prehension, they attributed to him a mastery of the black art of divination, and a possible intimacy with the devil himself.

In finishing his work, neither money nor labor was spared: the best illustrators were constantly employed; and one, M. Humbert, became noted, lived constantly with him, and died in his employ after twenty-five years of service.

Barrande found it necessary to be his own publisher. He accordingly organized a French press at Prague; and the typography of his books justify his own assertion, that they could not have been printed with greater technical elegance by any press in Paris. We know from personal inspection that errors are very rare. The quotations, which generally show carelessness, if any part of a book does, excel in this respect; and the desire for correctness has been carried so far, that, instead of tables of 'corrigenda,' he has carefully corrected errors with printed slips pasted upon the pages of the text. All this was done while engaged in administering a fortune of about fifty millions of francs, and arranging many complicated questions of business connected with his position, and relations to the Comte de Chambord, which required much time, and many journeys to different parts of Europe. That this was accomplished successfully is shown by the terms of the will of this last heir of the elder Bourbons, who appointed him his executor. The expenses of the whole work were met by the personal sacrifice of his own income from all sources, but principally by the generous assistance of his royal friend. These presents were always made with the greatest delicacy by the count as his subscriptions to the 'Système silurien de la Bohême;' and Barrande has recognized their essential importance in dedicating each of his volumes to this generous patron, and also by a direct statement that his own labors would have failed but for this assistance. The world of science owes to the Bourbon family its perpetual recognition of this example of friendship and generosity, which has brought out to full fruition the life of one of its representative men.

No government can point to a finer single monument to science than this one, created by an exile in a foreign country; and the sums expended were large, since, as we are assured, the average cost of each of the twenty-two volumes, as estimated by Barrande himself, was not less than twenty thousand francs, making a grand total of nearly ninety thousand dollars for the parts published up to the present time. M. Barrande never married; and his only surviving relatives are a sister, Mme. Vuillet, and a brother somewhat younger, M. Joseph Barrande, a distinguished engineer.

It is impossible adequately to present a life so varied and so full of activity in every direction, at once scientific, and yet so picturesque from political and social stand-points. He had become, before his death, the only survivor of the ancient servitors of the royal house of France; and the cause, and even the surroundings, of his death, completed the beautiful picture of his life of voluntary exile and chivalrous service. He sacrificed himself to his duty as executor, and died from a cold contracted from exposure while engaged in carrying out the last wishes of the man who had been to him pupil, friend, patron, and rightful sovereign. His decease took place Oct. 5, at the Chateau of Frohsdorf, near Vienna, under the same roof, and within a short time after the death of the Comte de Chambord. We who are republicans cannot estimate his motives, nor feel with him as a royalist, but we can respect the rare moral qualities of his devotion; and we feel, also, that it is essential to express our reverence and gratitude to the memory of a really great man for his consideration and kindness to all young students in science who have had occasion to come into personal or professional relations with him.

WHIRLWINDS, CYCLONES, AND TORNADOES.[1]—IV.

THE beginning of the upsetting in a tropical cyclone is not fully accounted for by observation. It is not so easily explained as the first

[1] Continued from No. 42.

uprising on the desert, inasmuch as the ocean's calm surface is too smooth to offer any distinct starting-point for the up-draught. There are, however, several plausible ways out of the difficulty. It is possible that localized warmth and expansion where the air is calmest may produce a gentle up-current, which, once begun, will be soon well established. Again: an excess of evaporation will cause a rapid upward diffusion of vapor. It will reach an altitude where it must condense, and form a cloud-layer, and thereby warm the surrounding air both by its latent heat and by catching the warmth of the sun's rays; and, as this will go on at a considerable altitude, it will be especially effective. Finally, if after a time of calm a breeze should opportunely penetrate the district from an adjoining one of higher pressure, an ascending current would surely be started. In some such way a gradual overturning of the unbalanced air must begin, and its further action is now to be traced.

The rising mass expands as it escapes from the pressure of the air that it leaves below, and in expanding it is mechanically cooled. As it cools, some of the vapor with which it is well charged condenses into cloud, and, on accumulating, soon begins to fall as rain. Here we have the entrance of a new and potent cause of disturbance, — the bringing-forth of a great amount of energy in the form of heat from the condensation of the vapor. It is probable that this aid to the up-draught seldom takes the initiative: it waits till some other cause begins the upsetting, and then falls to with a will to help it along.

This effect of condensation is so important that it may well be considered a little more closely. As water evaporates, its molecules are spread widely apart, and take on a very active motion; but in doing so they must be furnished with energy in some form, for they cannot develop out of nothing the energy needed for their increased activity. As a general rule, the desired supply is found in the sun's radiant heat: so, when water evaporates from the sea-surface, it takes to itself nearly all the energy that comes down in the sun's rays, and thereby its molecules are enlivened up to the point of vaporization. It will be readily understood, that, if heat-energy be taken by the water and transformed into vapor-energy, it can no longer make itself felt as heat; and, so far as our senses are concerned, it is lost or hidden, and for this reason is called 'latent heat.' The term is misleading and improper, for it implies that the sun's energy still remains somewhere in the vapor as a kind of heat that we cannot feel; but this is wrong, for as heat it no longer exists. It will be further seen, that, when the vapor is condensed back again into water, all its vapor energy must take some other form: it must abandon the vapor molecules, and allow them to quiet down and approach one another as they resume the liquid condition; and the energy thus thrown out of employment must make itself felt in some other way. We are therefore prepared to find that condensation is attended with the production of just as much heat-energy as was lost in the process of evaporation. This is of capital importance in the understanding of storms.

It has already been seen, that the cause of continued action in a desert-whirl is found in the excessive warmth of the lower strata; in virtue of which the air in the ascending column finds itself warmer, and hence lighter, than the surrounding air, and consequently is impelled to rise as oil rises through water. It was further noted, that the ascending whirl will continue as long as it is supplied with excessively warm air at the base; but, as soon as the bottom air is not more than 1.6° warmer than the air three hundred feet above it, the whirl will die away. In the case of an ascending column of air saturated with vapor, it would also, as in the previous case, expand as it rose to higher levels of less pressure, and, in consequence of this expansion, it would cool. But when saturated air is cooled, some of its vapor must condense; and when vapor condenses, heat is evolved; and the heat thus produced will partly make up for the loss of heat by expansion, and therefore the ascending column of moist air will not be allowed to cool so fast as if it had not been saturated with vapor. Several important consequences now follow. In the first place, a less warming at the base is needed to produce unstable equilibrium in saturated than in dry air. In the latter, the turning-point is reached when there is a difference of 1.6° F. between the temperatures of the surface-air and that three hundred feet above. In the former, if the surface-temperature be 80°, as is common in the Bay of Bengal, a difference of only 0.6° is required. In other words, if a mass of dry air at 80° rise three hundred feet, its temperature falls to 78.4°: if a mass of saturated air at the same temperature (fig. 5) rise through the same distance, it is cooled only to 79.4°; and conse-

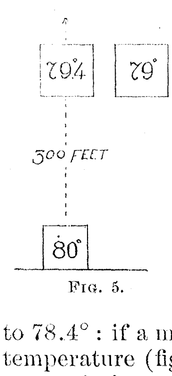

FIG. 5.

quently, for every three hundred feet of ascent it has an advantage over dry air of one degree of warmth (and more at great altitudes), tending to make it lighter than its surroundings, and so intensifying its upward motion. Moreover, a storm which is thus nourished may continue its activity through the night, instead of dying away as the sun declines; for it is supplied with energy continually brought out of the vapor storehouse. Of course, in both cases the sun's heat is the source of the disturbance; but on the desert there is no way of storing up the heat, while at sea a great amount of energy may be stored up before the final upsetting begins, and then the storm-winds arise, and show all this accumulated strength in their blowing.

We have much this kind of action, in a small way, in the formation of a heavy cumulus-cloud on a quiet, hot summer day. The air on the ground is warmed, and contains a good share of moisture; and, as it rises and cools, its vapor begins to be condensed. Some of the vapor-energy is given out as heat, and so the ascending current is re-enforced. If the air be very warm or very moist, or both, the ordinary cumulus-cloud may grow into a thunder-shower; and, being then unable to carry up all its condensed vapor, some of it falls as rain. It should be noted, that, when the lower air is not fully saturated, its temperature must be somewhat reduced to bring it to the point of saturation before any cloud is formed. This decrease is mechanically effected at the rate of 1.6° every three hundred feet, by the expansion of the rising air, — essentially the same rate as that already given for the cooling of a rising column of dry air; and, when enough cooling has been thus effected to reduce the air to its temperature of saturation, some of the vapor will be condensed into liquid cloud-particles, and so become visible. It is for this reason that cumulus-clouds have nearly level bases, and that a group of such clouds stands at about the same altitude. The air-currents rising from the warm ground have to ascend a certain distance, and cool a certain number of degrees, before condensation takes place. Their altitude in feet will be about a hundred and eighty-three times the number of degrees between the temperature of the lower air and its dew-point.

All tropical cyclones are attended by clouds and by excessively heavy rain; and this points very clearly to the important part played by the heat evolved in the condensation of so much vapor. The rapid reproduction of the heat stored up through many previous days of sunshine retards the cooling of the ascending current, excites the winds to active motion, and the storm is thus set going. Espy (1835) was the first to recognize the important part played by the condensing vapor in an ascending current of air, but he greatly exaggerated its effects. The proper measure of its action, and convenient statement of the results in tabular form, are chiefly due to Reye (1864) and Hann (1874).

The ascending current moves outward at a height of one or two miles, spreading itself over the surrounding atmosphere. To show its relation to the storm circulation, we may refer to the following figures. Fig. 6 shows the air in a quiescent state, before the storm begins. At such a time, there being no wind, the weight of the air, or the barometric pressure at sea-level, — say, 30 inches, — is uniform throughout the area preparing for cyclonic disturbance. The pressure is uniform, not only at the sea-surface, but also at any given altitude above it (the effect of the upper winds is here omitted as being non-essential to the explanation, as well as unknown); so that the lines in the figure will represent level surfaces of equal pressure of 28, 26, 24 inches, or isobaric planes at altitudes of about 1,600, 3,300, and 5,000 feet. As long as the vertical gravitative pressure is at right angles to these planes, the air is not tempted to move, but will remain at rest till disturbed by some new condition. This new condition will be some form of the disturbing actions already suggested, by which a central region of greatest warmth is determined, in consequence of which there will be an expansion of the atmosphere at that place. The isobaric planes will become convex there, as in fig. 7; for the altitudes at which barometric pressures of 28, 26, 24 inches are found mu now be greater than before. As there been, as yet, no lateral motion, this p no change in the pressure at sea-level

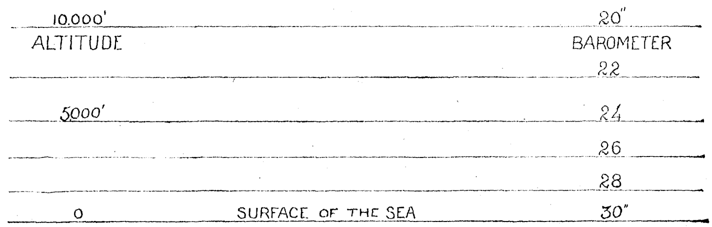

FIG. 6.

reason for lateral motion has now appeared: the gravitative pressure of the upper air is no longer at right angles to the convex isobaric surfaces, and consequently there will be a tendency for the air to slide down from the centre. In obedience to this impulse, some of the central expanded air moves laterally or radially outward to the marginal region; and now there

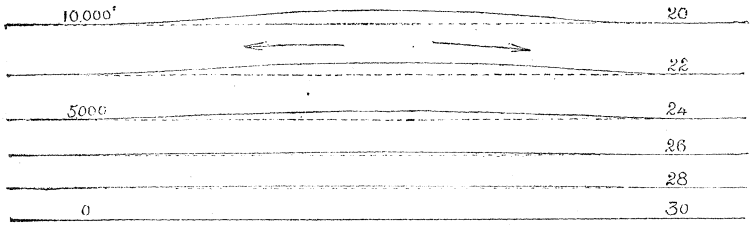

FIG. 7.

is no longer a uniform pressure of 30 inches at sea-level. At the centre, whence the upper air has rolled away, the pressure will be reduced, let us say, to 29 inches: on the surrounding district, over which the air has advanced, the pressure has increased to 30.25 inches. In this new arrangement of pressures there is cause for still further gravitative motion; namely, a rising of the air at the centre, a sinking at the marginal region, and a horizontal motion along the sea-surface, toward the centre of low pressure, in the attempt to restore an equilibrium. But this will not fully overcome the inequality of pressures, or correct the sloping of the isobars; for the existence of an ascending and expanding warm current at the centre requires that the isobaric surfaces there shall be separated by a greater vertical distance than in the normal cooler air of fig. 6. Further, the marginal descending current of air, greatly cooled by radiation in the upper regions, is heavier, volume for volume, than the ascending current, and hence has its isobaric

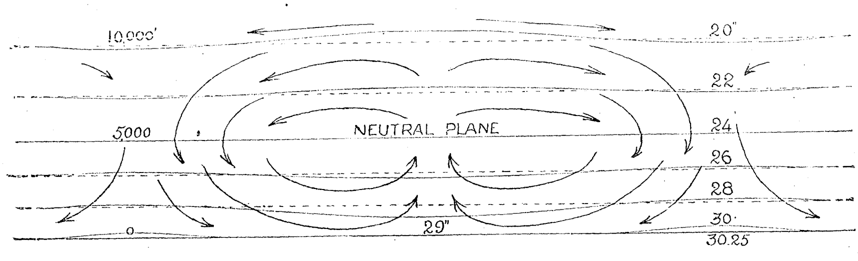

FIG. 8.

surfaces closer together than usual. A shorter vertical column of it is needed to balance an 'nch of mercury in the barometer. Fig. 8 shows 's final condition, — the diminished pressure greater separation of the isobaric lines arm centre; the increased pressure and 'ach of the isobaric lines in the cooler margin. Now, in virtue of the greater distance between the isobars at the centre, the altitude of some surface, say that of 24 inches, will be as great there as over the marginal region, in spite of the inequalities of pressure and inward slope of the isobars at sea-level; and at greater altitudes the isobaric surfaces will become convex, and hence slope outwards, instead of inwards, as below. The two directions of slope will be separated by a level or neutral plane, on which there will be no tendency to motion. Here we have excellent illustration of the convectional motion of the wind in a storm. It ascends at the centre, where it is lightest; it then flows outward, down the barometric gradient; it sinks at the marginal region of higher pressure, and then flows inward, down the reversed gradient, back to the centre again. This may be called the vertical circulation of the storm; and it will be continued as long as the central current is warmed to excess, so as to raise its isobaric surfaces. In the desert-whirlwind we have seen that the supply of warm air depends immediately upon contact with the surface-sands heated by direct sunshine. In the cyclone at sea, the greatest part of the warmth needed is given out by the vapor that condenses at the centre, and falls in the heavy rains, without which a cyclone cannot form. Such a storm may last many days.

The explanations thus far given of the beginning of a cyclone apply strictly only to the hurricanes of tropical latitudes; for in the temperate zones our numerous storms are by no means always dependent on local warmth and calmness of the air. The most that can now be safely said of the origin of such storms is, that they depend on some immediately preceding disturbance, somewhat as one water-wave depends on another; for no one has yet been able to trace one of our storms so far back as to show it quite independent of previous storms, as seems to be the case with the tropical cyclones. In the irregular blowing of the winds of higher latitudes, for which no full explanation can be given, too much air is accumulated in certain districts, which then appear as regions of high pressure. In seeking a better balanced re-arrangement, surface-currents are established with a rotary deflection, as explained below, toward intermediate areas of lower pressure; and an up-draught is formed at their meeting. This becomes a storm-centre. It might be said that friction would soon cause all these local disturbances to cease, and atmospheric pressure would then remain more uniform. So it might, if the air were dry; but the condensation of vapor, by which the cooling of the ascending current is retarded, brings out a new supply of energy every time an up-current is established; and thus the disturbed condition of the atmosphere is maintained. It cannot settle down into a condition of equilibrium as long as the sun shines, and water evaporates. Some maintain that it is unlikely that the storms of the torrid and temperate zones should have different causes, and that as temperate storms certainly do not, as a rule, arise in a warm calm, tropical storms cannot have such an origin. But as already stated, and as will be further shown, the regions and seasons of tropical cyclones point very conclusively to this origin; and, moreover, it is not necessary that similar results should have identical causes. All the peculiarities of a rotary storm can be satisfactorily explained from either starting-point. And the essential contrast between the two cases is, that in one, differences of temperature precede and bring about differences of pressure, and, in the other, differences of pressure precede and bring about differences of temperature; so that, in both cases, the established storm differs in temperature and pressure from the surrounding atmosphere: and, once established, the motions of rotation and translation, yet to be described, are closely alike in the two cases.

(*To be continued.*)

THE ELECTRIC LIGHT ON THE U. S. FISH-COMMISSION STEAMER ALBATROSS.[1] — III.

To determine the efficiency of the system of incandescent lamps, I measured, by means of a steam-engine indicator, the power required to run the engine and dynamo, the current being switched off. By the same instrument I measured the indicated power required to run 45, 50, and 70 lamps, respectively. By deducting from these experiments, respectively, the power required to run the engine and dynamo, we obtained the power applied to the shaft; and from this quantity we deducted the friction of the load, leaving, as a remainder, the net powers required to revolve the armature in the magnetic field with 45, 50, and 70 lamps in circuit. The lamps used were each of eight-candle power.

Efficiency of the incandescent lamps.

Horse-power required to run the engine and dynamo	5.36
Indicated horse-power required to run 45 incandescent lamps	5.79
Indicated horse-power required to run 50 incandescent lamps	5.85
Indicated horse-power required to run 70 incandescent lamps	6.92
Net horse-power applied to the revolution of the armature in the magnetic field, using 45 incandescent lamps	1.80
Net horse-power applied to the revolution of the armature in the magnetic field, using 50 incandescent lamps	1.85
Net horse-power applied to the revolution of the armature in the magnetic field, using 70 incandescent lamps	2.84
Mean number of incandescent lamps per indicated H.P., using 45 lamps	7.77
Mean number of incandescent lamps per indicated H.P., using 50 lamps	8.50
Mean number of incandescent lamps per indicated H.P., using 70 lamps	10.11
Mean number of incandescent lamps per net H.P., using 45 lamps	25.
Mean number of incandescent lamps per net H.P., using 50 lamps	27.02
Mean number of incandescent lamps per net H.P., using 70 lamps	24.63

The wires being fixed, their resistance may be considered a constant quantity, and the only variation as existing in the engine and dynamo. The distribution of the power, as above recorded, may, if necessary, be verified by electrical measurements on the wires.

To illuminate the machinery on deck, the derrick-gaff, the lead of the cable, the trawl as it comes on deck, and to afford ample light to the naturalists while culling the contents of the trawl as delivered on deck, an arc-light of great power became indispensable. In the then existing state of electric lighting, an additional dynamo appeared to be imperative, as no arc-light had been run from a tension of 51 volts.

The Edison company, however, was willing to experiment, and in a short time produced a

[1] Concluded from No. 42.