Lieut. Ch. H. Davis
from his friend the author
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MAURY'S

SAILING DIRECTIONS,

THIRD EDITION,

IMPROVED AND ENLARGED.

NOVEMBER, 1851.

EXPLANATIONS AND SAILING DIRECTIONS

TO ACCOMPANY THE

WIND AND CURRENT CHARTS,

APPROVED BY

COMMODORE LEWIS WARRINGTON,

CHIEF OF THE BUREAU OF ORDNANCE AND HYDROGRAPHY;

AND PUBLISHED BY AUTHORITY OF

HON. WILLIAM A. GRAHAM,

SECRETARY OF THE NAVY.

BY LIEUT. M. F. MAURY, U. S. N.

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WIND AND CURRENT CHARTS.

The great demand for these charts among seamen, and the interest which they have excited among philosophers, make it proper that I should give a more detailed account than I have yet given as to the progress of the work, the objects in view, and the prospects ahead.

This is the more proper because I hope thereby to impress seafaring men and others, who have it in their power to facilitate or retard the work, with the importance of the undertaking.

"In the present condition of the surface of our planet," says the most celebrated traveller and philosopher of the age, "the area of the solid is to that of the fluid parts as 1 to $2\frac{1}{5}$, (according to Rigaud, as 100 to 270.) The islands form scarcely $\frac{1}{27}$ of the continental masses, which are so unequally divided that they consist of three times more land in the northern than in the southern hemisphere; the latter being, therefore, preeminently oceanic. From 40° South Latitude, to the Antartic Pole, the Earth is almost entirely covered with water. The fluid element predominates in like manner between the eastern shores of the old, and the western shores of the new continent, being only interspersed with some few insular groups. The learned hydrographer, Fleurieu, has very justly named this vast oceanic basin which, under the tropics, extends over 145° of Longitude, the Great Ocean, in contradistinction to all other seas. The southern and western hemispheres (reckoning the latter from the meridian of Teneriffe) are, therefore, more rich in water than any other region of the whole earth.

"These are the main points involved in the consideration of the relative quantity of land and sea, a relation which exercises so important an influence on the distribution of temperature, the variation in atmospheric pressure, the direction of the winds, and the quantity of moisture contained in the air, with which the development of vegetation is so essentially connected. When we consider that nearly three-fourths of the upper surface of our planet are covered with water, we shall be less surprised at the imperfect condition of meteorology before the beginning of the present century; since it is only during the subsequent period that numerous accurate observations on the temperature of the sea at different latitudes, and at different seasons, have been made and numerically compared together."—*Cosmos.*

"I beg you to express to Lieut. Maury, the author of the beautiful Charts of the Winds and Currents, prepared with so much care and profound learning, my hearty gratitude and esteem. It is a great undertaking, equally important to the practical navigator and for the advance of meteorology in general. It has been viewed in this light in Germany by all persons who have a taste for physical geography. In an analogous way anything of isothermal countries (countries of equal annual temperature,) has for the first time become really

fruitful, since Dove has taught us the isotherms of the several months chiefly on the land; since two-thirds of the atmosphere rests upon the sea, Maury's work is so much the more welcome and valuable because it includes at the same time the oceanic currents, the course of the winds and the temperature. How remarkable are the relations of temperatures, in Sheet No. 2, South Atlantic, East and West of Longitude 40; how much would this department of meteorology gain if it were filled up according to Maury's proposition in Commodore Lewis Warrington's Log Book. The shortening of the voyage from the United States to the Equator, is a beautiful result of this undertaking. The bountiful manner in which these Charts are distributed raises our expectations still higher."—*Baron Von Humboldt to Dr. Flügel, U. S. Consul, Leipsic.*

It is not for the benefit of navigation alone that seamen are invited to make observations and collect materials for the Wind and Current Charts; other great interests besides those of commerce have their origin in the ocean or the air; and these interests are to be benefitted by a better knowledge than we now have of the laws which govern the circulation of the atmosphere, and regulate the movements of the aqueous portions of our planet.

The truth of the proposition is so obvious, that the agricultural capacities of any place are as dependent upon the hygrometrical as upon the thermometrical condition of the atmosphere, needs only to be stated as a proposition to secure the assent of all.

Each kind of plant requires for its most perfect development a certain degree of moisture, and the winds which bring it that moisture can only get it from the sea or other evaporating surfaces.

It is often argued because wine and olives, or other staples are produced upon a given parallel of latitude, that therefore they should be produced upon the same parallel wherever the proper soil is to be found.

Whereas, the consideration as to the route which the winds from the ocean have to pursue in order to reach the situation of the supposed parallel, has much to do with the case.

Virginia and California are between the same parallels, yet how different their agricultural resources, the character and the flavor of their fruits, all owing not so much to difference of soil as to the way the winds blow, the quantity of moisture they bring with them, the proportion of clouds and sunshine allotted to each place.

The system of researches embraced by the Wind and Current Charts, therefore it would appear, concern the philosopher and the husbandman, as well as the mariner, the merchant and the statesman.

A wider field, or one more rich with promise, has never engaged the attention of the philosopher. Though much trodden and often frequented, it has never been explored, if we take exploration to mean the collecting and grouping all those phenomena which mariners observe in relation to the ocean and the air above it, with the view of tracing, in the true spirit of inductive philosophy, fact into effect, and effect up to cause.

The mariner, therefore, should bear it always in mind when he is making and recording out upon the wide ocean an observation in connection with these Charts, that upon the fidelity with which that observation and the record of it are made, depends the ability here to read aright the workings of those physical agents that are employed in the grand scheme of creation, to produce those results which are the subject of observation with him.

The wind and rain; the vapor and the cloud; the tide, the current, the saltness and depth, and temperature

and color of the sea; the shade of the sky; the temperature of the air; the tint and shape of the clouds; the height of the tree on the shore, the size of the leaves, the brilliancy of the flowers;—all may be regarded as the exponents of certain physical combinations, and, therefore, as the expressions in which nature chooses to announce her own meaning, or if we please, as the language in which she writes down the operation of her own laws. No fact gathered in such a field as this is can come amiss to those who tread the walks of inductive philosophy; for every such fact is a syllable in the hand book of nature, and it is by patiently collecting fact after fact, and by joining syllable after syllable together, that we may finally seek to read aright from the great volume before us.

Dr. Buist, a learned and eminent *savant* of India, has drawn a picture of the field in which navigators are so earnestly invited to labor and lend their help, which is so true and so glowing that I beg leave to hold it up here for their contemplation.

In the report on the affairs of the "Bombay Geographical Society," presented by the Secretary at the annual meeting, in May 1850, it is remarked: "The Assistant Secretary of your Society,* Mr. Macfarlane, has made considerable progress in the construction of Wind and Current Charts, founded on the information supplied by ship's logs, and on the principle of Lieutenant Maury. It is more than probable that besides the currents occasioned by the trade-winds, monsoons, and sets of the tides, we have a group of movements intermingled with these dependant mainly on evaporation. When it is remembered that on the western shore of the Arabian sea, including in this the Red sea and Persian gulf, from the line northward, we have an expanse of coast of no less than 6,000 miles, and a stretch of country of probably not less than 100 miles inland from this, where the average fall of rain does not amount to four inches annually, where not one-half of this ever reaches the sea, and where, to the best of our knowledge, the evaporation over the ocean averages at least a quarter of an inch daily, all the year round, or close on eight feet annually, some idea of the enormous abstracuon of water in the shape of vapor may be formed. On the assumption that this extends no further, on an average, than 50 miles out to sea, we shall have no less than 39 cubic miles of water raised annually in vapor from the northern and northwestern side of the basin, which must be supplied from the open ocean to the South, or the rains on the East. The fall of rain on the western side of the ridge of the mountain chain, from Cape Comorin to Cutch, averages pretty nearly 180 inches annually, and of this at least 160 is carried off to the sea: that on the Concan to 70 inches, of which probably 30 flow off to the ocean: or betwixt the two, over an area of twenty miles from the sea-shore to the ghauts, and about 1200 miles from the North to the South, or an area of 24,000 square miles in all, we shall probably have an average discharge of nine feet, or close on forty cubic miles of water,—an amount sufficient, were it not diffused, to raise the sea on our shores three feet high, over an area of 72,000 square miles. * * *

"The waters of the ocean cover nearly three-fourths of the surface of the globe; and of the thirty-eight millions of miles of dry land in existence, twenty-eight millions belong to the northern hemisphere. The mean depth of the ocean is somewhere about four miles—the greatest depth the sounding line has ever reached

* Vide Transactions Bombay Geographical Society, Vol. IX—1850, p. LXXX, et seq.

is five and a quarter miles.* The mean elevation of the land, again, is about one thousand feet—the highest point known to us, is nearly as much above the level of the sea, as the greatest depth that has been measured, is below it. The atmosphere, again, surrounds the earth like a vast envelope: its depth, by reason of the tenuity attained by it, as the superincumbent pressure is withdrawn, is unknown to us,—but is guessed at somewhere betwixt fifty and five hundred miles. Its weight, and its constituent elements, have been determined with the utmost accuracy. The weight of the mass is equal to that of a solid globe of lead sixty miles in diameter. Its principal elements are oxygen and nitrogen gases, with a vast quantity of water suspended in them in the shape of vapor, and commingled with these a quantity of carbon in the shape of fixed air, equal to restore from its mass, many fold the coal that now exists in the world. In common with all substances, the ocean and the air are increased in bulk, and consequently diminished in weight, by heat; like all fluids, they are mobile, tending to extend themselves equally in all directions, and to fill up depressions in whatever vacant spaces will admit them; hence, in these respects, the resemblance betwixt their movements. Water is not compressible or elastic, and it may be solidified into ice or vaporized into steam: air is elastic—it may be condensed to any extent by pressure, or expanded to an indefinite degree of tenuity by pressure being removed from it—it is not liable to undergo any change in its constitution beyond these, by any of the ordinary influences by which it is affected. These facts are few and simple enough—let us see what results arise from them. As the constant exposure of the Equatorial regions of the Earth to the Sun must necessarily here engender a vast amount of heat,—and as his absence from the polar regions must in like manner promote an infinite accumulation of cold,—to fit the entire Earth for a habitation to similar races of beings, a constant interchange and communion, betwixt the heat of the one and the cold of the other, must be carried on. The ease and simplicity with which this is effected, surpass all description. The air heated near the Equator by the overpowering influences of the Sun, is expanded and lightened: it ascends into upper space, leaving a partial vacuum at the surface to be supplied from the regions adjoining. Two currents from the poles towards the Equator, are thus established at the surface, while the sublimated air, diffusing itself by its mobility, flows in the upper regions of space from the equator towards the poles. Two vast whirlpools are thus established, constantly carrying away the heat from the torrid towards the icy regions, and these becoming cold by contact with the ice, carry back their gelid freight to refresh the torrid zone. Did the Earth, as was long believed, stand still while the Sun circled round it, we should have had two sets of meridianal currents blowing at the surface of the Earth, directly from North and South, towards the Equator, in the upper regions flowing back again to the place whence they came. On the other hand, were the heating and cooling influences, just referred to, to cease, and the Earth to fail in impressing its own motion on the atmosphere, we should have a furious hurricane rushing round the globe, at the rate of 1,000 miles an hour,—tornadoes of ten times the speed of the most violent now known to us, sweeping everything before them. A combination of the two influences, modified by the friction of the Earth, which tends to draw the air after it, gives us the trade winds, which

* Lieutenant Walsh, U. S. N., while co-operating in the U. S. Schooner "Tany," with me in these researches, reports a sounding in the North Atlantic of 6½ miles, (5700 fathoms,) without bottom. M.

sweep round the equatorial region of the globe unceasingly, at the speed of from ten to twenty miles an hour, the ærial current, quitting the polar regions with the comparatively tardy speed, from East to West, imposed on it by the velocity due to the 70th parallel, is left behind the globe, and deflected into an oblique current, as it advances southward, till, meeting the current from the opposite pole near the equator, the two combine and form the vast stream known as the trades,—separated in two, where the air ascends by the belt of variable winds and rains. Impressed with the motion of the air, constantly sweeping its surface in one direction, and obeying the same laws of motion, the great sea itself would be excited into currents similar to those of the air, were it not walled in by continents, and subjected to other control. As it is, there are constant currents flowing from the torrid towards the frigid zone, to supply the vast mass of vapor there drained off; while other whirlpools and currents, such as the gigantic Gulf Stream, come to perform their part in the same stupendous drama. The current just named, sweeps from the Cape of Good Hope, across the South Atlantic, to the Gulf of Mexico, and by the Straits of the Bahamas. Here it turns to the eastward again, travelling along the coast of America at the rate of from forty to a hundred miles a day; it now stands once more across the Atlantic, and divides itself into two branches;—one finds its way into the northern sea, warming the adjoining waters as it advances, and turning back, most likely to form a second great whirlpool, re-joining the original stream near Newfoundland. The main branch seeks the northern shores of Europe, and, sweeping along the coast of Spain and Portugal, travels southward by the Azores to rejoin the main whirlpool. The waters of this vast Ocean river, are to the North of the tropic greatly warmer than those around; the climate of every country it approaches is improved by it, and the Laplander is enabled by its means to live, and cultivate his barley, in a latitude which everywhere else, throughout the world is condemned to perpetual sterility. But there are other laws which the great sea obeys, which peculiarly adapt it as the vehicle of interchange of heat and cold betwixt those regions where either exists in excess. Water which contracts regularly from the boiling point downwards, at a temperature of 40°, has reached its maximum of density, and thence begins to grow lighter and expand. But for this most beneficent provision, the vast recesses of the northern ocean would be continually occupied with a fluid at the freezing point, which the least access of cold would convert into one solid mass of ice. The non-conducting power of water, which at present acts so valuable a part in the general economy, so far from being a blessing would be a curse. No warmth could ever penetrate to thaw the foundations of the frozen mass—no water find its way to float it from its foundations, so that, like the everlasting hills themselves, rooted immoveably in its place, every year adding to its mass; the solid structure would continually advance to the southward, hermetically sealing the polar ocean thus condemned to utter desolation, and encroaching on the North sea itself. Under existing circumstances, so soon as water is cooled down to 40°, it sinks to the bottom, and, still eight degrees warmer than ice, it attacks the bases and saps the foundations of the icebergs—themselves gigantic glaciers, which have fallen from the mountains into the sea, or which have grown to their present size in the shelter of bays and estuaries, and by accumulations from above. Once forced from their anchorage, the first storm that arises drifts them to sea, where the beautiful law which renders ice lighter than the warmest water enables it to float,—and drifts southward a vast magazine of cold to

cool the tepid water which bears it along,—the evaporation at the equator causing a deficit, the melting and accumulation of the ice in the frigid zone giving rise to an excess of accumulation, which tends along with the action of the air, and other causes, to institute and maintain the transporting current. These stupendous masses, which have been seen at sea in the form of church spires and gothic towers, and minarets, rising to the height of from 300 to 600 feet, and extending over an area of not less than six square miles, the masses above water being only one-tenth of the whole, are often to be found within the tropics. A striking fact dependant on this general law, has just been brought to light; their is a line extending from pole to pole, at or under the surface of the ocean, where an invariable temperature of 39.5 is maintained. The depth of this varies with the latitude; at the equator it is 7,200 feet—at latitude 56° it ascends to the surface, the temperature of the sea being here uniform throughout. North and South of this the cold water is uppermost, and at latitude 70° the line of uniform temperature descends to 4,500. But these, though amongst the most regular and magnificent, are but a small number of the contrivances by which the vast and beneficent ends of nature are brought about. Ascent from the surface of the Earth, produces the same change in point of climate, as an approach to the poles; even under the torrid zone, mountains reach the line of perpetual congelation at nearly a third less altitude than the extreme elevation which they sometimes attain: at the poles, snow is perpetual at the ground, and at the different intervening latitudes, reaches some intermediate point of congelation, betwixt one and 20,000 feet. In America, from the line south to the tropics, as also, as there is now every reason to believe, in Africa, within similar latitudes, vast ridges of mountains covered with perpetual snow, run northward and southward in the line of the meridian right across the path of the trade winds. A similar ridge, though of less magnificent dimensions, traverses the peninsula of Hindoostan, increasing in altitude as it approaches the line,—attaining an elevation of 8,500 feet at Dodabetta, and above 6,000 in Ceylon. The Alps in Europe, and the gigantic chain of the Himalayas in Asia, both far South in the temperate zone, stretch from East to West, and intercept the ærial current from the North. Others of lesser note, in the equatorial or meridianal, or some intermediate direction, cross the paths of the atmospherical currents in every direction, imparting to them fresh supplies of cold, as they themselves obtain from them warmth in exchange; in strictness, the two operations are the same. Magnificent and stupendous as are the effects and results of the water and of air acting independently on each other, in equalising the temperature of the globe, they are still more so when combined. One cubic inch of water when invested with a sufficiency of heat, will form one cubic foot of steam—the water before its evaporation, and the vapor which it forms, being exactly of the same temperature, though in reality, in the process of conversion, 1,700 degrees of heat have been absorbed or carried away from the vicinage, and rendered latent or imperceptible; this heat is returned in a sensible and perceptible form the moment the vapor is converted once more into water. The general fact is the same in the case of vapor carried off by dry air, at any temperature that may be imagined, for down far below the freezing point, evaporation proceeds uninterruptedly, or raised into steam by artificial means. The air, heated and dried as it sweeps over the arid surface of the soil, drinks up by day myriads of tons of moisture from the sea—as much indeed as would, were no moisture restored to it, depress its whole surface at the rate of

four feet annually over the surface of the globe. The quantity of heat thus converted from a sensible or perceptible, to an insensible or latent state, is almost incredible. The action equally goes on, and with the like results, over the surface of the Earth, as over that of the sea, where there is moisture to be withdrawn. But night, and the seasons of the year, come around, and the surplus temperature thus withdrawn and stored away, at the time it might have proved superfluous or inconvenient, is reserved, and rendered back so soon as it is required; and the cold of night, and the rigor of winter, are modified by the heat given out at the point of condensation, by dew, rain, hail, and snow.

"There are, however, cases in which were the process of evaporation to go on without interruption and without limit, that order and regularity might be disturbed which it is the great object of the Creator apparently for an indefinite time to maintain, and in the arrangements for equalizing temperature the equilibrium of saltness be disturbed in certain portions of the sea, and that of moisture under ground in the warmer regions of the earth. To prevent this, checks and counterpoises interpose just as their services come to be required. It could scarcely be imagined that in such of our inland seas as were connected by a narrow strait with the Ocean, and were thus cut off from free access to its waters, the supply of fresh water which pours into them from the rivers around would exactly supply the amount carried away by evaporation. Salt never rises in steam, and it is the pure element alone that is drawn off. We have in such cases as the Black and Baltic seas an excess of supply over what is required, the surplus in the latter case flowing off through the Dardanelles, in the former through the Great and Little Belts. The vapor withdrawn from the Mediterranean exceeds by about a third the whole amount of fresh water poured into it; the difference is made up by a current through the straits of Gibraltar in the latter: and a similar arrangement, modified by circumstances, must exist in all cases where circumstances are similar,—the supply of water rushing through the strait from the open ocean being in exact proportion to the difference betwixt that provided from rain or by rivers, and that required by the efflux of vapor; seas wholly isolated, such as the Caspian and the Dead sea, attain in course of time a state of perfect equilibrium—their surface becoming lowered in level and diminished in area, till it becomes exactly of the proper size to yield in vapor the whole waters poured in. The Dead sea, before attaining this condition of repose, has sunk thirteen hundred feet below the Mediterranean, the Caspian about one-fourth of this. Lakes originally salt, and which to all appearance, are no more than fragments severed from the sea by the earthquake or volcano, and which have no river or rain supplies whatever, in process of time dry up and become a mass of rock salt in their former basin. Such is the formation in progress in the lake near Tadjurra, nearly five hundred feet below the level of the sea, its waters having been this much depressed by evaporation, having now almost altogether vanished, one mass of salt remaining in their room. As it is clear in a case such as that of the Mediterranean, that where salt water to a large extent was poured in and fresh water only was drawn off, a constant concentration of brine must occur, the proposition was laid down by the most distinguished of our Geologists, and long held unquestionable, that huge accumulations of salt in mass larger than all that Cheshire contains, were being formed in its depths. The doctrine eminently improbable in itself, is now met by the discovery of an outward under-current, in all likelihood of brine. It is matter of easy

demonstration, that without some such arrangement as this, the Red sea must long ere now have been converted into one mass of salt, its upper waters at all events being known in reality to differ at present but little in saltness from those of the Southern ocean. The Red sea forms an excellent illustration of all kindred cases. Here we have salt water flowing in perpetually through the straits of Babelmandeb, to furnish the supplies for a mass of vapor calculated, were the strait shut up, to lower the whole surface of the sea eight feet annually,—and even with the open strait, to add to its contents a proportionate quantity of salt. But an under-current of brine, which from its gravity, seeks the bottom, flows out again to mingle with the waters of the Great Arabian sea, where swept along by currents, and raised to the surface by tides and shoals, it is mingled by the waves through the other waters which yearly receive the enormous monsoon torrents, the Concan and the Ghaut's supply, become diluted to the proper strength of sea water and rendered uniform in their constitution, by the agitation of the storms which then prevail. Flowing back again from the coasts of India, where they are now in excess, to those of Africa, where they suffer from perpetual drainage, the same round of operations go on continually; and the sea, with all its estuaries and its inlets, retains the same limit, and nearly the same constitution, for unnumbered ages. A like check prevents on shore the extreme heating and desiccation from which the ground would otherwise suffer. The earth is a bad conductor of heat: the rays of the Sun which enter its surface, and raise the temperature to 100 or 150°, scarcely penetrate a foot into the ground; a few feet down, the warmth of the ground is nearly the same night and day. The moisture which is there preserved free from the influence of currents of air, is never raised into vapor: so soon as the upper stratum of earth becomes thoroughly dried, capillary action by means of which all excess of water was withdrawn, ceases, and even under the heats of the tropics, the soil two feet down will be found on the approach of the rains sufficiently moist for the nourishment of plants. The splendid flowers and vigorous foliage which burst forth in May, when the parched soil would lead us to look for nothing but sterility, need in no way surprise us: fountains of water, boundless in extent and limited in depth by the thickness of the soil which contains them, have been set aside and sealed up for their use, beyond the reach of those thirsty winds or burning rays which are suffered only to carry off the water which is superfluous, and would be pernicious, removing it to other lands where its agency is required, or treasuring it up in the crystal vault of the firmament, as the material of clouds and dew—and the source when the fitting season comes round again, of those deluges of rain which provide for the wants of the year.

"Such are some of the examples which may be supplied of general laws operating over nearly the whole surface of the terraqueous globe. Amongst the local provisions ancillary to these, are the monsoons of India and the land and sea-breezes prevalent throughout the tropical coasts. When a promontory such as that of India intrudes iuto the region of the trade winds, the continuous western current is interrupted, and in its room appear alternating currents from the northeast and southwest, which change their direction as the Sun passes the latitude of the place. On the Malabar coast, as the Sun approaches from the southward, clouds and variable winds attend him, and his transit northward is in a week or ten days followed by that furious burst of thunder and tempest which heralds the rainy season. His southward transit is less distinctly marked;

it is the sign of approaching fair weather, and is also attended by thunder and storm. The alternating land and sea-breezes are occasioned by the alternate heating and cooling of the soil, the temperature of the sea remaining nearly uniform. At present, when most powerfully felt, the earth by noon will often be found to have attained a temperature of 120°, while the sea rarely rises above 80°.* The air, heated and expanded, of course ascends, and draws from the sea a fresh supply to fill its room: the current thus generated constitutes the breeze. During the night the earth often sinks to a temperature of 50° or 60°, cooling the conterminous air, and condensing in the form of dew, the moisture floating around. The sea is now from 15° to 20° warmer than the earth—the greatest difference between the two existing at sunrise; and in then rushes the air, and draws off a current from the shore.

"We have not noticed the tides, which obedient to the Sun and Moon, daily convey two vast masses of water round the globe, and which twice a month, rising to an unusual height, visit elevations which otherwise are dry. During one half of the year the highest tides visit us by day, the other half by night, and at Bombay, at Springs, the depths of the two differ by two or three feet from each other. The tides simply rise and fall in the open ocean, to an elevation of two or three feet in all: along our shores, and up gulfs and estuaries, they sweep with the violence of a torrent, having a general range of ten or twelve feet—sometimes, as at Fundy in America, at Brest and Milford Haven in Europe, to a height of from forty to sixty feet. They sweep our shores from filth and purify our rivers and inlets, affording to the residents of our Islands and Continents the benefits of a bi-diurnal ablution, and giving a health and freshness and purity wherever they appear. Obedient to the influences of bodies many millions of miles removed from them, their subjection is not the less complete: the vast volume of water capable of crushing by its weight the most stupendous barriers that can be opposed to it, and bearing on its bosom the navies of the world, impetuously rushing against our shores, gently stops at a given line, and flows back again to its place when the word goes forth—'thus far shalt thou go, and no farther;' and that which no human power or contrivance could have repelled, returns at its appointed time so regularly and surely, that the hour of its approach, and measure of its mass, may be predicted with unerring certainty centuries beforehand. The hurricanes which whirl with such fearful violence over the surface, raising the waters of the sea to enormous elevations, and submerging coasts and islands, attended as they are by the fearful attributes of thunder and deluges of rain—seem requisite to deflagrate the noxious gases which have accumulated—to commingle in one healthful mass the polluted elements of the air, and restore it fitted for the ends designed for it. It is with the ordinary, not with the exceptionable, operations we have at present to deal, and the laws which rule the hurricane form themselves the subject of a treatise.

"We have hitherto dealt with the sea and air,—the one the medium through which the commerce of all nations is transported, the other the means by which it is moved along,—as themselves the great vehicles of moisture, heat, and cold, throughout the regions of the world—the means of securing the interchange of these inestimable commodities, so that excess may be removed to where deficiency exists, deficiency substituted for excess, to the unbounded advantage of all. We have selected this group of illustrations for our views, be-

*The temperature of certain parts of the Indian Ocean—the hottest sea in the world—is 90°.—M.