·2	31·5	40·3	48·7	42·2	33·4	33·9	32·1	28·0	26·3	26·1	23·3	31·2	43·2	58·5	45·5	45·0	42·0	36·0
May ...																									
June ...																									
July ...																									
August ...	14·5	13·4	9·9	8·6	6·2	6·9	5·3	4·5	6·2	13·3	26·6	35·5	43·6	43·6	44·3	46·1	41·2	39·6	49·1	66·1	62·2	47·7	43·8	26·0	29·3
September ...	30·4	23·6	14·9	10·5	10·4	10·0	8·5	10·0	18·2	35·8	45·4	42·9	47·6	50·8	44·3	44·3	45·5	51·6	54·6	62·9	58·8	38·7	31·5	28·7	34·0
October ...	52·1	45·0	35·1	31·4	30·5	25·4	36·1	40·5	39·6	51·9	55·7	51·6	59·1	54·5	49·1	46·4	46·5	47·3	68·2	90·0	87·1	81·1	66·7	63·4	52·3
November ...	38·3	32·1	28·1	21·0	15·4	14·4	21·3	33·9	42·8	52·3	53·5	54·4	52·3	49·4	42·6	39·4	40·4	43·7	58·0	86·6	87·1	71·6	49·3	32·0	44·1
December ...	35·6	20·8	17·6	17·2	19·7	17·1	18·6	29·1	34·8	45·6	50·5	47·0	50·3	44·3	46·3	44·1	41·8	44·1	60·5	79·3	83·2	71·6	57·7	44·4	42·5

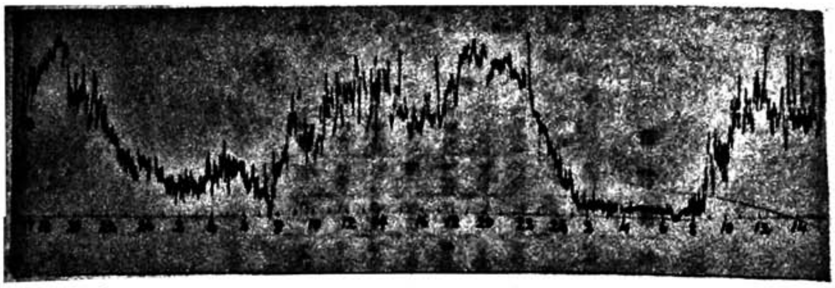
Monthly mean values of the potential gradient (volts/meter) at the different hours of the day——on fine days only.

TABLE 2.

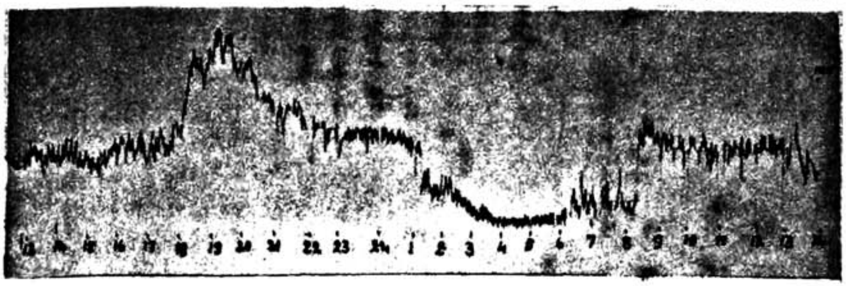
1928.

Hour of Day.	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Mean.
January ...	31·3	18·5	18·0	10·7	11·7	10·2	7·6	9·9	15·5	40·6	44·2	41·3	38·5	50·2	41·2	38·6	41·8	44·7	52·3	75·2	75·2	64·9	50·2	37·0	36·3
February ...	41·2	37·5	37·5	31·6	28·7	28·2	28·5	38·0	40·5	34·8	39·6	38·3	39·8	41·8	39·6	33·9	35·5	42·8	51·0	74·9	91·3	79·5	59·5	46·1	44·2
March ...	56·4	64·2	54·1	48·7	47·5	36·5	37·3	54·8	50·5	60·1	47·9	49·9	45·1	42·7	34·5	28·8	29·6	31·2	37·8	60·6	69·3	59·7	60·8	58·3	48·6
April ...	40·9	39·7	33·1	35·1	40·9	41·9	37·2	47·6	53·0	59·4	56·7	48·3	43·2	45·1	43·9	34·1	34·2	34·9	38·2	48·5	51·6	54·7	49·7	46·5	44·1
May ...	42·1	39·6	34·1	25·3	27·2	23·0	17·1	20·9	10·3	52·1	62·6	64·3	55·7	57·6	47·7	43·5	39·6	41·2	45·4	54·8	69·8	69·4	54·5	46·7	44·7
June ...	37·3	25·7	20·8	13·4	9·2	10·1	21·0	25·2	26·0	44·7	45·8	65·4	65·8	59·2	53·5	51·1	50·2	52·1	60·2	66·3	62·9	55·8	51·2	48·7	42·5
July ...	21·6	15·3	13·7	9·8	8·3	6·4	6·8	7·5	10·0	19·7	28·0	47·0	61·2	53·8	70·1	60·2	57·6	60·9	62·1	61·6	69·8	56·2	44·4	29·3	36·7
August ...	30·0	24·5	20·9	20·5	14·5	12·0	8·6	8·2	8·9	13·4	18·8	31·4	53·4	56·6	69·3	72·0	63·3	65·4	65·7	80·9	57·4	43·8	40·7	34·7	38·2
September ...	41·8	35·3	27·6	26·8	27·1	26·1	28·5	26·8	23·9	46·4	41·6	55·7	59·8	57·7	58·7	59·4	52·3	56·3	57·6	72·6	73·1	71·8	56·7	50·4	47·2
October ...	42·3	30·4	25·2	23·1	23·1	21·2	23·5	32·1	31·6	55·3	60·0	55·9	57·4	59·8	46·3	48·7	51·3	51·6	70·7	82·7	88·9	64·0	59·0	47·8	48·0
November ...	36·7	32·0	24·7	22·0	20·2	20·8	24·6	11·3	39·9	44·3	57·0	56·0	54·6	52·2	45·6	42·9	39·2	44·9	55·3	64·4	70·4	60·2	54·2	43·5	43·7
December ...	22·0	17·5	10·6	11·3	12·1	10·4	12·8	18·1	24·2	30·1	32·0	40·0	48·9	44·4	45·9	45·2	41·7	45·2	54·7	71·3	63·8	57·1	43·3	27·2	34·6
Mean. ...	37·0	31·7	26·7	23·2	22·4	20·6	21·2	27·5	30·4	41·7	44·5	49·5	52·0	51·8	49·7	46·6	44·7	47·6	54·2	67·8	70·3	61·5	52·0	43·0	42·4

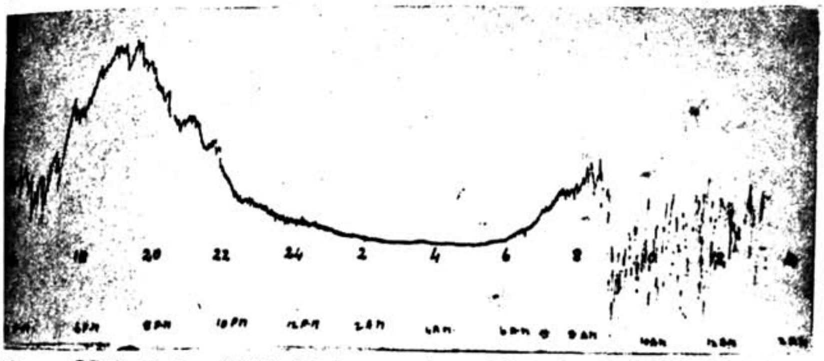
Monthly mean values of the Potential gradient $\frac{\text{volts}}{\text{meter}}$ at the different hours of the day—on fine days only.



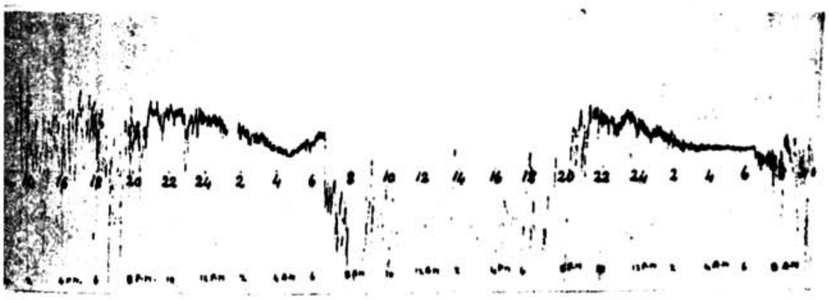
From 2nd Oct. 1927, 16 Hrs. to 4th Oct. 1927, 16 hrs.



From 11th Jan. 1928, 13 hrs. to 12th Jan. 1928, 14 hrs.



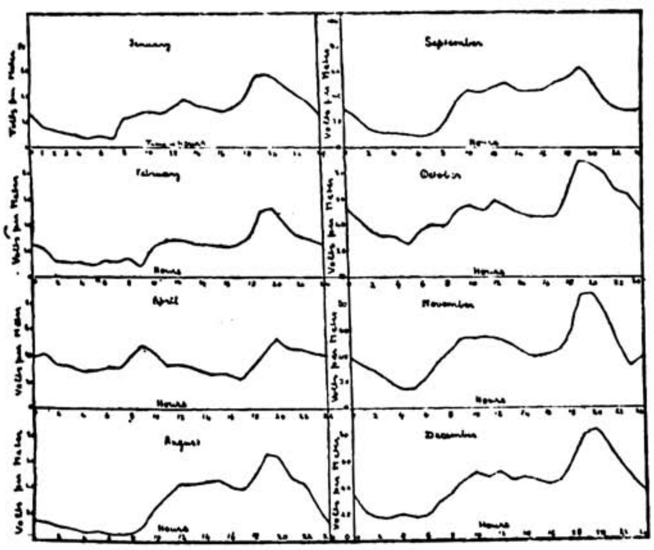
From 27th Oct. 1925, 16 hrs. to 28th Oct. 1925, 14 hrs.



From 9th June 1926, 13 hrs. to 11th June 1926, 10 hrs.

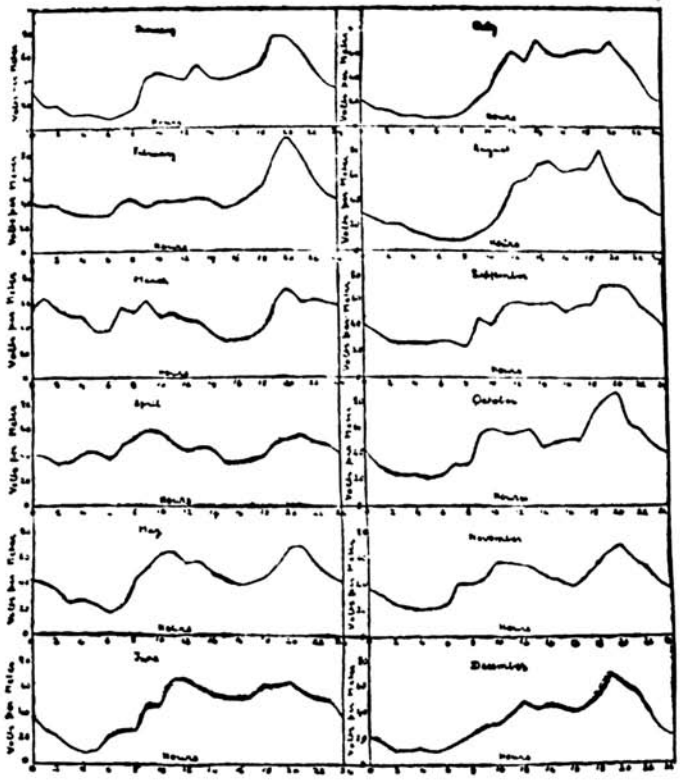
The hourly values of the potential on the selected days are determined (Tables 1 and 2) and the curves of mean diurnal variation drawn for each month, and the year. These curves are given in Figs. 5, 6 & 7. It will be seen that there are ordinarily two maxima and two minima each day. Of the minima the one near sunrise is the more important and lies between 5 and 6 hours. The other minimum is not so low and occurs between 15 and 16 hours. Of the maxima, the one in the evening is the outstanding one and lies between 19 and 20 hours. The other maximum in the earlier part of the day is neither always pronounced nor regular. It may occur anywhere between 8 and 13 hours. An examination of the accompanying graphs render it probable that there are really more maxima than one in this interval of time, of these some one maximum being prominent on any particular day. This produces the effect of a maximum whose time of occurrence

Fig. 5.



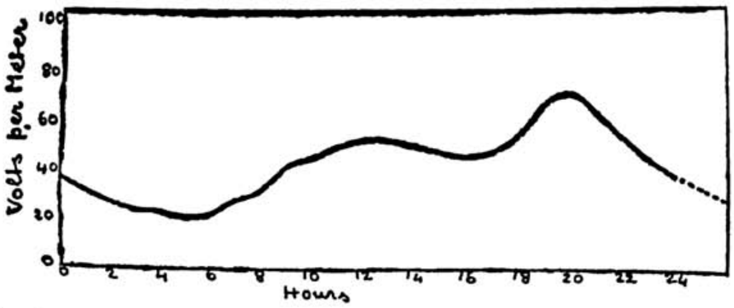
Hourly mean values of Potential Gradient on fine days for different months of 1927.

Fig. 6.



Hourly mean values of Potential Gradient on fine days for different months of 1928.

Fig. 7.

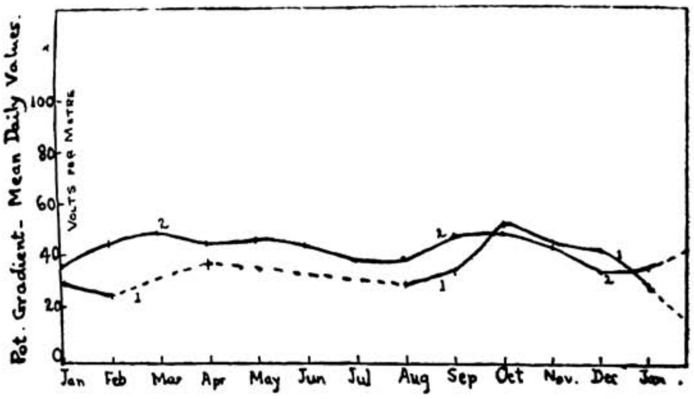


Hourly mean values of Potential Gradient on fine days for the whole year 1928.

is uncertain. On this basis we may notice maxima at the following times :—

8h, 10h, 12h, 13-14h. A method of dealing with this subject will be discussed in a different place. The changes in the diurnal curve with the months can be easily followed. In December and January the potential falls very low in the second half of the night and again in July and August. In the succeeding months there is a gradial change and in April the two minima and maxima are of nearly the same level, and the difference between a maximum and a minimum is least. Other particulars can be easily seen from the curves. The mean daily values change from month to month as shown in table and Fig. 8. The mean potential passes through minima

Fig. 8.



Monthly mean values of Potential Gradient.

Curve 1 ... ... 1927.
Curve 2 ... ... 1928.

in December-January and in July-August, and through maxima in March and in October.

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6th November, 1930.