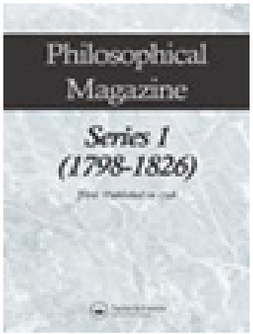

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LVI. On winds

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the view of procuring the beſt poſſible information on this ſubject, I applied to Leith, Aberdeen, and Peterhead, on the eaſt coaſt; and to Greenock, Dublin, Liverpool, and Briſtol, on the weſt.

In the appendix to this report I have inſerted the queries and anſwers; by which it may be ſeen that there is only one opinion as to the dangers and inconveniencies of the preſent navigation, and the advantages which may be expected from the propoſed inland navigation, if united with a naval ſtation in the Moray Frith, or on the adjacent coaſt of Scotland.

This ſanction of experienced people, who are all deeply intereſted in commercial concerns, will, I truſt, ſatisfy your lordſhips, that it has not been upon unſubſtantial grounds that I have ventured to recommend this great national object.

My eſtimate of the expenſe of forming this navigation is nearly 350,000l., and the time required to complete it would probably be about ſeven years: this diviſion would require an annual ſupply of 50,000 l.

Upwards of thirty veſſels have been wrecked on the coaſt of Caithneſs in the memory of Alexander Miller, of Staxigo.

[To be continued.]

LVI. *On Winds.* By RICHARD KIRWAN, *Eſq. LL.D. F.R.S. and P.R.I.A.**

Of the Origin of the general Trade Winds.

THOUGH the origin of the general trade winds appears to me to have been fully eſtabliſhed by Dr. Halley, yet it ſeems he has explained himſelf too briefly, ſince his explanation has been miſunderſtood by many, and was thought obſcure even by d'Alembert †.

To underſtand it more perfectly, let us ſuppoſe the ſun for the firſt time in the meridian, and to communicate its heat every inſtant fifteen degrees all around. If it were to remain in this ſituation the ſurrounding air could have no other motion but upwards, for the lateral dilatations being equal, would neceſſarily check each other, but in the ſecond, and all the ſucceeding inſtants, the ſun moves weſtwards; therefore, of the originally equidiſtant eaſtern and weſtern points,

* From his paper entitled "Of the Variations of the Atmoſphere 1801."

† Sur la Cauſe des Vents. v.

the weſtern, to which the ſun approaches nearer, is more heated than the eaſtern, from which the ſun recedes; therefore in this, and all the ſucceeding inſtants, the eaſtern, being more cooled, will preſs on the weſtern, and thus an eaſtern wind will be eſtabliſhed.

It is true, that, in the northern hemiſphere, the northern air alſo preſſes upon the more heated ſpaces; but as this alſo follows the ſun's path to the weſtward, it becomes alſo eaſterly, preſerving only a few points of its primitive direction. D'Alembert adds alſo the ſolar attraction, which, according to him, elevates the air in the points over which the ſun is vertical, and conſequently produces a dilatation advancing from eaſt to weſt. But M. De la Place, not denying this cauſe, conſiders it too weak to produce ſingly any conſiderable effect *.

About the year 1735 Mr. Hadley publiſhed a very different account of the origin of the trade winds (Phil. Tranſ. Abrid. viii. p. 500); which, however, has been rejected by the moſt diſtinguiſhed aſtronomers that have ſince attended to this object, as d'Alembert, ſur la Cauſe des Vents, art. 376 and 385; Gentil Voy.; Bergman Erde Beſchreib. ii. p. 91.

According to Mr. Hadley, the air, being rarefied towards the equator, is conſequently invaded in the northern hemiſphere by the northern, and in the ſouthern hemiſphere by the ſouthern colder air.

But as the parallels of latitude enlarge as they approach the equator, and as the equatorial ſpace is nearly in the proportion of 1000 to 917, the difference of their circumference is nearly 2083 miles; conſequently, the ſurface of the globe at the equator moves ſo much faſter than under the tropics; and hence the northern or ſouthern air, moving from the tropics towards the equator, muſt poſſeſs leſs velocity than the parts it arrives at, and conſequently appear to move in a direction contrary to that of the earth's motion; which being from weſt to eaſt, the air arriving ſooner at the weſtern parts, will appear to move from eaſt to weſt; and this relative motion being combined with that towards the equator, a north-eaſt wind will be produced on the north ſide, and a ſouth-eaſt wind on the ſouth ſide of the equator. Theſe as they approach the equator ſhould become ſtronger and more eaſterly, and appear due eaſt in the equator itſelf, by reaſon of the concourſe of both currents from the north and from the ſouth. There the velocity of each ſhould be at the rate of 2083 miles in the ſpace of one natural day, or above 1·33

* Mém. Paris 1776.

miles

miles per minute, if it had not been that before the air at the tropics could arrive at the equator, it muſt have gained ſome motion eaſtwards from the ſurface of the earth or ſea, whereby the relative motion is diminiſhed to the degree that actually exiſts in it.

This theory appears to me rather ingenious than ſolid, for the following reaſons:

1. The trade winds are commonly gentle, moving only at the rate of eight miles an hour; therefore they have ſufficient time to gain or participate of the motion of the earth; therefore their contrary courſe muſt ariſe from an abſolute cauſe, and cannot be deemed merely relative.

2. Becauſe the north-eaſt wind ſcarce ever approaches nearer than eight or ten degrees to the equator, and there dies away; whereas it ought there, according to this theory, to be ſtrongeſt. And, on the contrary, the ſouth-eaſt paſſes the equator ſeveral degrees, even when the ſun is in the ſouth tropic. A fact which, as Gentil remarks, is abſolutely irreconcileable with this theory. (Gentil Voy. i. p. 638; Ibid. v. p. 116.)

3. Becauſe, if the conſtant eaſterly wind was in the northern hemiſphere ſupplied ſolely from the north, and in the ſouthern hemiſphere ſolely from the ſouth, we ſhould in the former have a conſtant north wind at leaſt at 35 or 40 degrees from the equator, or at leaſt from ſome northern point, and in the latter a conſtant ſouth wind, or at leaſt from ſome ſouthern point; whereas, on the contrary, a ſouth wind often prevails in thoſe latitudes on the north ſide of the equator, and a north wind on the ſouth ſide. Thus La Perouſe met an E. S. E. in north latitude 32°, and a due eaſt in latitude 31°; and a S. S. E. in latitude 14°, and a due eaſt in latitude 16°; and a due north in latitude 20°, (where then was the relative motion?) and a due ſouth in latitude 33°. (See his Journal in La Peyr. Voy. iii.) He alſo met with a due north in latitude 27° and 42° ſouth, and a N. N. E. in latitude 25° ſouth. So captain Cook met a S. S. E. wind in latitude 30° north, and alſo in latitudes 40° and 41°, and a due ſouth wind in latitude 38° and 20°; and in the ſouthern hemiſphere a due north in latitude 3°, 4°, and 44°. I might produce other inſtances from ſea journals, and particularly from that, moſt ample and inſtructive, kept by major Dalrymple during a voyage to the Eaſt Indies (Phil. Tranſ. 1778) but I think the alleged ſufficiently prove that the general eaſt wind is not ſupplied ſolely from the north or ſouth in the different hemiſpheres reſpectively.

4. Becauſe, during our ſix ſummer months, when the ſun is in or approaches to the northern tropic, the eaſterly trade wind

wind partakes leſs of the northerly, than when the ſun is in or approaches to the ſouthern tropic, (Phil. Tranſ. Abrid. ii. p. 134; and Schued. Abhandl. 1762, p. 175:) which is directly contrary to Hadley's ſyſtem; for when the ſun is in the ſouthern tropic, the north wind muſt traverſe more of that ſpace in which the earth's motion eaſtward is ſtrongeſt, and therefore ſhould participate more of that motion, as Hadley himſelf ſtates: though ſtill partaking of it in a ſmaller degree than that which the globe itſelf poſſeſſes, it ſhould appear to move weſtwards; yet it ſhould proportionably retain leſs of its original direction from north to ſouth than when it had traverſed a ſpace more diſtant from the equator, whereas the fact is that it retains more, and often paſſes into the ſouthern hemiſphere into the 13° ſouth latitude without having any eaſtern direction, (Marchand iii. p. 551;) and an analogous fact is obſerved with reſpect to the ſouth-eaſt wind when the ſun is in the northern tropic. Hence it is evident, that it is from the approach of the ſun, and not from the latitude traverſed, that the eaſtern direction is derived; nay, the wind is often more eaſterly than northerly between latitude 23° and 28°: (Foſter's Obſervations, p. 126.) He even obſerved that the trade winds extended far beyond the tropics when the ſun is in the ſame hemiſphere, which ſhows it is the ſun that cauſes them.

Eddy is a term introduced on this ſubject, which explains nothing when its cauſe is not aſſigned and proved; the trade winds are often interrupted by the approach of land; but the interruption, as Foſter mentions, extends only to a few miles. Ibid. 127.

The *monſoons* or periodical trade winds depending on local circumſtances, ſufficiently explained by Dr. Halley, I ſhall here paſs over; though certainly much may be added from obſervations made by ſubſequent navigators and travellers. I ſhall therefore confine myſelf to the *variable* winds, a ſubject much more obſcure.

Of Variable Winds.

With reſpect to winds we muſt lay down one general and fundamental principle, which is, that they always originate at the extremity of that point towards which they proceed. Thus the eaſterly trade wind begins at the point neareſt the ſun, which it follows, and is perpetually renovated and ſupplied from parts ſtill more eaſterly. Thus in the year 1709 a north wind was ſooner perceived in England than at Dantzic (Phil. Tranſ. Abrid. iv. part ii. p. 115. And Wargentin notes, that when the wind changes to the weſt, this change takes place at Moſcow before it happens at Abo, which is ſeveral

ſeveral degrees weſt of it; and ſooner in Finland than in Sweden. (Schwd. Abhandl. 1762, p. 195.) And Dr. Franklin, in his xxxvith Letter, p. 389, thinks that the north-eaſt ſtorms in North America begin firſt, in point of time, in the ſouth-weſt parts; that is to ſay, ſooner in Georgia than in Carolina, and ſooner in Carolina than in Virginia, &c. He found that a north-eaſt ſtorm began at Philadelphia at ſeven o'clock, but did not extend to Boſton (about forty miles to the north-eaſt) until eleven o'clock. The reaſon of which he well explains, as the current muſt begin in the places neareſt to that in which the rarefaction ariſes, towards which the current is directed.

Of Weſterly Winds.

That eminent and laborious meteorologiſt C. La Cotte, infers from numerous obſervations of many years, that between latitude 47° and 60° on the weſtern ſide of our hemiſphere, the weſt wind, with ſome participation of the north or ſouth, is that which obtains oftener. (Roz. Jour. xxxix. p. 267.) Leche obtained the ſame reſult at Abo, latitude 60°, from twelve years obſervations; Muſchenbroeck, in Utrecht; Mr. Dalton, in Weſtmorland, latitude 54°, (ſee his Meteorological Eſſays, p. 48 and 88,) from five years obſervations.

This wind in our continent originates in the Pacific Ocean between the above-mentioned parallels, at leaſt in winter; the air incumbent on that ocean is then much warmer than that of Siberia and Chineſe Tartary that lie weſt of it; this therefore preſſes upon and flows into the ſupra-marine, and is immediately ſucceeded by air ſtill further weſtwards, and thus a current is gradually eſtabliſhed extending to the Atlantic, which, though in winter, being much warmer than the air of the iſlands and continent on which it flows, is forced into the current, both by the rupture of the equilibrium to the eaſtwards, and by the preſſure of the much colder air of the continent of North America.

Of Eaſterly Winds.

During the winter months there ſeems to be a frequent ſtruggle and conteſt betwixt the air incumbent over the Aſiatic continent and that incumbent on the North American lying betwixt the above-mentioned parallels and bordering on the Pacific Ocean, which of them ſhall rule over it.

The maſs of the American air being leſs conſiderable, and its efforts divided between the Pacific and the Atlantic, is generally obliged to yield to its antagoniſt; though ſometimes the Aſiatic being warmed, either by a diffuſion of the ſuperior

perior current or by ſoutherly winds, the colder American becomes more forcible. In ſummer this muſt happen frequently, the E. N. E. oftenеſt prevailing: upon the whole, however, Leche remarked that the eaſt and E. S. E. were nearly the moſt uncommon; as did La Cotte in the climate of Paris. (Meteorolog. p. 305.)

With us this wind is moſt frequent in the months of April and May; and I have obſerved in Cook's Journal, tables 9th, 10th, and 11th, that it prevails alſo in the ſame months in the Pacific, therefore the colder continental air then pours in upon us.

La Cotte alſo obſerves, that in the weſtern tracts of Europe, in latitudes below 48°, this wind occurs oftenеſt during the winter months*; for the ſuperior heat of the Atlantic in the low latitudes determines the colder air incumbent on Hungary and European Turkey to flow in upon it.

Of Southerly Winds.

A few years ago, no problem in meteorology appeared to me more difficult than to aſſign a cauſe for the frequent prevalence of a ſouth wind even in winter, it being contrary to the laws of nature that warm air ſhould ruſh upon colder; yet I ſince diſcovered that the conjectural ſolution I then offered is grounded on a real fact.

In the eaſtern parts of our hemiſphere, from longitude 72° to 160°, that is, from the coaſt of Malabar to the Moluccas, it blows from the north-eaſt conſtantly from October until April. Now this northern blaſt muſt be ſupplied and recruited from countries ſtill further north until we arrive at the pole, and the polar air muſt conſequently be ſupplied by that which lies ſouth of it, and thus a ſouthern current is eſtabliſhed on the weſtern ſide of our hemiſphere.

Inſtances to ſupport or contradict this theory do not often occur; yet I have found ſome that appear to me deciſive, independently of the general reaſon alleged. Thus I find in the ninth table of the third volume of Cook's Voyages, that in north latitude 59°, and eaſt longitude 207°, on the 25th of May 1778, a ſtrong north-weſt wind prevailed; and on the 29th day of the ſame month and year, an equally ſtrong ſouth-weſt wind prevailed at Peterſburgh, latitude 60° and longitude 30° eaſt. Now the places of obſervation were 177 degrees diſtant, one on the eaſtern and the other on the weſtern ſide of our hemiſphere, (which, at this proximity to the pole, argues not a ſuperior diſtance to that I have men-

* Mem. Meteorolog. ii. p. 189, &c.

tioned;)

tioned;) and four days is as ſhort a time as can be allowed to the ſouth-weſt to ſupply the more eaſtern north-weſt. (Mem. Peterſburgh 1778, p. 92.) So alſo in the ſame journal I find, that from the 4th to the 30th of May a north wind prevailed in the eaſtern part of our hemiſphere from latitude 58° to 61°, except ſeventeen days of variable winds; but in London it blew from the ſouth-weſt during the firſt fifteen days of June, thus replacing the northern air. And to replace the conſtant north-eaſt wind on the Indian peninſula to the Moluccas, there is a conſtant draught from the ſouth in the weſtern parts of our hemiſphere; accordingly Leſke obſerved, that on an average of twelve years it blew 126 days each year, from October until May, from ſome ſouth point, namely, 86 days from the ſouth or ſouth-weſt, and 40 from the ſouth-eaſt, at Abo, latitude 60°.

It is true, that he found it to take place very frequently alſo in ſummer; but this is occaſioned by the great heat that then prevails in the northern tracts of Lapland.

And, upon the whole, more of the ſouth air is drawn off in winter than in ſummer; for its flow is gentle in ſummer, but often ſtormy in winter. See Leſke's 9th, 11th, and 12th tables. If all other meteorological tables of a ſeries of years had been arranged with equal ſagacity and preciſion as thoſe of Leche and Dr. Horſeley, a vaſt fund of information might be extracted from them.

At Peterſburgh, during the year 1793, Euler junior found a ſouth or ſouth-weſt wind prevailed 79 days, 52 from October to the end of March, and only 27 in the ſummer months: it was ſtormy in November, December, and January. I have not noted the ſouth-eaſt.

Mr. Stritter alſo found the ſouth wind to predominate at Moſcow during the ſix winter months of that year, (N. Acta Petrop. xi. p. 569;) ſo that the frequency of this wind in high latitudes is certain.

Of Northerly Winds.

In the weſtern parts of our continent and hemiſphere theſe are of all others the leaſt frequent in latitudes above 48°. See La Cotte's and Leche's tables. The cauſe of this unfrequency appears from what has been ſaid of ſouth winds.

But in latitudes below 48° they occur oftener, and oftenеſt in thoſe that are ſtill lower, as La Cotte remarks. An admirable inſtance of Divine Providence, that the warmeſt winds ſhould prevail oftenеſt in winter in the coldeſt regions, and cold winds in the warmeſt!

But it may be aſked, why a ſouth wind ſhould not prevail

in the eaſtern parts of our hemiſphere to ſupply the conſtant north-eaſt wind that prevails in the low latitudes of the weſtern ſide? The reaſon is, that on the weſtern ſide the north-eaſt winds of low latitudes are eaſily ſupplied by the contiguous Atlantic, which is open up to the North Pole; and, as here, the upper current ſets and ceaſes, there can be no deficiency of air.

Of oppoſite concomitant Winds.

It has often been obſerved *, but of late, ſince the invention of balloons, evidently proved, that currents of air from different and even oppoſite points of the horizon, prevail at different heights in the atmoſphere over the ſame tracts of land or water. This was originally inferred from the different courſes of the higher and lower clouds; but as ſuch obſervations were often liable to optical deceptions, better proofs were wanting.

Mont Louis is within thirty miles of Perpignan, but about 5900 feet higher. Now in March 1780, north and north-eaſt winds prevailed at Perpignan and a weſterly wind at St. Louis. In Auguſt a north wind prevailed at Perpignan and an eaſt at Mont Louis. Mém. de la Société de Medecine de Paris 1780. Derham ſuſpected †, and Gentil has ſince ſhown, that changes of ſeaſons conſtantly begin in the upper atmoſphere; while a ſtrong wind blows from one point below, a wind from an oppoſite point reigns above, but more gentle, until at laſt (in about three weeks) it is propagated downwards. (Voy. ii. p. 23, 24, in 8vo.) The lower atmoſphere, he ſays, extends to the height of 2880 feet. (Vol. iv. p. 48.) At the commencement of winter, when the ſun approaches the ſouth tropic, and the north air begins to flow in and follow it, it muſt meet with more reſiſtance from the lower denſer air, as its impetuous courſe in an oppoſite direction is more ſlowly altered (this reſpects the monſoons) than in the rarer ſuperior ſtrata; and the ſame effect, but in a different direction, takes place when the ſun approaches to the northern tropic.

It has been ſaid by many, that winds in the ſuperior regions of the atmoſphere are much more violent and impetuous than in the lower. (Sauſſure Hygrom. p. 300: Ulloa's Voy. ii. p. 81: Muſchenbr. § 2612: Bergm. Erde kugel. ii. p. 99: De Luc, &c.) But the contrary has alſo been obſerved by Gentil, above quoted, and Morveau. (Aëroſt. de Dijon.)

* Ulloa's Voy. ii. p. 62. Engliſh.

† Phil. Tranſ. Abridg. iv. part ii. 125.

Of

Of the Succession of Winds.

Well eſtabliſhed general laws on this head would be extremely uſeful, as we might then foreſee what wind might next be expected. Beſides the *general* ſucceſſion in an open country, it is probable there is a *local*, confined to certain ſituations.

Gentil remarks, that in the ſouthern latitudes of our hemiſphere, a north-eaſt is ſucceeded by an eaſt, ſouth-eaſt, and ſouth. According to La Cotte, the order of ſucceſſion in the middle latitudes is ſouth-weſt, north, weſt, north-eaſt, ſouth, north-weſt, eaſt, ſouth-eaſt. (Roz. Journ. xxxix. p. 267.)

Of the Scirocco.

This is a ſouth or ſouth-eaſt wind, known in the ſouthern parts of Italy, Sicily, and Malta, diſtinguiſhed by peculiar debilitating effects, well deſcribed by Brydone, and by Dolomieu in his Treatiſe on the Temperature of Malta. The latter has ſhown that its malignity reſults from the conſtitution of the air it conveys, and not merely from its temperature, which is variable, from 55° to 80°. It contains a much ſmaller proportion of oxygen than air uſually does. The conſtitution of the African wind, called *harmattan*, is as yet unknown; it is, at leaſt on land, loaded with ſome unknown undiſſolved vapour, and is much hotter and drier than the *ſcirocco*, but not debilitating, and even wholeſome for animals; for though it parches their ſkin, it deſtroys infection and cures ſeveral diſorders. (See Phil. Tranſ. 1781, p. 46, &c.) Its direction is alſo weſtwards.

LVII. *Report preſented to the Claſs of the Exact Sciences of the Academy of Turin, January* 12, 1803, *on the Action of Galvaniſm, and the Application of this Fluid and of Electricity to Medicine. By* A. M. Vassali-Eandi*.

THE Galvanic experiments made on the 10th and 14th of Auguſt laſt, in the preſence of a great many ſpectators, by Giulio, Roſſi, and myſelf, on the head and trunk of three decapitated criminals, an account of which has been publiſhed, gave riſe to ſeveral queſtions in regard to this agent, and by analogy reſpecting electricity. Theſe two fluids, and the uſes to which they may be applied, have become a common ſubject of converſation among well-informed per-

* From the *Journal de Phyſique*, Germinal, an. 11.