It was found that "both the sediment and the volcanic ash contained, (1) small, transparent, glassy particles; (2) brownish, half-transparent, somewhat filamentous little staves; and (3) jet black, sharp-edged, small grains resembling augite. The average size of the particles observed in the sediment was of course much smaller than that of the constituents of the ash. These observations fortify us in our supposition, expressed above, that the ashes of Krakatoa have come down in Holland."

These analyses certainly tend to confirm the volcanic hypothesis, though it is interesting to note that some of the substances found by Mr. McPherson are also characteristic of meteoric matter. The evidence thus far accumulated seems to point positively to the truth of the volcanic hypothesis. The opponents of this view dwell upon the improbability of so much matter being thrown up to such a great height, and of its remaining so long a time in the atmosphere. But the magnitude of the Java eruption has certainly not been overrated; and the amount of material thrown into the atmosphere from this source alone is probably sufficient to account for the observed effects. If we add the amount from the Alaskan volcano, there is less reason to doubt the ability of the hypothesis to account for the quantity of material required. The objection on the ground of the persistence of the phenomenon has been met by Messrs. Preece and Crookes on electrical grounds. If the matter thrown up is charged with negative electricity, it would be repelled from the earth, and its particles would repel each other, thus causing the rapid dissemination of the material in the atmosphere, and its retention for an indefinite period. The decline of brilliancy has been slow during the time it has been observed in this country. In the Hawaiian Islands it is still a marked phenomenon, after a lapse of several months. We may therefore expect that for some time to come we shall observe it under favorable weather conditions, but that it will gradually become less prominent until it is known only as a fact of past history.

W. UPTON.

Washington, D.C., Jan. 1, 1884.

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

WE are now prepared to consider and explain the actual distribution and motion of cyclones.

The limitation of violent cyclones to the ocean is natural enough: the level surface of the sea allows a great accumulation of warm, moist air before the upsetting begins, and permits the full strength of the winds to reach a very low altitude. On land the air never waits so long as it may at sea, before upsetting; it never becomes so moist; and, when in motion, the inequalities of hill and valley hold back the lower winds by friction. On land the strong part of the cyclone is relatively higher than at sea, as the records of mountain observatories show; and we know less of it.

No violent cyclones are known to have occurred within four hundred miles of the equator. Here, — where the air is warm, quiet, and heavily charged with moisture; where heavy, quiet rains are frequent; where the conditions which have been mentioned as essential for starting a cyclone are of common occurrence, — cyclones are nevertheless unknown. They occur often enough, however, in the embryonic form of thunder-showers, but they never reach the adult stage; and this must be because at the equator the deflective effect of the earth's rotation is zero, and the inrushing winds are allowed to move directly toward the low-pressure centre and fill up the depression, instead of increasing it by their deflection and their centrifugal force. From this we learn, that, while warmth and moisture may be sufficient to begin a cyclone, they alone cannot maintain it. There would be no violent cyclones if the earth stood still.

It might be inferred from this that cyclones should increase in frequency and intensity as we recede from the equator toward the poles, for in the higher latitudes the earth's deflective force is known to increase. It is true that storms are much more frequent in high latitudes than near the equator; and this is very likely due to the greater ease with which moderate indraughts are here deflected so as to produce a central baric depression. But the more intense storms are all within thirty or thirty-five degrees of the equator, because, in more polar lâtitudes, the air is not warm or moist enough to co-operate effectively with the deflective forces, and produce violent winds. It has already been explained that a rising column of moist air cools more slowly than one of dry air; and on this there was shown to depend much of the greater energy of oceanic storms over that of desert whirls. It should now be added, that, of two ascending currents of saturated air, the warmer will rise much more vigorously than the cooler: hence the warm, saturated air of the tropical sea breeds hurricanes, cyclones, and typhoons of greater strength than the

[1] Continued from No. 45.

storms that are raised in temperate latitudes, although the latter outnumber the former on account of the more effective aid of the earth's rotative deflection at a distance from the equator.

We must next examine the cause that determines the season of cyclones, throws them near the western shores of their oceans, and requires them to move toward or parallel to the eastern coast of the adjoining continents. This will be found to depend on the general circulation of the winds, as may be seen on examining the air-currents of the North Atlantic at the seasons of the most frequent hurricanes. Poey has compiled a list of hurricanes observed in the West Indies since 1493, amounting to three hundred and sixty-five in all; and of these, two hundred and eighty-seven, or nearly eighty per cent, occurred in July, August, September, and October. Now, these are the very months when the equatorial calms or doldrums are farthest north of the equator, and hence in a position to allow the embryonic storms to develop by the aid of the earth's deflective force. At other seasons the trade-winds extend nearer to the equator; and then, in a latitude where storms might grow if once started, the steady blowing trades prevent even the formation of an embryo. The few storms that occur at these other seasons have less evident causes: they may arise in conflicting winds, and may be fairly thrown among those unexplained effects that we call accidental. Once formed, the storm is carried along, by the general circulation and by the strong winds, toward the West Indies. On nearing them, it moves to the north-west and north, mostly because branches of the trade-winds here turn to that direction in the cyclone season, so as to avoid the mountains farther west, and to run up over the warm land of our country; partly because of the continual polar tendency, or excess of deflection on the northern side of the storm. Even if the general surface-winds do not blow along the storm-tracks, it is very probable that the upper current, returning from the equatorial calms toward the prevailing westerly winds of the temperate latitudes, follows a course closely parallel to the average of the cyclone paths; and there is good reason to believe that the upper winds have a great control over the storm's progression. If the storm should begin on the eastern side of the Atlantic, it would probably be held so near the equator by the indraught of the trade-winds that it could not reach a destructive size. The greater Atlantic hurricanes are therefore those that begin in the western part of the calms or doldrums when they are farthest from the equator, and then, passing along their curved paths, take the West Indies and our south-eastern coast on their way up into the North Atlantic. As they go, their diameter greatly increases; because they draw their wind-supply from longer distances, and because in the temperate latitudes the earth's deflective force is greater than it was in the tropics. But with this increase in diameter there comes a diminution of intensity, because the winds are cooler and contain less vapor; and finally the storm dies away when the weakened updraught at the centre fails to throw its overflow outside of the limits of the whirl. The storm is then not working its way: friction will soon cause the winds to cease, and the disturbance will come to an end.

As for the South Atlantic, it possesses no cyclone region, because the doldrums never extend south of the equator. In spite of the sun's passing to the south in winter, the heat-equator, which determines the position of the doldrums, hardly passes the geographic equator in the Atlantic; the excess of land in the northern hemisphere, and the strong general winds of the southern hemisphere, keep it back: and so the South Atlantic has no cyclones such as occur in all the other oceans. The cyclones of the Pacific and Indian oceans depend on conditions such as have been described for the North Atlantic. They are commonest in the southern hemisphere in February for the same reason that they are most frequent in the northern in the months about September.

We have now considered the origin and motions of the cyclones and hurricanes, and the regions of their occurrence. This study has its highest aim in giving timely warning of their approach and in devising rules for avoiding them. If their tracks lay over the land, the telegraph could in all cases give sufficient notice of their coming, for their motion is slow; but they are at sea during much of their life, and the questions now arise, How can the captain of a vessel gain the first intimation of their coming? and, What should he best do to avoid their dangerous centre?

The storm's earliest effect on the atmosphere is shown by the barometer. It is ordinarily stated that the first effect is seen in a diminution of pressure; but it is very probable, both from theory and from careful observation, that a slight abnormal increase of pressure precedes this diminution. The tropical seas, where cyclones are most violent, have, as a rule, very small and very rare irregular changes in atmospheric pressure; and careful watching will pretty surely show a rising barometer, as the annulus of high pressure that surrounds the storm (see fig. 8) moves over the observer. The weather may still be clear, and the wind moderate and from its normal quarter; but this change in the glass demands renewed watchfulness. Let us suppose that such an observation be made on board a vessel lying east of the Lesser Antilles. The chart shows the captain that he is in the stormy belt. He may be directly in the path of the advancing storm, where he will feel its full violence; and he must make the best of his way out of it. Following the rising pressure, three other signs of increasing danger may be observed, — first, faint streamers of high cirrus-clouds may be seen, slowly advancing from the south-east to the north-west, or from the east to the west, in the high overflow from the storm's centre; this unpropitious change may accompany the rising of the barometer, or may be first seen when the barometer is highest: second, the barometer begins to fall, slowly at first, but more and more quickly when it reaches and passes twenty-nine inches; the vessel is then within the limits of the storm: third, the wind has shifted so as to blow from a distinctly northern quarter, and its strength goes on increasing; this is the indraught, blowing spirally toward the centre. There is then no longer any question that a storm is approaching; and as soon as a heavy bank of clouds makes itself seen, moving southward across the eastern horizon, then the central part of the storm is in sight. These clouds are the condensed vapor in the rising central spirals, and rain is falling from them. In deciding on a course to be pursued, the first point to be determined is, where is the storm's centre? That being known, its probable path can be laid down with considerable certainty in this part of the ocean; and then, perhaps, the greatest danger may be avoided. But here a very practical difficulty arises. To find the direction of the storm-centre, we must know the incurving angle of the wind's spiral, — the angle of inward inclination that it makes with a circle whose centre is at the storm's centre. The earlier students of the question — Dove, Redfield, Reid, and Piddington — considered the course of wind to be concentric circles, or inward spirals of very gradual pitch; so that they said the inclination of the wind is practically zero, and a line at right angles to its course must be a radius leading to the centre. Later studies showed this to be incorrect. The inclination of the wind inward from the circle's tangent was found to vary from 20° to 40° or 50°: but it was thought that this inclination was symmetrical on all sides; so that, with an average inclination of 30°, the storm's centre must always bear 60° to the left of the wind's course. Finally, the most recent results seem to show that the wind's course is neither circular nor symmetrically spiral; that the wind's inclination is very distinctly different in different latitudes, on different sides of the storm, in the different conditions found on sea and land, at different distances from the centre and at different altitudes. In so complicated a case, much judgment will be required to find where the storm-centre lies.

First, in regard to the latitude of a storm. Without considering its progression, the nearer it is to the equator, the less its indraught winds will be deflected to the right by the earth's rotation, — the more nearly radial they will be. But, as they move with much energy, they will gain in rotary motion rapidly as they approach the centre, and there will whirl around in almost perfect circles. Storms in low latitudes will therefore tend to have a comparatively small but violent central whirl, only one or two hundred miles in diameter, within which the winds may be almost circular; and the centre will there be nearly at right angles to the wind's course. Farther from the centre, the winds would be nearly radial; and, if storms could arise on the equator, they would have simply radial indraughts with a very small central whirl. On the other hand, in the temperate zone the inflowing winds will be strongly deflected to the right of their intended path; and they must depart widely from a direct line to the centre of low pressure, forming a whirl often one thousand miles in diameter: but, unless they inclined inward at a distinct angle, it would take them too long to reach the centre, and their strength would be lost in overcoming friction on the way. Their average inclination is therefore well marked. The steeper inclination of the winds close to the centre, observed in some northern storms (Toynbee), may be an effect of the tornado action in the cyclone, yet to be described.

Second, in regard to the sides of the storm, as affected by its progression. The inclination will generally be less than the average in front and on the right, and greater in the rear and on the left of the centre; for in whatever manner the storm advances, either by bodily transference or by successive transplanting, the motion of the wind must partake both of the direction of whirling and direction of progress, when seen by an observer not moving in either of these directions. In the case of bodily transferrence, the direction of the wind as shown by a vane will be the simple resultant of its whirling and progressive motions: in the case of successive transplanting, it will be the resultant of the earth's deflecting force and a curve of pursuit; a curve of pursuit being the path followed by a body moving towards a point that is continually changing its position. In either

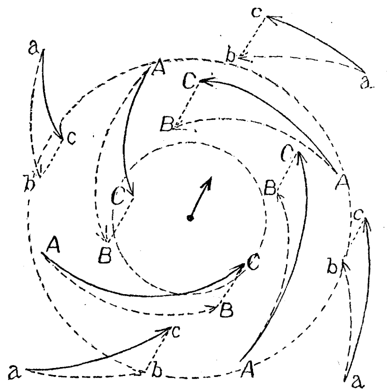

FIG. 18.

case, the effect may be sufficiently represented by fig. 18, in which the broken arrows show the motion of the wind with respect to the storm-centre, and the straight dotted lines measure the velocity of the storm's advance. The wind will seem to blow along the resultant of these two directions, as shown by the full arrows; and the resulting inclinations are

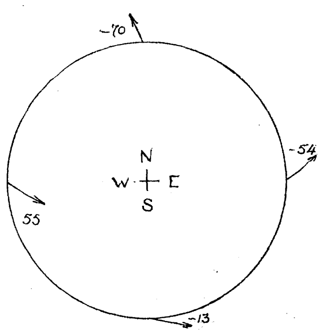

FIG. 19.

manifestly less in front than in the rear, and less on the right than on the left. With the variation of inclination, there will be an inverse change in the wind's velocity. It will blow faster on the right and rear or dangerous side of the storm, and slower on the left and front or manageable side. In the North Atlantic, where the storms often move rapidly, while a hurricane prevails south of the centre, very moderate winds may blow on the north; the difference between the two being about twice the storm's progressive motion. The change in inclination has been shown to occur in some of the West-Indian hurricanes, but it is not very pronounced in the land-storms of the temperate zone. Its best application is in storms on mountain summits; as on Mount Washington (fig. 19), and again in the case of the outflowing winds in the upper half of the storm, as shown by the motion of cirrus-clouds, and illustrated in fig. 20. Of course, in this case of outward motion, the less inclination is in the rear, and the greater in the front.

Third, in regard to land and sea storms. The inclination will be greater in the former than in the latter. On the sea, the centrifugal force of the earth's deflection will be most pronounced, and the winds will be more nearly circular than on land, where friction will tend

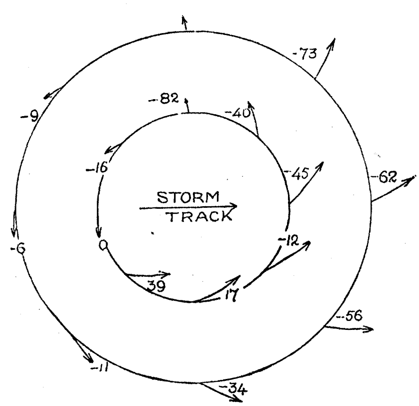

FIG. 20.

to destroy their original motion, and so allow them to run more directly into the storm-centre. This is fully borne out by observation, and is especially well shown in the contrasted cases of storms on the opposite sides of the northern Atlantic. Fig. 21 shows an average storm in the eastern United States, about ready to embark on the ocean; and in this the inclination of the winds is less on the sea than on the land side. This effect is doubtless produced in part by the preceding condition concerning the front and rear sides of the storm. But in examining a storm just about landing on the western shores of Europe, as shown in fig. 22, it is seen that here the front winds have the greater, not the lesser, inclination: hence position in regard to the centre cannot be the cause of the differing inclinations here. A better explanation is found in the fact that the eastern side of the storm receives its winds from the land, and the western side from the sea; and, in accordance with this, the eastern side should have the greater, and the western side the lesser inclination, as is the case. The fact that European storms have a less velocity of progression than those in this country would still further allow the land and sea conditions to control the inclination in the former region.

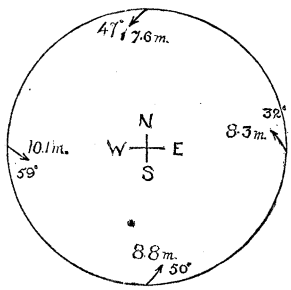

FIG. 21.

Fourth, it is manifest from all the preceding cases that the outermost winds of a storm are nearly radial, and that their direction becomes more circular as they advance. This results directly from the faster motion and less radius, consequently the greater centrifugal force near the centre, and requires no special illustration. It need only be noted, in recalling the first or latitude condition, that, at large distances from the centre, equatorial storms are generally more radial than those of the temperate zones; but, at small distances from the centre, this rule may have to be reversed. This is quite in accordance with the greater size but less intensity of the storms in the temperate zone.

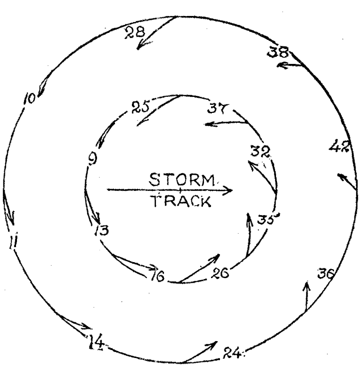

FIG. 22.

Fifth, in regard to altitude. The absence of strong friction will allow the upper winds to whirl in even more circular paths than they do at sea. Indeed, at a moderate altitude, say 7,000 feet, the winds are probably perfectly circular in the core of the storm; and at a little greater height they assume an outward inclination as they change to the outward spiral of the upper overflow. It is common, therefore, to note that the surface-winds of a storm are not parallel to the motion of the clouds. As the latter are more fully in control of the earth's deflecting force, they will always tend to the right of the former; and, in the extreme contrast of surface-indraught and uppermost outflow, the cirrus-clouds may drift slowly (in appearance) 90° or 120° to the right of the surface-winds. It is therefore usually to storm-disturbances of the general atmospheric circulation that the irregular drifting of different cloud-layers is to be ascribed. And now, after this long digression, we may return to the rescue of the vessel in the West-Indian hurricane.

(To be continued.)

THE BUSINESS OF THE NATURALIST.[1]

THE Society of naturalists of the eastern United States is an association in which all preliminaries should be brief, and ceremonious speeches out of place. Our first official meeting at Springfield was, however, almost wholly occupied with the technicalities of organization, and we necessarily gave but little time to other matters. The attendance at that meeting, on account of the natural aversion of scientific men to details of such an uninteresting nature, was small, compared with the numbers now present; and our list of members is also more than double what it was then. Under these circumstances a few preliminary words of explanation will not be wholly without usefulness. Our correspondence with scientific men also shows that the novelty of the organization and objects of this society requires some explanation in a comprehensive and condensed form from some one person.

So far as I am aware, this is the first attempt to form an association for the transaction of what may be called, without derogation to the dignity of our future labors, the business of naturalists.

Heretofore scientific associations have been founded and conducted upon the idea that the technical interests of science were necessarily inseparable from the results of scientific work, and should be considered by the same body which also attends to the presentation, discussion, and publication of the records of discovery and research. It has seemed to me for at least seven years past, that, on the contrary, a division of labor was necessary, and ought to be brought about. The technicalities of science have increased to an enormous extent within the last decade; and some effectual means of mutual culture and

[1] Address delivered in New York before the Society of naturalists of the eastern United States, Dec. 28, by the president, Professor Alpheus Hyatt of Cambridge.