



LII. Hydrographical Notices:—Remarks on the method of investigating the direction and force of the currents of the ocean; presence of the water of the gulf-stream on the coasts of Europe in January 1822; summary of the currents experienced by his Majesty's ship pheasant, in a voyage from Sierra Leone to Bahia, and thence to New York; Stream of the River Amazons crossed, three hundred miles from the mouth of the river

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acid, containing a little naphthaline, and some free sulphuric acid; whilst the *lighter substance* is a solution of the dry acid in naphthaline; the water present in the oil of vitriol originally used being sufficient to cause a separation of a part, but not of the whole.

[To be continued.]

LII. *Hydrographical Notices :—Remarks on the Method of investigating the Direction and Force of the Currents of the Ocean; Presence of the Water of the Gulf-Stream on the Coasts of Europe in January 1822; Summary of the Currents experienced by His Majesty's Ship Pheasant, in a Voyage from Sierra Leone to Bahia, and thence to New York; Stream of the River Amazons crossed, three hundred Miles from the Mouth of the River. By Capt. EDWARD SABINE, R.A. F.R. & L.S. &c.**

PREVIOUSLY to my leaving England in 1821, I had had the great advantage of much conversation with Major Rennell, on the subject of the currents in the northern and southern Atlantic Oceans, and of having my attention directed by him to those points in particular, concerning their velocity, limits, and temperature, on which further inquiries might conduce to the advancement of hydrographical knowledge.

The method of ascertaining the existence, direction and velocity of a current, where land is not in sight, and a ship cannot be rendered stationary by anchorage, is to compare her position at intervals of sufficient length (generally of 24 hours) by observation and by reckoning. By the former is learnt her real change of geographical position in the interval; by the latter, the course and distance that she has gone through the water; should the position by the reckoning not agree with the position by the observation, the difference (presuming both to be correct) is the indication and measure of current.

To determine a ship's position from day to day by observation, or rather, her relative position on one day to the preceding, has become, since the introduction of chronometers, a matter of very simple accomplishment, and capable of much precision. It is far otherwise with the reckoning, however, when more is sought by it than such a rough approximation as may serve the ordinary purposes of navigation: it must, in fact, require the most assiduous and unremitting attention, as well as considerable nautical experience and judgement, to

* From Captain Sabine's newly-published Account of his Experiments to determine the Figure of the Earth.

estimate

estimate correctly the continually varying effects of the winds and sea, on a body that is also continually varying the measure of her exposure to their influence. It may be in the power of an individual in a vessel, to obtain, by his own exertions alone, that portion of the materials towards the evidence of currents, which depends on her real change of position; but the completion of the evidence by a sufficiently correct reckoning must be the result of an interest participated in by all the executive officers of a ship; or by the establishment of such habits of accuracy, under the authority of her commander, as are not of usual practice, because they are not necessary for the general purposes of navigation; the employment of chronometers, by which the position of a ship is ascertained and a fresh departure taken on every day that the sun shines, has superseded the necessity of that vigilant and scrupulous regard, which the older navigators paid to all the details of the reckoning, on which alone they had to depend; and has tended to substitute general habits of loose and vague estimation, for the considerate and well-practised judgement with which allowances were formerly made for the incidental circumstances of steerage, leeway, making and shortening sail, &c. &c., on a due attention to which the accuracy of a reckoning so materially depends.

In ships of war especially, the reckoning is further embarrassed by a difficulty less obvious, but not less generally operative, by which, if not properly provided against, the knowledge of the true course which the ship has made is necessarily rendered very uncertain: it arises from the usual practice of directing the course by the binnacle compasses, which are two in number for the convenience of the helmsmen, and being placed one on the larboard and the other on the starboard side of the midship, with a space between them of greater or less extent according to the size of the vessel, can scarcely fail, and are, in fact, generally influenced differently by the ship's iron; and being subject to different *systems* of attraction, the compasses not only disagree, but their disagreement varies according to the direction of ship's head, the amount of the dip of the needle, and the force of terrestrial magnetism. It is customary always to steer by the weather compass; and thus each is liable to become in its turn the directing compass for periods of more or less duration, and the corrections of the courses for the disturbing influence of the ship's iron, becomes so various and complicated, as to render the deduction of a correct reckoning practically unattainable. For example, the binnacle compasses of the *Iphigenia*, on her passage from Eng-
land

land to Madeira, were observed to differ from each other half a point in one direction when on south-westerly courses, and less than half a point in the opposite direction when on easterly courses, the indications of the compasses having crossed each other, and agreed at some intermediate point; it was requisite, therefore, that the correction to be allowed on every course by each of the two compasses should be ascertained, and that the compass by which each course was directed should be specially recorded, in order that the true course should be known.

The most obvious mode of preventing so much inconvenience and trouble, as well as the more correct practice, is to direct and note the ship's course by one compass only, stationed permanently in some convenient situation, without reference to the helmsmen, and to use the binnacle compasses solely to steer by, on the point which may be noticed at the time to agree with the magnetic course of the standard compass; and by employing an azimuth compass for the latter purpose, the advantage is gained of enabling the variation to be observed directly with the compass by which the course is governed, and thus of avoiding intermediate comparisons, in which time is occupied, and errors frequently introduced. This arrangement of a standard compass was adopted by Captain Clavering in the Pheasant, and subsequently in the Griper, and was found to answer its purpose perfectly, and to be attended with no practical inconvenience whatsoever.

Although from the courses above noticed, no satisfactory investigation of the direction or velocity of currents could be made in the Iphigenia, in her passage from England to the coast of Africa, a remarkable and very interesting evidence was obtained by observations on the temperature of the sea, of the accidental presence in that year of the water of the Gulf-stream, in longitudes much to the eastward of its ordinary extension. The Iphigenia sailed from Plymouth on the 4th of January, after an almost continuous succession of very heavy westerly and south-westerly gales, by which she had been repeatedly driven back and detained in the ports of the Channel. The following memorandum exhibits her position at noon on each day of her subsequent voyage from Plymouth to Madeira, and from thence to Cape Verd Islands, the temperature of the air in the shade and to windward, and that of the surface of the sea; it also exhibits in comparison, the ordinary temperature of the ocean at that season, in the respective parallels, which Major Rennell has been so kind as to permit me to insert on his authority, as an approximation founded

founded on his extensive inquiries; the last column shows the excess or defect in the temperature observed in the Iphigenia's passage.

Date.	Latit. N.	Longit. W.	Air.	Surface Water.		Excess- or Defect.	
				Observed.	Usual.		
1822.							
Plymouth to Madeira.	Jan. 5	47° 30'	7° 30'	47°	49°	50°	-1
		64 4	20 9	30 52.5	55.7	52.5	+3.2
		7 41	22 11	37 54	58.2	54	+4.2
		8 38	54 13	20 54.2	61.7	55.7	+6
		9	no observ.		56	63	58
Madeira to the C. Verds.		10 33	40 15	30 60.7	64	60	+4
		19 26	00 17	50 66	65.5	67	-1.5
		20 24	30 18	50 68	67	68.4	-1.4
		21 23	06 20	00 69	69	69.5	-0.5
		22 21	02 21	27 69.5	69.5	71.2	-1.7
	23 19	20 23	00 70.6	70.2	71.6	-1.4	

It is seen by the preceding memorandum, that in the passage from Plymouth to Madeira, the Iphigenia found the temperature of the sea, between the parallels of $44\frac{1}{3}^{\circ}$ and $33\frac{2}{3}^{\circ}$, several degrees warmer than its usual temperature in the same season; namely, $3^{\circ}.2$ in $44\frac{1}{3}^{\circ}$, increasing to 6° in 39° , and again diminishing to 4° in $33\frac{2}{3}^{\circ}$; whilst at the same period, the general temperature of the ocean in the adjoining parallels, both to the northward and to the southward, even as far as the Cape Verd Islands in $19\frac{2}{3}^{\circ}$, was colder by a degree and upwards than the usual average. The evidence of many careful observers at different seasons and in different years, whose observations have been collected and compared by Major Rennell, has satisfactorily shown, that the water of the Gulf-stream, distinguished by the high temperature which it brings from its origin in the Gulf of Mexico, is not usually found to extend to the eastward of the Azores. Vessels navigating the ocean between the Azores and the continent of Europe, find at all seasons a temperature progressively increasing as they approach the sun; the absolute amount varies according to the season, the maximum in summer being about 14 degrees warmer than the maximum in winter; but the progression in respect to latitude is regular, and is nearly the same in winter as in summer, being an increase of 3° of Fahrenheit for every 5° of latitude. It is further observed, that the ordinary condition of the temperature, in the part of the ocean under notice, is little subject to disturbance, and that in any particular parallel

parallel and season, the limits of variation in different years are usually very small: after westerly winds of much strength or continuance, the sea in all the parallels is rather colder than the average temperature, on account of the increased velocity communicated to the general set of the waters of the north-eastern Atlantic towards the southward. To the heavy westerly gales which had prevailed almost without intermission in the last fortnight in November, and during the whole of December, may therefore be attributed the colder temperatures observed in the latitude of $47\frac{1}{2}^{\circ}$, and in those between 26° and $19\frac{1}{3}^{\circ}$.

If doubt could exist in regard to the higher temperatures between $44\frac{1}{3}^{\circ}$ and $33\frac{2}{3}^{\circ}$, being a consequence of the extension in that year of the Gulf-stream in the direction of its general course, it might be removed by a circumstance well deserving of notice; namely, that the greatest excess above the natural temperature of the ocean was found in or about the latitude of 39° , being the parallel where the middle of the stream, indicated by the warmest water, would arrive, by continuing to flow to the eastward of the Azores, in the prolongation of the great circle in which it is known to reach the mid Atlantic.

One previous and similar instance is on record, in which the water of the Gulf-stream was traced by its temperature quite across the Atlantic to the coasts of Europe; this was by Dr. Franklin, in a passage from the United States to France, in November 1776*. The latter part of his voyage, *i.e.* from the meridian of 35° to the Bay of Biscay, was performed with little deviation in the latitude of 45° ; in this run, exceeding 1200 miles, in a parallel of which the usual temperature, towards the close of November, is about $55\frac{1}{2}^{\circ}$, he found 63° in the longitude of 35° W., diminishing to 60° in the Bay of Biscay; and 61° in 10° west longitude, near the same spot where the *Iphigenia* found $55^{\circ}\cdot7$ on the 6th of January, being about five weeks later in the season. At this spot then, where the *Iphigenia* crossed Dr. Franklin's track, the temperature in November 1776 was $5\frac{1}{2}^{\circ}$, and in January 1822, $3^{\circ}\cdot2$ above the ordinary temperature of the season.

There can be little hesitation in attributing the unusual extension of the stream in particular years to its greater initial velocity, occasioned by a more than ordinary difference in the levels of the Gulf of Mexico and of the Atlantic: it has been computed by Major Rennell, from the known velocity of the stream at various points of its course, that in the summer months, when its rapidity is greatest, the water requires about

* Franklin's Works, 8vo, London 1806, vol. ii. pp. 200, 201.

eleven weeks to run from the outlet of the Gulf of Mexico to the Azores, being about 3000 geographical miles; and he has further supposed, in the case of the water, of which the temperature was examined by Dr. Franklin, that perhaps not less than three months were occupied in addition by its passage to the coasts of Europe, being altogether a course exceeding 4000 geographical miles. On this supposition, the water of the latter end of November 1776, may have quitted the Gulf of Mexico, with a temperature of 83° in June; and that of January 1822, towards the end of July, with nearly the same temperature. The summer months, particularly July and August, are those of the greatest initial velocity of the stream, because it is the period when the level of the Caribbean sea and Gulf of Mexico is most deranged.

It is not difficult to imagine, that the space between the Azores and the coasts of the old continent, being traversed by the stream, slowly as it must be, at a much colder season in the instance observed by the *Iphigenia* than in that by Dr. Franklin, its temperature may have been cooled thereby to a nearer approximation to the natural temperature of the ocean in the former than in the latter case; and that the difference between the excess of $5^{\circ}\cdot5$ in November, and of $3^{\circ}\cdot2$ in January, may be thus accounted for.

If the explanation of the apparently very unusual facts observed by Dr. Franklin in 1776, and by the *Iphigenia* in 1822, be correct, how highly curious is the connexion thus traced between a more than ordinary strength of the winds within the tropics in the summer, occasioning the derangement of the level of the Mexican and Caribbean seas, and the high temperature of the sea between the British Channel and Madeira, in the following winter.

Nor is the probable meteorological influence undeserving of attention, of so considerable an increase in the temperature of the surface-water over an extent of ocean exceeding 600 miles in latitude and 1000 in longitude, situated so importantly in relation to the western parts of Europe. It is at least a remarkable coincidence, that in November and December 1821, and in January 1822, the state of the weather was so unusual in the southern parts of Great Britain and in France, as to have excited general observation; in the meteorological journals of the period it is characterized "as most extraordinarily hot, damp, stormy, and oppressive:" it is stated "that an unusual quantity of rain fell both in November and December, but particularly in the latter;" that, "the gales from the west and south-west were almost without intermission," and that

in December, the mercury in the barometer was lower than it had been known for 35 years before*.

On leaving the Cape Verd Islands, the *Iphigenia* proceeded to make the continent of Africa at Cape Verd. The distance between the Cape and the Islands is about 400 miles, both being in the same parallel of latitude. This passage afforded an interesting opportunity of observing on the approach to land, the influence of its vicinity on the temperature of the sea. The general temperature of the surface in that parallel and at that season may be considered $71^{\circ} \cdot 7$, the observations made at sunrise, noon, and sunset, in the first 350 miles of the passage, varying from 71° to $72^{\circ} \cdot 4$: but at sunrise on the 31st of January, being then at the distance of 26 miles west of Cape Verd, with no land as yet in sight, the surface-water had lowered to $69^{\circ} \cdot 6$. On approaching nearer it progressively diminished, until at

* The following description of this very remarkable winter is extracted from Mr. Daniell's Essay on the Climate of London (Meteorological Essays, London 1823, pages 297 and 298), and becomes highly curious when viewed in connexion with the unusual temperature of the ocean in the direction from which the principal winds proceeded.

"November 1821, differed from the mean, and from both the preceding years, in a very extraordinary way. The average temperature was 5° above the usual amount, and although its dryness was in excess," [the relative dryness, in consequence of the increased temperature] "the quantity of rain exceeded the mean quantity by one half. The barometer on the whole was not below the mean. All the low lands were flooded, and the sowing of wheat very much interrupted by the wet.

"In December, the quantity of rain was very nearly double its usual amount. The barometer averaged considerably below the mean, and descended lower than had been known for 35 years. Its range was from 30.27 inches to 28.12 inches. The temperature was still high for the season, and the weather continued, as in the last month, in an uninterrupted course of wind and rain; the former often approaching to an hurricane, and the latter inundating all the low grounds. The water-sodden state of the soil, in many parts, prevented wheat sowing, or following the land at the regular season. The mild temperature pushed forward all the early sown wheats to an height and luxuriance scarcely ever before witnessed. The grass, and every green production, increased in an equal proportion.

January 1822. This most extraordinary season still continued above the mean temperature, but the rain, as if exhausted in the preceding month, fell much below the usual quantity in this. There was not one day on which the frost lasted during the twenty-four hours.

"Serious apprehensions were entertained lest the wheats, drawn up as they had been by warm and moist weather, without the slightest check from frost, should be exhausted by excessive vegetation, and ultimately be more productive in straw than corn.

"The month of February, still five degrees above the mean temperature, ended a winter which has never been paralleled."

It would not be difficult to trace in detail, each of the effects described in the preceding extract, to the cause which has been thus placed in connexion with them.

one mile from the shore, it had fallen as low as 64 degrees, and continued from 64 to 65 degrees, between Cape Manoel and Goree. Cape Verd is situated nearly at equal distances, exceeding 70 miles, from the mouths of the Senegal and Gambia, the one being to the north and the other to the south. It is probable that the water of both these rivers is always colder at their entrance into the sea, than the ocean temperature of the parallel; that of the Gambia certainly was so at that season, but it was not so cold as the sea in the vicinity of Cape Verd, as on approaching the entrance of the Gambia, the temperature of the surface rose to $67^{\circ}5$, and varied in the river itself at different hours from 66° to $67^{\circ}5$; and at the depth of 36 feet, being within six feet of the bottom, a self-registering thermometer indicated at high water less than a degree colder than the surface. The coast in the neighbourhood of Cape Verd is every where low and sandy, and is covered with trees to the water's edge. Such, indeed, is the general character of the shores of western Africa, with the exception of Cape Sierra Leone; but at no other part of the coast was the diminution of the temperature of the water, on approaching the land, so great, as in the instance which has been mentioned. Between the Gambia and Sierra Leone are a succession of rivers, originating in land of less elevation than the Senegal and Gambia, and much exceeding them in the temperature of the waters which they convey into the ocean; in the mid-channel of the Rio Grande, at a few miles from its mouth, the surface was never less than 74° , and occasionally as high as $77^{\circ}5$, and at the depth of 30 or 40 feet was less than a degree colder than the surface. At the entrance of the River Noonez the surface-water was $77^{\circ}5$, and at that of the Rokelle 80° . To the south of the Rokelle, and from thence to the extremity of the Gulf of Guinea, the coast is swept by a current of considerable rapidity, which renders the cooling effect of the land less apparent; but in the bays of the coast, where the current sweeps from point to point, and leaves still water in the inside, a difference is commonly found amounting to three and four degrees*.

[To be continued.]

LIII. On

* The passage from the Cape Verd Islands to Cape Verd and the Gambia, afforded a not less interesting opportunity of observing the difference in the hygrometrical state of the atmosphere at sea, and in the vicinity of the continent, in the region of the trade winds. We had entered the N.E. trade in the latitude of 24° North, nine degrees to the northward of the Cape Verd Islands, and did not lose it until the afternoon of the day on which we quitted the Gambia, the strength declining on the approach to the continent, but the direction continuing unchanged. On the 28th, 29th, and 30th of January, in navigating the first 350 miles of the passage from the islands to the continent, the air in the shade and to windward varied at different hours of the day from $70^{\circ}2$ to $71^{\circ}2$, and the dew-point from 63°