Atmospheric Electricity.[1]

THE director and staff of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington have of late years given much attention to atmospheric electricity, and have published several conclusions of much interest, the evidence for which is contained in the volume before us. Thus, although it includes a variety of other interesting matter — magnetic, meteorological, and instrumental—we shall confine our present remarks to the subject of the potential gradient of atmospheric electricity, a subject dealt with by Messrs Bauer, Ault, and Mauchly, especially the last mentioned.

Perhaps the most remarkable conclusion, due to Dr. Mauchly, is that re-stated on p. 402: " At least the greater part of the diurnal variation of the potential gradient over the oceans is due to a wave which progresses according to universal rather than local time. . . . All potential-gradient observations at sea tend to give values which are lower than the mean of the day if made in the forenoon of the Greenwich civil day, and values higher than the mean of the day if made in the afternoon of the Greenwich day."

The main evidence for this conclusion is a series of 24-hourly data from 59 Greenwich days, given on pp. 390-391. Details of the actual observations appear on pp. 212-265.

The natural way of checking Dr. Mauchly's conclusion would be to group the observations according to longitude. If we do so, taking 30° zones centering respectively at 0°, 30° E., etc., we find that there are only four zones—those centering at 180° E., 210° E., 240° E., and 270° E.—for which there are more than four days' observations. In an element so variable as potential gradient, uncertainties are sure to be large unless a considerable number of days is employed. Diurnal variations have thus been calculated only for the four zones stated, the 'days' available numbering respectively 9, 14, 9, and 10. Diurnal variations were also calculated for two groups each of five days from the 270° zone, and finally for the whole 42 days included in the four zones. Space allows us to mention only a few of the details, the hours referring to Greenwich civil time.

Zone. E.	Daily Mean. v/m.	Minimum. h.	Minimum. v/m.	Maximum. h.	Maximum. v/m.	Range. v/m.
180°	128	2	112	20	152	40
210	106	3	93	19	136	43
240	124	6	100	15	156	56
270	133	0	113	19	165	52
270*a*	145	4	117	19	194	77
270*b*	122	23	101	12	160	59
42 days	121	3	105	19	148	43

The inequality derived from the 42 days accords with Dr. Mauchly's conclusion that potential gradient at sea tends to be below the mean in the Greenwich forenoon, and the times it gives for maximum and minimum, 19 h. and 3 h., are in general accord with his. But the 42 days results refer only to a limited part of the ocean, and the results from the different zones differ amongst themselves. In the case of the 270° zone the results from the two groups of days are widely different, and the inequality from the whole 10 days shows a prominent secondary maximum and minimum at 12 h. and 14 h. respectively.

When we look more closely into the data two unsatisfactory features appear. About 12 per cent. of the hourly values for the 59 days are interpolations; for the observations of 1921 the percentage is 21. In the majority of cases the interpolations represent arithmetic means from two observations separated by two hours, but in other cases they are of a more questionable character. For example, for 'day' 52 the earliest and latest observations available refer respectively to 18 h. on one Greenwich day and to 13 h. on the next. These appear as 13 h. and 18 h. on the same day, and data are interpolated for 14 h., 15 h., 16 h., and 17 h. as if this were the case. The probable existence of a progressive change in the 24 hours is neglected.

The second unsatisfactory feature is the total disregard of n.c. changes. Usually only 24 successive hourly values were obtained, and it is impossible to say what the n.c. change really was. So far as the run of the figures enables us to judge, it was usually very sensible, and sometimes very large. We have, for example, the following data assigned to three successive hours, 259 | 165, 184; 166 | 51, 53; 118, 139 | 266; 313, 300 | 150. In each case the entries which immediately precede and follow the vertical line represent respectively the latest and the earliest of the observations taken during the 'day.' If the hour at which the 'day' began was quite irregular, and if there were a very large number of days, uncertainties would naturally largely cancel out. But such cancellation cannot be assumed when the number of days is limited, and several of the inequalities, the results of which appear above, were apparently seriously prejudiced.

In the case of 210° E. longitude three n.c. discontinuities lead to an apparent excess of 160 *v/m* at 18 h. over 17 h., the excess in the aggregate from the whole 14 days being 182 *v/m*; and two n.c. discontinuities cause an apparent excess of 157 *v/m* at 19 h. over 18 h., the excess in the aggregate from the whole 14 days being only 92 *v/m*. Thus the maximum at 19 h. in the inequality from the 14 days may have been entirely due to the neglect of n.c. changes. As it so happens, these n.c. discontinuities in the case of the four zones considered were almost entirely confined to the (Greenwich) afternoon. Only one serious n.c. discontinuity appeared in the (Greenwich) forenoon. It led on 'day' No. 3 to an apparent fall of 98 *v/m* between 1 h. and 2 h., and was probably responsible for the hour at which the minimum occurred in the 180° zone. The effect of this discontinuity is not wholly negligible even in the case of the 42-day inequality. In spite of it, a remarkable feature stands out, namely, a close approach to constancy in the voltage from 1 h. to 6 h. G.M.T. Hourly means during the six hours vary only between 105·5 *v/m* at 3 h. and 108·7 *v/m* at 1 h. This suggests a diurnal variation, which is either very small or largely dependent on local time.

The results now obtained should not be regarded as disproving Dr. Mauchly's conclusions, but they unquestionably do suggest that further observations on somewhat different lines are required to justify any final conclusion. A term in the diurnal variation following universal time is not perhaps improbable *a priori*. The earth's surface varies notably in different zones, and there may be regions, *e.g.* the Himalayas, which exercise a dominant influence on the diurnal flow of the air-earth current on land. But even if a term depending on universal time exists, there may be even at sea terms of equal or greater importance depending on local time. The ideal arrangement to investigate the matter properly would be to have three similar ships—which need not be non-magnetic—with similar apparatus, observing simultaneously at three limited areas about the same latitude, the two extreme areas being about

[1] Researches of the Department of Terrestrial Magnetism, vol. 5: "Ocean Magnetic and Electric Observations, 1915–1921." Washington, D.C. Published by the Carnegie Institution of Washington, 1926. Pp. vii+430, with 15 plates and 31 figures in the text.

180° apart, and the third midway. Each ship should observe in succession at each area for a month or two, as continuously as possible. In any case, an overlap of two or three hours should be secured for each 'day's' observations.

The relation of potential gradient to sunspots has been dealt with by Dr. Bauer in various recent papers which have been discussed in NATURE. Dr. Mauchly refers on pp. 405-406 to the bearing of the ocean observations on this point. He says: "The mean values for each 3-month period . . . show throughout the years beginning with 1915, first an increase to 1916 or 1917, and then a gradual and consistent decrease to the end of 1921. This is so closely in accord with what has been observed at land stations, where reliable or undisturbed data of required extent are available, as to leave no doubt regarding the reality and universality of this phenomenon" (*l.c.* p. 405); and again: "in all latitudes for which there were sufficient observations . . . the mean values observed on cruise VI (mean epoch 1920·8) were from 15 to 20 per cent. lower than those observed in cruise IV. (mean epoch 1916·2)" (*l.c.* p. 406). These statements should, however, be taken in conjunction with the following two: "It should be noted that all potential gradient values shown in the graphs and tables of this report are of the order of 20 to 25 per cent. greater than those given in the author's earlier papers" (*l.c.* p. 397); and "At that time (1920), owing to various causes brought on by the War, there had been no final determinations of the instrumental constants to be used for reducing to absolute values the results of the . . . observations made aboard the vessel" (*l.c.* p. 387). Apparently all the observational data depend on reduction factors got out during expedition No. VI., and these are apparently assumed to have been unchanged since 1915. Those having experience in these matters may perhaps be pardoned a doubt whether the factors used in Dr. Mauchly's earlier papers were so much in error as he now supposes.

The general subject of sunspot influence is considered in more detail by Dr. Bauer himself, pp. 361-384. The following statement (*l.c.* p. 381) embodies his present opinions: "The general conclusion from the investigations based on land and ocean results . . . is to indicate with a high degree of probability that during the cycle of 1913-1922 the atmospheric potential gradient increased with increasing sun-spottedness by at least 20 per cent. of its mean value for the cycle between the years of minimum and maximum sun-spottedness. The same statement applies with regard to measures of the diurnal variation and of the annual variation of the potential gradient." These conclusions are based on the results obtained by the *Carnegie* at sea and on the published data of the Ebro, Eskdalemuir, and Kew observatories. The methods employed seem practically the same as in Dr. Bauer's earlier papers on the subject. No notice seems to be taken of the criticisms which have appeared in NATURE, and no further vindication is supplied of the omission of the results from Potsdam, which gave a small decline in potential gradient with increased sun-spottedness. The reason assigned for disregarding Potsdam is alleged uncertainty as to the reduction factor. But uncertainty on this ground has been denied by the Potsdam authorities, and it seems scarcely likely *a priori* to have been more serious than in the case of the ocean observations which Dr. Bauer seems to have no doubts about.

As considerable use is made of the amplitudes and phase angles of Fourier coefficients by both Dr. Bauer and Dr. Mauchly, it may not be amiss to point out that the calculation of these coefficients from data in which large n.c. changes exist and have not been eliminated is unsatisfactory from the mathematical point of view. Unless the n.c. change is very small as compared with the daily range the effect of its neglect may be serious, especially in the case of the waves of least amplitude.

C. CHREE.

The Formation of Lactic Acid in Muscle.

A VERY important advance in our knowledge of this fundamental process has been made by Prof. Meyerhof in continuation of his well-known researches on the subject. Last January he announced (in *Die Naturwissenschaften*, **14**, Heft 10) that he had succeeded in extracting the enzyme responsible for the production of lactic acid from carbohydrates in muscle, and gave an account of its properties. He has now carried matters a step further (*Die Naturwissenschaften*, **14**, 32) and has been able to penetrate much more deeply into the mechanism of the change. The enzyme, obtained by extracting the finely divided muscle with isotonic potassium chloride solution at $-1°$ to $-2°$ and then centrifuging, readily forms lactic acid from starch and glycogen at a rate about two-thirds of that of the spontaneous formation of the acid in minced muscle. It is separated by ultra-filtration into a heat-labile inactive residue and a stable filtrate—the previously known coenzyme—which reactivates this residue. The coenzyme can be obtained either from muscle or yeast, and its addition greatly increases the amount of lactic acid producible from an excess of glycogen. The hexoses and the disaccharides are scarcely attacked, whereas lactic acid is freely formed, and at nearly the same rate, from glycogen, starch, and various degradation products of starch.

Hexosediphosphoric acid, the monophosphoric ester obtained from it by partial hydrolysis (Neuberg), and the isomeric monophosphoric ester from yeast juice (Harden and Robison) are all attacked. This decomposition of hexosephosphoric acid into equivalent amounts of lactic acid and phosphoric acid is, however, independent of the presence of the coenzyme which is necessary for the decomposition of glycogen and starch.

The production of lactic acid, either from glycogen or glucose, is preceded by the formation of a hexosephosphoric acid, and the reason why glycogen is the more easily acted on appears to be that a reactive hexose is formed from it which is more readily esterified than glucose in its stable form.

Meyerhof, hoping to be able to accelerate the action on the hexoses, turned to yeast—that unfailing storehouse of physiological surprises—and met with astonishing success. By precipitating autolysed yeast with 50 per cent. alcohol he obtained a new activator—different from zymase, coenzyme, and insulin—which, when added to the mixture of muscle enzyme and the hexoses, increases the rate of lactic acid formation until it amounts to several times that of its production from glycogen and 10 times that of the spontaneous production of lactic acid in minced muscle. The decomposition of glycogen, on the other hand, is scarcely affected.

At the same time the esterification of the phosphoric acid is still more accelerated, and the result is that during the first 15-30 minutes there is a rapid accumulation of hexosephosphoric acid, which continues so long as both hexose and free phosphoric acid are present. The rate of production of the acid then falls rapidly, and is followed, when the supply of both hexose and phosphoric acid is exhausted, by