THE DIURNAL VARIATION OF THE AMOUNT OF RADIOACTIVE EMANATION IN THE ATMOSPHERE.

By P. H. Dike.

It is a well-known fact that the atmosphere contains a radioactive emanation capable of making a negatively charged wire exposed to it temporarily active. It has also been observed that the amount of the emanation present, as measured by the intensity of the excited activity of the wire, exposed for a given time, varies widely and seems to be dependent on a variety of conditions,—the direction and velocity of the wind, the height of the barometer, etc.

In view of the fact that experiments at present being carried on at the Cavendish Laboratory show a more or less regular diurnal variation in the spontaneous ionization of the air inside a closed vessel, it was thought to be of interst to determine if the amount of radioactive emanation present in the atmosphere shows a similar variation, as this might be of aid in explaining the former fact.

At least two other observers have done work along this line. Simpson[1] in Lapland made three determinations per day, morning, noon and evening, during the greater part of a year, finding a maximum in the morning and a minimum about midday. Gockel[2] at Freiberg also found an increase in the early morning, with nearly constant value through the day and sometimes a depression at noon.

Both these observers used the usual method of keeping a bare wire stretched horizontally at a high negative potential—from 4,000 to 10,000 volts—for from one to two hours, then reeling it up and observing its effect in discharging a gold leaf electroscope. This method seems somewhat unsatisfactory, since with varying wind conditions the wire will have varying amounts of air brought into its vicinity and the results obtained will not be comparable.

To avoid this difficulty it was decided to use the following method in this series of observations: By means of a large blower, enclosed in a box and driven at constant speed by a water motor, a steady current of air was drawn in through a wooden pipe, 11x9.5 cm. inside dimensions, by 2.5 meters long, forming the only inlet to the box, the air being discharged into the room. The free end of

[1] London, Phil. Trans. R. Soc., 1905. Series A. v. CCV, pp. 61–87.

[2] Physik. Zs., Leipzig, 5, 1904, p. 591.

the pipe was carefully coated with sealing wax, and metal strips cemented on to form grooves into which could slide a rectangular piece of wire gauze, so as to cover the mouth of the pipe. The gauze was well insulated by a sealing wax, and could be kept charged by means of a rubber covered wire leading to the negative pole of a small Wimshurst machine. The end of the pipe projected to a distance of about 1.5 meter from the side of the building through a window opening on a large court surrounded by buildings and was about 10 meters above the ground. It is evident that by means of this arrangement a definite and controlable volume of air is brought under the influence of the negatively charged conductor in a given time, and the results obtained for equal times should be strictly comparable.

For determining the intensity of the excited radioactivity on the wire gauze use was made of an ionization chamber containing two parallel brass plates, 5.2 cm. apart. The lower one upon which the wire gauze was laid while being tested was connected with a storage battery, giving a potential of 160 volts, while the upper plate was connected by means of a wire passing through a sulphur plug in the top of the ionization chamber, with the leaf of a tilting electroscope, which was kept at a sensitiveness of from 20 to 30 scale divisions per volt. The rate of leakage between the two plates could thus be measured. In order to avoid frequent calibration of the scale, the time required for the gold leaf to pass over 20 divisions, starting from the zero position, was used as the measure of the ionization produced, the rate of leak being inversely proportional to the time.

As experiments seemed to show that the effect produced is independent of the potential of the gauze between wide limits,—from 2000 to 6000 volts—no attempt was made to keep this potential perfectly uniform, and it was found impossible in the early morning hours when the air was saturated with moisture to keep it at as high a potential as during the day, the moisture allowing the charge to leak off over the sealing wax insulation. For the same reason observations could not be made during a rain, it being impossible to keep up a charge. A system of insulation to remedy this defect could be devised, but, owing to the limited time available it was not attempted. The volume of air drawn through the gauze was of the order of 150 cubic meters per hour. An absolute determination of this quantity was not made, but the velocity of the air current was kept approximately constant, the reading of a vane acted on by the air as it left the box being taken as its measure.

The principal difficulty experienced was that of keeping the electroscope at uniform sensitiveness, and this source of error is by far the most important. The electroscope was extremely sensitive to any slight change in the potential of the storage battery charging it, and constant adjustments were necessary. For this reason the results obtained on different days are not strictly comparable, but as the results aimed at are relative, rather than quantitative, this is not entirely unallowable.

A single observation required about an hour and a quarter, the wire gauze being exposed for one hour, while the blower and the Wimshurst were kept in operation, the potential and air current being maintained as nearly constant as possible. At the end of the hour both machines were stopped, and the gauze removed from the end of the pipe and placed in position in the ionization chamber, the gold leaf being earthed. The zero position of the leaf was read and the earth connection broken, the time being taken at the same instant. The time required for the gold leaf to pass over 20 scale divisions was noted and also, as checks, its position at the end of the fifth and tenth minutes. The gauze was then removed and placed in a bath of hydrochloric acid to remove the excited radioactivity, while a similar piece of gauze was placed in position over the end of the pipe and a new exposure begun.

The rate of the leak with the unexposed gauze in the ionization chamber was from two to four scale divisions in ten minutes with a sensitiveness of 25 divisions per volt.

The actual observations extended over a period of about three weeks, beginning June 20th and included six sets extending over approximately 24 hours. The observations are of course too few to furnish ground for general statements, but they point strongly to a quite definite diurnal variation, with well-marked maximum and minimum. The curves obtained by plotting the reciprocals of the times of passing over 20 scale divisions as ordinates show marked similarities, and though quite irregular, as is to be expected, the general tendency is unmistakable. This is more clearly shown by compounding the curves for the six long series of observations. Though the number is too small to eliminate all the irregularities the curve obtained is fairly smooth and shows a minimum about 6 P. M. after which it rapidly rises to a maximum at 1 A. M. followed by a slight drop, and then comes a second maximum about equal to the first at 4 A. M. The depression between 1 and 4 A. M. is a feature of nearly all the curves and is not accidental. After 4 A. M. the value drops nearly as rapidly as it rose, but during the afternoon it is irregular, though always low and generally decreasing.

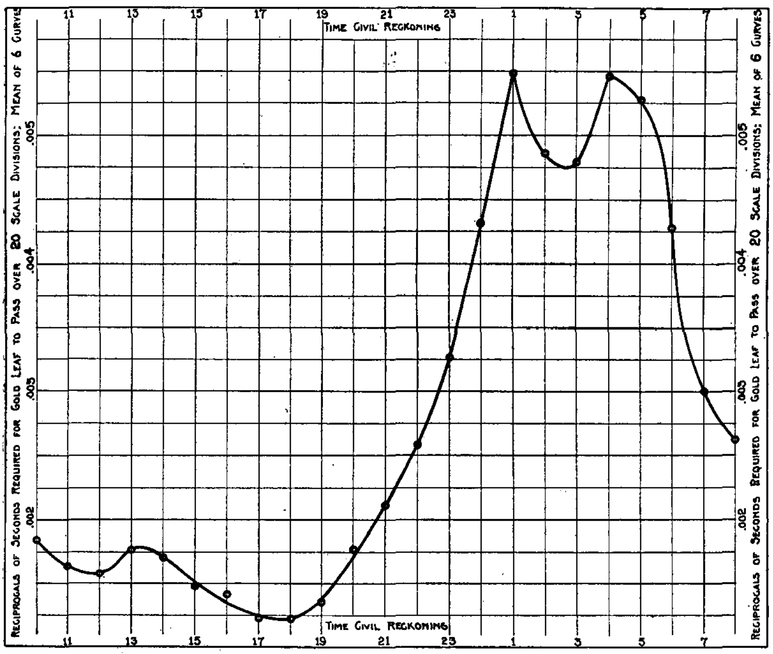
Weather conditions have an important influence on the amount of emanation present in the air. There is more on a still, bright day than on a cloudy, windy one. With the wind south or west the effect is greater than when it is north or east; with a northeast wind almost no effect was obtainable.

Results of Observations at Cambridge, England, from July 6, 10 a. m. to July 7, 9 a. m.

Date, 1906	Weather	Time of Exposure	Potential of Gauze	Relative Velocity of Air	Sensitiveness of Electroscope Scale div. per Volt	Readings of Gold Leaf				Time of of Passing 20 Scale Div.	Reciprocal of Time in Seconds
						0 Min.	5 Min.	10 Min.	Diff.		
		h m	Volts							m s	
July 6	Part Cloudy Wind S	10 00 11 00	4000	8	20	55.3	40.8	28.3	27.0	6 50	.002439
"	"	11 14 12 16	"	8	24	53.2	41.8	33.0	20.2	9 50	1695
"	"	12 30 1 30	"	8	24	62.2	46.6	35.1	27.1	6 45	2469
"	"	2 50 3 50	"	8	25	69.9	60.2	47.8	22.1	9 02	1846
"	"	4 02 5 02	5000	7	21	70.9	55.7	43.0	27.9	6 35	2532
"	"	5 17 6 17	"	7	21	71.9	65.1	52.7	19.2	10 15	1626
"	"	6 30 7 30	"	8	21	73.7	66.9	54.9	18.8	10 35	1575
"	N Wind	7 43 8 43	"	8	21	74.3	58.3	44.9	29.4	6 20	2632
"	"	8 55 9 55	4000	9	21	73.0	59.8	48.0	25.0	7 25	2248
"	"	10 06 11 06	"	9	21	71.9	50.0	31.8	40.1	4 35	3604
"	"	11 18 12 18	"	9	21	73.1	40.0	20.4	52.7	3 00	5555
July 7	"	12 31 1 33	"	9	21	70.5	33.2	13.8	56.7	2 40	6250
"	"	1 45 2 45	3000	9	21	51.5	29.7	16.5	32.0	4 35	3604
"	Clear N Wind	2 58 3 58	2000	9	21	57.0	31.1	14.9	42.1	3 30	4762
"	"	4 10 5 10	"	9	21	57.8	27.0	11.5	46.3	2 50	5882
"	"	5 21 6 21	"	9	21	57.0	33.2	18.0	39.0	4 06	4024
"	Wind W	6 34 7 34	3000	8	21	57.9	43.0	30.2	27.7	7 00	2381
"	"	7 47 8 47	4000	7	22	57.8	46.2	36.1	21.7	8 18	2008

For some hours after a rain the amount is very small, while during a fog with the insulation so wet that a potential of 1500 volts was with difficulty maintained on the gauze, a very high value was obtained followed by a very low one while the fog was clearing, but returning to a high value after the fog had cleared away.

These results are rather suggestive than conclusive and of course apply only to the vicinity of the Cavendish Laboratory at this particular season of the year, and very different results might be obtained in other places and at other seasons. The method employed seems to be an improvement on the one generally in use, and seems not to have been tried successfully before. Observations should be made in other localities and covering longer periods of time before theories are advanced to account for this diurnal variation.



The work was undertaken at the suggestion of Professor J. J. Thomson to whom I am indebted for the use of the facilities of the Cavendish Laboratory, and numerous valuable ideas as to the methods employed.

Department Terrestrial Magnetism,
Carnegie Institution, Washington, D. C.