MR. MELDRUM ON THE ORIGIN OF STORMS IN THE BAY OF BENGAL *

THE writer commenced by observing that in various papers published during the last ten years, he had stated, as the result of an examination of a large body of observations, that the tropical cyclones of the Indian Ocean, south of the Equator, originated between two contrary streams of air, viz., the N.W. monsoon and the S.E. trade-wind; and, in a paper read on the 10th of November last, he remarked that what had been found to hold good in that part of the ocean might be found to do so generally. As the observations collected by the Society only referred to the Indian Ocean, he could not directly test the matter with regard to the cyclones of other parts of the world. But cyclones also occurred in the Indian Ocean, north of the Equator, and as the Society possessed observations which had been taken there, he proposed to examine the records with a view of ascertaining whether these cyclones were formed, as he believed those south of the Equator were, between two oppositely directed currents of air which had pre-existed. It was to that point alone that he wished to direct attention at present. How the barometric depression in the heart of a cyclone was formed, whether owing to an ascending current, to condensation of vapour, or to other causes, why the air moved more or less round a central area in a particular direction, and why the cyclone had a progressive movement, were subjects upon which he would not then touch; for the question of the existence or non-existence of opposite winds, previously to the formation of the cyclone, had, in his opinion, an important bearing upon all the others, and should therefore be taken up first.

The cyclones of the Indian Ocean, south of the Equator, as was well known, took place during six months of the year, viz., November to May. During that period the N.W. monsoon prevailed from near the Equator to 10° or 15° S., sometimes stretching as far south as the tropic. Still farther south the S.E. trade-wind prevailed. The line or belt separating the two winds often ran obliquely across the ocean from 18° S., near Madagascar, towards the Straits of Sunda. It was in that belt of comparatively low barometer, calms, and variables, that the tropical cyclones of the Indian Ocean, south of the Equator, were formed. The N.W. monsoon was a continuation of the N.E. trade-wind of the northern hemisphere. This might be seen on almost any day from November to April or May, by laying down the directions of the wind at a sufficient number of points; and the daily charts which had been prepared for various periods showed it very clearly. On examining those for February, 1861, for example, which had lately been lithographed, it would be seen that the N.E. trade-wind prevailed over the Bay of Bengal and the Arabian Sea, that as it approached the Equator it became more northerly, and after crossing the Equator into the southern hemisphere it became the N.W. monsoon. The southern limits of the N.W. monsoon, and the northern limits of the S.E. trade, or, in other words, the position of the belt of variables between them, moved backwards and forwards according to the season. It was farthest S. when the southern hemisphere was warmest. As the temperature decreased, towards the end of March, this belt retreated northwards with the sun, came up to the Equator, and crossed it into the northern hemisphere. In whatever part, N. or S. of the Equator, the belt of calms existed, the prevailing winds on either side of it were from opposite directions. When it was S. of the Equator, the prevailing wind to the southward of it was from the S.E. or E. (the S.E. trade), and to the northward of it from N.W. or W. (the N.W. monsoon.) The latter extended at least as far N. as the Equator, and the N.E. trade, of which it was the continuation, prevailed over the Bay of Bengal. The former at the same time prevailed as far south as the parallel of 30° or 40° S. When the belt of calms was N. of the Equator, the prevailing wind to the S. of it was from S.W. or West, and to the N. of it from N.E. or E. The former was the S.W. monsoon, and the latter the N.E. trade-wind. In July and August, when the belt was far N., the S.W. monsoon prevailed over the whole of the Bay of Bengal, and was a continuation of the S.E. trade-wind, just as the N.W. monsoon in February and March was a continuation of the N.E. trade-wind. The belt of calms followed the sun, moving from one tropic to the other, and often passing them. Hence, when it was at its northernmost limit, the S.W. monsoon swept over the Bay of Bengal, and when at its southernmost limit, the N.E. trade-wind did so. But at certain seasons, when the belt of calms stretched across the Bay, the S.W. monsoon blew over one part of it and the N.E. trade over the other.

As, then, observation had shown that the tropical cyclones of the Indian Ocean, south of the Equator, were formed in the belt of calms between the N.W. monsoon and the S.E. trade-wind, and nowhere else, there was at least a presumption that the cyclones of the Bay of Bengal were also formed in that belt, at those seasons when it stretched across the Bay, and separated the N.E. trade wind from the S.W. monsoon; and this presumption was strengthened by the fact that most, if not all, of the cyclones that occurred there, did so at the change of the monsoons; that is, when two contrary winds prevailed in the Bay, and were more or less in conflict.

These general considerations rendered it possible, if not probable, that the cyclones of the Bay of Bengal were formed between two contrary and pre-existing winds. But that was not sufficient. It was necessary to bring the matter to the test of facts; and this could only be done by examining the observations taken in particular storms. He would begin with the destructive storm which visited Calcutta on the 5th October, 1864. On the 12th September in that year, the ship *Furness Abbey*, Capt. Roddock, in 19° 08′ N. and 88° 55′ E., had a fresh breeze from W.S.W. and S.W., and she carried that wind to 4° 44′ N. and 92° 38′ E. on the 21st. The *Victoria Nyanza*, Capt. A. J. Reed, had a strong wind from S.W. on the 21st. Sept., in 18° 17′ N., and 87° 46′ E., and she carried that wind to 0° 45′ S. and 91° 02′ E. on the 25th. The French barque *Leonide*, Capt. Martin, outward bound, approached the Equator with the S.E. trade-wind, which gradually veered to S. and S.S.W., and from 1° 59′ N. and 84 05′ E. on the 6th, to 19° 29′ N. and 88° 27′ E. on the 13th Sept., she had fresh and strong winds from the S.W. Moreover, he had prepared a chart for the 21st September, which showed that on that day eleven vessels, from the Equator to 20° N., in the Bay of Bengal, had the wind from W.S.W. and S.W., in moderate and fresh breezes. These observations proved that up to that date the S.W. monsoon prevailed in the Bay. But a change was at hand. On the 26th September, the wind in the northern part of the Bay was light from the northward, and in the southern part moderate from westward. On the 29th September there was a strong breeze blowing from the W.S.W., with squally rainy weather from near the Equator to at least 10° N., whilst in the northern part of the Bay the wind was light from the N. On the 2nd Oct. there were signs of a cyclone. To the S.W. of the Nicobars a strong breeze was blowing from the W.S.W., with squally rainy weather. In the Gulf of Martaban there was a gale from the S.E., with much rain and lightning. To the S.E. of Coringa the wind was increasing from N.E., with thunder and lightning. On the 3rd and 4th there was strong evidence of the existence of two contrary winds, the one from N.E. and the other from S.W., with a cyclone between them; but the S.W. wind was apparently overcoming the other. On the 5th, when the storm was at Calcutta, the S.W. wind had established itself over the greater part of the Bay. But this was only a temporary victory, for by the 8th the N.E. wind was blowing fresh over the northern portion of the Bay. The S.W. wind, however, still prevailed farther south. By noon on the 15th the N.E. wind prevailed over the whole Bay.

He had not been able to examine the subject farther, but would return to it at next meeting. In the meantime, he thought that the evidence adduced went to show that the storm originated in the belt of calms between the N.E. trade and the S.W. monsoon.

* Paper read before the Meteorological Society of Mauritius, March 24, 1870.

CHEMISTRY

Specific Gravities of Aqueous Solutions

IN Gerlach's *Sammlung der specifischen Gewichte wässeriger Lösungen* is a large amount of information which will prove of great use to manufacturers and others who have to deal with aqueous solutions of acids, alkalies, and salts.

The first table consists of nine columns marked with letters. In column A are placed the formulæ and combining weights, according to the old notation, of the bodies dissolved, both in the anhydrous and hydrated condition. Column B contains the weight of the dissolved body in the hydrated condition, or with water of crystallisation, which is present in 100 parts by weight of the solution. C shows the weight of the dissolved substance in the anhydrous condition. The numbers in this column may be calculated from those in the second column by multiplying by the combining weight of the anhydrous and dividing by that of the hydrated substance. Column D gives the weight of the body in the dry state, which is dissolved in 100 parts of water, and is calculated by multiplying the numbers in column C by 100 and dividing by 100—C:—

$$D = \frac{C \times 100}{100 - C}$$

Column E contains the number of atoms of the anhydrous salt in 100 parts by weight of water. The expression *atom* is here synonymous with *equivalent*. The atom of hydrogen is taken at $\frac{1}{100}$:—

$$E = \frac{D \times 100}{A \text{ (anhydrous)}}$$

F gives the volume of the solution; 100 parts by weight of the water of the solution being taken as 100 volumes:—

$$F = \frac{D \times 100}{\text{spec. grav.}}$$

G indicates the specific gravities of the solutions. H contains the volumeter degrees, according to the scale of Guy Lussac, which correspond to the specific gravities:—

$$H = \frac{100}{G}$$

In column I are found the names of the observers, the temperature, and the references to the sources from which the numbers were obtained.

In this first table we find the various numbers corresponding to solutions of different states of concentration. In some cases the numbers are given for solutions at intervals of 1 per cent. of the salt, in others of 5 per cent., and in others of 10. The table commences with caustic alkalies, including ammonia, potash, and soda. Then follow the potassic and sodic carbonates, the chlorides of ammonium, potassium, sodium, lithium, aluminium, magnesium, calcium, strontium, barium, cadmium, and zinc, and stannous and stannic chlorides. The next section contains the bromides of potassium, sodium, lithium, magnesium, calcium, strontium, barium, cadmium, and zinc; whilst under the iodine compounds we find potassic, sodic, lithic, magnesic, calcic, strontic, baric, cadmic, and zincic iodides. Next comes sodic hyposulphate, and the sulphates of ammonium, potassium, sodium, manganese, and iron, the double sulphate of iron and ammonium, magnesic sulphate, potassia-magnesic sulphate, and the sulphates of zinc and copper. This series is followed by sections containing potassic chromate and bichromate, hydric disodic, and trisodic phosphates; hydric disodic, and trisodic arseniates; nitrates of potassium, sodium, magnesium, strontium, barium, and lead; chlorates of potassium and sodium; bromates of potassium and sodium, iodates of potassium and sodium; potassic ferrocyanide and ferricyanide; plumbic acetate; potassic and sodic tartrate; and Rochelle salt. The remainder of the table is devoted to the acids, and includes the following:—Hydrochloric, sulphuric, sulphurous, phosphoric, arsenic, nitric, acetic, tartaric, and citric.

After the table follows a chapter discussing the relations existing between the specific gravities of equally concentrated solutions; and three others: On the change of volume produced by solution of salts; on the change of volume produced on the dilution of aqueous solutions; and on the change of volume produced by mixing different solutions.

The pamphlet concludes with a table extending over 19 pages, and containing the specific gravities of solutions, in most cases from 1 per cent. to nearly the point of saturation, though in some few instances they are given at every 5 per cent. This table gives, in addition to those of the substances above enumerated, the specific gravities of solutions of sugar and alcohol. Dr. Gerlach deserves the thanks of chemists and chemical manufacturers for undertaking the tedious labour of collecting and arranging in tables the large series of numbers which are found in this pamphlet.

SCIENTIFIC SERIALS

THE *American Journal of Science* for May, 1870, contains a good article "On a simple method of Avoiding Observations of Temperature and Pressure in Gas Analyses," by Wolcott Gibbs, M.D., Professor in Harvard University.

In absolute determinations of nitrogen and other gases, accurate observations of temperature and pressure are, in the ordinary methods of analysis, necessary, and when made require subsequent calculations which, when the analyses are numerous, become rather tedious. By the following simple method these observations may be altogether dispensed with, and the true weight or the reduced volume of the observed gas, obtained at once by a single arithmetical operation.

"A graduated tube, holding about 150 cubic centimetres, is filled with mercury, and inverted into a mercury trough. Two thirds or three fourths of the mercury are then displaced by air, care being taken to allow the walls of the tube to be slightly moist, so as to saturate the air. This tube may be called the companion tube; the volume of air which it contains must be carefully determined in the usual manner by five or six separate observations, taking into account, of course, all the circumstances of temperature and pressure. The mean of the reduced volumes is then to be found, and forms a constant quantity. The gas to be measured is transferred from the receiver in which it is collected, into a (moist) eudiometer tube, which is then suspended by the side of the companion tube, and in the same trough or cistern. Both tubes being supported by cords passing over pulleys, it is easy to bring the level of the mercury in the two tubes to an exact coincidence. The pressure on the gas is then the same in each tube. The temperature is also the same, as the tubes hang side by side in the room set apart for gas analyses, and are equally affected by any thermometric change. It is then only necessary to read off the volumes of the gas in the two tubes to have all the data necessary for calculating the weight of the gas to be measured. . . . . As the observed volume of the air in the companion tube is to the observed volume of the gas in the measuring tube, so is the reduced volume of the air in the first—previously determined as above—to the reduced volume of the gas to be measured. This method of course applies to the reduction of any gaseous mixture whatever to the normal pressure and temperature. . . . . In practice, a companion tube filled with mercury will last with a little care for a very long time. Even when filled with water I have found that excellent results may be obtained, and that the tube will last for some weeks. Williamson and Russell, in their processes for gas analysis, have employed a companion tube for bringing a gas to be measured to a constant pressure, but the application made above is, I believe, wholly new."

SOCIETIES AND ACADEMIES

LONDON

Royal Society, May 19.—"A Ninth Memoir on Quantics." By Prof. Cayley.

It was shown not long ago by Prof. Gordan that the number of the irreducible covariants of a binary quantic of any order is finite (see his memoir "Beweis das jede Covariante und Invariante einer binären Form eine ganze Function mit numerischen Coefficienten einer endlichen Anzahl solcher Formen ist," Crelle, t. 69 (1869), memoir dated 8th June 1868), and in particular that for a binary quantic the number of irreducible covariants (including the quantic and the invariants) is = 23, and that for a binary sextic the number is = 26. From the theory given in my "Second Memoir on Quantics," *Phil. Trans.* 1856, I derived the conclusion, which as it now appears was erroneous, that for a binary quintic the number of irreducible covariants was infinite. The theory requires, in fact, a modification, by reason that certain linear relations, which I had assumed to be independent, are really not independent, but, on the contrary, linearly connected together: the interconnection in question does not occur in regard to the quadric, cubic, or quartic; and for these cases respectively the theory is true as it stands; for the quintic the interconnection first presents itself in regard to the degree 8 in the coefficients, and order 14 in the variables; viz., the theory gives correctly the number of covariants of any degree not exceeding 7, and also those of the degree 8, and order less than 14; but for the order 14 the theory as it stands gives a non-existent irreducible covariant