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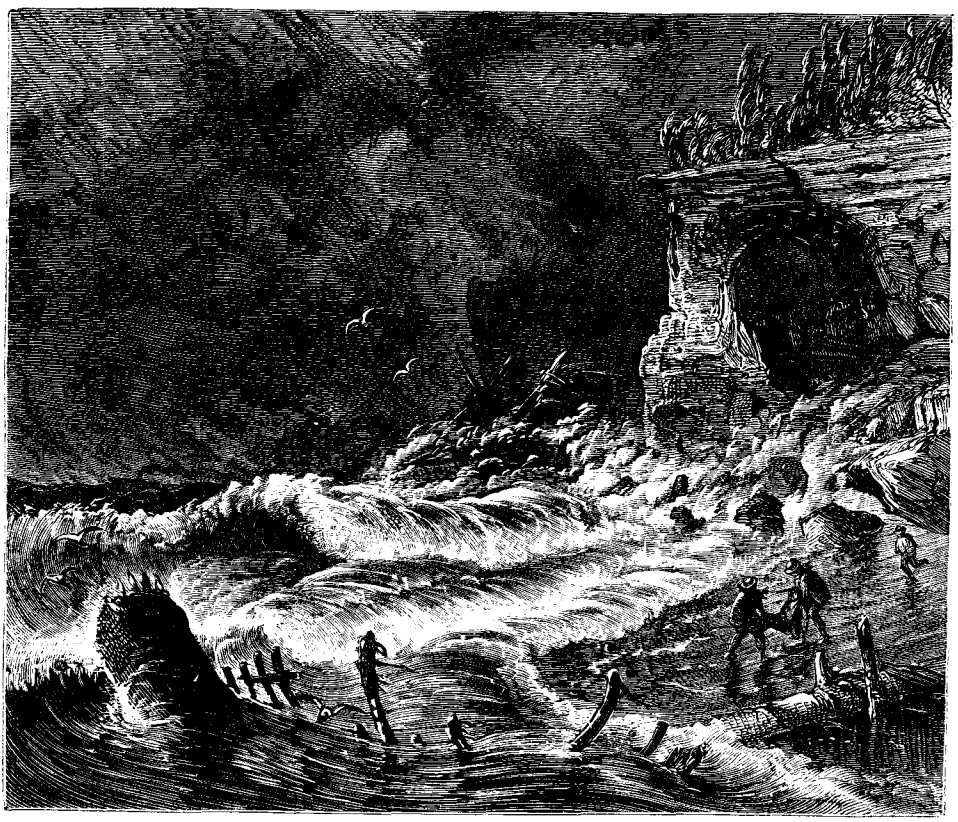
WEATHER-TELEGRAMS AND STORM-FORECASTS BY THE AMERICAN SIGNAL SERVICE.

SECOND ARTICLE.



A STORM-SCENE ON LAKE SUPERIOR.

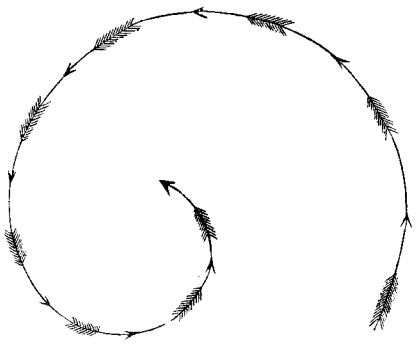
FOR many centuries of the world's history, a certain fiery meteor was thought to be a fierce and dreadful visitant, filling mankind with terror, as described by the poet:—

> "A pathless comet and a curse,
> The menace of the universe,
> Still rolling on with innate force,
> Without a sphere, without a course."

But since Halley's time the arrival of every comet has been foretold to within a few hours, almost as nicely as the clock tells us the revolution of the earth on its axis.

In 1831, that great meteorologist, William C. Redfield, of New York, from a large mass of observations, demonstrated *that there is a law of storms.*

It is not saying too much when we venture an assertion that a century hence the law of



CURVE OF CYCLONES IN NORTHERN HEMISPHERE.

storms, as demonstrated by Redfield, and after him elaborated by Reid, Piddington, Thom, Buys-Ballot, Prof. Henry, Sir John Herschel, Dové, Fitzroy, and others equally eminent, will take its rank among the great physical discoveries of Kepler, Newton, and Halley.

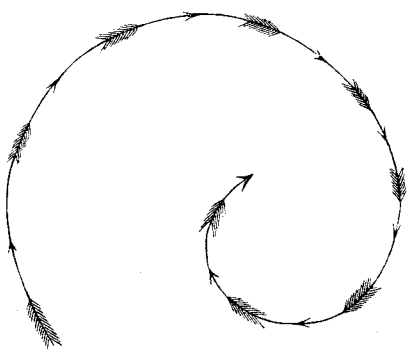
Mr. Redfield showed that the storms of the American coast were of a *rotary* character; that they were *progressive* whirlwinds, moving forward on the line of an *incurving spiral* at a considerable rate, and that *they revolve, in the Northern hemisphere from east to west, against the hands of a watch, and in the Southern hemisphere from west to east, with the hands of a watch.*

The published researches of Mr. Redfield were followed by those of Major-General Reid of the British Army, in the introduction to his *Law of Storms*. Speaking of the Atlantic gales, he said:—"The Tropical Hurricane has now been traced on the west side of the Atlantic, beyond the fiftieth degree of latitude, which is the latitude of the southernmost point of England, and has been proved to be a whirlwind whilst passing over Newfoundland to Labrador. By their rotatory motion such storms neutralize or reverse the trade-winds, and by their progressive motion they cause those changes of the wind which give the name of 'Variables' to certain latitudes.

"A residence of nearly eight years in the Bermudas, on the thirty-second parallel of latitude, satisfied me that all the Bermuda gales, of whatever degree of force, *in which the wind veers and the barometer falls*, are progressive revolving gales; and I was struck when hearing the inhabitants call them 'roundabouts.'" *

The centre of the storm, it was afterwards more fully shown, is marked by a *lull* or *calm*, and by an exceedingly *low barometer*. So low and so suddenly does the mercury fall in the Torricellian tube, that in the celebrated instances of the Havana hurricane of October 12, 1846, and the Natchez tornado of 1840, mentioned by Prof. Dové, of Berlin, the windows of the houses, by the expansive force of the confined air, were blown *outwards*. The character of the cyclone is understood if we look at a carriage wheel revolving fast over a muddy turnpike. The whole wheel moves forward on the road, and the dirt on the upper rim is thrown forward and that on the lower rim backward. While the cyclone is moving with great rapidity on its exterior, perhaps 100 miles an hour or more, its centre and body may be marching so slowly that steamers, and even sailing vessels, sometimes overtake it and run into imminent danger.

Thus we see that a ship caught in a cyclone will find the wind to veer from point to point until finally it has made a complete recurvation. The brig, "Charles Heddle," so famous in the annals of cyclonology, in the Mauritius hurricane from the 22d to the 27th of February, 1845, was carried round and round the cyclone, at an average distance of 50 miles from the centre, scudding 1,300 miles in the five days, and yet found herself afterwards only 354 miles from the port from



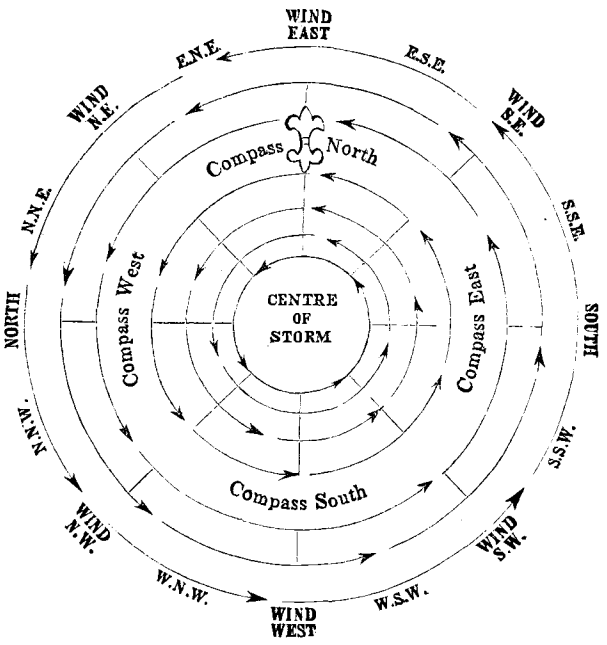
CURVE OF CYCLONES IN SOUTHERN HEMISPHERE.

* Reid's *Law of Storms*, p. 2.

which she had started, as the storm had made five complete revolutions with her.

If we can further imagine an enormous disk or circular body of air hundreds of feet high, revolving *horizontally* over the surface of water, we can further see how ships on different sides of the cyclone would be affected, and how easily, if they correctly understand its motion, they may *sail around* it, or with it, instead of going into its vortex. By observing the veerings of the wind, the seaman can ascertain the direction of the dreaded centre of the storm, and, knowing the centre, can easily escape the danger.

To facilitate this calculation, Mr. Piddington, President of the Marine Court at Calcutta, prepared two Horn-Cards, one for the Northern hemisphere and one for the Southern.



PIDDINGTON'S STORM-CARD FOR NORTHERN HEMISPHERES.

Should a ship find herself in a cyclone in the northern hemisphere, her master has only to lay down the horn-card (which is transparent) on his chart, taking care to always keep the *fleur-de-lis* on the magnetic meridian, and to lay the *wind's place* on the card at the time exactly over the *ship's place* on the chart, moving the card, of course, along the known track of the storm. Thus, "suppose your ship," says Piddington, "in 16° North (lat.) and 72° West (long.), with all appearances of a cyclone, and the wind at W. N. W., and she is bound to Grenada (U. S. of Colombia). Mark off her place, and lay the W. N. W. of the horn-card over it; and you see at once that it is a storm of which the centre lies about N. N. E. from you, *i. e.*, between you and the shores of St. Domingo, which it is probably then ravaging; and you moreover see that for you it is a fair wind, by which you may safely and surely profit, hauling first a little to the southward, to be sure of a good offing from the more violent and dangerous part, and also to get room to keep away a little if the sea should be heavy on the S. Eastern quadrant of the cyclone, when the wind, as you see, will haul to the S. W." * Or, suppose a vessel from Europe bound to New York meets with a strong S. S. Easterly gale and falling barometer about the meridian of Bermuda, the seaman will discover by the tracks and by the use of his storm-card that he is on the eastern side of a cyclone, which is traveling towards him on an E. N. E. or north-easterly course, and that if he stands on he will inevitably encounter it. He has only to run off to the N. W. till he has brought the wind to at least E. N. E. or N. E. and he finds his barometer rising, and he has entirely eluded the centre of the cyclone. What is true for the northern hemisphere, if reversed, is true for the southern hemisphere, as has been expressed in the following unpoetic lines :—

"Your back to the wind will the centre define,
If you only consider the place of THE LINE.†
For North of it LEFT—or South the RIGHT hand,
Stick out like a sign-post and quietly stand;
And each points to the *Centre*, whose place you demand." ‡

* See Piddington's *Horn-Book*, p. 137.

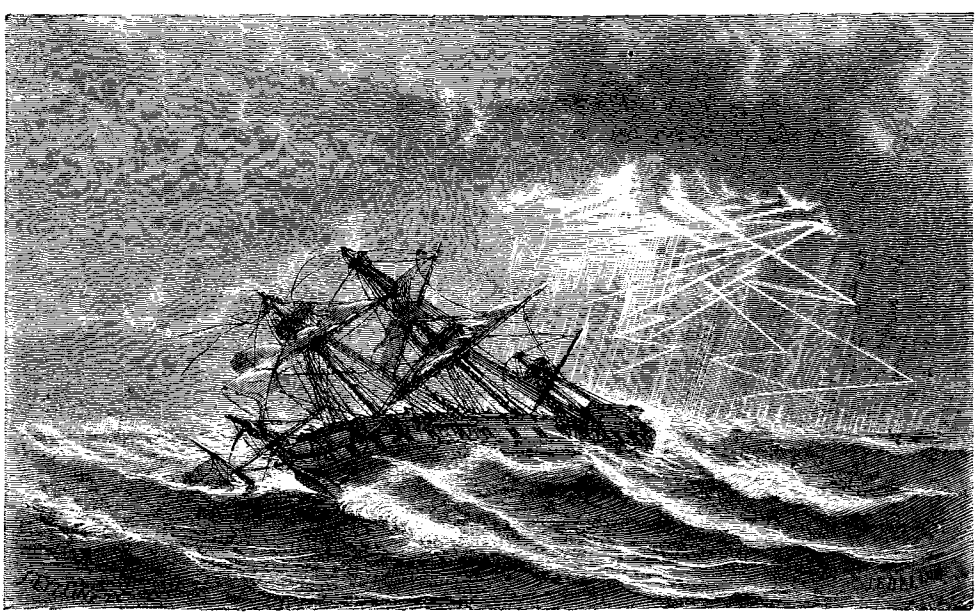
† Sailors call the Equator the Line.

‡ See a little work of Piddington's: *Conversations About Hurricanes*, p. 29.

We began our inquiries in this paper mainly to ascertain those dreadful movements of the atmosphere that every year, nay, at every change of the earth in its orbital position, bring desolation in their pathway and strew our lake coasts and our seaboard with hundreds of wrecks.

But we have already seen that the *sea*, whose surface is a uniform level, upon which the atmospheric currents meet no obstacles to deflect them from their wonted and lawful path, is the best field on which to study the laws of all atmospheric phenomena. Next to the sea, the *desert* of the earth, "*the sea of sand*," furnishes us with the most exact notions of the normal courses of winds and storms, when they are subjected to no deviation from ridges of mountains and the deep valleys between them. If, then, "the law of storms," as established by Redfield, be demonstrated for the ocean, it is good for the land also, provided we are careful to note the features and orographical peculiarities of any section of country, and thus determine the modifications of the law. This law of storms, we do not hesitate to assert, has substantially been demonstrated by evidence which, if we set aside as insufficient, by parity of reasoning we must also set aside Newton's demonstration of the earth's spheroidal shape, from the retardation of the pendulum at the equator. Indeed, we must cast contempt upon the whole Baconian system of inductive science. The law of storms stands emphatically on a basis of facts, and is an induction of many thousands of observations.

Striking instances of its application are countless. Mr. Thom quotes the case of a ship which, in the hurricane of 1840, at Mauritius, slipped with the gale from S. E., hove to and drifted from the island, but the next day was carried back by the N. W. wind, and thrown on the reefs at the entrance of Grand River, at the place she had left. The same year, in September, three ships—the *Golconda*, a British transport, with 400 souls on board; the *Thetis* of Calcutta, and the *Thetis* of London—met a double typhoon in the China seas. The *Thetis* of London, perfectly aware of her position, and her captain well acquainted with the law of storms, hove to at the right time and place, and sustained no damage. The second, the *Thetis* of Calcutta, ran on, evidently in ignorance, till she could run no longer, losing her mainmast, which in falling crushed her pumps, and she barely escaped going down. The third, the *Golconda*, ran up into the meeting-



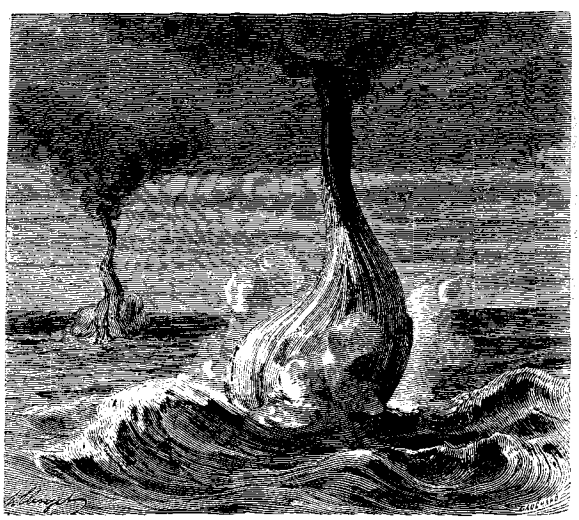
A HURRICANE.

FORMATION OF MARINE WATER-SPOUTS.

place of the two cyclones and almost immediately foundered.

During the progress of a cyclone near St. Croix, which was situated in the south or left-hand side of the storm's track, the veering of the wind was recorded by Mr. Andrew Long, who for fifty years had paid much attention to the West Indian hurricanes. The results were strikingly confirmatory of the law of the rotation of storms, showing the wind blowing round and in upon the centre of least atmospheric pressure. On the morning of the 28th of September the wind was N. E. (the usual trade-wind); at 4 P.M. it was N.; on the 29th of September, at 6 A.M., it was W.; at 10 A.M., W. S. W.; on the 30th, at 6 A.M., it was S.; on the 1st of October, at 6 A.M., it was S. E. It then shifted to the east, and on the afternoon of the 2d, to E. N. E. Observations from six other places all show that the wind veered in precisely the same way, *i. e.*, from N. E. to N., W., S., E. The ship *Mexican*, whose course during the storm was 200 or 300 miles north-east of Nassau, experienced the same proofs of the rotary character of the hurricane.

The Bahama hurricane of 1866 was in some respects most extraordinary. Our chart* is borrowed from Buchan's, and exhibits the barometric pressure and the direction of the winds at different places in the West Indies at 8 P.M. on the 1st October, 1866, when the centre of the storm was at Nassau. At this instant the barometer was 27.7 inches at Nassau, while at a distance of 286 miles it was as high as 29.7 inches; at Bermuda, St. Thomas, and Barbadoes, it was at the average height; but to the east, north-east, and north of Barbadoes, it was above the average height of that part of the Atlantic. These figures show such extraordinary fluctuations of the barometer as never occur beyond the tropics. In Great Britain the fall of one-tenth of an inch of barometric pressure in an hour is reckoned a large fall, such as only accompanies great storms; but during this storm, when the barometer was falling most rapidly, it fell at Nassau 0.700 inch from 4 to 5 P.M. The fall of the barometer became more rapid as the centre of the storm approached; but at the centre the pressure remained nearly stationary for a time during the lull which there prevailed, and before the barometer began to rise. Since at Nassau the lull at the centre



WATER-SPOUTS.

* See first of these articles in *Scribner's Monthly*, Feb., 1871.

lasted from 7.20 P.M. to 8.50, we learn, from the rate at which the whole body of the hurricane was carried forward, that the calm at the centre covered an area of at least 23 miles across. This calm may be considered as bounded nearly by the isobarometric 27.800 inches, in the centre of which the pressure was only 27.700 inches. Since ordinarily, within the tropics, the barometer rises and falls so little that it may be practically regarded as stationary, such enormous changes of the barometer are the more striking; they are so sudden that the eye, in looking at the mercurial column, can plainly see it falling, and they may be regarded as registering rather than foretelling the different stages in the progress of the storm.

During a cyclone off the Malabar coast, the barometer on board ship in the centre of the storm read 28 inches, while at Ootacamund, on shore, 100 miles distant, it read 30 inches, thus showing a difference of two inches in 100 miles.

At Mauritius, Mr. Meldrum laid down the path of a storm from the Mauritius observations alone, and on afterward receiving, from captains of vessels who had encountered the storm, a note of the latitudes and longtitudes, stated to their surprise when and where they had the storm, and the direction and veerings of the wind during its continuance. "In Mr. Meldrum's Storm-warnings scarcely a failure has occurred."*

That close and sagacious observer, General Reid, further tested this cyclone theory, by examining how far the great waves raised by storms agree with the supposed movement of the storm. "Whilst sailing on the borders of the tropic in the northern Atlantic," he says, "I have frequently watched the gradual change in the direction of the swell, supposed to proceed from the distant gales of wind, and it seemed to change in conformity to the usual progressive track of storms (*cyclonic*). When living in the Bermuda Islands, I was frequently interested by observing the change of direction in the surf which beat against their shores. A coming storm would roll its undulations so as to break upon the south and south-west side of these Atlantic Islands; and as gales proceed northward, the sea was seen breaking on their northern reefs."* The cyclonic motion of storms is further verified by common water-spouts.

We have now demonstrated the law of storms for the sea. One more link in the chain of thought and it is complete.

DOES THE LAW HOLD GOOD FOR THE LAND?

We believe that meteorological observations have shown that *generally* the law does hold good for the land as well as for the sea, and that, if this be true, *we have a solid basis for a system of storm-forecasts and storm-warnings*, and, as was lately said in an editorial of one of the first commercial papers of the country, "there is no science looming up with grander prospects of future results than that of storm-telegraphy."

It is true, exact observations have not been carried very far, but enough has been done to establish the application of the law of storms to the land. If this be questioned for some parts of the earth so boldly marked as the regions of Central Asia, with its towering summits, the Alps of Switzerland, and the lofty Andean States of South America, there can be little doubt as regards the comparatively level area of America east of the Rocky Mountains.

All that we do know of the storms that sweep over the land surface of the earth bears out this theory. In our hemisphere, as Fitzroy and others have long ago observed, "bad or worse weather usually follows shifts of wind *against* watch-hands, or with them in South latitude."

Tornadoes are probably cyclonic. In the Mississippi valley the tornado makes its clean road through the forest a few hundred yards broad, twisting enormous trees off by the roots. Lewis Back, an eye-witness of the great tornado in New Brunswick, June 19, 1835, stated that it was an unmistakable whirlwind.†

* Buchan, p. 341.

* Reid's *Law of Storms*, p. 32.

† The practical application of meteorologic information may be of great utility in the preservation of our houses. Thus, General Reid says:—"When a storm

Dust whirlwinds in India and Nubia are strikingly characterized by the "vorticose" motion. In one instance, carefully observed by Mr. Piddington, "the rotation," he says, "was according to the law for the Northern Hemisphere, and the incurving of the wind most distinctly marked by the dust."*

General Reid describes the great moving pillars of sand in the Nubian desert, as seen by Bruce, who at one time counted eleven of them together, and describes them as being 200 feet high, though only 10 feet in diameter, chasing each other in a circle.

But the character of land storms more conspicuously displays itself in the general storms which sweep over large tracts of country.

On the 2d of November, 1863, a large storm visited Western Europe. A chart giving simultaneous or synoptic observations, made at one hundred and forty places scattered over that continent, was constructed. This chart shows at a glance the atmospheric pressure, the direction and force of the wind at all these points at 8 A.M. The centre of this storm was in England, where the barometer was lowest, just as in the centre of an Atlantic cyclone. The arrows on the chart, representing the winds *exactly as observed at the different stations*, show that the general direction was as follows: W. S. W. and S. W. in the north-west and middle of France, in Belgium, and in Holland; S. E. in the north of England and south-west of Norway; E. and N. E. in Scotland and Iceland; N. in the west of Scotland and the north and east of Ireland; N. W. and W. N. W. in the west of Ireland and south-west of England.

"Thus," says the distinguished Secretary of the Scottish Meteorological Society, who compiled the observations, "the wind blew in all directions around the central patch of least pressure!"

It seems at the very time this storm was raging in Southern Europe, another prevailed in Lapland and the north of Norway, which was marked by the same cyclonic or rotary characteristics.

Mr. Buchan, again speaking of the behavior of the two storms, says: "From this it follows that in these cases the wind blew round the area of low barometer in a circular manner, and in a direction contrary to the motion of the hands of a watch, with—and be this particularly noted—a constant tendency to turn inwards towards the centre of least pressure. It will be observed that the greater the force of the wind was at any place, the more nearly was the direction here indicated approximated to; and that where the direction showed any material departure from the general law, such winds were light, and consequently more under local influences which tend to turn them out of their course. Hence in these storms the winds circulated round the region of least pressure; or, to state it more accurately, the whole atmospheric system appeared to *flow in upon the* CENTRAL *area of low pressure in an in-moving spiral course.* This peculiarity is common to all European storms I have yet examined, and it should be particularly noted that it is no mere theory or opinion, but a simple statement of what has been constantly observed."*

Professor Loomis, in his invaluable work on Meteorology, has given a similar chart of the European storm of rain and snow of December 25th, 1836, which repeats the cyclone at sea in a most striking manner,†—the wind moving against the hands of a watch and around the centre of low barometer.

He also gives the American storm of February 16th, 1842, which is even more perfectly cyclonic.

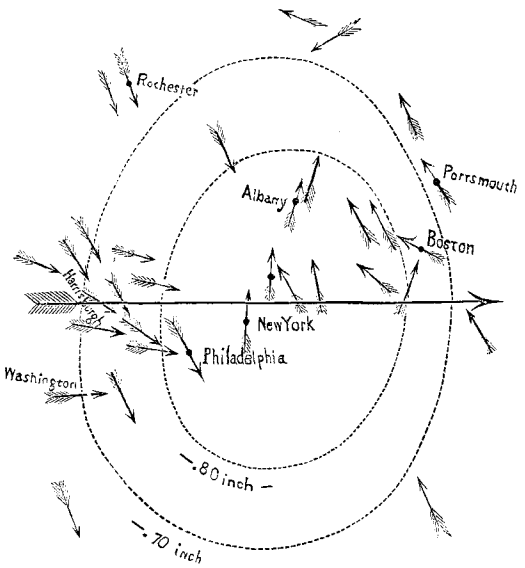
In the diagram of this storm, the smaller oval shows the area within which the barometer sunk eight-tenths of an inch below the mean, and the larger oval shows the area of seven-

comes from the East, it will set in at Barbadoes with the wind at north. When it comes from the south-east, it will set in at Barbadoes with the wind at north-east. The north-east and north sides of houses are, therefore, the sides which should be first barricaded, whilst the opposite doors and windows may be safely left open. They should be barricaded in succession, according to the way in which the wind veers round. The same rules apply to the other windward West India Islands."

* Piddington's *Horn Book*, p. 299.

* Buchan, p. 252.

† See Loomis' *Meteorology*, pp. 141, 142.



AMERICAN STORM, FEB. 16TH, 1842.

tenths in barometric depression. The short arrows show direction of wind.

In making this statement, the intelligent reader will reflect that the axial rotation of the earth from west to east would conspire to cause the winds to flow in and round upon the centre. No doubt they assist in forming the revolving storm. But the point here aimed at is to show that there is a *rule in the behavior of our continental storms*, as in that of ocean hurricanes.

The rotation of the globe, while it may explain the *ordinary* circulation of the winds over any country, as Europe or the United States, cannot explain the *extraordinary* phenomena of the atmosphere. And we are shut up to the conclusion that the violent rotation of these continental storms proves their cyclonic origin and nature.

In an able paper read before the Board of Trade by Mr. William Stevenson, of Berwickshire, England, the well-known meteorologist, he says: "The storms which pass over the British Isles are found generally to act in strict accordance with the cyclonic theory." *

This view of the cyclone, rising in the equatorial ocean and extending with its ramifying offshoots into every corner of the temperate zones, is eminently in keeping with the apparent design of the Meteor. The storm is as much a part of the terrestrial machinery—a wheel in the atmospheric engine—as the Trade Wind or the Gulf Stream. It is necessary to supply the earth with aqueous vapor * and all those electric and hygrometric phenomena that follow in its track. It is necessary that the cyclonic movement should penetrate into the heart of the broadest continent, in order to accomplish its appointed mission and fulfil its lofty functions.

The surface of the country in England is comparatively so level that it does not destroy the cyclone. In the United States, east of the Rocky Mountains, the law of storms doubtless in many instances prevails, and will continue to prevail, unless in some throe of nature a Himalayan chain of mountains be upheaved to intercept the regular winds and to divert the storm from its ordained pathway.

We may therefore conclude, that while local storms may be governed by local causes, the law laid down by Mr. Redfield holds good for general storm-warning purposes.

THE ORIGIN OF CYCLONES.

The Chinese call the island of Hainan "*The Typhoon Mother*," and we may give such a name to the Windward Antilles.

Hainan lies in the midst of a great volcanic basin, and the West Indies lie in the embrace of one of those fiery arms spread forth by the

* Report of the Meteorological Department of Board of Trade. 1862.

* "The climates of different countries," says General Reid, "may be influenced by the storm-tracks; and this is a very interesting part of meteorology to be pursued. The moist climate of the west coast of England, and more especially of the west coast of Ireland, is no doubt in part owing to the many Atlantic whirlwind gales which infringe on these coasts. The extreme dryness of other countries may likewise be in some degree owing to storms being arrested in their course by very high mountains." The Cordilleras of South America lying eastward of Peru and Chili, by arresting the whirlwind gales, cause their drought; the Abyssinian thus render Egypt dry; and the Himalayan mountains, by arresting Indian storms, render the regions north of them arid and unprofitable.

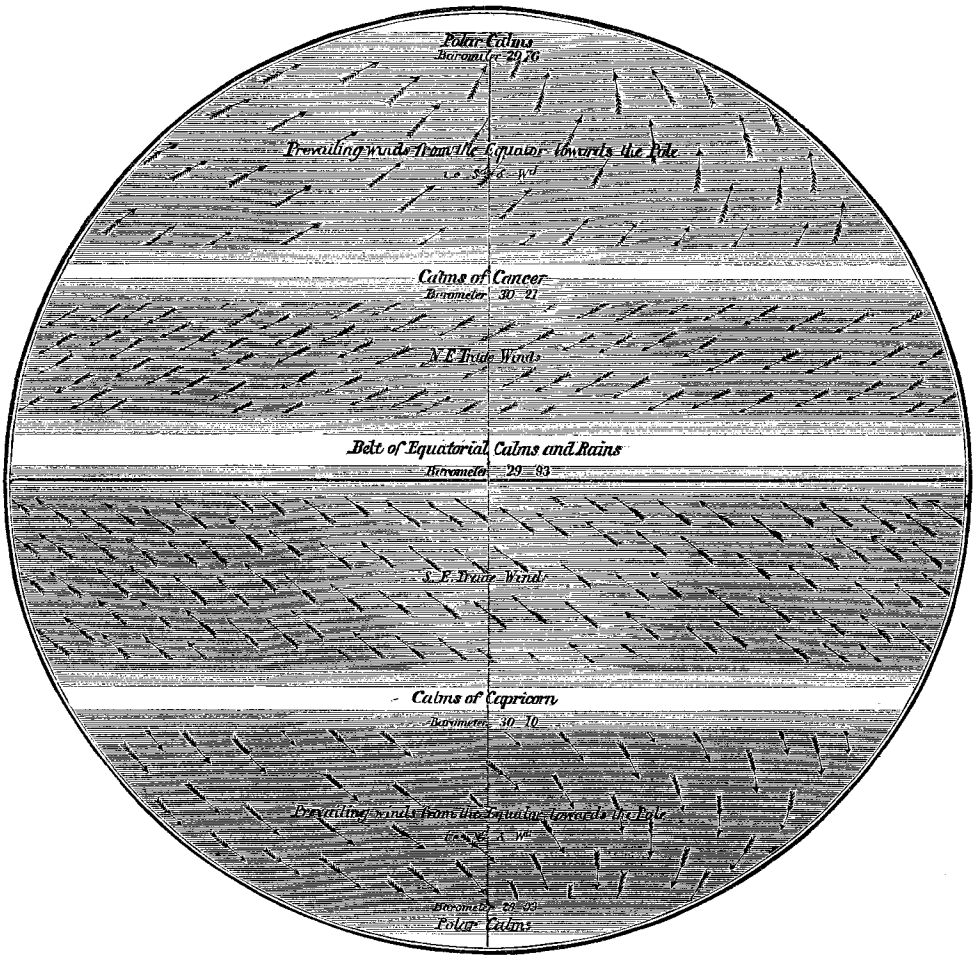


DIAGRAM OF THE WINDS. (ARROWS FLY WITH THE WIND.)

vast volcanic region described by Dr. Gerald Malloy, which stretches from Tierra del Fuego along the Andes through California, as far as the Columbia River.

To comprehend the origin of cyclones, we are forced to revert to what has been advanced with regard to the Trade-Winds. Theory points to the fact that the atmosphere brought by the Trade-Winds to the Equator flows back towards the poles (after rising to great altitudes) *as an upper current.* The existence of this upper or poleward current of air has more than once been distinctly proved, and the points or parallels of latitude where it passes another current *from* the pole has been distinctly observed on various parts of the earth's surface. The level at which this return Trade Wind moves in the equatorial regions is so elevated that no observer has distinctly marked it, even on the loftiest summit of the Andean Cordilleras. But the phenomenon has been distinguished by unmistakable occurrences. On the night of April 30th and May 1st, 1812, explosions as if of heavy artillery were heard at the island of Barbadoes, and the British garrison at Fort St. Anne was put under arms. At dawn on the 1st of May the eastern part of the horizon was clear, while the remainder of the sky was enveloped in a black and portentous cloud. The darkness soon became general, and of such a pitchy intensity that it was impossible to

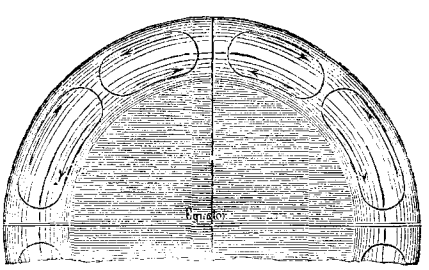
distinguish the windows in the houses, and the sugar-cane, and even some of the stoutest trees, groaned and gave way beneath the loads of ashes showered upon them from the overhanging cloud. The awe-stricken inhabitants questioned and wondered whence came these ashes. In the months of April and May, the North-East Trade-Wind in the latitude of Barbadoes is at its height, and every one supposed that the ashes had come from the volcanoes of the Azores. It was afterwards found they had not then been in eruption. The true source of the ashes was the crater of Morne Garou, in the island of St. Vincent, lying 100 miles west from Barbadoes — a point from which it is impossible for ships at this time to reach Barbadoes, except by sailing in a very circuitous route, in consequence of the direction of the Trade-Wind. The ashes of the volcano had been ejected upwards with great violence through the *under* or surface Trade-Wind, and had passed into the *upper* or return current, which took them to Barbadoes.

Again, on the 20th of January, 1835, the entire isthmus of Central America was convulsed by an earthquake which followed the eruption of the volcano of Coseguina, lying on Lake Nicaragua. So fearful was the eruption that the sounds were heard at Santa Fé de Bogota, at a distance of a thousand miles; and the cloud of ashes was so dense that Union, a seaport town on the west coast of the Bay of Conchagua, was draped in total darkness for forty-three hours. Ashes also fell at Kingston, and at other places in Jamaica, so that the inhabitants thus learned that the explosive reverberations they had heard were volcanic, and not artificial. Jamaica lies nearly 800 miles north-east of Coseguina. On the very day that this island received the volcanic shower, which could not have been borne to it except by the upper or counter Trade-Wind, the English ship *Conway*, sailing 700 miles to the *south-west* of Coseguina, and in the Pacific Ocean, received on her sails and decks a similar and thick shower of ashes, borne in the contrary direction by the regular under Trade-Wind.

The conclusion naturally drawn from these facts has often been confirmed by travelers while visiting the majestic cone of Teneriffe, rising 12,358 feet, in the Canary Islands.*

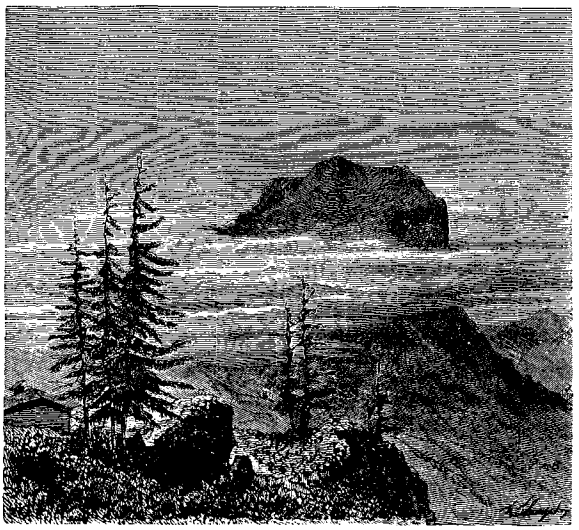
Humboldt ascended the peak on the 21st of June. When he reached the edge of the crater he could scarcely keep his feet, such was the violence of the west wind. (Relat., 1., p. 132.) George Glass, an accurate observer, says, from much experience on the peak :—"A strong westerly wind is constantly blowing at the highest points of these islands during the prevalence of the north-east wind below." Beyond all doubt it is this very wind that sailors look for and generally find on the summer voyage from Teneriffe to England, and which makes them call the voyage from New York to England sailing *down hill*, and the returning, sailing *up hill*.

Humboldt, Piazzi Smith, Tyndall, and many other visitors of the peak of Teneriffe, tell us that at its base, while the surface Trade-Wind blows from the north-east, the wind at the summit is simultaneously from the south-west. So also it has been found that on the volcano of Mauna Loa, rising over thirteen thousand feet in the Sandwich Islands, during the prevalence of the north-east Trade-Wind at the base, the summit is swept by the wet south-westerly counter trade from the equator. Indeed, as Halley long ago (1686) pointed out — "The north-east Trade-Wind below will be attended with a south-westerly above, and the south-easterly with a north-westerly



THEORY OF UPPER AND LOWER TRADES.

* Leopold von Buch, speaking from his own experience, says :—"Even throughout the summer, when the North-east Trade-Wind was blowing with the greatest violence at the sea-level, the peak of Teneriffe is high enough to reach the upper current even at midsummer. It is hard to find an account of an ascent of the peak in which the strong west wind which had been met with on the summit is not mentioned."



A CLOUD STRATUM BELOW A PEAK.

above. That this is more than a bare conjecture, the almost instantaneous change of the wind to the opposite point, which is frequently found on passing the limits of the Trade Winds, seems to assure us." *

If we can but unravel the mystery of the West India cyclone we can then understand the American storms, which, as we saw in the first article, are born in the Antilles.

Now it is an established fact, that the West India hurricanes rise at the inner edge or on the equatorial side of the belt of north-east Trade Winds, in the so-called region of Equatorial Calms. Along this inner edge of the Trade Wind Zone, the air brought by the Trade Winds is moist and light, and hence ascends and flows away in the upper strata in a direction opposite to that of the surface Trade.

The hurricane, or cyclone, may therefore be explained in one of two ways. The two opposing Trade-Winds are not, perhaps, the only atmospheric forces that may be present within the tropical zone. According to Prof. Dové, a *third* and potential force intervenes, in the form of a *high atmospheric movement in the tropics, from east to west.* This may be accounted for, perhaps, just as we account for the *counter equatorial* drift-current in the Pacific Ocean (which runs from west to east, while the main current runs from east to west), and all those counter-currents or drifts which, as you may see by glancing at any good chart of oceanic phenomena, are always found alongside of the regular ocean streams. Or the high easterly atmospheric movement may be explained, as Prof. Dové has explained it, by the high readings of the barometer in the North Atlantic Ocean, as seen at the Canary Islands, and the high readings in the whole north-east Trade Wind belt, compared with those in the south east Trade-Wind belt, as seen in the Diagram of the Winds.

The ashes from Coseguina, already alluded to, were carried to the *Conway*, but in a direction more decidedly westward than the surface trade-wind would have borne them. They must have received an impulse from a cross current, or one flowing nearly at right angles to the upper trade in a direction from east to west. It is well known, too, that there is in the North Atlantic a frequent and heavy fall of red dust, which is supposed to come from Africa. This dust rises to such a height that Piazzi Smith, as quoted by Dové,* found it on the Peak of Teneriffe, at a level of 10,700 feet above the sea, to obscure the sun before he sank at evening into the stratum of clouds below.

"Such a current as this," says Professor Dové, "must have a tendency to interfere with the free passage of the upper or counter trade-wind on its way to the tropic, and to force it down into the lower or direct trade wind, and the point where this intrusion takes place must advance at the same rate as the upper cross-current, which produces it, moves forward from east to west. *The interference of a current flowing from east to west, with another which is flowing from south-east to north-east, must necessarily generate a rotary motion, and in a direction opposite to that of the hands of a watch.*" According to this view, the cyclone, which advances from S.E. to

* *Philosophical Transactions*, 1686, p. 167.

* *Law of Storms*, p. 188.

N.W., in the under trade-wind, represents the advancing point of contact of two other currents in the upper strata which are moving in directions at right angles to each other. "This is the primary cause of the rotary motion, and the further progress of the cyclone will necessarily follow."

But this explanation cannot be regarded as clear and satisfactory, or, at least, as more than plausible and ingenious. Its author, the great physicist of Germany, is himself not confident of its soundness. This is not the place to discuss it. But it may be remarked the solution does not take in nor does it cover the grand and universal phenomena in question. If it explains the West India hurricanes, what light does it cast on those of the East Indies?

I believe it can be demonstrated that the origin of cyclones is found in the tendency of *the south-east trade-winds to invade the territory of the north-east trades, by sweeping over the equator into our hemisphere.* Such an

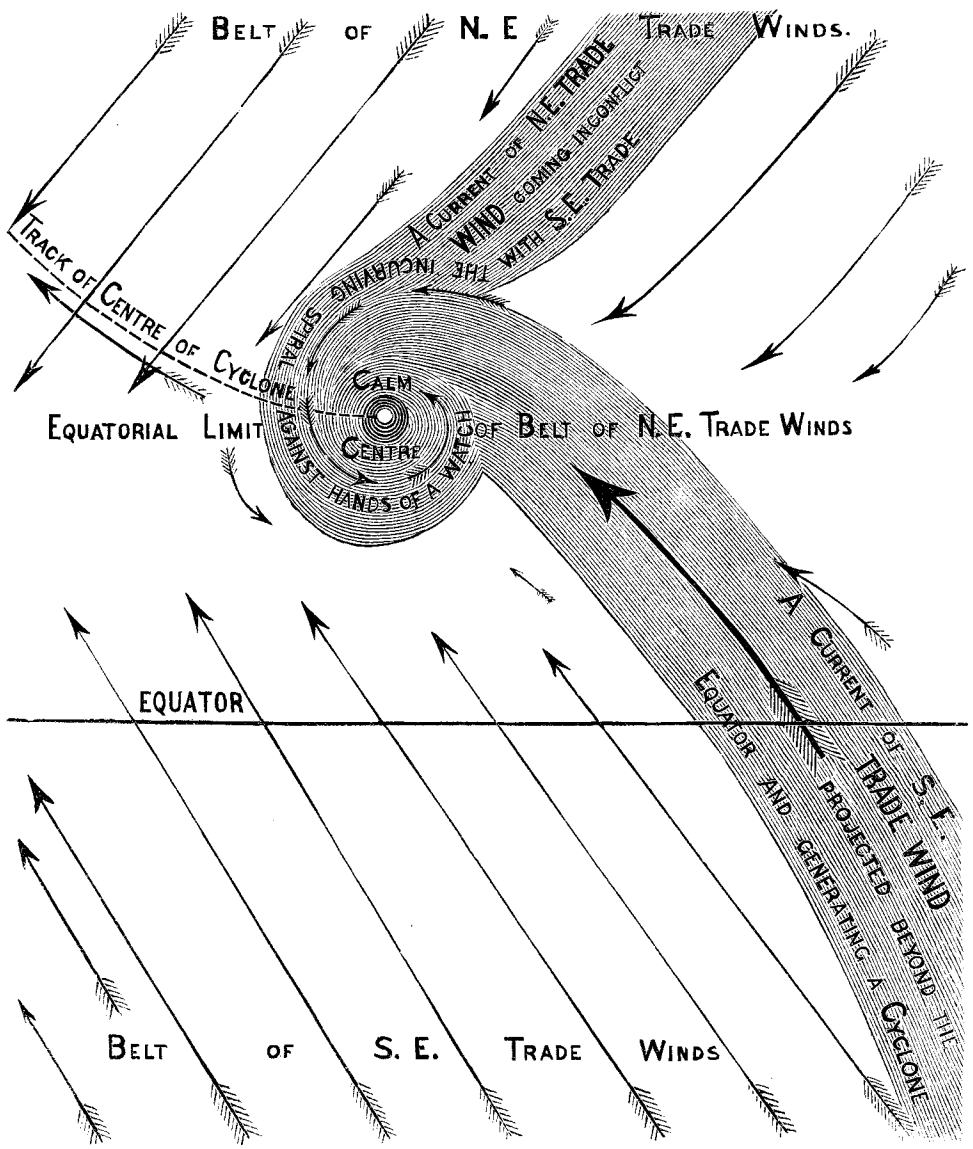


DIAGRAM ILLUSTRATING THE GENERATION OF A WEST INDIA CYCLONE.

irruption will explain the phenomena of the cyclone, and explain them more naturally than does Dové's abnormal upper wind moving from east to west. It is a well-known fact that the S. E. trade-wind belt is broader than that of the N. E. trades, and that the S. E. trades blow with more freshness and vigor than the latter. (See Diagram of the Winds.) So strong and steady are these winds from the Cape of Good Hope to Cape St. Roque, the most easterly cape of South America, that sailors call the direct ship track "*The Gulf Stream in the Air.*"

This solution of the origin of cyclones is further and strongly borne out by the fact mentioned by all writers, but strongly expressed by Sir John Herschel: "Cyclones originate between the tropics, and run outwards from the equator towards the poles. But *on the equator itself they never occur.*"* (Italics his.)

As far as I am aware, there is also a feebler and rarer manifestation of cyclonic phenomena south of the equator than north of that line. Ansted distinctly states: "The southern trade-wind region is much larger than the northern in the Atlantic Ocean. In this sea the south-east trades are fresher, and blow stronger than the others, and often reach to the tenth or fifteenth parallel of north latitude; whereas the northern trade-wind seldom gets south of the equator, and usually ranges from 9° to 29° north latitude."†

Now, if we regard the average velocity of the south-east trades as compared with that of the north-east trades, we shall find, according to the laborious researches of the National Observatory, that "the velocity of the north-east trades is from 14 to 18 miles per hour, that of the south-east from 25 to 30 miles an hour." Add to this the yet more significant fact, from the same authority, that "*The force of the trade-winds (S.E.), as determined by the average speed of 2,235 vessels sailing through them, is greater between 5° and 10° south, than it is between 25° and 30° south,*"† and we have what amounts well-nigh to a demonstration, that the south-east trades do overleap the equator and generate cyclones.

If any further proof be needed that such is the origin of the West India hurricanes, it is found in a statement of Commodore Thornton A. Jenkins, Chief of the U. S. N. Bureau of Navigation, which agrees with all other accounts, that, "in the West Indies, the great storms called *cyclones* are almost exclusively confined to the months from July to October, being most common in the month of August; in the China Sea and Bay of Bengal they are most prevalent about the same period of the year. In southern latitudes they are most common from January to March." (See Commodore Jenkins's *Weather Guides*, p. 16.)

Commodore Jenkins also makes another statement in this connection, which is generally found in writers on the West India hurricanes, that "it has been found that the West India Islands cyclones first make their appearance completely developed at the Windward Islands." Fitzroy mentions one or two exceptions of cyclones encountered east of Barbadoes. Nearer the coast of Africa, sailors meet a monsoon blowing towards the African coast, which they call the "West Monsoon of the Line."

These facts, it need hardly be said, strikingly harmonize with the theory I have advanced, which makes *the intruding south-east trade-winds the cause of the West India cyclone.* From January to March, the trade-wind belts being depressed below the Equator, because the sun is in declination, the cyclone would of course be diverted to southern latitudes, and would move *with* the hands of a watch. In the Bay of Bengal the typhoon would follow in August, from the conflict of the two lateral currents of the south-east trade, and the north-east trade enfeebled by the counter monsoon influence. It is, doubtless, this *enfeebling* of the north-east trade that renders it an easier prey to the impact of the south-east trade; and this explains the violence of typhoons, which is greater than that of West India hurricanes.

Dové himself admits that the phenomena of the cyclone are explained, "if we assume that a portion of south-east trade-wind travels far over the Equator into the northern hemisphere." He adds: "The observations from New Mexico and California exhibit such an

* Herschel's *Meteorology*, p. 67.

† Ansted's *Physical Geography*, p. 253.

absence of rain in summer, that circumstances of relative dryness, similar to those in the deserts of the Old World, seem to exist. It is possible that this district may exert an attractive action on the south-east trade-wind, analogous to that which, on a much greater scale, gives rise to the south-west monsoon in Asia." *

The intrusion of the south-east trade-winds into the area of the north-east trade-wind satisfies all the conditions of the cyclone problem, and is, therefore, THE TRUE SOLUTION OF THE ORIGIN OF OUR CYCLONES.

It thus appears that storms are produced by the mutual lateral interference of two currents flowing in opposite directions. "If the polar atmospheric current," says Dové, "gives way in high latitudes to the equatorial current, which is nearly due *west*, the former will gradually veer round to the *east*, and we shall have in the north of Europe mild weather, with westerly winds; while in the south it will be very cold, with easterly winds;" and he cites the remarkable winter weather of January, 1855, to substantiate it. Throughout the whole of Prussia and Austria the winter set in with a high temperature, high winds from the west and northwest, and heavy falling weather. On the 1st of January the storm began. Between Siberia and Hamburg it was accompanied with thunder and lightning. Part of the island of Wangeroge was washed away by the violence, and the embankment along the north coast of Germany quivered at the furious lashing of the waves.

The storm was at its height, at Vienna, at 9 A.M.; at Berlin, at noon. In the forest of Lambach, near Kremsmünster, at 2.15 P.M., 30,000 trees were blown down in the space of about 1,000 acres. In Jaslo, on the morning of the 2d, the roof of the court-house was stripped off, and at Frankenau, men and laden wagons were blown down. In Zara there was a calm. The temperature of the latter half of January and February was unusually low. A letter written at this time from Greenland, says: "We had such fine warm days in February (which was desperately cold in Europe) and March, that we were almost tempted to ask if we were really in Greenland."

On the very day (Jan. 1st, 1855) that this cold current forced its way into the warm atmosphere of Europe, a southerly current forced its way to the northward in California. On that day, in the vicinity of New York, the barometer read 0.53 above its mean level; at Norfolk and Charleston it was 0.27 above the mean, while at San Francisco its level was unusually low (29.13 inches), and there was a hurricane from the southwest! At Benicia there was a similar storm, and the barometer stood 0.62 below its proper level.

The ablest and most accurate observers have frequently noticed that storms which have traveled over Europe have been succeeded by storms in America, or that the latter have preceded the former, and have suggested a connection between them as due to a common disturbance.

The suggestion is forcibly sustained by the statistics of rain-fall. The years 1857–'58 were so remarkably dry throughout Central Europe that the Seine in Paris was lower than it had ever before been, and portions of the bed of the Rhine were left dry as never before. During the same period the level of Lake Ontario was two feet higher than its mean level, as determined by fourteen years' observations. "It is not improbable," as Dové has suggested, "that the storms of the United States, which blow from the foot of the Rocky Mountains between November and March, and are preceded by a rise of the barometer, *equilibrate* the warm currents which advance from southwest towards northeast, accompanied by a rapid fall of the barometer, which traverse Europe at the same period." *

The irruption of the cold air of the polar current into the warm and rarefied air from the Equator is, doubtless, the fruitful source of storms. It was the violence of one of these polar currents, as it came in collision with a tropical current off the British coast, that, in October, 1859, overwhelmed the "Royal Charter," a vessel whose fate will ever be the study of the meteorologist. This irruption may be compared to the sudden and unseasonable drifting of an immense iceberg into an atmosphere comparatively mild, producing

* Dové's *Law of Storms*, p. 265.

* *Law of Storms*, p. 269.

atmospheric disturbance such as we have supposed the south-east trade, if projected into the northern hemisphere, would produce. That this is not mere theory appears from the following extract of a report of the weather at Iceland last winter, kindly sent me a few days ago by Commodore Sands, Superintendent of the National Observatory :—

EXTRACT FROM JOURNAL OF SCOTTISH METEOROLOGICAL SOCIETY.—April, 1870.

"*Correspondence with the Society's Observers at Stykkisholm, Iceland.*

"The unusual arrival of Spitzbergen ice in November occasioned pretty severe frosts, which continued to about 22d December, 1869. After this date milder weather set in, particularly during February, 1870, when the snow and ice completely melted away, and the low country generally began to look green. At the close of the month strong frost set in, accompanied with a slight fall of snow. There occurred a great hurricane December 12, 1869.

"The barometer fell to the lowest point, 28.950 inches, about 6 A.M. ; it began to rise at 7 A.M., and rose rapidly afterwards, as soon as the storm began to abate.

"This storm was the severest that has appeared at Stykkisholm in the memory of man."

We dare to go a step further, and to argue that the great American storms which do not come from the Gulf of Mexico and the Gulf stream cyclones, are generated by the lateral interference of a current of Polar air and a current of Equatorial air. Such an interference, when we consider the earth's rotative influence on the two currents, would evidently produce a cyclonical storm, precisely as the intrusion of the south-east trade-wind beyond the Equator, and its interference with a north-east trade (see diagram) generates the West India cyclone. Allowance of course must be made in the heart of our Continent for the *diverting* power of our mountains. The rotary storm generated by an interference of a Polar and an Equatorial current in the north-western regions of the United States would naturally be flattened and made oval by striking against the wall of the Rocky Mountains, and would thus advance towards the Lakes *side foremost, i.e.*, the storm covers a greater area in a direction north and south than in one east and west. This is exactly what Buchan, Blodget, R. Russel, Espy and others tell us takes place in the storms which reach the Lakes and the Valley of the upper Mississippi from the Rocky Mountains.*

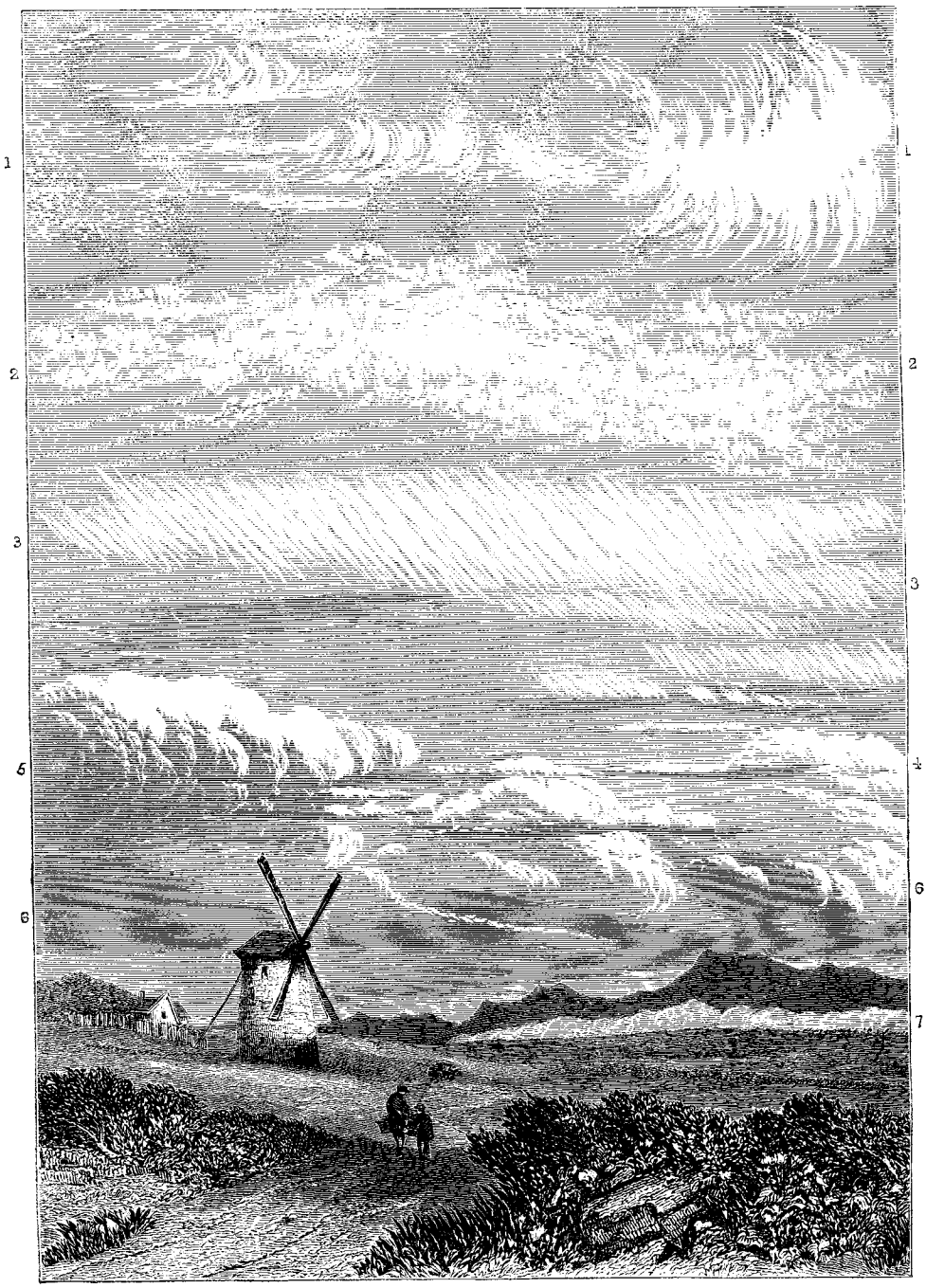
There are no doubt severe local atmospheric disturbances which do not partake of the cyclonical character. But there can be no doubt that normally, and except as affected by the land, whether born in the Tropics *or generated by interference of polar and tropical air currents in high latitudes*, ALL GREAT STORMS ARE CYCLONICAL.

PREMONITIONS OF STORMS.

The indications of the barometer, the sympiesometer, and the other great inventions of mechanical meteorology, which we shall presently describe, are the main reliances of storm-science, but they do not afford the only premonitions of storms. The cautious meteorologist has many sources of information besides his instruments; and, if wise, he will listen to the monitions which so often rightly guide the rudest peasant or the roughest tar.

The poet Virgil saw in the bird, as his countrymen were wont to do, an augur and a prophet of the mutations of weather. "A being eminently electrical, the bird," says Michelet, not without reason, "is more *en rapport* than any other with numerous meteorological phenomena of heat and magnetism, whose secrets neither our senses nor our appreciation can arrive at. He possesses, as it were, a kind of physical prescience. What more natural than that man, whose perception is much slower, and who does not recognize them until after the event, should interrogate this instructive precursor which announces them? Meteorology especially may derive hence a great advantage. It will possess the surest means, and already it has found a guide in the foresight of birds. Would that Napoleon, in 1812, had taken note of the premature migration of the birds of the North! From the storks and cranes he might have

* See Blodget, p. 381. "A noteworthy difference which exists between the storms of the two continents (Europe and America) is that in America they appear to have an elongated form and advance towards the east *sideways*—that is, the longest diameter is at right angles to the onward course of the storm."—Buchan, p. 264.



CLOUDS.

1. Cirrus. 2. Cirro-Cumulus. 3. Cirro-Stratus. 4. Cumulo-Stratus 5. Cumulus. 6. Nimbus. 7. Stratus.
(See Figures at sides.)

secured the most trustworthy information. In their precocious departure he might have divined the imminency of a severe and terrible winter. They hastened towards the South, and he—he remained at Moscow!" * May we not heed the suggestion of the same brilliant naturalist, when he tells us that in the midst of the ocean, the weary bird which reposes for a night on the vessel's mast, on the following morning resumes his flight without hesitation, choosing on the immense and trackless abyss the exact course which will lead him whither he wishes to go.

With no chart or compass, "no landmark, no guide, the currents of the atmosphere alone, or those of the water, perhaps, also some invisible magnetic currents, pilot the hardy voyager." †

The vegetation of a country furnishes another class of dumb but credible guides in the study of its meteorology. It is said by pioneers of the forest, that, in our hemisphere, knowing that the moss delights in shady places, they borrow the custom of the Indian, and find their way at midnight through unfrequented woods by feeling the moss on the northern side of the trees. "In every country," says Fitzroy, "the bark of trees and vegetation indicate the prevalent winds." If the wind blows constantly or chiefly in one direction in any country, the windward side of it is apt to be crowned with vegetation, while on the other side there is scarcely a shrub or a flower. This is the case in Peru, Patagonia, some portions of Arabia, Africa, and on many islands. In some places, wind carrying moisture affects one side of a hill or mountain chain, and does not affect the other. England and her sister isles receive westerly and southerly winds for about three-fourths of the year, producing a contrast very marked,—Ireland, the most windward, receiving the greatest amount of tepid vapor from the Gulf Stream, and thus obtaining the name of the "Emerald Isle." Some vegetation, however, as at Madeira, avoids the salt-bearing winds. At this little island the prevailing atmospheric currents are from the north-east; but the vintage which yields the celebrated Madeira wine is found at South Point, on the south-west coast.

Since rainbows in the morning, seen in the west, foreshadow the approach of a cloud of rain from the west, and when seen in the evening show a clearing up in the west, they have given rise to the popular prognostic—

> "A rainbow in the morning—
> Sailors, take warning;
> A rainbow at night
> Is the sailor's delight."

Another premonition of an approaching gale is afforded to seaport towns by the agitation of the ocean and the disturbance of its slimy bed. "The muddy appearance of the water in the sea, in anchoring depths, during violent storms," he says, "sometimes precedes the storm, being caused by heavy undulations affecting the bottom of the sea. This effect was remarkable around the Bermuda Islands in September, 1839, a day before the actual arrival of the tempest." *

Clouds are of the utmost utility in foretelling weather, especially the *Cirrus*, *Cirro-Stratus*, and *Cumulo-Stratus*.

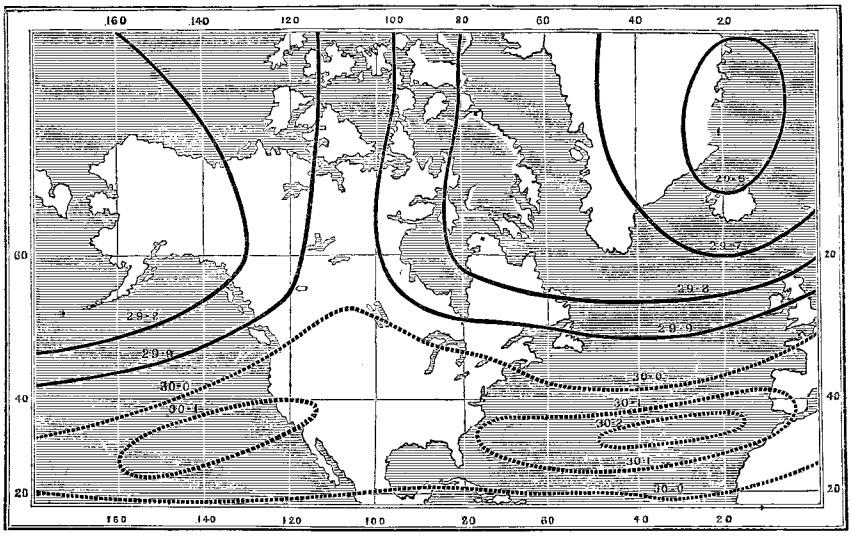
The Cirrus, called by sailors "*Cat's tail*," and sometimes by others the "*Curl cloud*," is made up of wavy parallel or diverging fibres, or slender filaments like white lines penciled on the blue sky. It is probably composed of minute snow-flakes or ice-crystals. Its movement is a fine index of the great atmospheric currents, and it is thus a valuable prognostic of stormy weather. It doubtless often reaches a height of ten miles above the earth. When the fine threads of the Cirrus appear blown or brushed backward at one end, as if by a wind prevailing in these lofty regions, the wind on the surface will sooner or later veer round to that point.

The Cirro-Stratus, partaking of the form of both the Cirrus and Stratus, Buchan says, "is markedly a precursor of storms; and from its

* Michelet's *Bird*, p. 183.

† Even the Stormy Petrel, "Mother Carey's Chickens,"—the bugbear of sailors,—if they really prognosticate stormy weather, may and probably do come up before a gale for shelter, being able, by their rapid flight, to outstrip it. Their behavior and movement might, if carefully interpreted, furnish a clue to the seaman for escaping from the approaching tempest.

* Reid's *Law of Storms*, p. 42.



ISOBAROMETRIC LINES, SHOWING, IN INCHES, THE MEAN ANNUAL ATMOSPHERIC PRESSURE FOR UNITED STATES.

greater or less abundance and permanence, it gives some indication of the time when the storm may be expected."

The Cumulo-Stratus is distinctly formed just before rain begins. It is the forerunner of the lurid display of the thunder-storm, as Tennyson has painted it :—

> "The wild unrest that lives in woe
> Would dote and pore on yonder cloud,
> That rises upward always higher,
> And onward drags a laboring breast,
> And topples round the dreary west,
> A looming bastion fringed with fire."

The "pocky cloud" is an almost unerring storm-warning. If clouds be *red* and *lowering* in the morning, the red color arises from a large amount of vapor in the vesicular state, when, as Forbes has shown, the blue rays of light are absorbed and the yellow and red rays pass. This gives rise to the weather proverb—

> "The evening gray and the morning red—
> Put on your hat or you'll wet your head"—

and may sometimes prove ominous of a storm.

The approach of the "Northers" of Texas and Mexico is generally indicated, as an eminent observer tells us, by,—"First, a general humidity of the atmosphere. Secondly, the peak of Orizaba mountain visible and clear, the lower parts only being enveloped in dense, hazy clouds. Thirdly, the distant mountains, far inland to the south-east, exceedingly clear, together with excessive heat and depression in the animal kingdom."

Prof. Brocklesby has well pointed out the additional and important fact that the top of the storm always *impends* — overhangs — the track on which it is advancing, because the base of the storm is retarded by friction with the earth's surface. This is of great significance, as always enabling the close observer to give warning. This is more easily done, from the fact that the front of most storms is marked by a *moist*, warm atmosphere.

In the Northern parts of the United States, according to Prof. Espy,* the wind in great storms generally sets in from the north of east, and terminates from the north of west; while in the Southern parts it generally sets in from the south of east, and terminates from the south of west. With these facts before him, the observer is ready to understand his instruments, and no meteorologist should depend on his instruments alone. Great changes of weather or storms are usually shown by falls of barometer exceeding half an inch, and by differences of temperature exceeding fifteen degrees. *A tenth of an inch* in an hour is a fall presaging a heavy storm or rain. The more rapidly such changes occur, the more

* See Espy's invaluable *Fourth Meteorological Report*, p. 10.

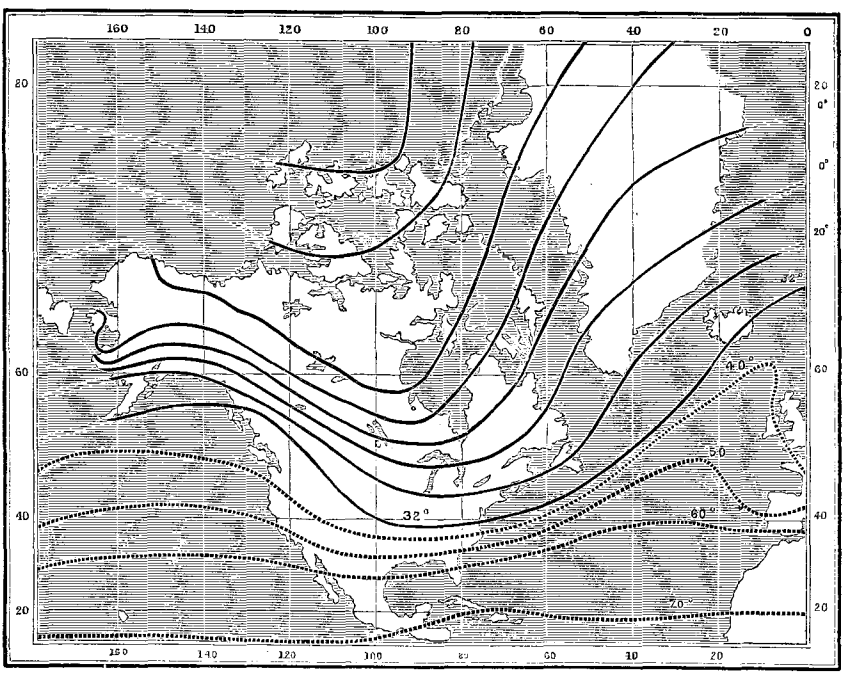
probable a violent atmospheric commotion. To understand the fluctuation of the barometer, we have only to compare it with its normal height for the time, and so with the thermometer. This may be done *generally* by examining an isobarometric chart, which gives you the lines along which the barometer ranges the same number of inches in clear weather, and the isothermal chart, showing the line of equal temperature. Barometers show the beatings—the pulsations of the atmosphere, and their diagrams express to practised observers, to use the words of Admiral Fitzroy, "what the 'indicator-card' of a steam-cylinder shows to a skillful engineer."

We have said nothing of the *electric* disturbances and *magnetic* storms which indicate the approach of the great tempests. Nor have we room to discuss the question. M. Marie Davy, Chief of the Meteorological Division in the Imperial Observatory, Paris, who has for some years made this a special study, states that "the perturbations of the magnetic needle are inseparably joined with one or more of the three following phenomena:—1. General disturbances of the telegraphic lines—due to wide-spread auroras, which mark general movements of the atmosphere in high latitudes and over the Atlantic. 2. Disturbing currents of a more local character, occurring over the telegraphic lines *some time before the storm appears* to which they owe their origin, *thus lengthening the distance and time at which the approach of the storm may be perceived!* 3. Disturbing currents, still more restricted, accompanying the electric changes when the storm itself is passing."* *Blood-red streamers* of aurora crossing the sky, and meteoric and electrical exhibitions preceded the gale in which the "Royal Charter" went down. If we could have more magnetic and meteorological observatories, as Buchan suggests, the magnetic and electric states of the atmosphere and auroras might be made our most valuable prognostics of storms.

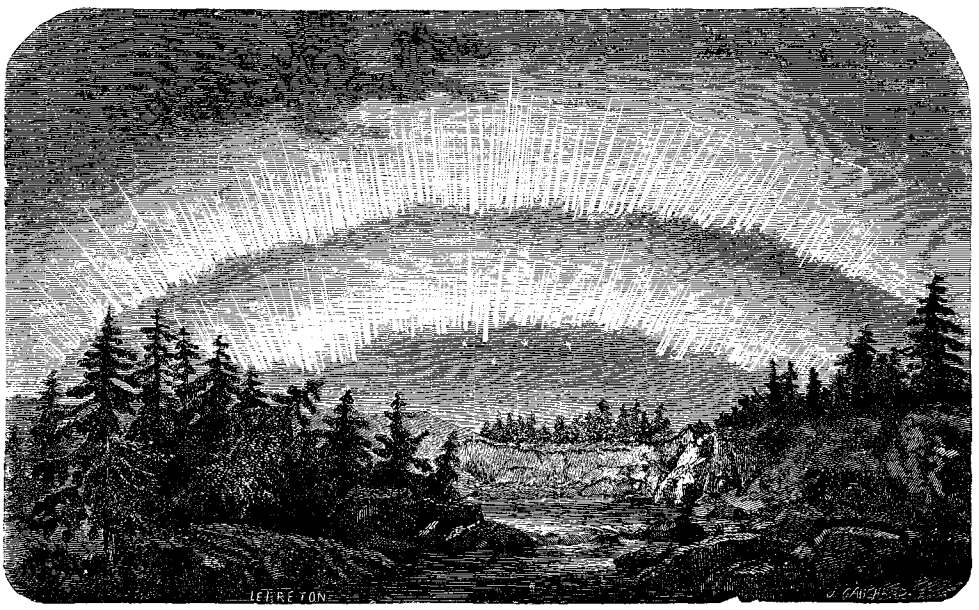
It has also been discovered that the presence of large quantities of ozone (which can easily be ascertained by ozone test-papers) foreshadow an impending atmospheric storm.

These unbidden monitions, together with many others—as the sun setting red, a remarkably red color of the clouds; the sign almost

* *De la Prévision du Temps*, p. 493. Paris, 1866.



ISOTHERMAL LINES FOR THE UNITED STATES IN WINTER.



AN AURORAL DISPLAY.

infallible, at Mauritius, of the brick-dust haze in the horizon; a thick, muddy atmosphere, but extraordinarily clear on mountains; frequent shiftings of breezes from all points, thick fog flying fast to the south, a bright halo round the moon, stars very brilliant and unusually twinkling at low altitudes, noises in caverns and wells like a storm, moisture on walls and pavements, sea-birds coming to land, water-fowl flying about; the swell of ocean rolling in, though the hurricane may be 600 miles distant; turtles floating in the calm, *apparently in a state of stupor;* the sea peculiarly clear at great depths, tides irregular; branches of trees not bent forward as by a stream, but constantly whirled about; water rising in wells and ponds; disturbances of currents on the telegraphic wires—are some of the oft-observed presages of the "thing of evil."

So far we have only hinted at a few of the premonitory occurrences which take place in Nature to warn us of the tempest.

THE INSTRUMENTS OF METEOROLOGY

must, however, always be the chief guides of the meteorologist. Whatever mistakes we may make in the interpretation of their story, as Admiral Fitzroy well remarks, "the glasses cannot err."

The invention of the barometer, it has been said, has led to the discovery of a new world to science; and we may apply the same statement to the thermometer, the anemometer, the pluviometer, hygrometer, and other instruments. That it may be seen what vast strides, even within a few years, meteorology has made—especially by the aid of the *automatic* or *self-registering* barometer, anemometer, and similar contrivances—a few of the instruments in use by General Myer will be mentioned. Each one of these is as valuable to him as the telescope is to the astronomer, the microscope to the naturalist, or the compass to the navigator.

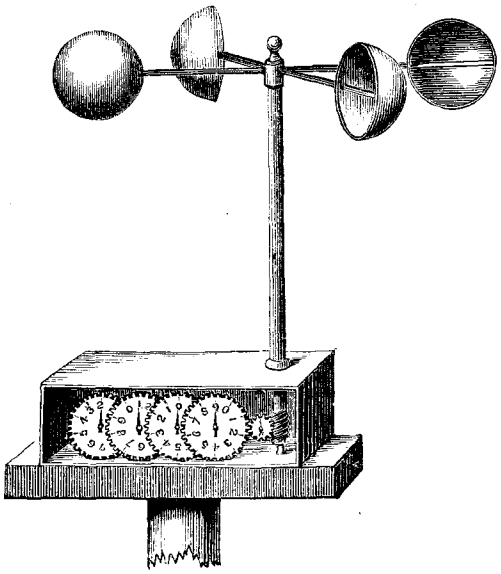
The ordinary thermometer is too well known to require notice. The maximum and minimum thermometers, however, are not generally understood. The former, when in use, is placed in a horizontal position. Inside the tube is a steel index; as the temperature rises, the mercury pushes the index before it; but as it falls, the index is left, thus registering the highest temperature. In the minimum thermometer, spirit is used and a steel index is inserted. As the temperature falls, the spirit drags the index with it, but when it rises, it does not move the index, leaving it at the lowest point to which it has been dragged. The two indications for each day are the most

important ones in meteorology. These thermometers can be set with a magnet, which brings the index to the surface of the fluid in the tube without disturbing the instrument.

To protect the thermometers from the direct and reflected rays of the sun, and at the same time to give them the benefit of a free circulation of air, they are hung in a Louvre Boarded Box Thermometer.

The *anemometer* is the instrument used for measuring the velocity and force of the wind. That in use by the Signal Service is the simplest and best, the *Hemispherical Cup Anemometer*. When placed in the wind the cups revolve; and the arms are of such a length, that when a mile of wind has passed the instrument, 500 revolutions are registered. The number of revolutions is registered by a system of index-wheels set in motion by an endless screw on the upright axis, which are read off in the same way as a gas-meter.*

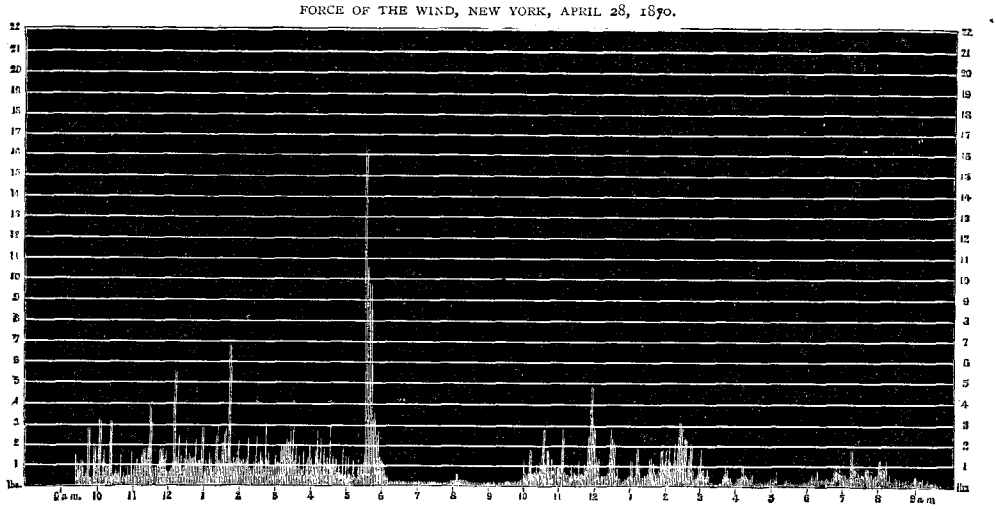
This anemometer only gives the velocity of the wind between two observations. To effect continuous registration, however, the Signal Service uses an elaborate automatic machinery, by which the results are transferred to paper by a pencil, or by photography. Similar contrivances are also used to register the force of the wind. The ordinary *wind-gauge* is a tube bent like a syphon, and half filled with water. It turns with the wind, being hung on an upright rod. One end of the tube is thus like a weather-vane, always pointing with open mouth to the wind. When the wind blows into the mouth, it drives the water up the opposite leg of the instrument, which is graduated. It may be made to register gusts of wind, by putting in



THE HEMISPHERICAL CUP ANEMOMETER.

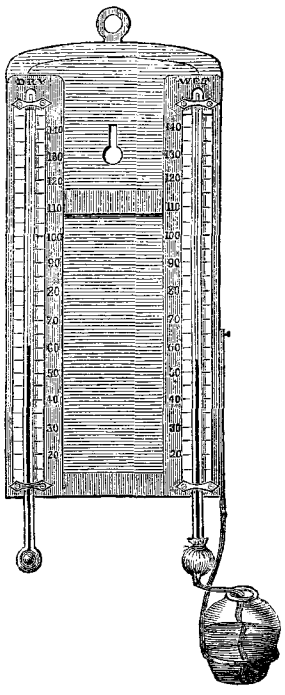
* The number of miles traveled by the wind per hour is found by multiplying the revolutions made in that time by 2, and dividing by 1,000. Thus, if 800 revolutions were made in two minutes, the velocity of the wind would be 48 miles an hour.

FORCE OF THE WIND, NEW YORK, APRIL 28, 1870.



SPECIMEN RECORD OF THE SELF-REGISTERING ANEMOMETER.

(The hours are marked on the bottom line; the pounds pressure per sq. ft., by the horizontal lines.)



THE WET AND DRY BULB THERMOMETER.

the water a chemical solution which colors bits of prepared paper, placed at intervals on the inside of the scale-limb.

Rain-gauges, for ascertaining the quantity of rain that falls, are of many designs. That in use by many observers is a copper cylinder, with a funnel closing the upper end so as to prevent evaporation. The rain is collected in a second vessel placed inside the cylinder, and thence poured into a glass measure of small diameter, nicely graduated. The aperture of the gauge is 12 or 15 square inches.

There are few things more important and indispensable, in forecasting the weather or ascertaining the approach of a storm, than to be apprised of the *humidity* of the air; for, as we have seen, the front of a storm is always moist. Steinmetz remarks that the hygrometer is almost as important a storm-indicator as the barometer.

The instrument for ascertaining the relative amount of vapor in the air is the *hygrometer*. The best form of this instrument consists of two mercurial thermometers, which, placed side by side, indicate the same temperature. When fixed together on a frame they are called the *wet and dry bulb thermometers*. The dry bulb is a common thermometer, intended to show the temperature of the air. The wet bulb is also a common thermometer, having its bulb covered with a piece of muslin, from which pass a few threads of darning cotton into a small vessel containing rain-water. The water rises by capillary attraction, thus keeping the muslin constantly wet. When the air is dry, evaporation goes on rapidly from the muslin, and on account of the heat lost by evaporation, the wet bulb indicates a lower temperature than the dry bulb. But when the air is damp, evaporation is slower, and the difference between the two thermometers becomes smaller. When the air is completely *saturated* with moisture, evaporation ceases entirely, and the two thermometers show the same temperature. The wide variation in the humidity of different bodies of air may be understood by a fact recorded by Roscoe, that whilst the air in England is often saturated with moisture, the driest air observed on the coast of the Red Sea, during a simoom, contained only one-fifteenth of the saturating quantity.

Commodore Jenkins, speaking of the hygrometer, observes that "in showery weather its indications vary rapidly, and a person making observations, at short intervals, may predict the approach of a storm, particularly if he take simultaneous observations with the barometer."

The Charles Heddle's gale in 1845 was announced in advance by great *thickness* of atmosphere, from being highly charged with vapor.

But the great instrument of the meteorologist is the *Barometer*. The barometer is to him what the stethoscope is to the physician; for with it he can detect the very breathings and read the fell purposes of the far-off but death-dealing meteor. It was designed by Torricelli to measure the height of a column of mercury supported by the pressure of the atmosphere. From this height the weight of the atmosphere at the place is ascertained.*


BAROMETER TUBE.

* The fundamental principle of the barometer cannot be better illustrated than by the following experiment. Take a glass tube 33 inches in length, open at one end; fill it with mercury, and, closing the open end with the finger, invert it and plunge the open end into a bowl also containing mercury. The column will fall into the tube to about 30 inches above the surface of the mercury in the bowl, if the experiment be made near the level of

At the centre of storms the mercury sometimes sinks *an inch* or two inches (as at Nassau, Oct. 1, 1866) below its mean height, and sometimes even more; and in the wake of storms it often stands an inch or more above the mean height. Buchan mentions instances of tropical tempests in which the fall has been as much as "1.693 inches in one hour and ten minutes!" *

Along the Atlantic coast of the United States, as Commodore Jenkins and many others have pointed out, the approach of a violent northeast storm is generally indicated by the barometer first rising above its mean height; at the same time the wind veers to the northeast and the air grows hazy. After the rain or snow commences, the barometer begins to fall; and when the barometer reaches its lowest point, the wind changes to north or northwest, after which the fluid in the tube begins to rise.†

Admiral Fitzroy proposed the following meteorologic rhymes for barometer scales :—

"When the glass falls low,
Prepare for a blow;
When it rises high,
Let all your kites fly.

"When rise begins after low,
Squalls expect, and clear blow.

"Long foretold—long last;
Short notice—soon past.

"First rise after low
Foretells stronger blow."

The height of the column of mercury is read by a graduated index on the side of the glass, just below the vacuum over the fluid. This scale (from 25 to 32 inches) is divided into inches and tenths of inches. For greater accuracy, the scale is read by the *vernier*.

Invaluable as is the ordinary barometer, its results are made many thousand times more valuable when, instead of being taken at intervals by human hand, they are obtained every minute in the twenty-four hours by an automatic and *self-registering* instrument.

These are but a few of many superb instruments whose silent but ceaseless and unerring monitions, so intelligible to the meteorologist, are invoked by Gen. Myer in his magnificent enterprise.

We have shown that, meteorologically, the United States is most happily and advantageously situated for maintaining a system of weather-telegraphy both for itself and the continent of the Old World, and that no storm can strike any part of the immense expanse of this continent, on which the sun scarcely sets, before every other part may be notified of the danger. More and better than all this, we have shown, from the records of the English and other foreign boards of trade and commercial societies, that, *in England, the high figure of* 73 *per cent. of storm warnings* have proved correct, and in *France, out of some* 100 *storms* signalled, *the number of those rightly signalled has, in different years, ranged from* 71 *to* 76, 89, *and even* 94! *

To this we may add the fact, stated in the Report of the North German Seewarte, that out of 30 telegrams or storm-warning signals (in which the drum was hoisted), for the benefit of the Hamburg shipping, 28 were verified.

Lest any one should challenge the import of these facts by saying that few meteorologists can be obtained who are capable of predicting the approach of tempests and hurricanes, I will answer by giving the words of the lamented Admiral Fitzroy, when asked—"If you are absent, who carries on the responsible duties of forecasting and giving cautionary notices when necessary?" The Admiral's reply was:—"An assistant is fully acquainted with the subject, and has generally executed these very duties. Besides ourselves, there *ought* to be two or three in training for these special duties,

the sea. The fluid is upheld in the tube by the air outside of it pressing on the mercury in the bowl; and since the one thus balances the other, it is evident that the mercurial column will serve as an accurate indicator of the varying pressure of air. The space in the tube above the mercury is one of the nearest approaches to a vacuum that can be made. It is called the *Torricellian vacuum*.

* *Meteorology*, p. 267.

† A great many of our nor'-easters come up from the Gulf Stream *viâ* the Chesapeake Bay. It is for this reason, among others, Gen. Myer has established a meteorologic station at Norfolk.

* See Buchan's *Handy Book of Meteorology*, pp. 342, 343, §§ 665, 666. See also the first of these articles in this Magazine for February, pp. 409-412.

now systematically established." * With the means at his command, the signal officer could train observers to be as accurate and expert as himself in forecasting the weather and preparing the bulletins to be telegraphed to exposed points on the lakes and the Atlantic seaboard.

SOME RECENT RESULTS AND FUTURE PLANS OF THE SIGNAL SERVICE.

To show how clearly the Signal Service is now enabled to trace some of our great storms, and anticipate their arrival on the Lakes, the following extract from the report of the Chicago *Observer* will suffice :—

* * * * * *

Dec. 11th. The severest storm we have yet had, and one of the highest significance to meteorologists, because of the clearness with which its course can be traced, from the time it left the Gulf till it reached Chicago. Its previous course would seem also to be indicated from the newspaper report that a violent storm was raging at Aspinwall about the 6th, causing many disasters to shipping. On the 9th, at 4 P.M. there is rain at New Orleans; at 11 P.M. at Mobile and Montgomery; at 4 P.M. on the 10th heavy rain at Augusta; at 11 P.M. snow at St. Louis. On the 11th, at 7 A.M. the storm had reached Chicago, and at 4 P.M. Milwaukee. The storm would seem to have traveled up the valley of the Mississippi in a northerly direction, and then, attracted by the moister atmosphere of the Lakes, to have turned eastward. The Alleghany mountains would seem to have intercepted a portion of the air-wave, and carried it up in the direction of Washington and New York. The two branches of the storm would then appear to have combined and remained almost stationary, covering the whole north for some days with heavy cloud.

* * * * * *

Captain H. W. Howgate, the energetic Assistant of Gen. Myer, writes :—

"The storm of December 19, of the year just expired, was announced along our sea-coast some hours in advance by Prof. Lapham, of the Signal Service, telegraphing it from Chicago. Gen. Paine, M.C., from Wisconsin, informed the chief signal officer a few days ago that he knew one instance where vessels with cargoes valued at over a million of dollars were held in the harbor of Milwaukee on the strength of the storm threatened and forecast by the Signal Service bulletin, and which actually swept the Lakes as anticipated. At the same time several vessels which sailed from port regardless of the bulletin encountered the storm, and two of them were lost. In making any estimate of the work done and good already accomplished by this Service, it should be borne in mind that the observers who do the actual work were put on duty after a hurried course of study, and without, in many cases, any previous knowledge of even ordinary military duty. No similar body of men has ever been raised, organized, and equipped. During the sixty days from November 1 to December 31, 1870, it has been clearly proved that men so raised and instructed could make the proper observations, and that, once made, these observations could be transmitted regularly and rapidly, three times daily, to the central points, and thence distributed promptly. This of itself was success enough, but in addition to this a tri-daily bulletin has been posted at several public places in every important city in the Union; weather maps similar to those you saw in our office put up in every Chamber of Commerce and Board of Trade now in the same cities, by which the movements of the atmosphere could be clearly traced; and, in addition to all this, the reports which are made synchronously are published synchronously throughout the country, thus far excelling, in point of circulation, the English reports, which have been the result of ten years' experiment. In England these reports are published once each day in the London *Times*, and reach a few thousand people, while ours are printed in several hundred newspapers, and are seen and read by hundreds of thousands. On the first of January the manifold map was commenced, and will be issued daily in all the large cities as soon as we get a sufficient number from the printer."

This is another step forward, and the next one, we are assured by Gen. Myer, will be to forecast the weather for a day or two in advance. This will be done as soon as sufficient data have been obtained to do it with safety. Then will come the display of signals or storm-warnings at points along our coast, but these will not be attempted until more experience has been had in the practical workings of the system.

The Philadelphia *Press* (Dec. 30) well said: "The observations of the Signal Service, so far as they tend to establish laws and bring system out of the chaos that now surrounds the system, will be of great interest and value not only for physicists, but to every class of the community."

Do we not then behold the most terrific and refractory agent in nature as *under law?* We even find the seaman *profiting* by it, and using the very demon of the storm as his minister, to swell his canvas and to speed him towards the haven where he would be, illustrating a happy sentiment, that "we have

* *Report of London Board of Trade*, 1864, p. vi.

only to study nature in order to prevail over her."

It was skeptically said by Dr. Johnson, that, when the philosophers of the 17th century congregated into the Royal Society of London, the time was supposed to be near when "engines should turn by a perpetual motion and health be secured by a universal medicine; when learning should be facilitated by a common character, and commerce extended by ships which could reach port in defiance of the tempest." The first three of these great expectations have been well-nigh realized. Why may not the last?

If the genius of that great philosopher, Benjamin Franklin, who first discovered the progressive movement of American storms, and who was ever quick to extract some immediate practical benefit from every principle of nature he discovered, had been impressed on the American mind, and had borne its fruits, what great advances might we not already have made in the science of storms? The moment Franklin ascertained that electricity and lightning were the same, he set about inventing a lightning-rod for insuring the safety of houses. He suffered no item of knowledge to lie as idle capital in his brain.

Happily for the cause of humanity, so universally and vitally interested in this science, the Signal Service of the United States Army, to whose able hands the Weather Telegrams and Storm-Forecasting system has been committed, has shown that it is wide awake and all astir with the practical spirit of the New England philosopher. The officer who has charge of it has proved that the labors of his office shall not terminate with the mere collection of meteorological statistics and the records of storms after they have done their work of destruction, laid our cities in ruins, and strewn our coasts with wrecks; but that, at the earliest possible moment the means in his possession shall suffice to obtain the requisite information, our sea-coasts and the shores of our lakes shall be duly forewarned of every impending tempest.

The combined voice of the world's civilization demands that no effort, no outlay of toil or treasure shall be spared or stinted in effecting all that can be effected in mitigating the horrors annually wrought by the furies of the storm.

Commerce is to a nation like the ancient river Pactolus, whose stream ran down on the streets of Sardis richly freighted with gold. It has been the wealth, the prosperity, the power of every people who have made much of it, from the day of the glory of Tyre to the present. The statistics of the Lake Boards of Trade show that there are nearly two thousand vessels annually engaged on these stormy inland waters, and that in consequence of the risks they run during the wintry and equinoctial gales, the increase of their tariffs is nearly doubled for the transportation of every product of the farmer, the merchant, and the mechanic.

Since the invention of the steamship, the commercial balance of power between the old and new world has been made to preponderate less heavily on the side of England than it did a century ago. The prospects for the United States of reaping at no distant day, through its inter-oceanic railways and an Isthmian canal, the advantages of its physical geography, when connected with other considerations, give deep significance to the efforts the nation is now putting forth to secure the interests of its shipping by every expedient science can offer, and to give encouragement to the growth of its commerce. Our press teems with suggestions for the promotion of the shipping interests. What better can be done to this end, than to protect the vessels already afloat by assuring navigation? A large, costly light-house system, and a fine coast survey, we have for warning ships of rocky shores and shoals upon which they may be driven. How much more do they need to be forewarned of the storm that drives them headlong upon these rocks, or enfolds and crushes them in deep water within its iron coils? Hundreds of thousands of dollars are lavished upon scientific expeditions for the observation of eclipses, for prosecuting geologic speculations, the survey of distant lands, and even for explorations in Arctic ice in search of the mysterious Pole. How insignificant are such objects when placed by the side of that now before us!

To take the lowest view of the present movement of the United States for storm sig-

nals, it will serve to quicken and fecundate all the sciences. The observations of the atmosphere at the thirty different stations scattered over the continent, under the charge of the Chief Signal Officer, will be the most important addition to the physical geography and our knowledge of the physical resources of the country.

Who can foresee the varied and golden harvests that the merchant, the seaman, the husbandman may reap from the labors of this Service in the splendid field of meteorologic research? They are not to be estimated by any pecuniary standard, or by the criterion of material value.

If any man hesitate to be the friend of such an institution as that whose mission has been inaugurated by the American Government, and here feebly set forth, let him but recall the grim vision of Clarence, as he sinks into the slimy deep :—

"Methought I saw a thousand fearful wrecks;
A thousand men that fishes gnawed upon,
Wedges of gold, great anchors, heaps of pearl,
Inestimable stores, unvalued jewels,
All scattered in the bottom of the sea."

KING GAMBRINUS AND HIS SUBJECTS.

ANCIENT story tells us that King Gambrinus once ruled in the Netherlands, and found his greatest glory in his greatest shame—that of leaving to his subjects a beverage that has made them slaves, creeping into their bodies to weaken their manly vigor, and pervading their brains to blunt the delicacy of their perceptions.

This god of beer has many sins to answer for, and daily holds high revel with his subjects the wide world over, though his central court is now, and long has been, in the famous city of Munich, of rare renown in modern art, though of singular subserviency to sense. Thither we must wander if we would see what slaves men's sensual nature can make of them.

AN OLD TOPER.

The great brewery where King Beer holds his court, and presides over the excesses of his subjects, is everywhere known as the Court Brewery, where, from early morning till after midnight, the frequenters of this realm worship at the altar of their god and passion. Among these subjects we find representative characters of all phases of this worship, and the place is therefore more than all others fitted for the study of the good or evil that so controlling an influence must inevitably exert on its votaries.

"Court Brewery" bears this name, truth bids us say, not because it is frequented by the Court, but because the term "Court