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

RESCUE OF THE "SAN FRANCISCO" BY THE "KILBY," DEC., 1853.

WITHIN a few months, the United States have embarked in an enterprise of vast moment.

The creation of the government Signal Service for obtaining weather-telegrams and dispatching storm-warnings to imperiled shipping on our lake shore and seaboard, will, there is reason to hope, mark a new era in American commerce.

With quiet activity, this service has been organized and equipped, and has already begun its career under auspices which promise to crown it with speedy success, and cause it to redound to the wisdom of its founders.

I purpose in this, the first of two successive papers, to inquire into the possibility of forecasting storms; to ascertain what, if any, benefits have been reaped in other countries from a system of forecasts; to determine the tracks and behavior of the cyclones that sweep over and desolate our land; in a word, to test the system in the crucible of meteorologic observation extended throughout the world.

In 1709 Athanasius Kircher, one of the most distinguished scientific men of the seventeenth century, published at Rome a startling theory of ocean currents. Delineating an open North Polar Sea, similar to that discovered in recent times by Dr. Kane, he represented the waters of the Atlantic and Pacific as pouring into the Polar Basin, and dashing round, so as to form a spiral current whose apex was the pole itself, into which, as a huge vortex, they ceaselessly entered. His description of this vortex was singular and ingenious. He argued that a ship coming within the influence of this vast eddy would be speedily engulphed and destroyed; and he went so far as to claim that the waters of the ocean, lost *in vasto gurgite*, after undergoing circulation in the interior of the earth, reissued in mighty currents from the South Pole.

Absurd and chimerical, reader, you may say. But this was the first attempt to explain the phenomena of ocean currents. However unsuccessful and inglorious may be the first effort to

unravel the mysteries of nature, it is not to be despised. It challenges the attention and provokes the reflections and researches of thinking men everywhere; and, in time, it enlists in the cause a band of successful explorers.

The hope that some such result may follow his effort, is the writer's apology for coming before the public. All that he shall advance shall be sustained by facts authenticated by quotations from the most eminent scientific observers. He feels that, in the humblest endeavor to throw light upon those terrible phenomena of nature, with which all men, but especially the seaman and the seafarer, must battle, he touches a chord of sympathy like that which thrills in the breast when, along the storm-beaten coast, the midnight gun tells a tale of distress.

To pursue the subject intelligently and interestedly, it may be necessary to take the reader into other fields of research than that merely pertaining to wind and weather; for nowhere more than in meteorological researches is nature found to be, though "distinct as the billows, yet one as the sea."

The task of the meteorologist is a difficult one, from the extent of the field over which he must keep a steady and sleepless eye. He is debarred that boon which is to a man of science the most inestimable—*experiment*. The natural philosopher may isolate a portion of the atmosphere in his apparatus and interrogate it; the chemist may analyze it. But the air-pump cannot detain the moving air-current. The whole aërial ocean that enshrouds our globe is a unit, whose thin masses are in inter-communication and sympathy, and whose invisible billows, in one hemisphere, quickly rise and roll, sensitive and responsive to agitations in the opposite. The very wave of atmosphere that, but a few days ago, was formed on the chilly steppes of Siberia, and but yesterday swept over the seas of China and Japan, may to-day be breaking against the Pacific shores of America or overleaping the summits of the Rocky Mountains.

But, notwithstanding all this—and we purposely give to those who despond of any good results from meteorological observations the darkest view of the subject—we must bear in mind that it is but little more than two centuries since Torricelli (1643) invented the barometer, and but little more than a century and a quarter since Fahrenheit (1714) made a thermometer that served the purposes of science.

It is true that for the present the work of the meteorologist must be largely that of faithful observation. In past ages we have been mostly shut up to the recording of facts, to use the figure of Sir William Herschel, resembling "a man who hears now and then a few fragments of a long history related, at distant intervals, by a prosy and unmethodical narrator." And yet are there not brilliant instances—as that of Niebuhr, the renowned historian of Rome—in which the scattered legends and widely disrupted parts of the record have been put together, the deficiencies supplied, and out of the whole there has been brought forth a clear, connected, and plausible story, where before all had been wrapt in mystery? Certain it is, no science can ever sustain the interest or command the labor that it needs to be bestowed upon its prosecution, if it does not aim to grapple with the practical questions which *the facts* registered suggest; if it does not seek to explain the observed phenomena of nature upon physical laws and principles.

"Indefinitely multiplied records," as the eminent meteorologist, Admiral Fitzroy, has so forcibly said, "only tend to make the work of their utilization discouraging, if not almost impossible. By less ambitious courses—by separating fields of labor, especially by treating of climates individually, and referring observations to independent centres—a prospect has been opened of immediately useful exertions. Stones may be shaped, bricks may be accumulated; but without an object in view—without an edifice to be constructed—how wearily unrewarding to the mind would be such toil, however animated by true scientific faith in future results!" It was in the spirit of these words, and against the wishes and recommendations of M. Le Verrier, of the Imperial Observatory at Paris, that Admiral Fitzroy declined to restrict himself to a mere system of telegraphing the

weather, and, as its able pioneer, boldly planned and put in operation that noble system of *forecasting* the weather which saves Great Britain annually many of her finest ships and hundreds of her most skillful seamen.

The study of meteorology, and the effort to divine atmospheric changes and utilize them, is as old as Aristotle, who discussed it in his work on *Meteors*, in which he characterized it is as "*the sublime science.*"

Cicero, Virgil, and other ancient writers discussed the subject in their works; but, in their ignorance of physical research, they threw no light upon it. Still, it has been the theme of universal interest; and its utility for both the ordinary and extraordinary affairs of life, has been recognized in every department of human activity.

The necessity for civilized nations putting forth every effort that science can suggest, to obtain, by certain and careful observations, information of the nature and tracks of storms, has long ago been conceded. If it ever needed demonstration to the most narrow-minded and skeptical, that demonstration is furnished by the long catalogue of disasters that have befallen the commerce of every nation, and the casualties that might have been diminished or largely mitigated by a forewarning of the more famous storms of history.

Could these fearful atmospheric commotions have been foreseen *only a few hours* in advance of the event, what untold calamities might have been averted!

It was failure here that led to the memorable destruction of the entire Persian army of Cambyses in the Libyan desert, about 525 B. C., in which the unlooked-for simoom buried 50,000 soldiers beneath its billows of sand. The failure of Napoleon in the Russian campaign, that terminated so fatally to his army in the retreat from Moscow, might have been avoided had that great captain duly understood the portentous yet delicate signs of that remarkable winter.* There are few more striking passages in naval history than that which relates the trying contests of Admiral Nelson, in 1805, with the French fleet under Villeneuve, and the masterly manner in which the subsequent hero of Trafalgar managed his squadron. Upon receiving the news of Villeneuve's departure from Toulon, the English commander, foreseeing a gale, before midnight was under sail, and during the night carried his vessels through the passage between Biscie and Sardinia, while his adversary, as he expected, was badly disabled and crippled. "Studying attentively the minutest precursory indications of every atmospheric disturbance," says a distinguished French officer,* "Nelson placed the highest confidence in barometrical observations, and his journal contains notes of the highest interest relative to them, which he entered daily with his own hand." The fiery Admiral afterward wrote Lord Melville that his fleet had defied the sudden and violent hurricanes of the Mediterranean for twenty-one months without losing a mast or a yard.

These are, however, but bare suggestions of the need and value of meteorological knowledge in a few of the critical occasions that now and then arise. The terrors of the tempest and the cyclone, however, are fearfully illustrated by the past records of nations. The very approach of a cyclone at sea is marked by a peculiar and ominous sound, the wind rising and falling with a moaning noise like that heard in old houses on winter nights.

* The great Prussian General, Von Moltke, is said to be distinguished by his untiring care and labor in informing himself of the physical geography and meteorology of the theatre of his recent campaigns. A late writer says of him:—"He had been convinced for some years past that war must come, sooner or later, with France, and had been preparing for it. By personal survey, and the careful explorations of his trained corps of topographical engineers, he had made himself so completely master of the topography and physical geography of the region lying between the Rhine provinces and Paris, that he might literally be said to know every foot of it. His officers, even down to lieutenants, were provided with pocket-maps, detailing all the physical features of the country, designating the fortified places, and indicating their strength. The French soldiers and officers were astounded to find that their adversaries knew France and its geography infinitely better than they did." The officers of the United States Army have long since been honored in Europe for their able contributions to the meteorology of this country, and their reports have been quoted as the highest authority by such men as Humboldt, Dove, Arago, Herschel, Le Verrier, and Fitzroy.

* M. de la Gravière, *Revue des Deux Mondes*, vol. xvii.

In the great storm of November 26th, 1703, even the ships in the Thames were all blown away from their moorings, and from Execution Dock to Limehouse Hole there were but four ships that rode it out. Such a tempest could not be supposed to be limited to this island; accordingly it appears to have spread over a great part of the north of Europe, though nowhere with equal impetuosity as with us. Over most parts of South Britain and Wales the tallest and stoutest timber-trees were uprooted or snapped off in the middle. It was computed that there were twenty-five parks in the several counties that lost a thousand trees each—the New Forest, Hants, above four thousand. Whole sheets of lead were blown away from the roofs of strong buildings; seven steeples, above four hundred wind-mills, and eight hundred dwelling-houses blown down; and barns, outhouses, and ricks in proportion, besides a great destruction of orchards. About one hundred and twenty persons lost their lives on land,—among whom were the Bishop of Bath and Wells, also the engineer of the then lighthouse at the Eddystone, who was blown into the sea along with the structure, which he had promised himself should bid defiance to the waves.

At sea there were few ships to sink—the previous terrible weather having brought them into port in unusual numbers—but in the harbors and roadsteads of England, so many vessels ran foul of each other and sank, or foundered at anchor, or were driven on the sands, or to sea where they were never heard of, that it is computed eight thousand seamen at least perished on the occasion.

The estuary of the Severn lying more particularly in the course of this storm, the parts bordering on that river suffered much from the breaking in of the sea. The country for a great extent was inundated, the vessels driven upon the pasture land, and many thousands of sheep and cattle drowned.

The spray of the sea was carried far inland in such quantities in little concretions or knobs of salt on the hedges, that at twenty-five miles from the sea, in Kent, it made the pasture so salt that the cattle for some time would not eat it. The total damage done by this great storm was considered to have exceeded that of the great fire of London!

In 1819 a hurricane ravaged the Leeward Islands from the 20th to the 22d of September, when, at the island of St. Thomas alone, one hundred and four vessels were lost. A hurricane at the Cape of Good Hope, in 1831, destroyed property of immense value. As late as the 5th of October, 1864, a terrible cyclone swept over the Bay of Bengal, which destroyed nearly one hundred ships; whole towns were reduced to shapeless masses of ruins, and 45,000 persons perished.* It was followed by a "bore," or spring-tide, in the Hoogly, which effected enormous damage, the water rising thirty feet above its usual level. The calamities that befell Lisbon in 1864, and St. Thomas in 1867, and the destruction that within a few months has strewn the Atlantic coasts of the United States with wrecks innumerable, and spread desolation and want over portions of our land, we need not stop to recount. Suffice it to say, that by the *Journal of the Statistical Society of London*,† the shipping casualties of England alone, for four periods of ten years each, sum up these figures:—To 1866, 3,443 vessels lost; to 1867, 3,457; to 1868, 3,420; to 1869, 3,343, *or nearly one vessel a day lost!* In addition, the average for stranded ships is quite as large, to say nothing of missing barks, and those which, like the ill-fated *City of Boston*, have disappeared without leaving a spar or a bucket to tell their fate.

Following close upon the track of the storm comes the storm wave. The centre of the hurricane or typhoon is supposed to be of cylindrical shape with an opening of large dimensions. Inside of the centre the barometer stands low, and the atmospheric pressure from around and outside forces the water of the sea into this hollow, forming an enormous tidal wave. As the storm moves forward over the sea the wave is propelled with it, and on many coasts bursts over the

* See this statement verified, page 267, in the able work on Meteorology, by Alexander Buchan, the Secretary of the Scottish Meteorological Society. Blackwood & Sons, Edinburgh.

† Journal for September, 1870.

land—producing more destruction on shore than the storm produces at sea.

The poetess Jean Ingelow has graphically told the tale of the fierce tide that ravaged the coast of Lincolnshire in 1571 :

> The old mayor climbed the belfry tower,
> The ringers ran by two, by three ;
> "Pull if ye never pulled before ;
> Good ringers, pull your best," quoth he :
> "Play uppe, play uppe, O Boston bells !
> Ply all your changes, all your swells,
> Play uppe 'The Brides of Enderby.'"
>
> Men say it was a stolen tyde—
> The Lord that sent it, He knows all ;
> But in myne years doth still abide
> The message that the bells let fall :
> And there was nought of strange beside,
> The flights of mews and peewits pied
> By millions crouched on the old sea wall.
>
> So farre, so fast the eygre drave,
> The heart had hardly time to beat,
> Before a shallow, seething wave
> Sobbed in the grasses at oure feet :
> The feet had hardly time to flee
> Before it brake against the knee,
> And all the world was in the sea.

Some idea of the storm-wave may be formed from the illustration of the tidal wave at Havre. The storm-wave that broke over Turk's Island a few years ago carried off all who did not save themselves by climbing the trees. That which swept over Calcutta in 1864, as we have already seen, destroyed 45,000 human beings.

But we gladly hasten to show what provision and what deliverance modern science and research have devised for the prevention of such horrors, and is now bringing practically forward. The question forces itself upon us : IS IT POSSIBLE, IN ANY MEASURE, TO FORECAST OUR GREAT STORMS ?

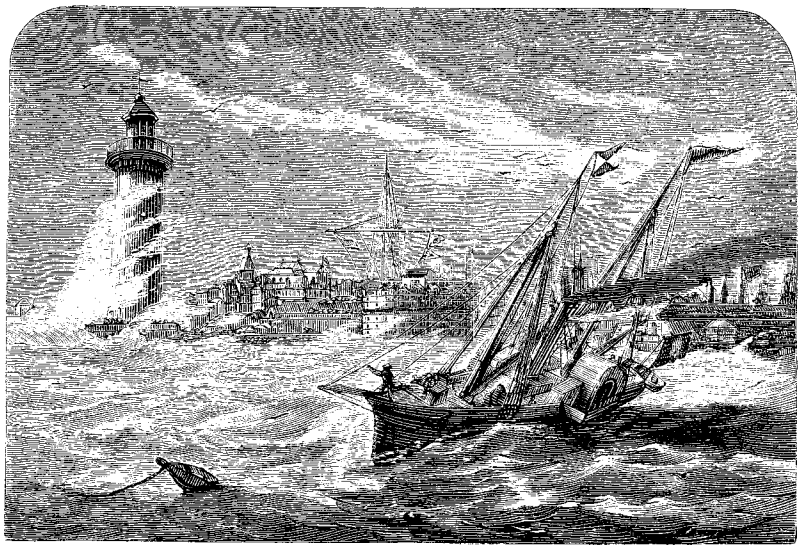
"It is," says Arthur Mangin, "a strange, and until recently a wholly unsuspected circumstance, that, in all their apparent tumult, these raging storms are subject to fixed laws and follow a predetermined path."* Is it, indeed, a thing incredible that man, whose lofty faculties and endowments have made him master over almost every power of nature, should learn to elude, at least occasionally, the furies of the tempest ? There are but few forces in nature that he has not brought within the circle of his control. On many parts of the globe he has changed the very aspects and face of nature. He has reduced enormous forests, like those of ancient Germany, to a state of cultivation and prosperity ; and again, by the planting of these very forests in arid and rainless regions, he has robbed the clouds of their moisture and made them drop down richness and verdure on the surrounding soil.* He has converted the most poisonous weeds into medicines for the healer's art. On the land he has redeemed the most pestilential spots, as the Pontine Marshes of Rome, which Arnold tells us could in early times be visited only by the hardy mountaineers when they came down to reap their harvests, daring never to inhale the nightly miasma, and returning, after a brief sojourn, forlorn and emaciated. On the ocean the agency of man has been put forth against many odds, but victoriously. There remains but a small polar territory yet to be explored and subjugated. The strong and dangerous currents of the sea, once the dread of the mariner, are now subservient to his skillful use. The very waves of the sea, as history has more than once recorded, have been successfully invoked to fight man's battles or deliver him from his enemies. Again, he has dexterously wrested and reclaimed vast regions from the empire of ocean. In the atmosphere, since the time when the great philosopher of New England, the Faraday of his age, Prometheus-like stole fire from heaven and robbed the clouds of their electric wrath, there has been a large promise of further conquests in this domain of nature.

The fierce monsoons of the Indian Ocean

* *Mysteries of the Ocean*, p. 160.

* During the French occupation of Egypt, in 1798, rain did not once fall for sixteen months. Since Mehemed Ali and Ibrahim Pacha have finished their immense plantations (the former planted more than 20 millions of olive and fig trees, cotton-wood, and many other varieties), rain is now not infrequent in the months of November, December, and January.—See Marsh's *Man and Nature*, p. 189.

"In France, there seems no doubt that the removal of the forests on the Vosges sensibly deteriorated the climate on the plains of Alsace."—Ansted's *Physical Geography*, p. 456.



AN EQUINOCTIAL TIDAL WAVE AT HAVRE.

have become the propitious gales on which many an argosy of commerce rides proudly into port. It has even been computed by the English Board of Trade, that the increase of meteorological knowledge within the past fifteen years has reduced the length of the passage of ships on the great and perilous highways of commerce at least one-third.

With such considerations before us, we are prepared to expect, even had we no facts to ponder, that the age is ripe for an invasion of the immense but splendid and tempting domain of meteorologic science. Happily these facts are at hand, and ought to be the cherished heritage of Americans.

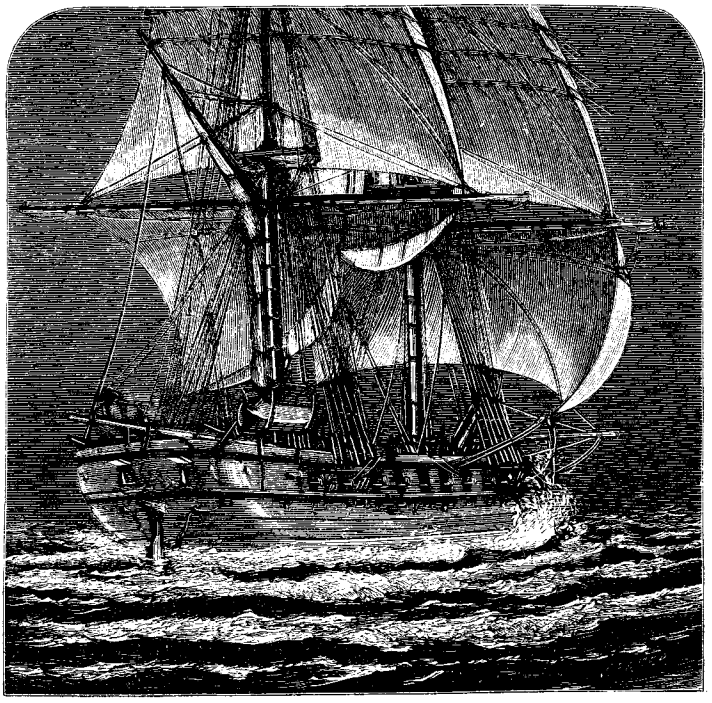
The United States was the first of the great nations who led the way in commencing a systematic collection of observations over all the habitable world, commencing with meteorologic observations at sea.* The eminent British meteorologist already mentioned, Admiral Fitzroy, recalling the year 1853, when the views of the United States were presented to English statesmen and applications were made for co-operation by England, has feelingly spoken, "from personal knowledge, how coldly" these views and applications "were received in this country (England) prior to 1853, when they first found earnest and adequate supporters in Admiral Smyth and Lord Wrottesly." *

Previous to the great movement in America scarcely anything had been attempted. In 1853, however, a conference of the great maritime nations was held at Brussels, where a general plan for co-operation and research for investigating the phenomena of sea and air was proposed. This led to the establishment of the Meteorological Department of the Board of Trade in London (over which Admiral Fitzroy so ably presided), and to similar institutions in Holland, France, and elsewhere. Scarcely had these efforts of scientific men commenced when an occasion arose which crowned them with signal and unexpected glory. Close by our American shores moves the mighty current of tropical water known as the Gulf Stream. Sailors call it "*the Weather-Breeder*," and others give it the name of "*the Storm-King*." For hundreds of miles after it leaves the torrid zone—the zone of the vertical sun and of

* "The establishment of Meteorological Societies during the last twenty years," says Alexander Buchan, the celebrated Scottish meteorologist, "must also be commemorated as contributing in a high degree to the solid advancement of the science which, more than any other, depends on extensive and carefully conducted observations. In this respect the United States stand pre-eminent, the observers there numbering 800."—Buchan's *Handy-Book of Meteorology*, p. 9.

* Fitzroy's *Weather-Book*, p. 49.

volcanic fires—its course is marked by tepid vapor and fog; and lighted up from beneath by the nightly glow of myriads of phosphorescent animalcules, and from above by the glare of the electric flash, it is (as we shall presently see) the natural track and pathway of the hurricane or cyclone.



PHOSPHORESCENT SEA.

It was in the Gulf Stream, in the month of December, 1853, that the American steamer *San Francisco*, having on board a regiment of soldiers for California, was encountered by a gale which speedily reduced her to a most lamentable condition. "A single wave," if we may use the description of a disinterested and foreign penman, the French physicist, Figuier, "sweeping the deck from stem to stern, carried away the masts, destroyed the machinery, and hurried into a premature death one hundred and ninety-nine officers and soldiers. The unhappy vessel lay upon the waters a miserable wreck, drifting in whatever direction the wind and the billows carried it. On the following day it was seen in this condition by a ship bound for New York; a few days later another vessel fell in with it; but neither could lend it any assistance, for they were occupied in endeavoring to secure their own safety. As soon as news of the calamity reached New York, two steam-tugs were ordered to the assistance of the *San Francisco*. But in what direction should they steer? What part of the sea should they explore? A chart was made of the region in which the dismasted steamer would probably be carried, and the route defined to be followed by the two steam-tugs dispatched to her assistance. The crew of the *San Francisco* were saved by three ships, which had descried her in the open sea before the New York steam-tugs arrived. But the point where they saw the steamer founder was precisely that which had been laid down on the chart. Had but the tugs set out in time from New York the triumph would have been complete. We may note, however, that the bark *Kilby*, which had caught sight of the drifting ship by day, and had lost it during the night, succeeded in recovering it by a course of reasoning analogous to that used in constructing the chart, and was thus enabled, in conjunction with two other vessels, to save those on board." *

This triumph was not alone. From the year 1831, when the study of the laws which were supposed to govern the motions of storms received a fresh impulse from the writings of another great American meteorologist, Mr. William C. Redfield, of New York, the scientific world began in earnest the study of storm-meteorology. In this connection, the names of Redfield, Reid, Thom, Espy, Dové, Piddington, and Fitzroy stand pre-eminent. The knowledge of storms furnished by their labors

* See Figuier's elegant work, *Earth and Sea*, republished in London, 1870, p. 638.

suggested the possibility of inaugurating a system of weather observation, and of using the results for the benefit of commerce and navigation, both on the sea and the land. The giving effect to this idea, as Buchan remarks, constitutes the splended contribution to practical meteorology made by Admiral Fitzroy in February, 1861, by the system of *storm-warnings* or *forecasts*, which has since been adopted by almost every country in Europe."

THE FITZROY STORM-WARNING SIGNALS,

As used on the English coasts, are very simple and discernible from a great distance.

A cone, three feet high, with the point upward, shows that a gale is *probable* from the northward. NORTH CONE.

A cone, with the point downward, shows that a gale is probable from the *southward.* SOUTH CONE.

A DRUM, alone, shows that stormy winds may be expected from more than one quarter successively.

A cone *and* drum give warning of *dangerous* winds, the probable first direction being shown by the position of the cone.

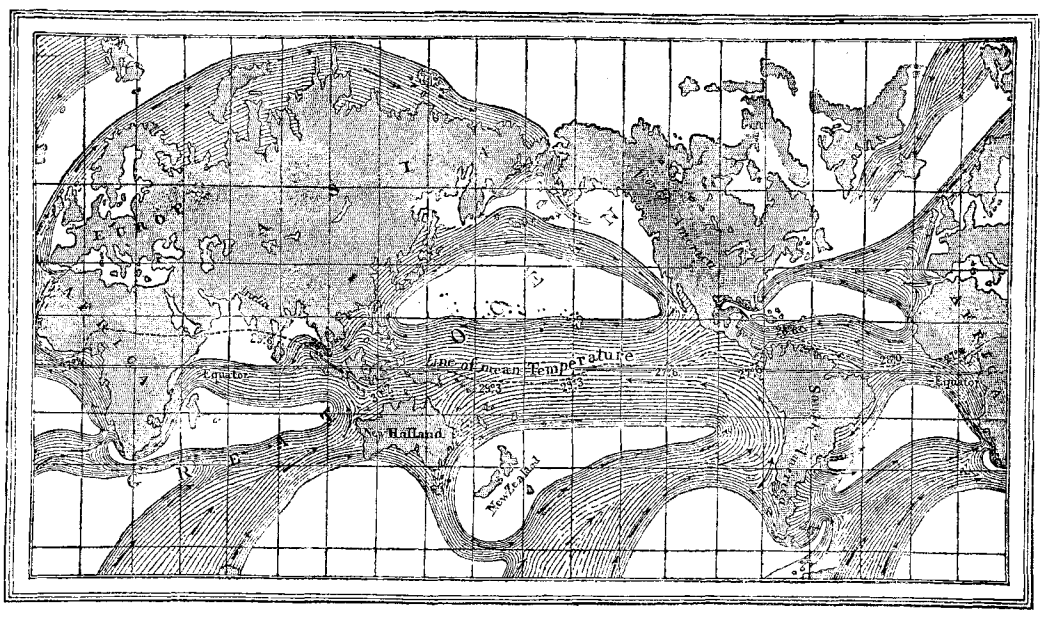
The NIGHT SIGNALS are signal lanterns intended to be hoisted with the lights in the triangle or square.

How far this system has proved a success is a question of the greatest moment.

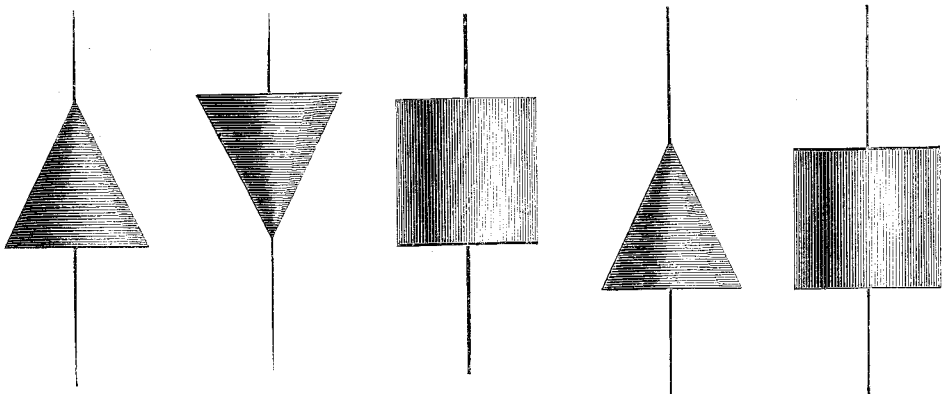
In 1863 the Board of Trade reported a large percentage of the Storm Signals which had been placed on the English coast as correct, and through their warning many lives and vessels had been saved.

From this time the promptness and accuracy of the signals greatly increased, although the system was incomplete, and the means of communicating them to distant parts of the coast so imperfect that the storm sometimes outran the Signal.

"In his letter of the 15th of June, 1865, to the Board of Trade," says the Secretary of the Scottish Meteorological Society, "General Sabine states that he had examined the warnings given on the British coasts during the two years ending March 31, 1865, and found that in the first year fifty per cent., and in the second year *seventy-three per cent. were right.* Captain de Rostaing, while at the head of the French Marine Meteorological Department, compared the warnings sent from the Meteorological Office, in London, with the gales which occurred in France during the two winters 1864–'65 and 1865–'66. The results were published in the *Revue Marine et Coloniale*, showing that out of 100 warnings sent to the



MAP OF MARINE CURRENTS



CAUTIONARY SIGNALS.

To be suspended from a Mast and Yard, or a Staff, or even a Pole.

Gale probably from the Northward.

Gale probably from the Southward.

Gales successively.

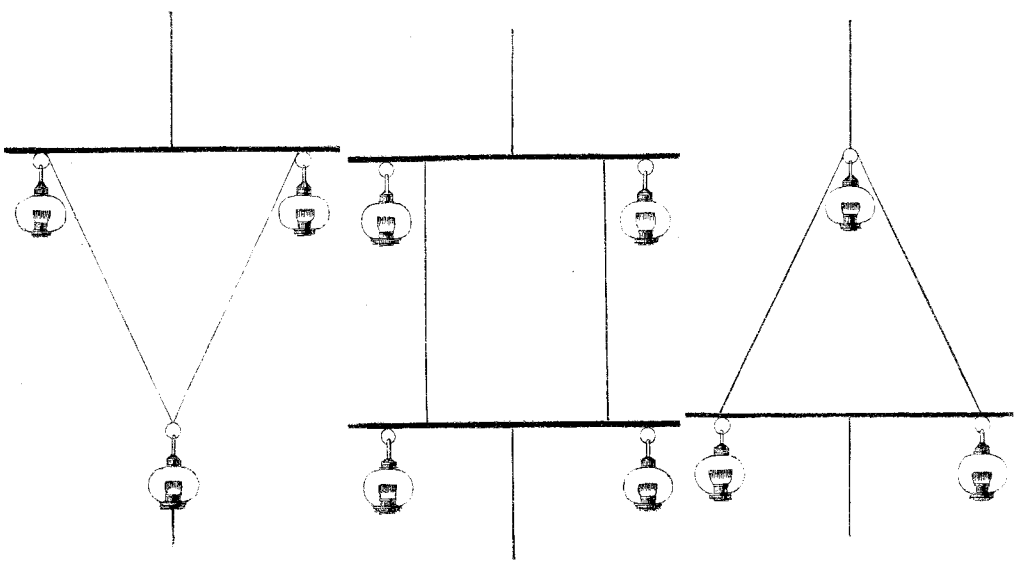
Dangerous Winds probably at first from the Northward.

Dangerous Winds probably at first from the Southward.

NIGHT SIGNALS.

(instead of the above)

Lights in triangle, or square.



FITZROY'S WEATHER SIGNALS.

north coast of France during the first of these winters, 71 were realized, and during the second winter, 76; and out of 100 storms which occurred, 89 were signalled during the first winter, and 94 during the second winter. This result is remarkable, *as showing that of the storms which occurred in the north of France during these two winters, warning of the approach of* 11 *out of* 12 *was sent!*" *

The Report of the Board of Trade of London, in 1866, says:—

"34. *Popularity and Utility of Storm-Warnings.* As regards the popularity and utility of these storm-warnings, we have no doubt that they have been favorably received by the public in general, as well as by those most interested in them. Though the replies made to inquiries by the Board of Trade, in 1862, and published in the Reports of the Meteorological Department for that year, are not unanimously or universally favorable, they undoubtedly show a general desire at that time that the experiments then commenced should be continued. And from inquiries we have made through trustworthy persons at most of the principal ports, we find that seafaring men look upon them more favorably than they did at first; that they believe them to be more correct, and rely upon them more; and that there would be great regret if they were discontinued. The same year (1866), while as yet the system of Storm-Warnings was in its infancy, the following interrogatory note was addressed by order of the Board of Trade to various mercantile bodies and officials:—

"QUESTIONS.

"An inquiry is being made into the Meteorological Department of the Board of Trade, and we are anxious to learn, after some years' experience, what is the real opinion of seafaring men concerning the value of the late Admiral Fitzroy's signals. Can you help us by telling me what is thought of them by the most competent judges at ( )?

"I remain, &c., &c.,

(Signed) "T. H. FARRER."

ANSWERS TO THE ABOVE.

Mr. James Kellas, Secretary to the Local Marine Board.	Aberdeen.	"The utility of the Signals is generally acknowledged."
Mr. Anthony Traill, Examiner in Seamanship, Local Marine Board.	Dundee.	"The correctness of the Storm Signals at this port is a matter of common remark." They "are very generally appreciated."
Shipowners' Society, through Mr. Ingham, M.P.	South Shields.	"The exhibition of the Storm Signals is of much value, by giving timely warning of approaching storms."
Mr. John Lambton, Superintendent of the Mercantile Marine Office.	Sunderland.	"The Signals are regarded as decidedly valuable. A daily account of the weather, kept by the Dockmaster, shows that the warnings have for some time now been more correct and reliable than formerly."
Mr. J. Palmer, Receiver of Wreck.	Great Yarmouth.	"There is a general and growing admission that the Signals are correct."
Mr. J. G. Flower, Collector of Customs.	Deal.	"There is but one opinion concerning the value of these Signals. They have been the means of saving lives and property to an immense extent."
Mercantile Marine Association.	Liverpool.	"Decidedly in favor of the continuance of the Signals."
Mr. Towson, Examiner in Navigation, Local Marine Board.	Liverpool.	"There exists an universal opinion that these Signals are very valuable; that the amount of accuracy has gradually increased." *

These and several other testimonies from the highest quarters, with a single qualifying report, seem to give a strong indorsement to a system just inaugurated, and, like everything new, misunderstood and depreciated as well as imperfectly managed.

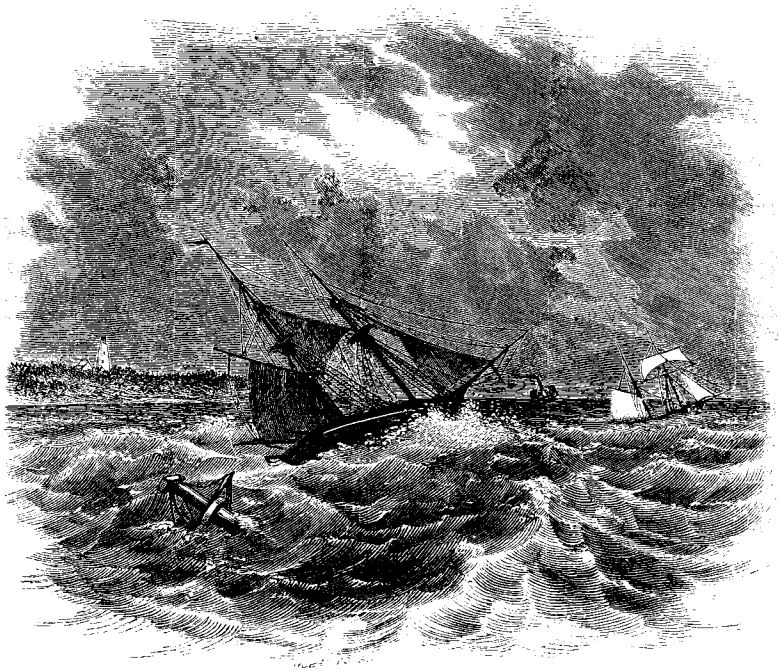
The reports of the Meteorological Department of the Board of Trade, for the past few years, have more than sustained the happy inference to be drawn from these facts for the utility and popularity of Storm-Warnings.

The system of sending telegrams and storm-warnings to their seaports has for some years been in use in France, Holland, Austria, Sweden, and Italy. We have not spoken of them because the storms of these countries come to them mostly from England.

"On the 2d of December, 1863, during the daytime, I received two despatches stating that a severe storm was about to traverse France," writes the President of the Toulon Chamber of Commerce to M. Le Verrier; "they were published and posted up immedi-

* Alexander Buchan's *Handy-Book of Meteorology*, pp. 342, 343.

* See Report of the Meteorological Department of the Board of Trade of London for 1866.



STORM ON LAKE ERIE.

ately, and the merchant vessels in the roadstead had time to provide, and did provide against all risks. The maritime prefecture, on its behalf, directed all officers who were on shore to hasten on board their vessels. The storm burst forth with all its fury about half-past three o'clock in the afternoon. The first telegram sent on the 2d, confirming that of the day before, had therefore gained four hours' time ahead of the storm, and everything was ready to meet the emergency. *Thanks to the precautions thus taken*, there was no damage, no disaster to deplore."

The Genoese *Journal* of Dec. 3d, 1869, says that "the prediction telegraphed by the Paris Observatory to Turin, and immediately communicated to the ports on the western coast of Italy, on the 1st inst., was fully realized. The first signs of the storm were felt yesterday about 7.30 P.M. During the night it raged furiously; but there appears, nevertheless, to have been no disastrous occurrence in our neighborhood. The commandant of the port had hastened to take all proper measures, and we may be thankful for them."

The following is *the first official storm warning made in the United States.* It was bulletined at noon (Nov. 8th), in the Merchants' Exchange at Chicago, and telegraphed along the Lakes :—

"*To all observers along the Lakes.*

"*Bulletin this at once :*

"*A high wind all day yesterday at Cheyenne and Omaha.—A very high wind reported this morning at Omaha.—Barometers falling with high wind at Chicago and Milwaukee.—Barometers falling and Thermometers rising at Detroit, Toledo, Cleveland, Buffalo, and Rochester.—High winds probable along the Lakes.*

(*Signed*)

"*JAMES MACKINTOSH,*

"*Observer.*"

The foregoing bulletin was prepared by General Albert J. Myer, the Chief Signal Officer of the army, and the Chief of the Meteorological Bureau, who was in Chicago at the time. The following extract from the *Cleveland Herald* of November 10th, will show the weather that followed the warning : "The value of the storm-signal service established by the government has already been shown. On Tuesday noon (the 8th inst.) a bulletin from the Meteorological Department announced the movements of a storm that left the Rocky Mountains on the previous day and was traveling eastward. On Tuesday and Wednesday it blew heavily on the lakes, finishing up Wednesday night with

squalls, bringing a little snow. Sailors on the lakes are disposed to sneer at these weather despatches as of no practical value, just as the sailors on the English coast at first ridiculed similar bulletins put out by the English Government; but the loss of many lives and much property by a systematic disregard of these warnings, and the saving of life and property through heeding them, have changed the views of the English sailors materially, as they will those of the lake navigators. As vessel-owners are more careful of their property than sailors are of their own lives, the value of the bulletins is more quickly acknowledged by the former than by the latter."

The following appeared in the *Cleveland Leader* of the 6th of December: "THE STORM YESTERDAY.—*The Utility of the United States Signal Service Offices.*—Yesterday afternoon despatches from Chicago and Detroit were published in the *Evening News*, stating that a heavy rain-storm, traveling east, prevailed in those places, and might be expected in Cleveland in the course of the afternoon. At twenty minutes after three the storm arrived, falling at once upon our city in its utmost fury, drenching the streets with floods of water, wrenching off signs, knocking down several chimneys, and causing the wildest consternation among pedestrians who were caught without a moment's warning in a terrific gale.

"The manner in which the storm was followed in its course establishes, beyond dispute, the utility of the signal offices."

The following is an extract from the Pittsburgh *United Presbyterian* (a part of a Cleveland correspondent's* letter), dated Dec. 7th, 1870: "The path of the late storm was at least 300 miles wide, from north to south. Where it started or spent its force I do not yet know; but telegrams from Milwaukee, Chicago, and Detroit announced its coming beforehand. How dangerous these storms are on the lakes may be inferred from the fact that many of the insurance companies take no marine risks here after the 1st of November. With some others, however, the policies run till November 20th and November 30th.

"The benefit of the new signal system of the government for announcing the weather has a fine illustration in the late storm. In October last a government signal station was established here under order of the Secretary of War. By this system of telegraphy the storm on Monday was known here three hours before its arrival, and it came true to time. The system will no doubt eventually be extended to the whole country."

Such are some of the first fruits in the practical application of meteorology to the wants of commerce.

Other results may be looked for from published meteorological reports. Buchan has well said that "in this way a storehouse of information is collected by which agriculturists may arrive at a knowledge of the character of the climate they have to deal with; and by which physicians may reason with more certainty than at present regarding the spread of diseases, the rates of mortality peculiar to different countries, and the places to which invalids may be sent, so as to enjoy the greatest safety or receive the greatest advantage to be derived from a change of climate."

A former superintendent of one of the large Western railroads has informed me that by keeping an aneroid barometer and noting it carefully, it was of great service to him in preventing accidents to trains, arising from injury to the road by the furious storms of the West.

The telegrams and reports of the Signal Service might be made of great value to the Pacific Railroad Superintendent, during the winter, when their trains are liable to be "snowed up."

As we shall presently see, the more destructive American storms come from distant regions of the continent, whence by telegram we can obtain speedier and more exact information than the English meteorologist can ever expect.

"In the Lake districts and along the Atlantic seaboard such prediction of storms," says Blodget, in his invaluable *Climatology of the United States*, "if for a few hours only, would be of incalculable service to practical interests. It is now easy to indicate the advance

* Robert Audley Browne, Esq.

of one from Chicago to Buffalo and from Buffalo to Boston.

"In the vicinity of the lakes there is a greater opportunity than elsewhere to profit by the knowledge we have of these facts of exterior appearance and general movement, and from Milwaukee to Detroit, Cleveland, and Buffalo the communication is very direct, and the succession of events quite the same. The barometer here is of less use than at sea, though always of great value, because some of the short and violent gales are scarcely indicated by it.

"A violent north-east gale at Milwaukee is certain to be felt with some force a few hours later at Detroit, and one violent at Detroit is equally certain to be felt severely at Buffalo. North-westerly gales are always to be indicated in the line of the wind's direction, and they rarely fail to go to Buffalo from any point of the lakes westward. North-east winds recede *eastward:* in short, all the phenomena travel eastward in all cases, at a rate not less than twenty miles an hour, and usually at thirty to forty in the season of high west winds, or in winter."*

This is clearly understood from a passage we beg leave to quote from Mr. Buchan, in which he says: "It is impossible to overestimate the value of storm-warnings to the shipping interests. In the north temperate zone, observation shows that storms almost invariably come from some westerly point, and thence follow an easterly course. In the United States of America it is easy to warn seaports of the approach of storms, for as soon as a storm appears in the Western States bordering on the Rocky Mountains, it is intimated to the central office in Washington, followed in its march by the telegraph, and timely warning of its approach is sent to the coasts which it will visit. The United States of America is thus favorably circumstanced for carrying out effectually the system of storm-warnings."† Although we may not accept this statement as to the almost invariable direction of American storms, it is of great value.

In an able article published a year ago in the Chicago *Bureau*, a most stirring and reliable mercantile magazine, Prof. I. A. Lapham presented a chart of the great storm of March 13th–17th, 1859, showing its origin and progress over the country:

"The storm first struck our coast in Western Texas, about 2 P.M. of the 13th; from thence it moved to the northward and eastward, touching Lake Michigan twenty-four hours, and the Atlantic coast forty-eight hours later, thus allowing ample opportunity, with the aid of the telegraph, to prepare for its dangers, both upon the lakes and upon the sea. This storm occupied one more day in reaching Nova Scotia, and another before it finally left the continent, at St. John, Newfoundland. We have, therefore, in this case another very complete confirmation of the general deductions of Prof. Espy."

The accomplished editor of the *Bureau*, Charles W. Jenks, Esq., in commenting upon this paper and upon the storm itself, said:

"The same storm, as appears from authentic records, caused the total destruction of 2 propellers, 2 barques, 4 brigs, 19 schooners, 2 barges, and 6 scows—making an aggregate of 10,942 tons of shipping, whose value was $468,600. Sixty-two other vessels of different classes, were more or less injured. So that the total loss and damage to vessels upon the lakes, by this one storm of four days' continuance, may be set down as not less than one million of dollars; and if we add to this, as would be just, the value of the cargoes destroyed and damaged, and the minor losses not usually reported, we shall increase this sum to the fearful aggregate of over *two millions* of dollars!" *

May we not, indeed, with these facts before us, feel that the establishment of a thorough system of Meteorological observations, with a view to practical Storm-Warnings, is assured?

It is a common remark of meteorologists, that the masses gladly welcome their efforts in foretelling the weather. Indeed it is often a necessity with the poor man to foreknow the weather, and experience is his guide.

* Blodget's *Climatology*, p. 374.

† *Handy Book of Meteorology*, p. 11.

* *Bureau*, January, 1870.

"The certainty with which the lower animals," says Steinmetz, "foresee the changes of the weather; the impressions which they receive long before man himself is influenced; that solemn expectancy of all nature, which manifests itself before every shock of the elements,—all tend to show us that the forecasting of the weather is not a mere chimera."

"It is around the great lakes of America," says Margollé, the eminent French meteorologist, "where disasters are so frequent, that this system of communication was first put in play to signal the approach of storms; adopted subsequently by the principal States of Europe, it has already rendered the greatest service to navigators, and should likewise aid in diminishing the losses that unexpected bad weather so often inflicts upon agriculture."

M. Le Verrier, in his reply to the Ministry of Public Instruction in France, on the subject of the observations that it would be possible to organize in France, in order to obtain data useful to agriculture, recently said: "The reception accorded by our maritime populations of the warnings furnished them by the observatory, causes us to foresee the time at hand when our farmers will claim similar attention from the solicitude of the government."

"Your Excellency will, no doubt, remember that it was the urgent request of Prussia, on behalf of a society of agriculturists, at Mecklenberg, that gave occasion to our first despatches predicting the state of the weather, and that as early as 1854, after a storm that had devastated Provence, the Agricultural Board of Toulon addressed a long letter to the Minister of Agriculture, in order to set forth to him the advantages that would result from the pre-announcement at the right time of the approach of bad weather."

It is to be hoped that the time will come when each of our villages, as each of our seaports, may be furnished with weather warnings.

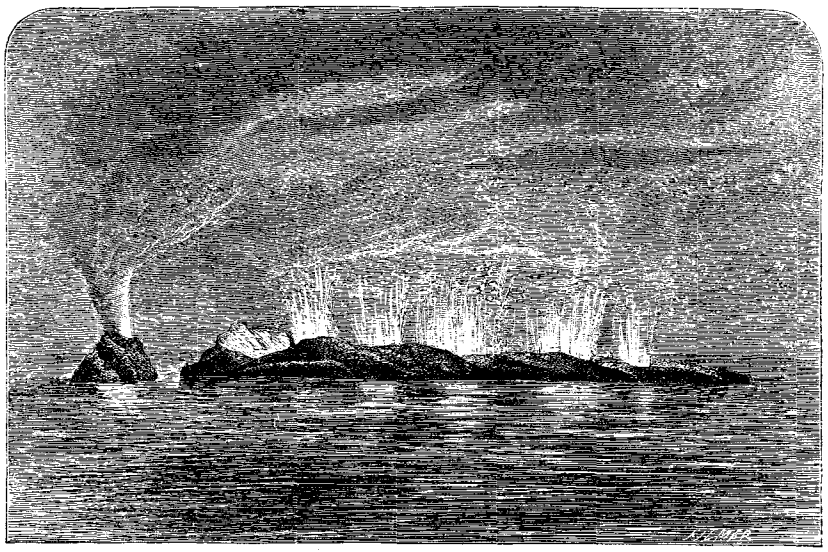
The question which arises, in the present stage of our inquiries, is an all-important one: *Are storms guided in their motion by any law? Have they any fixed tracks?*

It is evident that no results can be looked for (on an extended scale) in the use of Storm Forecasts unless this question can be answered in the affirmative. Upon whatever hypothesis different and differing meteorologists have explained the phenomena of storms, they have been nearly unanimous as regards the tracks of these violent meteors.

Rightly to understand the laws which govern the ordinary circulation of the atmosphere, we must take the ocean as the field on which the atmospheric forces perform their wonted and natural evolutions.

On the land, unless we except immense deserts, which have been, like Sahara, compared to "*a sea of sand*," the normal and regular winds are disturbed and diverted from their channels by the high mountain-walls, and even by ridges of lofty height. It has long since been observed by seamen that even small islands in the Pacific Ocean (*e.g.*, the Sandwich Islands) turn the gentle trades aside and cause them to reflow or blow backwards for a distance of some miles from the land. Now, as the laws of storms, or the extraordinary motions of our great gaseous ocean, are largely determined by the direction of the ordinary air currents, we must ascertain what the latter currents are. This interesting inquiry, extended by thousands of observers, for many centuries, over all parts of the ocean, and at every season of the year, with results carefully recorded and preserved in their log-books, furnishes us the materials for an intelligent conclusion. Columbus was one of the first of these meteorological observers, for he carefully noted, amid the terrors of his crew, that the Trade Winds within the tropics blew steadily towards the west (away from home); and the modern sailor finds them blowing to-day just where Columbus found them. Columbus also observed and recorded the great equatorial current of the Atlantic, writing, in the diary of his Third Voyage, these remarkable words: "I regard it as proved that the waters (within the tropics) move from east to west, as do the heavens (*las aguas van con los cielos*), that is to say, like the apparent motion of the sun, moon, and stars."

In the circulation of the atmosphere two mighty forces may be distinguished as the most potential agents at work. One of these



ISLE OF FERNANDINA, IN AUGUST, 1831.

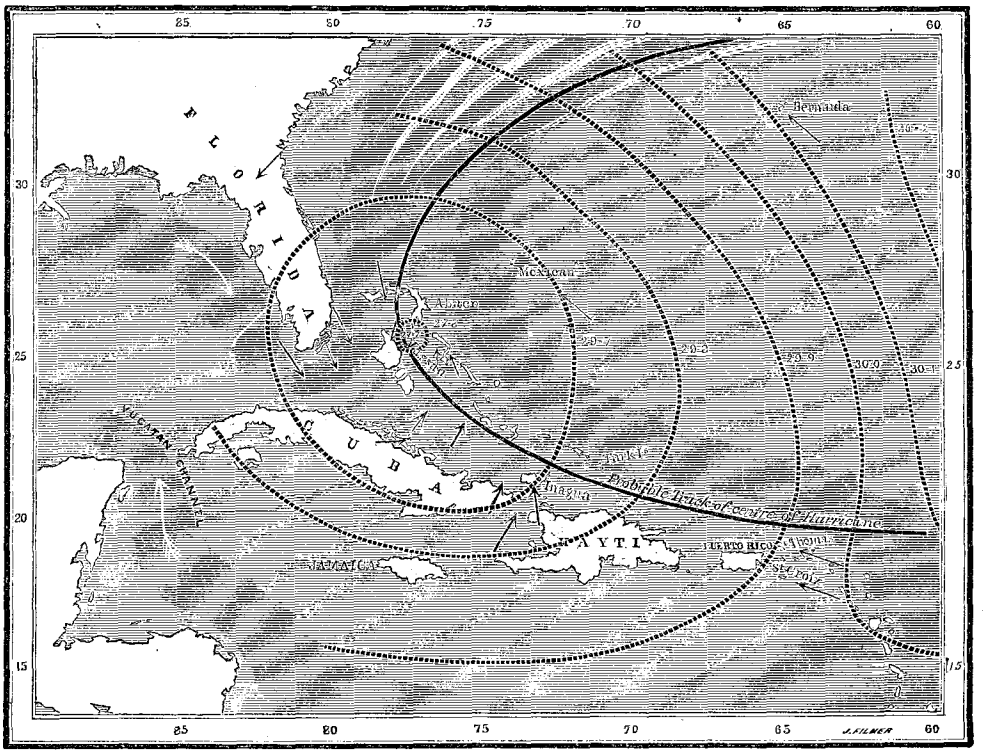
is the *sun's heat*—the reservoir of motive and mechanical power for the earth—which falls directly on the torrid zone. Here it co-operates with the submarine and volcanic furnace which, Humboldt, Ritter, Von Buch, and all physical geographers have agreed, underlies the central zone as a belt of ever-glowing fire.* To realize the mighty resources of this seething furnace, we have only to recall the history of the many islands of the sea which have sprung up in a night, and of as many others which have suddenly disappeared, as did Fernandina in the Mediterranean, maintaining itself above the water only a few weeks.

The other force, which controls the circulation of the atmosphere perhaps even more than the combined agencies of solar and subterranean heat, and which therefore demands most attention from the meteorologist, is the earth's rotation on its axis, by that mighty impulse originally received from the hand of the Almighty. Could an observer take his place on the moon, and with his telescope watch the daily revolution of the Earth, he would see it as an immense satellite, fourteen times the size of our full moon, revolving from West to East. Should his eye first rest upon the luminous land masses of America, they would for six hours move in the panorama; the Pacific Ocean would next appear, and successively Asia and Australia, Europe and Africa, and the Atlantic.* Upon the simple fact, thus disclosed, largely, if not mainly, depend the meteorologic and geographic characteristics of the whole planet, for, in the words of Sir John Herschel, "the Earth's rotation gives their peculiar character to all the great aërial currents which prevail over the globe."† To apprehend this we have but to conceive of the solid and fluid globe passing in daily and ceaseless revolution under the vast atmospheric envelope which covers its surface. As our planet rotates from West to East, and is continually slipping under the air, the effect is a broad band of wind ever moving around the globe from East to West. The winds thus created in the tropics, and depositing their loads of moisture on the soil, produce a marked contrast between the eastern and western coasts. Could the earth stop in its axial rotation, or begin to rotate from East to West, what vast revolutions would be immediately wrought! Brazi-

* How far subterranean heat affects the crust of the earth the reader will see ably set forth through five chapters of a work by Gerald Molloy, D.D., of England, lately republished by G. P. Putnam & Sons.

* For a beautiful description of the "Earth seen from the Moon," see Fay's Outline of Geography, G. P. Putnam & Son.

† Herschel's *Meteorology*, p. 57.



METEOROLOGICAL CHART OF WEST INDIES, FOR 1ST OF OCT., 1866, 8 P.M.

(Light-feathered arrows show course of currents : unfeathered arrows, winds.)

lian South America, now teeming with life and fertility dropped down upon it by the watery trade-winds, would become like the desert of Atacama and the rainless Peruvian slopes of the Andes.* The climatology of the globe and its physical aspects would be radically altered. If the earth did not revolve on its axis the trade-winds would blow from the north and the south directly towards the equator. As, however, the earth revolves from west to east, and the girth round the tropical circle where the trades begin to blow is not so great as at the equator, and consequently has less eastward velocity, the winds, as they approach the equator, find the earth revolving faster and faster and slipping from under them. They therefore lag behind and thus seem to blow from the northeast, north of the equator, and from the southeast, south of the equator.

As there is an incessant current of air poured upon the equatorial belt from both the north and south, it follows that the same quantity of atmosphere must return towards the poles, or else all the aërial ocean would be piled upon the equator. As this returning air, which moves from the equator as an *upper* current (called "*the upper trade*"), reaches the Tropic of Cancer it sinks to the earth's surface, and then moves in a northwardly and eastwardly direction. It takes this course for the same reason that the Gulf Stream, after leaving the Florida Channel, spreads itself out like a slightly-opened hand, and under the influence of the earth's diurnal rotation moves towards the British Isles in the path of a trajectory. Were the earth's axial rotation to cease, the Gulf Stream, with its warm, smoking waters, would no longer come in contact with the shores of Britain, but it would flow due north. Greenland would then be entitled to the name which was wrongfully given it, and Ireland would cease to be "Green Erin."

* See A. Keith Johnston's *Physical Atlas*, p. 119.

If we suppose it possible the great atmospheric currents could be *colored*, each with a hue of its own (as we color the Gulf Stream and other ocean currents upon a painted chart), and that at one glance we beheld the entire aërial ocean in circulation, we should instantly discover a most startling fact. We should discover that the currents of the sea and the currents of the air move nearly together, and that the great laws which control the pulsations of the liquid sea, with certain modifications, vitally affect the respirations of the gaseous ocean. There is this difference: the bottom of the aërial ocean moves approximately with the surface of the watery ocean, and conversely. If we compare for a moment the Map of Marine Currents and a diagram of the surface winds of the earth, we shall see how closely they conform to each other. Take the Gulf Stream for an example. It has been described by a distinguished writer as a mighty *river in the ocean*, whose banks and whose bottom are of cold water, as was proved by the researches of the United States Coast Survey. "The Gulf Stream plays a grand part in the system of Atlantic circulation. It carries the tepid and milk-warm water of the tropics into the frozen regions of the north;" it is an incessant preserver of the oceanic equilibrium, and, in the eloquent words of Michelet, "it flows onward to console the pole." But the Gulf Stream is a great liquid avenue, over whose blue waters roll mighty masses of atmosphere and ride in terrific triumph the fiercest cyclones.

Its track is overhung by aqueous vapor, and is thus a region of rarefied air and of a low barometer.

Here is a natural ATMOSPHERIC RIVER-BED. Its banks are of colder and heavier air and its bottom is the bosom of the sea itself. The storm, as it passes along this great highway carved out for it by an ordinance of the Almighty, may rub and fret against its bounds, as the locomotive, thundering along the curve of the road, may chafe against and batter the steel edges of the unyielding rail. It may even, like the engine, leave and leap its track and fly off in tangential fury. But it has a track, an ordained track, in which man may ordinarily expect to find it.

It is a well-known fact that the Gulf Stream, after leaving the Florida Channel, breaks into streaks of hot water, separated by streaks of cold water.* In his Coast Survey Reports, Lieut. Bache often speaks of these "bands." "There are two cold streaks outside of the (main axis of the) Gulf Stream, and a warm one between them: the position of the next warm streak is quite uncertain."† The thermometer indicates a great difference in the temperature as you cross these streaks of water, and they are well enough defined to be indicated on all good charts. (See these *streaks* in the Gulf Stream, as shown in the Meteorological Chart of the West Indies for 1st of October, 1866, at 8 P.M.) The same streaks were found by Capt. Bent in the celebrated Kuro Siwo, or Black Stream of Japan, similar to the Gulf Stream. The Gulf Stream thus appears like an open hand, the wrist resting on the Florida Pass and the Bahama Banks, the forefinger on the Grand Bank of Newfoundland, and the other fingers on the Azores, the British Isles, and Norway.

I beg now to ask the reader especially to compare those courses and offshoots of the great Tropical Current with the following remark, which I have just received while I write, in a letter from Captain Silas Bent, the distinguished hydrographer, and flag-officer of Commodore Perry's Japan Expedition.

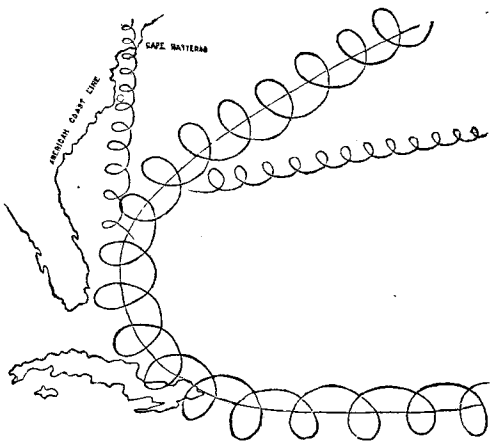
Writing with no reference whatever to the views here advanced, he says, in speaking from his twenty-five years' experience in managing vessels in storms and cyclones:—"The storm as it advances not unfrequently throws off small cyclones from its sides, but which are as perfect and symmetrical themselves as the parent storm."

Now each one of the diverging streaks of warm water in the Gulf Stream may be regarded as a little gulf stream in itself, offering a track for the offshoot, and inducing its separation from the main storm, whose centre is traveling on the central axis of the Gulf Stream.

Is it not, at any rate, perfectly clear that the general course of the heated waters of

* See Berghaus' Chart of the World.

† Coast Survey Report, p. 50. 1854.



OFFSHOOTING CYCLONES.

the Equatorial Current is the track of the cyclone?

Buchan, describing the direction in which European storms advance, says:—"About half the storms of Middle and Northern Europe travel from Southwest or W. S. W. towards N. E. or E. N. E., and nineteen out of every twenty, at least, travel toward some point in the quadrant of the compass from the northeast to the southeast. Thus the general direction from which storms come is westerly." * The reader has only to trace the Gulf Stream from its great parent, the Equatorial Current of the Atlantic, to its recurvation from the American shores toward England, to see that it may be truly regarded as the great *Storm-Bearer* of the West Indian hurricanes. This is attested by vast numbers of charts of storms arising in the Caribbean Sea and curving from a westerly to a northerly, and thence to a northeasterly course. In the work of charting these moving storms, the name of William C. Redfield, of New York, will ever be gratefully remembered by the seaman and the merchant.

"If a storm," says Prof. Loomis, "commences anywhere in the vicinity of the Gulf Stream, it naturally tends towards that stream, because here is the greatest amount of vapor to be precipitated, and when a storm has once encountered the Gulf Stream it continues to follow that stream in its progress eastward."

* P. 244, *Handy-Book of Meteorology.*

It is susceptible of demonstration that the major part of the Equatorial Current, diverted by the Windward or Lesser Antilles, and moving in obedience to physical law, does not enter the Gulf of Mexico, but flows by a curve off the northern shores of the Antilles, forming "The Northwest Branch" of the Equatorial Current.* It is the same case with what may be called the great *Aërial Equatorial Current*, which, flowing to the westward, conspires to work off most of the hurricanes into the track of the super-heated water, and causes them to follow the route indicated on the hurricane chart. Here we have then one of the

TRACKS OF AMERICAN STORMS.

Offshooting cyclones frequently strike the Atlantic coast of the United States, and move with great power into the interior. They are most frequently arrested, or their force broken, on the summit of the Blue Ridge Mountains, or on the Alleghanies. But they often break over the mountain barrier and pour their destruction on the western slopes of these ridges.

Had we synchronous reports from the towns visited by the fearful September storm and flood in Virginia, it is believed, we would be able to demonstrate that it was one of these offshoots from a Gulf-Stream cyclone. Its centre seems to have passed toward the mountain sources of the James River, whose bed was crowded and choked with the fatal torrent. Overleaping the Blue Ridge, it descended upon the fair valley of the Shenandoah, reaping its grand harvest of destruction and death.†

Why these cyclones should travel from the tropics toward the temperate region, is discovered from the chart of isobarometric lines, or the lines along which the barometric pressure is the same. As the atmosphere will ever move from a point of high barometer to one of low barometer, we can easily comprehend the phenomenon.‡

* See this demonstrated by the present writer in an article on "Hot Current of the Atlantic," *Harper's Monthly*, June, 1870.

† It did not reach the upper waters of the Potomac, but the loss of property and life is stated by the press to have been immense.

‡ See Buchan, p. 285.

Here, too, it may be well to remark, if meteorologists can rely upon anything they may rely upon these two facts :—First, That the atmosphere will naturally move from a point of high barometer to a point of low barometer,—just as naturally as the Mississippi river will run into the Gulf of Mexico, or as water runs down hill. Second, That the region of great aqueous vapor is always a region of low barometer. The southern hemisphere being the *water*-hemisphere, or, as Dové calls it, "*the boiler*," for which the northern hemisphere is the "condenser," is a striking illustration of the fact, the barometer always reading lower at Cape Horn and in the Antarctic regions than at any similar latitudes in the northern hemisphere.

We have but to take at random one out of the long catalogue of the charted hurricanes of the West Indies to see all that is here advanced verified, *e.g.* :—

"1827. August 17th to 27th (*Redfield*). Hurricane, August 17th, at Barbadoes; 19th, near Hayti; 24th, east of Charleston; 25th, off Cape Hatteras; 27th, east of New York; 28th, east of Halifax. This was central to the Gulf Stream through its whole track, and nearly midway between Bermuda and Charleston. Mr. Redfield gives eleven nautical miles per hour as the rate of movement of this storm."

It is the influence of the trade winds that gives the hurricane its westward motion at first. Reaching the northern limit of the trade-wind belt in latitude 30° North, it is relieved of this influence and moves to the north-east.

A second track taken by the fierce cyclone generated in the great Aërial Equatorial Current, is the track of the Gulf Stream through the Yucatan Channel. Penetrating the Gulf of Mexico through this gateway, the cyclone travels with the stream, or is projected to one side, falling sometimes with relentless fury upon the coast of Texas or Louisiana, and thence following, by a course more or less direct, the basin of the "Father of Waters." Over the bed of this mighty river—the drainage of a continent—the atmosphere is ever in a condition to offer transit to the moving storm. From the Gulf of Mexico, along the Mississippi up to its head-waters, and along its great tributary the Ohio, numbers of these fierce meteors, born in the tropics, have been traced. The reader will find one of them charted by Prof. I. A. Lapham, from materials furnished by the Smithsonian Institute, and published in the Chicago *Bureau*, the journal which has, more than any we know of in the land, been the earliest and most determined advocate of the Storm-Signal System. According to Capt. Bent, the storms from the equatorial Atlantic "emerge from the basin of the Gulf of Mexico between New Orleans and Tampico, and bend gradually to the N. E., passing over Texas, Arkansas, Missouri, Illinois, and Indiana to the Lakes and the St. Lawrence, requiring sometimes three or four days (or more) to travel from the Gulf to the Lakes, and ample time for information to be conveyed by telegraph in advance, so as to give warning of their approach not only to the shipping on the Lakes, but also to the railroads and farmers, who will, I am sure, in a few years learn so well to profit by such information, that the latter will consult the Meteorological Reports before sowing their grain or reaping their harvests." "To railroads," he adds, "the Reports may be made of great service—especially in the winter, as I know from experience—by lightening the trains so as to prevent being blocked by snow; and in the summer, to put the trainmen on the lookout for washed embankments or broken culverts and bridges."

The storms which strike upon the Texan coast are generally equinoctial or winter storms; for, when the sun is in his winter declination, the equatorial currents of the ocean are depressed, or drawn more into south latitude—the *thermal* equator vibrating with the sun causes all the currents of the sea and air to do the same, and thus the sweep of the hurricane is more likely to reach the coasts of the Gulf of Mexico.

A third track of American storms is from the eastern base of the Rocky Mountains over the plains in an eastwardly direction. It is difficult to explain this fact, but none have questioned it. It is, however, to be feared that meteorologists have dwelt too exclusively upon this source of our storms.

To comprehend how great disturbances are propagated from the region of the Rocky

Mountains eastwardly, we must regard three facts.

First, the general tendency of the atmosphere in the north temperate zone is from the south-west or west.

"Over a large part of British America and all the United States, except the most southerly districts, at a height ranging above seven thousand feet," says Dr. Draper, a "west wind is perpetually blowing. It moves in the middle latitudes at a rate of about twenty miles per hour, and there is reason to believe passes all around the globe. In a general manner, however, all our atmospheric disturbances move from the west to the east."

Moreover, as the Gulf Stream of the Atlantic is the natural channel for the storms which beat upon the British coast, so the Kuro-Siwo, or Black Stream of Japan, a mightier gulf stream than ours, whose recurving waters wash and warm the Pacific coasts of America,* affords a pathway for cyclones generated in the Pacific Ocean and the China seas. This latter region of the earth is near the very womb and nursery of the tempest and the typhoon. The storm engendered in its bosom finds, in the atmospheric river-bed overhanging the smoking waters of the Kuro-Siwo, a free and ready transit.

We have seen that the great majority of Atlantic storms move over the Gulf Stream to England and western Europe, and it is not hard to see how the coasts of California and the western declivities of the Sierra Nevada and the Rocky Mountains are called to receive the shocks of cyclones from the Kuro-Siwo.

"The great storms at sea off the coast (of Japan)," says Blodget, "also appear to be like those of the Gulf Stream and Atlantic coast." † "When we take into account," says Piddington, "that this warm ocean stream is found exactly on the lines which connect the greatest volcanic chain of our globe, we are struck with the analogy which this presents with the Florida Gulf Stream; and we call necessarily to mind the prevalence of cyclones within its limits and their tendency to follow its track."*

Vessels and Japanese junks, dismasted off the coast of Japan, have been drifted by the Kuro-Siwo to the coast of California, just as beans and vegetables from the West Indies have been drifted to Iceland and Spitzbergen by the Gulf Stream. Is it then strange that the Pacific storms should be propagated on the Kuro-Siwo to our continent?

Observations in the Western Pacific have been comparatively meagre; but Mr. William C. Redfield, in the second volume of Com. Perry's Japan Expedition Report, has given a chart of the cyclones off the coast of China and Japan which bears out, as far as it goes, the view here expressed of the recurvation of these storms towards the American shores of the Pacific.

Mountain systems on the Pacific coast are, it is true, to be regarded. "The effect of the mountain systems of Asia, in particular the Yablonoi or Stanovoi Mountains," according to Buchan, "in shutting in the cold, dense air within that region is to be referred to. Indeed, but for this high mountain range, the singular distribution of the pressure which is seen to obtain from Yakutsk eastward to Kamtchatka could not be maintained,† and in all probability the whole winter pressure of Central Asia would be materially reduced."

But these Asiatic mountain-walls tower up far beyond the summits of the Rocky Mountain barrier, and the air which seeks to pass the latter is not the cold, dense atmosphere of Siberia. It is not impossible, therefore, to see how the Pacific storm, after traveling to the east, overleaps the mountains, and, once over, sweeps eastward with undiminished velocity. As it rolls on over the great western plain it meets no obstacle, and reaching the valley of the Upper Mississippi naturally ascends it, or, as is often the case, makes its fiery way to the Great Lakes. The heavy atmospheric pressure on the cold regions of British America would serve as a wall against the northerly or north-easterly movement of these storms.

The storms which fall upon the north-east

* At Fort Steilacoom (Puget's Sound) the temperature is higher than at Santa Fé, 800 miles farther south.

† *Climatology of the United States*, p. 117.

* See Piddington's *Horn-Book*, p. 70.

† Meteorology, p. 51.

coast of the United States, in New England and the Middle States, have a steady movement beginning in the south or south-west, and gradually work around to a north-east point. Some of them work up along the Atlantic seaboard. They are, doubtless, originally small cyclones thrown off into and across the Gulf of Mexico from the Equatorial Current or the Gulf Steam. It is a singular fact that these storms too, like that charted by Professor Lapham, are not summer storms, but winter or equinoctial storms, thrown off from the Equatorial Current while the sun is vertically on or *below* the equator, and hence while the current itself and the trade-wind belt also are drawn down and depressed to a low latitude. At this time, of course, the hurricane track of the West Indies, instead of running north of Cuba, will run south of Cuba or along the northern coast of South America.

If the meteorological labors of the government Signal Service and Bureau of Telegrams and Reports (now under the guidance of the able and enterprising Chief Signal Officer of the United States Army, who has in a few months organized a system of weather-telegraphy which will compare favorably with systems in Europe which have been the work of years) can be sufficiently extended, these and all other important American storms may be forecast, and mariners along our northern and lake coasts be forewarned at least twenty-four hours, and often two or three days. It may be well in this connection to consider the following remark of Admiral Fitzroy: "There is no discrepancy between the results of ten years' investigation, published by Dr. Lloyd in 'Transactions of the Royal Irish Academy,' the three years inquiries published by Mr. W. Stevenson, and other investigations which have been brought together during the last few years. They all tell the same story. Gales from the south and west are followed by dangerous storms from the north and east; and those from the north and east do most damage on our coasts. By tracing the facts it is shown that storms which come from the west and south come on gradually, but that those from the north and east begin suddenly, and often with extraordinary force. The barometer, with these north-eastern storms, does not give direct warning upon this coast, because it ranges higher than the wind from the opposite quarter.

"But though the barometer does not give much indication of a north-east storm, the thermometer does; and the known average temperature of every morning in the year affords the means (from the temperature being much above or below the mean average of the time of year) of knowing, by comparisons, whether the wind will be northerly or southerly," &c.

THE VELOCITY

of these storms, and of all our cyclones, is variously estimated from five to thirty miles per hour, which is, at the maximum, not more than that of an ordinary railroad train. "On rare occasions the rate at which storms travel, according to Buchan, is as great as forty-five miles an hour." "Since the distance from the south-west of Ireland to the east of Great Britain," he adds, "is about four hundred and fifty miles, it follows that even after a storm has appeared on the west of Ireland, the eastern seaports may be generally warned of its approach twenty-four hours before the force of the gale begins to be felt, even though no warning be issued until the storm has actually made its appearance in Ireland." *

The space fails us for the present, but the most interesting phases of the subject remain. We have seen that the most furious cyclones are not wandering meteors and fitful nomads, but that they pursue their ordained and beaten tracks, observing something of that precision with which our planet describes the elliptic orbit around its central star.

The question then arises, *By what law do they move?*

[The second article on this subject in the next number of the Magazine, will present its more interesting and popular phases, *e.g.*, the nature and laws of storms; the premonitions and causes of American storms; the meteorological instruments and methods of observation adopted for the service by the Chief Signal Officer of the United States Army; the system of despatching and bulletining the telegrams and storm-warnings; and the latest results and prospects of the enterprise. The illustrations will be done with peculiar care, and by the first artists.]

* *Meteorology*, p. 248.