

REPORT
OF THE
METEOROLOGICAL DEPARTMENT
OF THE
BOARD OF TRADE.

1862.

Presented to both Houses of Parliament by Command of Her Majesty.



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N.B.—For official or general purposes, the first and two last Chapters may be read without the intermediate ones, which are solely meteorological.

R. F.

REPORT.

CHAPTER I.

SIR,

May 1862.

IN June 1858 my last Report to the President of the Board of Trade was presented: since which time perhaps sufficient progress has been made in Meteorology to call for a special report on the branch for which I have the honour of being responsible.

2. Seven years have elapsed since Mr. Cardwell organised this department—experimentally. A full account of its origin, and arrangements, was printed with my report to Lord Stanley of Alderley, in 1857, and in the following year a brief summary of our proceedings, until June 1858, was published.

3. In those pages, after mentioning various works in progress within this office, special reference was made to anemometers,* at Bermuda and Halifax—and to series of simultaneous observations undertaken, extensively, in co-operation with this department.

4. It was then that preliminary measures were commenced which have since led to results said to be so useful as to warrant the present consideration of meteorology as an “applied science.”

5. Besides the organisation and commencement of synchronous observations—improvements in methods of acting, among observers, and of utilising records on paper, were adopted, in order to systematise and render manageable an accumulation of observations.

6. By circulating *Manuals* of instruction—by lending instruments—and by those invaluable *loans*, to less affluent places, which the Board of Trade had made by means of “Fishery barometers”—an extent of actual and immediate benefit has accrued, which may be best estimated by those who are most acquainted with our exposed sea coasts, and the fisheries in particular—as well as by nautical men and maritime interests, generally.

7. Possession of weather glasses, however good, being of little avail, comparatively, unless acquaintance with their use is understood to a far greater degree than can be improvised; even by the ablest and most sagacious:—the general distribution, and forced circulation of small books of instruction—never before available—seemed indispensable:—and the consequences of such measures have been most satisfactory.

* Self-registering wind gages.

8. By continued and consecutive series of charts, several hundred in number, constructed on the simultaneous or synchronous principle, an insight into the laws of our atmosphere—into meteorological dynamics, (distinct from statical results previously obtained at observatories and elsewhere), has been gained; which has enabled us to know what weather will prevail during the next two or three days, and, as a corollary, when a storm may occur. These seem to be satisfactory and rewarding results. Their basis shall be popularly explained in the following Chapters of this Report.

9. In September 1859, the British Association for the Advancement of Science met at Aberdeen under the presidency of the universally lamented Prince Consort. It was then resolved by their Council that application should be made to Her Majesty's Government for an organisation and trial of a plan by which the approach of storms might be telegraphed to distant localities. At two meetings in Buckingham Palace, early the following year (1860), minutes were authorized on this subject, and correspondence ensued which resulted in establishing a telegraphic communication of meteorological facts between 20 home stations, besides foreign ones—and daily with Paris.

10. The Aberdeen meeting had only just terminated, when public attention was startled by the loss of the "Royal Charter." It so happened that the storm which caused the destruction of that iron ship—(notwithstanding power of steam additional to that of sails—and while a *sailing* ship, managed differently, was bearing its brunt uninjured within a few miles distant;*) that storm, completely cyclonic, passed over the middle of England, and could be more fully investigated than *any* storm hitherto, because in every direction observers happened to be ready, who recorded ample statical facts, and many valuable dynamical results.

11. That remarkable tempest was soon followed by another, also carefully analysed, but temporarily. Further information, and time to give to its consideration, will enable us to add a good deal to the printed discussion of those subjects, (hitherto circulated in our tenth number of Meteorological Papers,—and its accompanying atlas of charts.)

12. When the British Association met at Oxford in July 1860, a paper was read on these and some other British storms; on the measures also then proposed for meteorological telegraphy, which obtained approval without eliciting any opposition.

13. Instruments having been placed at selected stations, and all arrangements organised for observing and telegraphing, our commencement was made on the first day of September (1860), since when no break or interruption has occurred in the system of weather reporting: to which the principal newspapers have borne daily witness; as they have been pleased to publish the

* The "Cumming."

reports sent to them, gratis, by the Board of Trade; and those carefully prepared documents have been forwarded, to each paper, uninterruptedly.

14. Advancing gradually, the first cautionary or storm-warning signals were made early in 1861;* but on that occasion were unhappily disregarded in the Tyne, and on the following days awful losses of life were witnessed on the north-east coasts. From that time to the present similar warnings have been given there and elsewhere,—with increasingly advantageous effects, it appears—if one may judge, in the first instance, by applications since sent officially from all the principal ports, and from the chief associations of Underwriters, in addition to Admiralty approval, and the co-operation of the Coast-guard.†

15. In August 1861 the first *published* “forecasts” of weather were tried; and after *another* half year had elapsed for gaining experience by varied tentative arrangements, the *present* system was established. Twenty reports are now received each morning (except Sundays), and ten each afternoon, besides five from the Continent. Double forecasts (*two* days in advance) are published, with the full tables (on which they *chiefly* depend), and are sent to six *daily* papers, to one weekly,—to Lloyds,—to the Admiralty,—and to the Horse Guards, besides the Board of Trade.

16. These forecasts add almost nothing to the pecuniary expense of the system,—while their usefulness, practically, is said to be more and more recognized. Warnings of storms arise out of them, and (scarcely enough considered) the satisfaction of knowing that no very bad weather is imminent,—may be very great to a person about to cross the sea. Thus their negative evidence may be actually little less valuable than the positive.

17. Prophecies or predictions they are not:—the term forecast is strictly applicable to such an *opinion* as is the result of a scientific combination and calculation, liable to be occasionally, though rarely, marred by an unexpected “downrush,”‡ or southerly wind, or by a rapid electrical action not yet sufficiently indicated to our extremely limited sight and feeling. We shall know more and more by degrees. At present it is satisfactory to know that the measures practised daily in these proceedings do not depend solely on one *individual*. They are the results of facts exactly recorded,—and deductions from their consideration, for which rules have been given. My assistant has been practised and is able to share their responsibility. Others are also advancing in the subject of dynamical meteorology.

18. Meanwhile most of the main objects, for which this department was instituted, are pressed forward as opportunities and time admit. Having already collected a great store of valuable materials, it seems advisable to utilise them, while manageable, rather than continue a mere accumulation, at the risk of being confused, if not overwhelmed.

* February 5 and 6—at a few places only.

† See the last Chapter for further remarks on this special subject.

‡ Herschel.

19. This applies specially to observations made on board the *generality* of merchant ships, following tracks now well known. Their officers ask for repetitions of our *loans* of instruments, and gratis supplies of various instructive nautical books*—a process too expensive to be *indefinitely* continued—(which, indeed, was never intended), however useful hitherto in the results secured—of a documentary character—and in the moral effects on the rising generation of sea commanders, by stimulating them not only to make observations, but by teaching exactly what and how to observe. This may *now* be done by various publications which did not formerly exist, or were *unattainable*.

20. While the proceedings above mentioned have occupied the principal part of our time, Admiralty duties have not been neglected for a day, exigent as they may have been, necessarily.

Supplies of meteorological instruments and books have always been maintained in readiness at home, at the Royal Dockyards and at depôts elsewhere; and those instruments have been gradually improved until a class of character has been attained which is satisfactory. Barometers are now supplied to Her Majesty's ships, which are not only accurate, legible, and very durable, but actually can withstand the concussion of heavy guns fired close to them.† Aneroids have been also improved, as suggested *here*, and some are now made—small enough for the pocket—useful for comparing heights in reconnoitring, besides being reliable as good weather-glasses. They have been verified at Kew Meteorological Observatory. With all the instruments sent afloat for the Admiralty through the Hydrographer—manuals of information, for the younger officers' instruction—are always inclosed. Copies of all the publications of this department are also freely circulated, and are continuously supplied, in ample number, to the Royal Naval College, and to H.M.S. "Britannia."

21. Very few, comparatively, of Her Majesty's ships are so circumstanced as to admit of attention and time being given to regular observations, and to records specially for scientific purposes; but all are required by the Admiralty to register a considerable number of the most valuable practical observations—in much improved modern logbooks—which now, with *reliable* instruments, and known corrections, have an inexhaustible supply of meteorological facts.

22. From some, however, of the Queen's ships, extra or special registers have been transmitted, by officers as keenly interested in these subjects as zealous in ordinary duties:—and many valuable continuous records have been received from vessels employed in surveying. Among the Queen's officers who have aided in this collection—Lieut. Chimmo, Mr. Hull, Captains Aldham, Harvey, Ommaney, Shadwell, Nolloth, Cochrane, Thomas, and Richards, besides Sir Frederick Grey, have contributed the largest amount of valuable information during limited opportunities.

Sir Frederick Grey's register, even while his flag was flying on

* Meteorological and Magnetical.

† Proved on board H.M.S. "Excellent."

board H.M.S. "Boscawen," was kept, and the observations were all made throughout, by *himself*, a unique instance—exemplary to junior officers. He also experimented with an anemometer, at sea, satisfactorily; the only instance yet recorded.

23. In addition to all these sources of information—to the large library of logbooks arranged regularly at the Admiralty (Somerset House), and to the long lists of published voyages—many superior collections of data have been received from foreign or colonial observatories, and many fragmentary gatherings from isolated distant stations—with some from the casual researches of travellers.

24. To show what has been doing in the merchant marine, I might ask for reference to the Mercantile Navy List, page xi. and now would only quote the following passages: "To the present time, 1862, not less than five thousand five hundred months of good meteorological registration have been received from about eight hundred selected ships in the mercantile navy."

"More than eight hundred selected merchant ships have been supplied by Government with tested and reliable instruments, *lent* to them, besides charts and books given *gratis*."

"The character of these ships, and their captains, may be inferred from the subjoined lists."*

"The greater part of these registers are well filled with information, not only useful to seamen, but truly valuable to scientific inquirers into physical phenomena."

"They do honour to those who have kept them, and to the mercantile navy of Great Britain."

N.B.—Perhaps the following Seven short Chapters may be passed over for the present, as the Ninth and Tenth are more directly official.

CHAPTER II.

REMARKS ON RECENT METEOROLOGICAL PROCEEDINGS.

IN the Meteorological Department of the Board of Trade much has been effected by simultaneous observations at many places, in addition to the registration of atmospheric occurrences sedulously carried on at sea and on land in many parts of the world.

Practically, these extensive observations of facts, occurring in various climates and under a variety of conditions, from arctic or

* See Mercantile Navy List, 1862, pp. xi. to xxiii.

antarctic regions to those of the tropics, have directly tended to prove the uniformity of those laws by which our atmosphere is governed and the differences of climates determined.

Meteorology, which had been thought a complicated and vague subject, has approached the character of an exact science; and the tabulated labours of many observers, in successive periods of years during the last two centuries, have begun to bear fruit in their present usefulness to practical, as well as to theoretical, students of atmospherical phenomena.

It is now by no means difficult to estimate the climate and winds of any geographical position.

The hours of highest and lowest temperature and barometric pressure, the normal height of the mercurial column, the prevalence of moist air, rain, or dryness, much or little cloud, &c., and the force as well as direction of principal winds, can be predicated approximately for any part of the world, although in that particular place no observations may yet have been registered.

More than this, however, and more directly valuable, is our confirmed knowledge of the "laws of storms," and our further acquaintance with the nature and succession of the prevalent or various winds over the earth and ocean.

Consequent on the recorded observations of numerous contributors* to meteorological science, we have now a general and, in some branches, a detailed acquaintance with the subject; we have good instruments and tables, and the use of them is better known.

Her Majesty's Government has endeavoured to diffuse practical knowledge of winds, weather, currents, storms, and climates, not only among mariners engaged in voyages to distant regions, but among the coasters and fishermen along our own shores.

Instruments and instructions have been liberally lent (at the public expense) to selected captains of ships; while other such aids, of a kind expressly suitable, have been similarly lent to more than fifty of the most exposed and least affluent fishing villages.

The hardy populations of these places have already derived much benefit, and have strongly expressed their sense of gratitude for the use of these barometers, thermometers, and plain instructions; while the registers returned from numerous ships among the finest of our merchantmen, besides men-of-war, now constitute a mine of valuable maritime and scientific information.

Among many results indirectly or immediately flowing from the recorded observations on board so many ships, thus supplied by Government with reliable instruments, verified at the Kew Observatory, has been one which cannot be too widely known among voyagers,—namely, that near the equator, between five and ten degrees of north latitude, the range of the barometer is so small

* Dampier, Halley, Hadley, De Foe, Franklin, Cook, Capper, Flinders, Howard, Horsburgh, Redfield, Dové, Daniells, Kamtz, Esby, Sabine, Lloyd, Robinson, Reid, Piddington, Herschel, and Humboldt, besides other original observers; and numerous compilers, among whom is the popular Maury.

and so regular, as to time, that any such or similar instrument may be verified, while crossing that zone, more satisfactorily than by a removal to the shore for comparison with a standard: a test of the utmost value also for meteorological records made on long voyages with uncomparated instruments; at any time.*

Another simple result deduced from multiplied observations, and as important as it is simple, is, that in a gale or storm, while *facing* the wind, the centre of the circling or cyclonic current of the atmosphere is to the *right* in *north* latitude, but to the *left* in the *southern* hemisphere.

Not that these rules are without occasional *apparent* exceptions—apparent rather than real—caused by a second, perhaps even a third, cyclonic, or rather, irregularly elliptical eddy impinging on the first circulation, either horizontally or angularly (with reference to the horizon).

The *first* movement may be likewise more or less inclined to the horizontal plane, if not occasionally almost vertical, as in a “*descending squall*.”

Such phenomena are readily explicable, after due consideration of Dové’s theory of polar and equatorial currents (translated and published by the Board of Trade), and they are so marked by *weather-glasses* that it is now inexcusable to navigate without them or to undervalue their warnings.

Why the barometer rises and falls, *how* it, and its indispensable companion, the thermometer, are affected by a coming change, are questions often asked by the inexperienced in their use, and may perhaps be answered here at once in a few sentences.

Cold, dry air, coming from a polar direction, is heavier in specific gravity than warm, moist air (containing gas or aqueous vapour) flowing from equatorial or tropical regions.

The normal condition of our atmosphere is a continual rising and westward movement of inter-tropical, may one say *sub-solar*, atmosphere, consequent on its expansion, and being lightened by the sun’s action, while the earth is rotating on its axis.

This rise and westward impulse is accompanied by general movements from polar directions to fill the space that would otherwise become *comparatively* vacant. Air, like water, seeks equilibrium, but, unlike water, it is *very* elastic and *excessively* mobile.

Yet air, however rarefied, cannot rise beyond a certain distance. Cold and gravity check its elevation. It must, however, move onwards somewhere. Having momentum, and being pressed behind by ever-rising air, it overflows (as it were) the polar under-currents and moves towards those regions which the polar currents have quitted and are *continually quitting*. But those regions are vastly smaller in area than the equatorial, and opposition, if not a conflict, occurs soon between the main streams or currents, so unequal in breadths and characters.

Portions of the overflowing quantities from the sub-solar regions

* See the SEVENTH NUMBER of our Meteorological Publications—On Intertropical Diurnal Range.

combine, between the tropical limits and about the thirty-fifth degree of latitude, with the normal and general movement of tradewinds or monsoons, and other parts divide, mixing with, or opposing the polar currents in a variety of ways, between the tropics and arctic (or antarctic) regions.

Such currents sometimes flow side by side, though in opposite directions, as 'parallel streams,' for hundreds or even thousands of miles.* Sometimes they are more or less superposed—occasionally, indeed *frequently*, crossing at various angles;† sometimes combining, and by the *composition* of their forces and *qualities* causing those varieties of weather that are experienced as the wind veers more toward or from the equator or the nearest pole; and sometimes so antagonistic in their angular collision as to cause those large circling eddies or rotatory storms called cyclones (in modern parlance), which are really like the greater storms in all parts of the world, although they do *not* quite assimilate to those local whirlwinds, dust-storms, and other commotions of atmosphere which seem to be more *electrical* in their origin and characteristics.

Whenever a polar current prevails at any place, or is *approaching*, the air becomes heavy, and the barometer is high or rises. When the opposite (equatorial or tropical) prevails or approaches, the mercury is low or falls, because the air is, or is *becoming*, specifically lighter, and these changes take place *slowly*.

Whenever, from any cause—electrical, chemical, or simply mechanical—either current, or any combination of currents, ceases to press onwards‡ *without being opposed*, a *gradual* lightening of the atmosphere, through a greater or less area of hundreds, or perhaps thousands, of miles occurs, not suddenly, but very gradually, and the barometer falls.§ There is less tension.

To restore equilibrium, the nearest *disposable* body of air (so to speak) or most moveable, advances first; but an impulse, at the same time, may be given to other and greater masses that—though later in arriving—may be stronger—last longer, and cause greater pressure mechanically as well as by combination. Air, like water, mingles very slowly, either from above or laterally.

Taking, with Dové, north-east and south-west (*true*) as the "windpoles," all intermediate directions are found to be more or less assimilated to the characteristics of those extremes; while all the variations of pressure, or *tension*, many of those caused by temperature, and all varieties of winds, may be clearly and directly traced to the operations of two constant principal currents—equatorial or tropical, and polar—our north-east and south-west.

* Like Sabine's currents of the sea, on the coast of Africa.—'Pendulum Experiments,' published in 1825.

† Green, Rush, and Welsh.—'Balloon Ascents.'

‡ If *opposed*, mechanical pressure increases; and this may be caused by high land, as well as by opposing wind.

§ Evaporation, rarefaction, or condensation of vapour in air, reduces its specific gravity—the two former by expanding bulk, but rendering it lighter; the latter, —through mechanical diminution of quantity, by falling to the earth as rain, &c., likewise causing expansion; and, therefore, lightening of the elastic atmosphere. Moreover, there is more or less motion, directly *away* from the place of stationary air, which helps to lessen its *elasticity* or tension, and cause the barometer to fall.

SECTION 2.

Gradual progress of Meteorology. Storm Telegraphy.

Meteorology is not a science in which great progress can be made in a short time, but many steps have been taken by Government directly tending to utilise this branch of knowledge in a general and important manner, with as little delay as practicable.

In 1857 it was first arranged that simultaneous observations should be made daily at a large number of selected stations in the British Islands, also in, and around the Atlantic, and at places on the European continental coasts.

By combining these observations in synchronous charts, and otherwise, it was discovered that, irregular as changes of wind and weather seem to our usual apprehension, there is really so much uniformity and similarity of character in successive variations, that by means of a comparatively small number of observations made daily at a few selected stations, sufficiently far apart; and by the use of self-registering barometers at a central station; to which meteorological telegrams are sent from the outlying stations—it was seen that distinct intimation of marked changes of weather, and warning of dangerous storms, might be given at the centre, and thence to all other points of any telegraphic combination.

The idea of giving warning of storms by telegraph was familiar to many meteorological observers in America as well as in Europe; and it was suggested before the year 1836, with a reference only to the semaphoric telegraph: but when electricity became man's messenger, its applicability to this object occurred immediately to various persons.

Yet the subject attracted too little popular interest to be taken up by any influential body, until in September 1859, at Aberdeen, the British Association resolved to express to Government their view of its importance.

The late Prince Consort, then President of the British Association, directed steps to be taken. Communications were made to the Board of Trade. The Treasury and the Admiralty were consulted, and the result was—the establishment of a system, experimentally, by means of which it was hoped that much loss of valuable property, and a much more serious loss, of invaluable lives, might be prevented.

This system, now generally known through the newspapers, was commenced in September, 1860: but until January it was limited to receiving reports from practising observers.

On the 6th of February 1861 the first warnings were given. Between that date and March 19th, eight other cautions were given, after which no remarkable windy or general atmospheric disturbance occurred for some time.

The warning of February 6th was disregarded at Shields by a fleet of vessels, and many were wrecked on the 8th or 9th.

Subsequently, whether from having appreciated these storm signals, or from other reasons, the *fact is* that very few wrecks

occurred on our coasts during the notoriously tempestuous weather of February and March 1861, and comparatively few since.*

It is known that M. Le Verrier, and other scientific authorities on the continent—especially M. Buys Ballot in Holland—have for some time had their attention directed to simultaneous meteorological observations, and their possible utilisation for maritime, commercial, and geographical interests.

But the range of M. Buys Ballot's stations is small, and, on the other hand, that of M. Le Verrier is so extensive, that great difficulty must be found in grouping, combining, and drawing conclusions from them for practical use.

M. Le Verrier's letter to his English colleague at Greenwich, in April 1860, arrived opportunely at the time our Government had under consideration those suggestions of the British Association, which originated at Aberdeen, and undoubtedly it had the weight due to such an authority.

Our own Islands have very peculiar facilities for meteorological communication by telegraph, between outlying stations on the sea coast and a central place—all being at nearly the same level, and nearly all comparatively uninfluenced by mountain ranges.

SECTION 3.

Some special peculiarities.

Great distinction should be marked between those ever alternate and often conflicting main currents—tropical and polar, and the *local effects* of their union, or antagonism, namely mixed winds—whether westerly or easterly, with occasional cyclones or circulating eddies, on a large or small scale.

During the whole month of April last year, and even generally to the middle of June, a polar current, very extensive and uniform, moved southwards *near* or along the surface of our island and adjacent area; while its counter, and then *superposed* current progressed in a more or less contrary direction, usually above, but at times intermixing locally with, and often affecting or influencing the lower and normal *ab-polar* movement, by here and there pressing down and onwards irregularly.

Considering that the lower current does not ordinarily extend far upward (only a few thousand yards, or even feet), and that high land, mountains, especially *ranges* of mountains, alter and impede its progress, a variety of eddy winds, or as it were streams of wind, with local and apparently anomalous effects, must be frequently caused.

Electrical action, condensation of vapour into hail, snow, rain, or fog, causing *heat*; or its other changes, namely, evaporation,

* At a recent meeting of the shareholders of the Great Western Docks, at Stonehouse, Plymouth, it was stated officially that "the deficiency (in revenue) is to be attributed chiefly to the absence of vessels requiring the use of the graving docks for the purpose of repairing the damages occasioned by storms and casualties at sea."—(*Shipping Gazette*, Feb. 24, 1862.)

rarefaction, and expansion—absorbing heat, and therefore causing *cold*—immediately affect currents of air in a degree proportional to such influence;—inducing horizontal motion.

The polar current always *advances* from the polar quarter, while *laterally* moving eastward, (like a ship making lee-way,) being pressed towards the east by the tropical flow which advances from the *south-westward*, usually above and at an angle with the polar stream or current of air, often mixing with it, but at times *separately* penetrating downward, then sweeping and warming the earth's surface, uncombined with the polar current, even while feeling its approaching influence: and thus, as it were, forcing passages between streams of chilling polar air that at the same time are moving in opposite and nearly parallel directions.

Sometimes their opposition is so equal, and equilibrium is so complete, that a *calm* is the result, no sensible movement *horizontally* along the earth's surface being perceptible.

Self-registering barometers show the alterations in tension, or so to speak, the *pulsations*, on a large scale, of atmosphere, by hourly marks, and the diagram expresses to a practised observer what the "indicator card" of a steam cylinder shows to a skilful engineer, or a stethoscope to a physician.

Improved aneroids, on more correct principles of construction, some much *smaller* than those made by their ingenious inventor, M. Vidi, previous to the expiration of the French patent, others suitable for measuring heights, as aids to surveyors—are now made.*

New constructions of mountain mercurial barometers have been suggested, but not sufficiently proved by practical use.

Perhaps it will be difficult to devise a better one than that of Gay Lussac, if made stronger; with the glass-blower's work better executed than has been the case with some that have been found too delicate for mountain ascents.

Travellers should not be influenced in such cases by the very precise refinement desirable in an instrument for an established observatory, (to which ideal perfection many an opportunity of observation, with really *sufficient* accuracy for its purpose, has been sacrificed), but should endeavour to secure a reliable, though less minutely accurate, means of ensuring results, within *known limits of moderate error*. Nearly a tenth of an inch of alteration in the Torricellian column is caused by one hundred feet of change in elevation; but what is this compared with some twenty thousand feet of altitude, and the yet little known atmospheric influences of such a height, where the mercury falls to about twelve inches? Yet to attain a nicety of measurement, to the thousandth of an inch, instruments *are offered* to zealous travellers so delicate as to be suitable only for use at permanent stations where there is every convenience for their management.

* For not much exceeding five thousand feet can they be *trusted*, though made to range higher.

This defect, if it may be so called, (though really an excess of certain merits) has been too general in marine barometers, of late years,—excellently made, admirable in principle,—respecting accuracy, and permanent reliability; but too finely graduated for an ordinary observer *at sea or by night*; and too delicate in structure to bear the common shocks unavoidable in a ship of war.

Such objections have been lately obviated by a less minute graduation on a *porcelain* scale (instead of a metal one liable to tarnish or rust), and by "*packing*" the glass tube with vulcanized india rubber.

Thus constructed, accuracy and reliability in a marine barometer are obtained to the nearest hundredth of an inch, with the quality of withstanding heavy gun firing (as proved on board H.M.S. "Excellent"), and a facility for adopting spare portable tubes, boiled, and with their cisterns capable of adjustment to any similar barometer, without the aid of an optician.

In using a marine barometer, an invaluable instrument, which some voyagers would rather have than a chronometer, (one costing only three pounds and the other about forty,) it is well to have some definite idea of the *amount* of change which indicates unusually violent wind, such as that experienced in the St. Kilda cyclone of October 1860, in the "Camilla" typhoon of the same date nearly, of the "Royal Charter" gale of October 1859, that of November following, and many others. In each of these similar storms the barometer fell at the rate of nearly a *tenth of an inch an hour* before the shift of wind occurred; shortly previous to which it ceased falling, then began to rise, and while the violence of the tempest prevailed, rose as rapidly as it had previously fallen.

Generally speaking, *sudden* changes, approaching the rate of a tenth of an inch an hour, are indicative of immediate and great atmospheric commotion. On the other hand, an hourly change of about, or less than the hundredth of an inch, however remarkable may be the atmospheric alteration *eventually*, indicates a *gradual* and therefore not so dangerous a change; for, *if followed* by strong gales, ample warning of their probability will have been given in sufficient time for due preparations.

SECTION 4.

Gales and Cautionary or Warning Storm Signals.—Weather Reports.

It is impossible for those who have studied practical meteorology, and know what power is now available for diffusing knowledge by telegraphy, not to feel a keen consciousness that many lives risked in gales or storms might be saved by simple modern appliances employed extensively.

While no man had the means of knowing anything about the weather beyond his sight, or the *feeling* of his own instruments, it was scarcely possible to foretell changes of importance, at a distance, as well as on the spot: but now the case is exceedingly different. A daily glance at the published "Weather Reports,"

a recollection of their principal features during the few previous days, a look at the glasses at home, and an eye turned occasionally to the heavens, may enable any one, after a little practice, who pleases to take the trouble, to foresee, at least a day in advance, with probability of being nearly right, the principal changes of our very variable, though *regularly* varying, climate.

As the *least* irregular and the most prolonged motion of our atmosphere is along the surface of the earth from the northward, it may be considered almost the normal movement.

With the occasional continuance, even for weeks, of comparatively cold, clear, and dry northerly winds all are familiar, and opposite qualities are usually expected with southerly winds.

But we were formerly unaware that the alteration, the opposition, and the intermixture, whether laterally, while flowing in different directions, or while superposed, cause the principal changes and varieties of weather.

Into the origin of these currents themselves it would be inexpedient to enter here : having to deal now with the facts in evidence, and draw practical conclusions useful even in ordinary life—but to the seaman most important.

Numerous, and differing extremely in area as well as in rate of motion, either slow or rapid, are the circulations of our ever *influenced*, highly elastic, and fluid atmosphere.

Not only does it always seek its level, like water, but, directly any pressure on it alters, it expands or it is contracted, like—*itself alone*, the most elastic, compressible, mobile and expansible of compound substances.

Hence a great change over any place affects not only that locality, but a wide area round ; and, as matter, even gaseous, is neither moveable nor ceases to move *suddenly*, vast accumulations of atmospheric air, hundreds of miles in extent—although *feeling* distant changes quickly, *acquire* motion but slowly at first, and, after being moved, are carried on by their own momentum, after the first impulsion has ceased.

Owing to this, the barometer and its companion, the thermometer, *foretell* changes, and, after the original cause of rise or fall has ceased to operate, the barometric column continues its ascent or descent, for a certain time, being influenced by air currents retaining their momentum.

The meeting of such currents raises the barometer ; their retreat always lowers it. It may be repeated, that their appulse and varying combinations occasion all the varieties of rain, hail, snow, or fog, cloud or misty vapour that we experience.

And now, the results are, that, having daily knowledge of weather (including ordinary facts of a meteorological nature), at the extreme limits and centre of our British islands, we are warned of any *great change* taking place, the greater atmospherical changes being measured by days—rather than by hours. Only local changes, however violent they may be occasionally (and dangerous in proportion to their suddenness and violence),—only such changes

are unfelt at a distance, and do not influence great breadths,—say, hundreds of miles in area,—of atmosphere.

Extensive changes, showing differences of pressure, above or below the normal or mean level,* amounting to an inch or thereabouts, are certain to be followed by a marked commotion of the elements in the course of a few days. If the fall has been sudden, or the rise very rapid,—swift, but brief, will be the resulting elementary movement; if slow, or gradual,—time will elapse before the change, and the altered state of weather will take place more gradually, but last longer.

Warning may thus be obtained, and given, a few hours, or a day, or even some days, before any important change in the weather actually occurs.

But the necessity of having advanced cautiously—and not without experimental trial—is obvious. Some persons are ever ready to blame hastily, and the fabulous cry of “Wolf!” would have been raised, if the cautions at first circulated had been proved erroneous.

I will now try to explain some principal facts connected with the indications of one week’s weather—as an example.

On the 2d of February 1861, the barometer was 30·80 at Penzance, and 30·07 at Nairn, where on the 4th it became 29·04. Everywhere the barometer was falling rapidly from an unusual height, and the temperature was *much above* the average of the season. These signs, even alone, foretold a southerly gale. On the 5th every barometer was still falling, each thermometer continued high (for the time of year), while atmospheric and other signs of a southerly gale, in the air, on the shore, and otherwise, increased.

Arrangements having been but partially made, only very limited warning could then be given. That little was attempted, as a first essay, on Tuesday evening, the 5th; by telegraphing to show signal drum all the next day, the 6th. It blew furiously from the southward that night and afterwards; but on the 7th there was a treacherous lull.† On the 8th, 9th, and 10th there was a widely extended and heavy gale from the northward. The barometer began to rise just *before* the gale set in from the northward, rising more rapidly as it blew stronger. And why? Because the polar current of wind was rushing, like a current of any other fluid, towards the place of low barometer, or less *tension*, where a *comparative* deficiency had existed, which it not only filled, but, having once acquired impetus or momentum, pressed to a height, or *tension*, above that usual at the mean sea level, or above 30 inches. The fall of the barometer, with unusually high temperature, expressed, as plainly as by words, *southerly wind, with rain*. That wind, however, though it blew hard, did not

* Which may be termed the *Par* height—about 29·90 to 30·00 inches between the parallels of 60 and 50 degrees North.

† Caused by a *second* circuit, see page xxxii.

restore the level or equilibrium of the atmosphere, and, therefore, till the polar current approached, the glass continued to fall; or oscillated while low. Directly the northerly wind's *approach* was felt, the barometer began to rise, the thermometer having already fallen, and both then continued to move in opposite directions, one rising for the northerly *direction* of the wind, as the other fell for its *temperature*.

SECTION 5.

Barometers and Weather Reports.

Alterations in the words on barometer scales having been suggested, and daily tables of weather having been published, respecting which various questions have arisen, may I, as the person responsible for them, venture now to submit a few brief explanatory remarks on their subjects.

As it is impossible to have *many* words on a barometer scale that may be read easily by any light; my object was to condense the purport of such few words as are most wanted, in a systematic manner, rather as notes adverting to *instructions* elsewhere, and suitable for *general application*, as notes rather than directions.

By comparison with the meteorological reports now published daily, one may ascertain the state of a barometer, aneroid, or sympiesometer, or measure an elevation above the sea level, by comparisons made between eight and nine in the morning, with two or three of the observations published, for the same time, and for places near, but on different sides of the observer.

It is unnecessary to draw general attention to the uses of such simultaneous, uniform, and continuous series of observations as are available in these tables; but to practical seafaring members of our very maritime community, to pilots and fishermen especially, who possess weather-glasses, and will take this easy method of verifying them, while studying the weather with the aid of these daily reports, they may be found very valuable.

Aneroids being now made portable, a pilot or chief boatman may carry one in his pocket, as a railway guard carries his timekeeper; and thus provided, pilots cruising for expected ships may be able to caution strangers arriving, if bad weather should be impending, or give warning to coasters or fishing boats.

Harbours of Refuge, however excellent and important, are not always accessible, even when most wanted, as in snow, rain, or darkness, when neither land, nor buoy, nor even a lighthouse light can be seen.

Not only do these daily statements of weather and indications of accurate instruments show, to all who are sufficiently interested to compare them day by day, the present and recently past character of the weather *generally*, besides at many specified places, but they enable one to foresee the probable nature of wind and weather during the next day or two, sometimes even for the next few following days.

CHAPTER III.

MOVEMENTS OF THE ATMOSPHERE.

RECENT comparisons of accumulated facts have induced the conclusion that winds move in parallel currents, or—circulate around a *central* area; and that whether the extension of such movement or circulation be immense, as between the tropics and the polar regions, or whether it be small even as the dust-whirl, the *laws* of circulation, or gyration,* are *uniform*, unless in such very rare and *limited* cases as to be unimportant exceptions.

When movements of the atmosphere, such as those of the perennial trade winds, or the very prevalent westerly winds, the “anti-trades,”† are on the largest scale, the wind appears, at any one place, to move in straight lines, owing to the really circular arc having so little curvature; but when circulation is comparatively limited, as in a cyclone, rapid changes in the wind’s direction are obvious to every observer.

When such movements are not horizontal, but inclined to the surface, more or less, perhaps nearly vertical, or partaking of varied directions, they are exceedingly difficult to trace, except by upper clouds seen crossing heavenly bodies, or by visits to high mountains, by balloons, or by “dust,”‡ (so called) carried from far distant places through the higher regions of our atmosphere.

Nevertheless, it appears from the facts ascertained, that the current—from polar regions—tends *upward* when *arrived between* the tropics, and then as a tropical current, *above*, to the eastward—while the lower *ab-polar* movement is southward and, apparently, westward. *Apparently*, because it is caused by the earth turning towards the east; not by its own inclination or impulse, which is almost southerly. Near the equator it has indeed acquired the equatorial (rather than centrifugal) impetus, which, as it rises into an upper region, causes it to move *eastward* while returning towards either pole, and losing this impulse gradually, as it approaches that centre, by gravitation, and by friction along the surfaces of land, or water, or even air-currents.

This circulation, therefore, closely followed out, is similar to that of all the smaller cyclonic motions (*ellipsonic?*)—*against* watch hands in north latitude, *with* the hands of a watch in the southern hemisphere.

A practical and important, but little noticed consequence of these facts is, that lines drawn on a map, at right angles to the right of the wind’s direction *towards* any one *facing* it (*left* in south

* Dové.

† Herschel.

‡ Ashes, or Infusoria.

latitude), all tend more or less toward the *central* area (whether oval, elliptic, or circular), around which there is then a movement of circulation, more or less varying; and, therefore, that a fair average of such lines of direction as (radii), drawn from various stations, will show (where they intersect each other *most nearly*) the approximate centre of such general circulation, which, even thus roughly ascertained, may enable any person, acquainted with the subject, to complete the circles on paper—to show how the wind is then blowing, with its probable relative strength at any parts around, and over what countries or coasts the central part of such circulation will probably pass.

Having such knowledge, it obviously follows that telegraphic warning may be sent in any direction reached by the wires, and that occasionally, on the occurrence of very ominous signs, barometric and other—including always those of the heavens—such cautions may be given before storms as will tend to diminish the risks, and loss of life, so frequent on our exposed and tempestuous shores.

It has been proved also, lately, that storms, indeed all the greater circulations of atmosphere between the tropics and polar regions, have an eastward motion, bodily, while circulating around a central area. Within the tropics it is otherwise, or westward, till they *recurve*.

This universal motion, however irregular or modified in some few localities, by exceptional and minor causes, is additional to the regular circulation above mentioned (which, constrained by the earth's surface, and by general gravitation, occasions movements like "parallel currents," (first described by Dové). These circulations of the polar and tropical currents, with their attendant peculiarities of dry, cold, and heavy air, or moist, warm, and light air, raising or lowering the barometer, as they pass over any country, have caused an *appearance* of "atmospheric waves"—corresponding to barometrical oscillations—as well as to the "gyrations" of wind, so well elucidated by that eminent meteorologist.

Such currents, prolonged and excessively broad, are always flowing, in nearly *opposite* directions, and always moving eastward at an average rate of about five miles an hour in our latitude. If near the earth's service, they may be side by side, or parallel; but if overlapping, or entirely superposed, *crossing* in various directions, and more or less impinging on or *intermingling* with each other. These greater currents, incessantly in motion, occasion with their eddies the minor movements of cyclones, successive, and perhaps numerous—one cyclone following, impinging on, or *counteracting* another, more or less, and thus causing those complicated changes of wind, sudden shifts and *apparent* contradictions of the general law, which have so baffled some investigators, and have caused temporary doubts of the reliability and the universality of the laws of storms.

While these normal *ab-polar* and tropical currents are respectively moving, one towards the wide inter-tropical regions, and

the other towards those very *limited* spaces around the poles of our world, they have also, as has been mentioned, but may be repeated for reminder, a general movement, in mass, laterally towards the east.

The body of air raised, rarefied by warmth, loaded with vapour, and expanded, around the whole globe, about its equatorial bulk, is vastly greatly than the aggregate of cold, dry, condensed and heavy air in the polar regions. This equatorial mass of air, surrounding the world, has acquired a temporary impulse *eastward* with *nearly* the rotating velocity of that zone. Prevented by gravitation from rising *above* a certain distance, pressed on continuously by air in motion below (or behind), toward either pole it must go, to seek its level, and equilibrate the atmosphere.

While moving towards either pole—retaining for a time, though gradually losing, its acquired *eastward* motion, which is continued only till the momentum of its weight and velocity fails in effect towards polar circles—there must be a continual impact, a constant impulsion from the westward laterally against the *polar* current, as it is drawn *towards* and *after* the rising intertropical or *sub-solar* part of the atmosphere.

The polar current has no *lateral* impulse of *its own*;* it is *drawn* towards the west, *in appearance only*, because the earth's surface has a greater rotatory velocity eastward than the polar current, proportionally to its earlier approach to the equator; though, on the other hand, that current is gradually acquiring equatorial motion, the *greatest* westward effects being near the tropics, where the trades are generally found *strongest*.

Therefore the sensible result on the *whole system* of circulation must be continual *easterly* progression in the temperate zones; a *general* motion of the atmosphere towards the east, over the earth's surface, while in the lower latitudes and (perennial) trade winds its motion is different from that in higher latitudes, being there towards the west.

The continuous impulse of the upper tropical current *eastward*, while that of the polar stream is nearly southward, *in itself*, seems to be one cause of that universal law of gyration—*against* watch-hands in north latitude, *with* them in the southern hemisphere—which is now generally recognized, though not explained nor accounted for *originally*, previous to Dové's publications.†

The normal state of our atmosphere appears to be a regular alternation or circulation of currents between polar and tropical regions—the polar *usually*, but not always, advancing along the earth's service,—the return current *generally* above, at higher elevations.

Sometimes, even for weeks together, a polar current prevails—excessively broad—many thousand miles in width, and in latitude

* The inter-tropical zone is heated permanently, all round the world, nearly alike, on an average; although hottest nearly under the sun.

† Mr. Ferrel's able mathematical paper on this subject has but lately reached England, in Silliman's American Journal.

reaching from icy regions through the perennial trade winds, quite to the sub-solar zone. The more marked characteristics of this current, where it does not blow over an expanse of comparatively warm ocean, are (relative) cold, dryness, and heaviness—much pressure, or tension, with *positive* or *plus electricity*.

During such a normal condition of atmosphere a return, or tropical, current, passing above, is made evident by light upper clouds seen crossing heavenly bodies: and by the sensation of feeling, at high elevations, on mountains, or in balloons.

At other times, and by far the more prevalent, there is a more or less conflicting alternation, along the earth's surface, or in the upper air, of these great principal currents, in such a variety of proportion and combination, that observers, however careful and discriminating, cannot be otherwise than perplexed until more is ascertained, not only of the mechanical, but the chemical and electrical laws of the atmosphere. With the tropical current there is little, if any, positive electricity manifested in the air: but sometimes, particularly with moist deposit, including hail, there is negative or a minus state of electricity in a greater or less degree.

SECTION 2.

Currents of Air.

Part of the tropical current *descends*, between the latitudes of 20 and 40 degrees, turns there towards the equator and combines with the perennial, or with periodical winds (monsoons). The rest flows on towards the polar region, invariably coming down, or descending towards the earth's surface, wherever the *ab-polar current fails*; and then, having obtained access, like an elastic wedge, it increases in breadth and strength till a revival of the polar current's energy enables it to turn, overcome, and eventually displace its usurping antagonist.

As the *polar* current diminishes, or fails, *gradually*, and irregularly, (somewhat like horizontal tongues of flickering flame,) while moving *southward*; and as the first descent of the upper tropical stream is more or less *from* the westward, the feeble extremities of the polar current are turned *to* the eastward, and, as they become combined with the advancing tropical stream, turn actually northward till *lost*—thus causing a rotatory movement, *against* watch-hands—a movement as constant in the northern hemisphere as its analogous motion, in the contrary direction, is general in southern latitudes.

When the polar current recovers strength, being recruited from far remote sources, it usually presses suddenly, if not violently, against the polar side of the tropical current, which is flowing *from* the equator and from the *westward*, making it diverge in direction by curving away from the place of most pressure, and thus increasing the *tendency* to circulate, as above mentioned, in one direction rather than another. These currents combine, or mix, variously, in nature as well as in direction. There is also an

electrical agency, not yet traced distinctly, though frequently indicated, and by instrumental means fully ascertained to exist.

Although these appear to be *general outlines* in accordance with observed facts, it ought to be borne in mind that, while similar features or peculiarities occur on even a *small* scale in some localities, there are apparent exceptions or contradictions in others (such as *temporary* land or sea breezes, occasional gyration of a *local* whirlwind or waterspout, *contrary* to usual law); so exceptional, however, that they may truly be said to prove the *generality* of those great laws so necessary to be carefully studied and sufficiently mastered by seamen.

It was said in a previous paragraph that—"The more marked characteristics of the polar current, where it does not blow over an expanse of comparatively warm ocean, are (relative) cold, dryness and heaviness, or *tension*, with positive electricity." To which may be here added, that by relative heaviness was meant specific gravity—the weight of a given bulk (say a cubic yard) of polar air compared with an equal bulk (by dimension) of air in a tropical current; and, by tension, was implied its elasticity.

When such a body of atmosphere as a wide tropical current flows against high land, it is speedily deprived of much aqueous vapour (condensed into rain or snow), and if it afterwards crosses a considerable tract of country it is as *dry*, though still *specifically* light air, with inferior tension,—until *mixed*, by degrees, with polar air.

Masses of land, with arid deserts or large forests; high, perhaps snow-covered ranges of mountains, extensive valleys, or rivers on a great scale, influence atmospheric currents, as they cross, in almost every conceivable variety of ways; and it is exceedingly difficult, in some localities, to eliminate special effects, or peculiarities, from the great general, or normal, conditions of the world's atmosphere, which must always be kept in view.

In estimating the effect of air pressing on mercury in the cistern of a barometer, there is a consideration which should be carefully weighed. By Mr. Barlow's experiments in 1849,* instituted to discover how far vertical pressure is diminished by horizontal speed, he *seemed to show* that a velocity of fifty miles an hour caused one-seventh less vertical pressure than when the moveable body was stationary. In the familiar instance of skating, ice will bear a man in rapid motion, which would break if he stood still. If air in swift motion have its vertical weight and tension diminished, the barometric column must show it. If it were moving with the horizontal velocity of thirty miles an hour (about one-third only of its swiftness in a violent storm), and that the pressure or tension were diminished only one-thirtieth instead of one-seventh, the column of mercury might fall about an inch from this cause only—possibly much more?

Besides this reason for a descent of mercury in the Torricellian tube, there appear to be at least two others which influence it even

* P. W. Barlow, Esq., C. E.

in still air. One is the effect on the specific gravity of air caused by gas, steam, or aqueous vapour, which, bulk for bulk, is lighter than *dry air*, and the other is the expansion of air by heat, also diminishing its specific gravity. How far electrical agency operates is yet to be ascertained by further observations.

That there are "*waves*" of air—atmospheric undulations, or *pulsations*,—we have authority for accepting; but that they are not such as have been sometimes supposed, while looking at barometric curves of oscillation, seems clear. Vibratory undulations may exist on a greater or less scale in all elastic fluids that are not at rest; but the direct consequence of such motions in the atmosphere on those of the mercurial column appears inconsistent with the facts that, sometimes, while either polar or tropical current lasts several weeks with settled weather (the former much more frequently) there is little or no sensible change in the column of mercury, while the wind is steadily in one quarter; yet with, or shortly before, a *change* of wind's *direction* only, the mercury falls or rises; and this, while there are notable abnormal motions in other regions of atmosphere, amply sufficient to cause the transmission of undulatory vibrations, or atmospheric waves. What has been termed the "trough" of the wave, being the lightest air, ought to mount *highest, as it does between the tropics*; while the (so called) "crest" being in the middle of heavy dry air, should take a lower position; as we find to be the case with the polar current, invariably.

In answer to a question from the Royal Commissioners on lights, buoys, and beacons, Sir John Herschel stated that—"the most important meteorological communication which could be telegraphed, would be information *just fresh received by telegraph*, of a cyclone actually in progress at a great distance, and working its way towards the locality. There is no doubt that the progress of a cyclone may be telegraphed, and might secure many a ship from danger by forewarning."

Perhaps, however, this answer has tended to induce some persons (among them Captain Maury) to pass rather too lightly over the facts that very few lighthouses are yet connected by wires to any telegraphic organisation; that the lightkeepers are not at present telegraphically instructed; and that the expenditure requisite for such an extension, however desirable, must be rather inconveniently large.

CHAPTER IV.

FURTHER CONSIDERATIONS AND EXPLANATORY SUGGESTIONS.

As even the earnest and experienced student of meteorology is often perplexed, if not in error, while drawing hasty conclusions from first views of facts: how much risk of incorrect decision must there not be when persons insufficiently acquainted with the subjects are obliged to decide, at once, on the course of a storm—or when anticipating a great atmospheric commotion.

Yet the laws are sure and uniform to which all storms are accordant ; and only require to be familiarly known.

In order to assist in explaining those laws, and to aid in attaining a distinct view of their operation, the following brief considerations are submitted.

Looking at a globe, as an eye in space beyond our atmosphere would see the earth,—its relative features, polar regions, equatorial and intermediate zones, its diameter, 8,000 miles ; its swift rotation at the equator but slow motion near its poles, the convergence of meridians, and the small depth of *sensible* atmosphere, about ten miles, above which *may* be some twenty miles of very light gas:—Bearing in mind the nature and extension of numerous ranges of mountains, some being four or five miles high ; the relative proportions of sea and land in each hemisphere, the constant cold of polar regions : and the constant heat of inter-tropical zones—*all around the world*—(not in one place, under the sun, or *sub-solar*, for a short time *only*)—and then, for simplification, *imagining* the earth to be still, not rotating, *other* conditions of atmosphere, heat and cold, being the same, *without* the sun—what would the movements of air then be ? They would be *convective*, like the convection of water heated at one place.

From equatorial to polar regions there would be an action, like that of fluid heated unequally, in direct lines (or meridians) from equator to pole, and again to the equator. Expanding in the intertropical zone, all around, checked by gravitation from rising above a certain height, and overflowing towards the poles, whence, cooled, the air again would move, along the earth's surface, towards the equator.

But the equatorially heated spaces, or bodies of air in mass, require more extent of area, even irrespective of expansion, than is in the polar regions towards which they tend—therefore compression—a conflict with air moving below in a contrary direction—and a considerable union with it *before* reaching middle latitudes, must occur. Thence much air would return towards the equator,—the remainder continuing toward a pole, and descending to earth's surface whenever the flow from the pole became diminished, or might be temporarily interrupted. These contrary currents (*supposed* in meridian lines) would occasion comparative stagnation, with tension or pressure on the equatorial side of middle latitudes (“horse-latitudes”) and commotions (storms) in or beyond the middle, and even higher, latitudes, quite into the polar regions. (Still *supposing* the earth not rotating.) The ab-polar current may expand as it goes towards the equator, having increasing space, though it is checked considerably by the return current that descends near the tropics, just mentioned. Hence comparative freedom from storms, and usual tranquillity of inter-tropical latitudes near the equator. Hence also greater prevalence of storms in the winter-half of a year in temperate or high latitudes ; and their infrequency in the summer half ; because each approximates at those seasons more towards the characters of polar or equatorial regions. The inter-tropical zone is nearly equal, in area, to all the other zones together.

SECTION 2.

Currents of Air affected by Earth's Rotation.

Now, considering the world as it exists—in rotation : and consequently the directions of atmospheric currents altered to more or less diagonal ones, across meridians—owing to solar influence acting around, consecutively, and continually ; we see that rotation must occasion atmospheric circuits or currents, combined with the simpler convective action above described, and a grand general circulation of air.

These currents, near the equator, are neither eastward, with the earth's rotation—in speed—nor much in a contrary direction. Affected by the sub-solar inclination at the same time, but in varying degrees, the *sensible* movement is intermediate between the extremes of diurnal solar action, or *drag*, and equatorial rotation to the eastward (antagonistic impulses), the results being equatorial motion of air *very* much less in speed westwardly than the daily sub-solar position, *rather less eastwardly* than the earth's surface, and therefore, *really*, along it towards the west, in the equatorial zones.

Thence, raised by heat, expanded, having *nearly* the centrifugal or rotatory eastward motion of the equator—held, however, by gravitation,—towards the poles the upper currents flow—with (for a time) their equatorial impetus carrying them more and more across the converging meridians until it is lost, gradually, near the poles—whence, again drawn, they move, not only towards the equator—but—more and more diagonally as they meet augmenting velocity of rotation, and cross expanding meridians, their direction becoming more and more easterly, or from the eastward, until so much checked and influenced by the earth's rotation *towards* the east, that they become gradually intermediate in movement between the antagonistic motions, as above described.

This grand general circulation affecting all the atmosphere round the whole world, (and therefore always to be considered in connection with any limited or special meteorological case), is, however, affected, and exceedingly modified, locally, by continents, oceans, mountainous ranges, and deserts ; which much augment conflicts of air currents, and occasion the varieties of winds, storms, and climate experienced in each hemisphere ; all alike in origin, all in accordance as to general principles, and all explicable by the same natural laws.

Wherever currents of wind, either the main currents, tropical and polar, (of which all others are more or less compounded), or any other streams of air, meet or mutually oppose, their tendency is to cause a calm,—or a gyration ; and if the latter, always in one direction, *against* watch hands in the northern hemisphere, *with* the watch in south latitude.

Currents from a pole move directly towards the equator and towards the west also, with a *lateral* easterly motion, it has been shown : and those from the tropics move towards the east while

going toward a pole. Their mutual approach occasions a movement of the intermediate air, rotatory, in one direction only ; a consequence of the directions of these antagonistic air currents, as well as of *convergence of meridians, and differing latitudes*.

In the southern hemisphere a contrary effect, or *with the watch*, is obviously certain, on similar principles : and it is very important that these gyrations should be clearly understood and relied on by seamen—many mistakes having been made by confusing the cases of cyclone centres passing *between* the pole and observer, or the *contrary*, and by supposing a case at variance with fact.

SECTION 3.

Succession of Circuits.

Successive, or rather, *consecutive* gyrations, circuits, or cyclones often affect one another, acting as temporary mutual checks, until a combination and joint action occurs ; their union causing even *greater* effects : as may be seen even in water currents,—as well as in the atmosphere.

Between the tropics and the polar regions, or in temperate zones, the main currents are incessantly active, while more or less antagonistic, from the causes above mentioned : besides which, wherever considerable changes of temperature, development of electricity, heavy rain, or these in combination, cause temporary disturbance of atmospheric equilibrium (or a much altered *tension* of air) these grand agents of nature, the two great currents, speedily move by the *least resisting lines*, to restore equilibrium, or fill the comparative void. One current arrives, probably, or acts *sooner* than the other,—but invariably collision occurs, of some kind or degree, usually occasioning a circuit, a cyclonic or ellipsonic gyration ; little noticed when gentle, or moderate in force.

As there must be resistance to moving air (or conflicting currents), to cause gyration, and as there are no such causes, on a large scale, near the equator, there are no storms (except local squalls) in very low latitudes.

It is at some distance, from about five to twenty degrees from the equator that hurricanes are occasionally felt in their violence.

They originate in or near those hot and densely-clouded spaces, sometimes spoken of as the "*cloud-ring*," where aggregated aqueous vapour is at times condensed into heavy rain (partly by vivid electrical action) and a comparative vacuum is suddenly caused, towards which air rushes from all sides. That which arrives from a higher latitude has a westwardly, that from a lower an eastwardly tendency, due to the earth's rotation, and to the change of latitude, whence a chief cause of the cyclone's invariable rotation in one direction, as above explained.

The hurricane or cyclone is impelled to the *west*, in *low* latitudes, because the tendency of *both* currents there is to the westward, along the surface : although one, the tropical, is *much less so*, and becomes actually easterly *near* the tropic, after which its equatorial centrifugal force is more and more evident, while the *westwardly*

tendency of the polar current diminishes ; and therefore, at that latitude, hurricane cyclones cease to move westward, (re-curve), go then eastwardly, and toward the polar quarter.

SECTION 4.

Uses of the Weather Reports.

As some persons are not yet sufficiently aware of the precise objects of the daily published weather tables, it may be here repeated, that great and important changes of weather and wind are *preceded*, as well as accompanied, by notable alterations in the state of the atmosphere :—that such changes, being indicated at *some* places sooner than at others around the British Islands, give frequent premonitions ; and, therefore, that great *differences* of pressure (or tension) shown by barometer ; of temperature, of dryness or moisture, and direction of wind, should be considered as *signs of changes, likely to occur soon*.

It will be observed, on any continued comparison of weather reports, that during the stronger winds a far greater degree of uniformity and regularity is shown than during the prevalence of moderate or light breezes : and this should be remembered.

When neither of the greater and more extensive atmospheric currents is sweeping across the British islands,—currents of which the causes are remote, and on a large scale,—the nature or character of our winds approaches, and is rather like, that of land and sea breezes in low latitudes ; especially in summer.

Either the cooler sea wind is drawn in, over land heated by the summer sun ; or cold air from frosty heights, snow-covered lands, or chilly valleys, moves towards the sea, which is so *uniform in temperature* for many weeks together, changing so *slowly*, and but little, in comparison with land, during the year. These light *variables* may at such times be numerous, simultaneously, around the compass, on the various coasts of the British islands.

Frequently it has been asked, “ In this country, how much rise or fall of the glasses may foretell remarkable change, or a dangerous storm ? ”

To which can now be replied,—great changes or storms are *usually* shown by falls of barometer exceeding an inch ; and by differences of temperature exceeding about fifteen degrees. A tenth of an inch an hour is a fall indicating a storm or very heavy rain. The more rapidly such changes occur, the more risk there is of dangerous atmospheric commotion.

As all barometric instruments often, if not usually, show what may be expected, a day, or even days in advance, rather than the weather of the present or next few hours, and as wind, or its *direction*, affects them much more than rain or snow, due allowance should always be made for days, as well as for hours, to come.

The following table of average temperatures, between eight and nine o'clock A.M. near London, may be used, with allowance for ordinary differences between Greenwich temperatures and those of

other places, to assist in foretelling the direction and nature of coming wind and weather.

The thermometer (shaded, and in open air) when much *higher*, between eight and nine A.M., than the average, indicates southerly or westerly wind (tropical) ; but when considerably lower, the reverse or northerly (polar) currents of air, *approaching*, if not present.

The average temperatures at Greenwich, in the shade and open air between eight and nine A.M., are nearly the mean temperature of each twenty-four hours, taking the year through, around London, and, with allowance for the difference between the *means* of Greenwich temperatures and those of other localities, may be taken, generally, for the British Islands as follows : namely, for about the middle of—

January	-	-	37°	July	-	-	-	62°
February	-	-	39°	August	-	-	-	61°
March	-	-	41°	September	-	-	-	57°
April	-	-	46°	October	-	-	-	50°
May	-	-	53°	November	-	-	-	43°
June	-	-	59°	December	-	-	-	39°

The daily statements of the weather, and indications of verified as well as reliable *standard* instruments, show to those who are interested, and who regularly compare the accurate, simultaneous observations thus generally available, not only what were the general and various states of atmosphere over Great Britain, Ireland, and the West of Europe—from Copenhagen to Lisbon,—the same or the previous morning (according to the time of day, and the newspaper referred to) ; but by such comparisons enable a useful degree of foreknowledge of weather, during the coming day or two, or even three following days, to be attained by any observant and considerate person who gives continuous attention to the subject.

Where a note of interrogation is inserted in a report it shows that the number next to it is doubted at the Central Office, on account of its apparent discrepancy, or some suspected inaccuracy.

Adjacent stations are such excellent checks on each other that any error of importance is soon observed, and generally corrected.

CHAPTER V.

CHARACTER OF STORMS AFFECTING ENGLAND.

HAVING given a brief outline of meteorological views applicable to practically useful results, and intending to conclude this report by reasons why such results are worth a certain amount of public expenditure, it is indispensable to premise a sketch of such characteristics of British storms—and of their now ascertained peculiarities—as may form a basis for final conclusions.

It is well known that no year passes in which the British Islands are not visited by storms, and that they vary, in degree

of force, from what is usually called a gale, to a hurricane almost irresistible in violence. Only of late years, however, has it been supposed, and but recently proved, that nearly all, if not indeed the whole of these remarkable tempests, by which such excessive injury has been done, have been so much alike in character, and have been preceded by such similar warnings, as to warrant our reasoning inductively from their well-ascertained facts, and thence deducing laws. Every one looks back to some extraordinary storms as exceeding all others in a lifetime; but a tempest that is severely felt in one part of a country is not always extensive, it is usually the reverse, more or less limited in area, varying in range, direction, and force. It would be inexpedient to refer to many of even the most devastating tempests in much detail; therefore I propose to allude only to a few, and glance but summarily over their most marked features.

The first storm to which I would advert is that so well and so fully described by De Foe, 1703.* He calls it "the greatest, "the longest in duration, the widest in extent of all the tempests "and storms that history gives any account of since the beginning of time." "Our barometers," he continues, "informed "us that the night would be very tempestuous; the mercury "sank lower than ever I had observed it on any occasion;" it fell to 28·47.† This storm began at south and veered through the west towards the north, round to the south, and continued (chiefly between south-west and north-west) with more or less strength, for a whole week! Very remarkable it is that not only did De Foe suppose this storm began near the southern coast of North America, but that it traversed England, Denmark, and the Baltic, to lose itself in the Arctic regions. He recurs afterwards to its shifting from south-west to north-west, and coming from the west *like other storms in the south of England*, but does not advert to any corresponding north-easterly wind, nor had he evidently any idea of a rotatory or circulating atmospheric current. Probably, accounts from the north of England were less inquired for then: it is noted, however, that the north of England escaped the violence of that storm, which seems to have been one of a succession of cyclones.

I will not take more from De Foe, but may venture to say that his graphic accounts of many storms, and the more comprehensive views of Dampier, are well worth the notice of any meteorologists. To them and to Franklin, Capper, Horsburgh, Redfield, Reid, Piddington, and Dové, besides other and more scientific authorities, seamen may well be grateful for their works on storms; the facts and inferences compiled by them having been demonstrated to be generally true—and invaluable.

* The "Storm," 1704. A most striking collection of the then recorded tempests in England.

† In the Orkneys, Mr. Clouston has recorded 27·45. Perhaps De Foe's mercury could not fall more for want of space in the cistern,—a defect common in the earlier barometers, and not unknown now, occasionally.

Among other storms, two alone will probably suffice as types. The *Royal Charter* gale, so remarkable in its features, and so complete in its illustrations, I may say, from the fact of its having been noted at so many parts of our coast, and because the storm passed over the middle of the country, is one of the very best to examine which has occurred for some length of time. It occurred on the 25th and 26th of October 1859. The lowest barometer and a corresponding or simultaneous central *lull* prevailed over areas of from ten to twenty miles across successively. But at the time that this comparative lull existed, there were violent winds around the central space (by some called a vortex, but which can hardly be thus *appropriately* termed, because there was no central disturbance), while there were only variable winds or calms in the middle of the area. The wind attained a *maximum* velocity of from sixty to one hundred miles an hour, at a distance of twenty to fifty miles from the middle of this comparatively quiet space, and in successive spiral eddyings seemed to cross England towards the north-east, the wind blowing from all points of the compass consecutively around the lull; so that while at Anglesea the storm came from the north-north-east, in the Irish Channel it was northerly, and on the east of Ireland it was from the north-west; in the Straits of Dover it was from the south-west; and on the east coast it was easterly—at the *same minute*.

Thus there was an apparent circulation, or cyclonic commotion passing northwards from the 25th to the 27th, being two complete days from its first appearance in the Channel; while outside of this circuit the wind became less and less violent; and it is very remarkable that, even so near as on the west coast of Ireland, there was fine weather, with light winds, while in the Bristol Channel it blew a northerly and westerly gale. At Galway and at Limerick, on that occasion, there were light winds only, while over England the wind was passing in a tempest, blowing from all points of the compass in irregular succession around a central variable area. As it is the *north-west* half (from north-east to south-west, true), which seems to be principally influenced by the cold, dry, heavy, and positively electrified polar current; and the south-east half of the cyclone that apparently shows effects of tropical air,—(*warm, moist, light, and negatively, or less sensibly electrified,*) places over which one half of a cyclone passes, are affected differently from others over which the other part of the very same atmospheric eddy passes, the eddy itself being caused by the meeting of very extensive bodies of atmosphere moving in nearly, but not exactly opposite, directions, one of which gradually overpowers, or combines with the other.

On the polar side of a cyclone, continually supplied from that side, the sensible effects are chilling, drying up, and clearing the air—with a rising barometer and falling thermometer; while on the tropical or equatorial side, overpowering quantities of warm, moist air, rushing from comparatively inexhaustible supplies, push towards the north-east as long as their impetus lasts, and are

successively chilled, dried, and intermingled with the conflicting polar currents.

Another storm that occurred a few days after was similar in its nature, though it came from a slightly different direction. This one was on the 1st and 2nd of November, and its character was in most respects like that just mentioned. Its centre came more from the westward, passed across the north of Ireland, the Isle of Man, and the north of England; then went over the North Sea towards Denmark.

The general effect of these storms was felt unequally on our islands, and less inland than on the coasts. Lord Wrottesley has shown, by the anemometer at his observatory in Staffordshire, that wind is diminished or checked by its passage over land. The mountain ranges of Wales and Scotland, rising two to four thousand feet above the ocean level, must have great power to alter the direction, and probably the velocity of wind, independently of alterations caused by changes of temperature.

Very remarkable were the similarities of the storms of the 1st and 2nd of November,—the 25th and 26th of October,—the series of storms investigated by Dr. Lloyd during ten years; and the observations of Mr. William Stevenson in Berwickshire.* 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 with 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 average of the time of the year) of knowing, by comparisons, whether the wind will be northerly or southerly (thanks to Mr. Glaisher's deductions from more than eighty years' Greenwich observations).†

For a few days before the "*Royal Charter Gale*" came on, the thermometer was exceedingly low in most parts of the country: there were northerly winds in some places, with a good deal of snow; with low barometers. There had been a great deal of exceedingly dry and hot weather previously, which made the sudden change to unusually cold weather, with snow, more remarkable (for the season). In the north of Ireland, especially, at

* On the storms which pass over the British Isles, 1853.

† Besides electrical indications.

that time, thermometers were very low (on the 22nd and 23rd of October). Many days preceding the storm an extraordinary clearness in the atmosphere was noticed in the north of Ireland—the mountains of Scotland were never seen more prominently than they were in the few days preceding those on which it took place. The summer had been remarkable for its warmth; it was exceedingly dry and hot. All over the world, not only in the Arctic but in the Antarctic regions, in Australia, South America, in the West Indies, Bermuda, and elsewhere, auroras and meteors had been unusually prevalent, and they were more remarkable in their features and appearances than had been noticed for many years. There were also extraordinary disturbances of the currents along telegraphic wires, which were so disturbed at times that it was evident there were great electric or magnetic commotions in the atmosphere which could then be traced to no apparent cause. Perhaps, these electric disturbances were connected with a peculiar action of the sun upon our atmosphere. Certainly electrical wires above ground, and also submarine wires, were greatly disturbed, and these disturbances were followed within a few days by great commotions in the atmosphere, and by some remarkable change of weather.*

Instances of singular exceptions to the force of these particular storms occurred. At some places there was little or no wind; the barometer fell much, but there was no storm; the wind apparently circulating around those districts did not affect them, while at other places, only a few miles off, the tempest was tremendous.

A very remarkable storm was carefully traced, and its description published, by Mr. Rowell, of Oxford. This blast occurred near Calne, in Wiltshire, cutting through fields and high trees. It actually lifted an empty waggon *from the road over a hedge, into the next field!* The violence of the wind was confined to a limited line. The downward and onward pressure of the wind was so great, in that place, that it acquired such elasticity as to lift opposing weights and carry them on. I have known wind lift a boat into the air and shake it to pieces; and we have all heard of houses being unroofed; of great trees being torn up or broken by the force of the wind; but this is the first well authenticated instance, it may be presumed, of a *heavy waggon* being lifted up and hurled over a hedge.

An extract from Mr. Stevenson's paper will probably be useful. His explanation of the interference of following or

* Moorgate Street, London, March 28, 1860.

"*Last autumn* we had very remarkable weather. The changes on that occasion were preceded by tremendous 'magnetic storms.' Very powerful electric currents flew about the earth, and frequently paralyzed our circuits, submarine, and land.

"*To-day* we have had notable deflections, but not nearly so strong as those of last autumn.

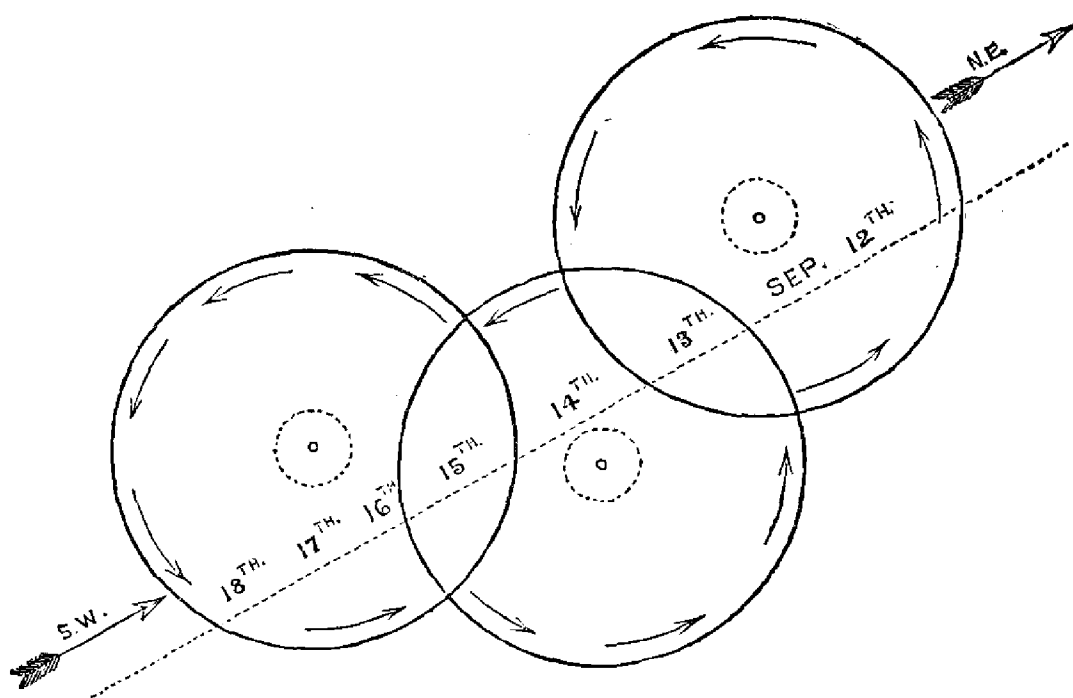
"As these probably indicate a change, I have thought it would be interesting to you to be informed.

"C. F. VARLEY."

consecutive cyclones is frequently corroborated by practical observations, and deserves study.

“I propose to state, as concisely as possible, some of the more important general conclusions regarding storms, to which I have been led by long-continued observations, made in the Merse of Berwickshire, compared with observations made in other localities ; and then to offer a few practical suggestions which have occurred to me while reflecting upon the subject.

“The storms which pass over the British Isles are found generally to act in strict accordance with the cyclonic theory. In many cases, however, this accordance is not so obvious, and the phenomena become highly complicated. This is a result which often happens when two or more cyclones interfere—an event of very frequent occurrence. When interferences of this description take place we have squalls, calms (often accompanied by heavy rains), thunder storms, great variations in the direction and force of the wind, and much irregularity in the barometric oscillations. These complex results are, however, completely explicable by the cyclonic theory, as I have tested in several instances. A very beautiful and striking example of a compound cyclonic disturbance of the atmosphere, at this place, was investigated by me in September 1840, and found to be due to the interference of three storms, in the manner shown in the subjoined diagram:—



“The dotted line and the dates show the progress of the storms over this locality, and the curved arrows the vertical or cyclonic movement, from right to left, which is found to hold with regard to the storms of the northern atmosphere. A glance will suffice to indicate the nature of the meteorological changes which might be expected to occur at any point upon the dotted line, or on parallel lines, during the passage of the storms in question. The complicated veerings of the wind, the risings and fallings of the barometer, the calms, irregular gusts and occasional heavy showers, which prevailed for about a week, while this system of cyclones

passed over this locality, appeared at first quite anomalous; and it was with no small pleasure that I found the varied phenomena explained in the most satisfactory manner, and agreeing beautifully with the received laws of storms, on the hypothesis of a combination similar to that shown in the diagram."

"Another striking instance of cyclonic interference was presented by a storm which passed over the North of Ireland on the 19th November 1850, and reached this place early on the following morning. On the 18th November, about noon, a storm commenced here from S.E., and continued till the afternoon of the 19th, at which time the wind had veered to S.W., showing that the centre of this storm had passed to northward. The completion of the veering of the wind was prevented by the arrival of the other storm above referred to, and the wind backed to S.E. A very great quantity of rain fell during the night and next day, the wind veering by N.E. and N. to N.N.W. The centre of this storm must therefore have passed to southward of this locality. The 21st was fine, wind light from S.W."

"A third example of the interference referred to, was exhibited by a series of storms which passed over Britain in a direction nearly N.W. to S.E., between the 18th and 27th of February, in the present year. The first commenced on the 18th, and had completed its course by mid-day of the 21st, the veering of the wind having been confined to points between W.N.W. and N.N.E., and the centre having passed to eastward. On the evening of the 21st, symptoms of a second storm began to appear. This one also moved in the same direction, its centre likewise passing to eastward. Its course was regular until the forenoon of the 24th, when it was interfered with by a third storm of quite the same character as the two preceding, but more nearly central here. The barometer fell until nine P.M., when it attained its lowest point, the wind being from S.W. At twelve P.M. the wind had veered to N., and the barometer had risen .05. The wind continued northerly, with a rising barometer, till about three P.M. of the next day, when the wind was backed to S.W. by a fourth storm coming over in the same direction. This one was nearly central here, and caused a great depression of the barometer. The 26th was very stormy, wind N.N.E. This, the last of the series, was permitted to complete its course with regularity, and by three P.M. of the 27th the atmosphere had become settled. During the passage of these storms, heavy snows and hail squalls, with high winds, occasionally interrupted by calms, were very prevalent."

"Numerous other instances of cyclonic interference might be cited, but those now given will, it is hoped, be sufficient to serve as examples of their general character. It not unfrequently happens that a series of cyclones follow hard upon each other for several weeks, the preceding members of the series being often overtaken and interfered with by those succeeding. It is, however, important to remark, that amidst all the complexity necessarily occasioned by such combinations—the greater and more violent

storms, and particularly that portion of them which is most dangerous and destructive, exhibit almost invariably the simple cyclonic character. It is thus with the 'Law of Storms' as with the 'Law of Gravitation;' the grand results of both are exceedingly simple, but the minor details become more and more complicated in proportion to their minuteness."

"The direction of the *progressive motion* of the storms which pass over Britain is most frequently from about S.W. to N.E., but *occasionally* from other points, including it would appear all points from S.E. round by S. and W. to N. They seem very rarely to come over from any point between N. (round by E.) and S.E. About ten years ago, I was led to form the opinion, that *the direction of the progressive motion of any storm coincides with that of the upper current of the atmosphere prevailing at the time, at the ordinary altitude of cirrus clouds.* Since then, I have met with no instance adverse to this view, but on the contrary, many highly confirmatory of it. The point cannot, however, be considered as determined, until placed beyond doubt by the concurrent testimony of other observers, and I would beg to impress upon meteorologists the importance of giving the subject their close attention. It is obviously of very great consequence that this point should be ascertained, since if found to hold universally or even generally true, the movements of cirrus clouds, at the time when a cyclone is approaching or passing over, would be of great utility in indicating the direction of its progressive motion, which being known, a little attention to the state of the barometer and the wind, will suffice to enable an observer to predicate, with confidence, general characters or elements of the storm, such as its probable violence, the manner in which the veering will take place, and the point from which the wind will blow with the greatest force."

"Our heaviest storms generally have a progressive motion from S.W. to N.E., and the most frequent track of their centres, is a line passing in that direction across the North of Ireland, and the South of Scotland. A great number of these storms are central in the Merse of Berwickshire, hence the barometric range is greater in general here than at places situated to northward or southward. The damage done by such storms is much greater at places situated within the range of the Southern semicircle of the whirl, at a certain distance from the centre, than at places within the northern semicircle, or even in the course of the central line. A remarkable instance of this was afforded by the memorable storm of 7th January 1839. The centre of this storm passed in a S.W. to N.E. direction, by Belfast, Dumfries, and the Merse. The barometer here fell rapidly with the wind at S.E., and rose with the wind from N.W., the wind in passing through the westerly points having been comparatively light. In the southern semicircle of the storm, particularly at Dublin, Liverpool, &c., the violence of the wind was much greater than at this place, and was most furious from S.W. In the northern semicircle, embracing the central and northern districts of Scotland, the wind blew from the easterly and northerly points, and caused

comparatively little damage. The greater force of the wind in the southern semicircle is readily explained by the consideration, that in it the maximum force of the wind is composed of the vortical force *plus* the progressive, whereas in the northern it consists of the vortical *minus* the progressive. If we suppose the vortical or rotatory velocity of the wind, in a storm such as that referred to, to be 60 miles an hour, and the rate of the progressive motion of the storm to be 15 miles an hour, the greatest velocity of the wind across the central line, or axis, would be 60 miles, at certain points in the northern semicircle 45 miles ($60 - 15$), and at others in the southern semicircle 75 miles an hour.*

“ If the views stated above, relative to the motions of the upper currents of the atmosphere at the elevation of the cirrus clouds, be found to be correct, they may prove to be of particular utility, in indicating at sea, or where there are no means of comparing observations, the directions of the progressive motion of any storm, and this is a point of essential importance to a thorough understanding of its other conditions.”

CHAPTER VI.

SPECIAL PECULIARITIES PREVIOUS TO GREAT ATMOSPHERIC COMMOTIONS.

BESIDES the familiar signs around an observer whose range of view is extensive, who is accustomed to notice changes of weather—and who duly watches his weather glasses;—there are some peculiarities less generally known,—which should be mentioned in this special report.

A great fall of rain, or snow, much lightning, unusual cold, or excessive heat, invariably precedes high winds or strong gales—which are the dynamical consequences of extensive precipitation of aqueous vapour or gas, condensed by cold into rain, hail, or snow, deposited on earth or ocean—liberating heat that ascends with air rarefied—and followed by horizontal currents of wind—more or less powerful, according to the scale of disturbance.

Sometimes such effects extend over areas of thousands of miles, sometimes they are locally limited to a small island: but the general causes and invariable effects are similar.

Whether electricity is a secondary *cause* of such effects—or their consequence only—has been much discussed. Here it seems more becoming in me only to state facts proved with regard to this mystery.

We know that changes occur in Arctic regions—and in tropical latitudes—on an immense scale of magnitude in some years, but not in others. Icebergs invade the temperate zones—sometimes

* It should be remarked, that although cyclones may practically be regarded as funnel-shaped, or as sweeping over areas approximately circular at any given moment,—they are, in reality, to a certain extent, spiral, or irregular in their movements.

to *less than fifty* north latitude, or *forty* south. Excessive droughts—or extraordinarily rainy seasons—and perhaps occasional influences of great and continued volcanic eruptions, affect the atmosphere on an immense scale, overruling and, as it were, masking ordinary and regular, or normal, movements.

Such special peculiarities were noticed from 1857 to 1859. The summer of 1859 was hot and dry, the two previous years were similar, and the intervening winters comparatively mild. In 1858 a severe drought prevailed in Africa, America, the West Indies, and Australia; and a mild winter followed in Western Europe, but without a sufficiency of rain, so that during spring and summer of 1859, drought was severely felt, especially in England.

Some violent local thunderstorms occurred, in summer, but not till September was there any important rainfall.

In Africa, however, at this time, the rains were excessive, and the rivers swollen greatly; so much that in even the sea entrance of the Bonny there were three feet more water than usual, and other rivers were similarly flooded by heavy rains in the interior of the country.*

Turning to the Arctic Regions, as affecting our temperate zone, on one side, while influenced by varying tropical conditions on the other, it was found that in 1860 great quantities of icebergs had accumulated on the coasts of Greenland, to an extent not previously known for about thirty years.†

Those masses of ice must have been moved by some abnormal cause, perhaps by the successive heats of 1857–8 and 1859: and such immense quantities—displaced from more northerly localities, indicated an unusual action in the arctic zone, near Iceland and Greenland, if not around the polar region.

To such natural and recurring events, of which the range is not limited to a small space of earth's surface, but extends through wide zones of atmosphere surrounding the globe, perhaps our remarkable variations of climate may be partly referred, rather than to any of those fanciful conjunctions, or relative planetary positions, so whimsically yet gravely described by "Astro-meteorologists."

The connexion of these great changes with electrical tension, with magnetic action, with the earth's rotation, and with their great *visible* cause, the sun, is sufficiently demonstrated by philosophers; though hard to trace, in detail, through special instances, where many facts, of importance to the issue, may be overlooked, if not altogether unknown.

Some eminent men of the first authority on such subjects, do not think that "magnetic storms,"—or even auroras, are directly connected with atmospheric currents, or have any special relation to storms of wind, but there are many facts on record that seem to point towards a different conclusion.

I have adverted to auroral exhibitions as preliminary to those sensibly felt changes which occur subsequently, because, whether really connected or not, their approximate coincidence seems to

* The late W. Laird, Esq., of Liverpool.

† Sir Leopold M Clintock, R.N.

many persons at least deserving of record. Let me add here, that among the more experienced seamen who have visited many climates, an opinion prevails that lightning, the aurora, meteors, or shooting stars,—are indicative of disturbance in the air,—and foretell wind or rain, if not both, in no long interval of days.

But as this *may be* like faith in change of weather at the moon's quartering (a mere illusory deduction from coincidences, many of which must occur within a day or two of limits bounding only one week), I mention it now, merely with the view of inducing further information.

That lightning in *high* latitudes, antarctic or arctic, is a certain indication of marked atmospheric disturbance—has been proved.

Besides several auroral, and some meteoric occurrences observed during September and October, 1859, the following are worthy of notice, as having been witnessed at Holyhead, and near Athlone, the evening of the *Charter* storm.

Sir W. Snow Harris, wrote to me from Plymouth (10th Nov. 1859),—

“ My son, who is on the Holyhead works as a civil engineer, under Mr. Hawkshaw, observed, on the evening of the late great storm, a very interesting phenomenon, which should, I think, be noticed. Here is an extract from his letter:—‘ Since Wednesday, 19th October, heavy breezes N.N.E. to N.N.W., with bitter storms of hail, sleet, and rain. In the evenings, brilliant lightning, with distant thunder ; Welsh hills covered with snow. Monday, 24th October, this weather seemed breaking up ; wind moderated ; weather becoming mild. Tuesday morning, 25th, preceding the gale, fine, with sunshine ; light easterly wind, with a thick dirty-looking sky to leeward, as if working up against the wind. The wind freshening a little, but not very much ; by-and-by, during the forenoon, the sky became overcast, with a uniform dull mass of vapour ; at 6 P.M. very heavy and dark ; wind had freshened to a strong breeze. At 7, a strong gale from east ; night *very dark*. *I was then walking into the town, and was startled by what appeared to be a bright ball of fire directly over my head ; the light of it was intense ; it pierced through the heavy mass of vapour which obscured the heavens, and illuminated the whole bay and land with the light of day. This meteor lasted from two to three seconds. Very soon after this appearance, the wind increased to a hurricane, and the rain came down like a deluge.*’

This was the evening and night previously to the wreck of the *Royal Charter*. When we consider that for a week or two previous to this northern hurricane we have had *blood-red streamers* of aurora crossing the sky, and other electrical exhibitions, such a phenomenon is important, and should be recorded.”

“ I observed, on the 12th, within a fortnight of the storm, blood-red streamers reaching quite across the zenith, from the western to the eastern horizon, about 7 to 9 P.M., most magnificent.

“ This is worthy of remark, as connecting electrical action with the source of such a storm.

“ Holyhead Harbour Works,
 “ 20th November 1859.

“ It is with much pleasure that I send you a brief account of the occurrence of a meteor of great brilliancy on the evening of Tuesday, 25th October, understanding that a description of the circumstances attending this phenomenon will be acceptable to you. I have heard of other meteors having been seen, both in this country and on the other side of the channel, at about the time of the late heavy gale on 25th and 26th October ; but having been much engaged lately, I have not been able to make proper inquiries respecting their appearance.

“ On Tuesday evening, October 25th, at about 7.15 P.M., my attention was suddenly arrested by the appearance, directly overhead, of a bright ball of fire, the light of which rapidly diffused itself and illumined the dense mass of vapour then filling the sky to such an extent that objects for a considerable distance around me became visible as by day. At this time it was blowing a pretty fresh gale from east, but the wind now began to increase so rapidly that by 9 P.M. a complete hurricane was raging, accompanied by a deluge of rain ; the wind continued increasing until it appeared to have reached its climax some time between 2 and 3 A.M. of October 26th, flying then into N.E., soon after sunrise going to N., and by 10 A.M. to N.N.W., from which point it blew, if possible, harder than ever until 11 A.M., when the weather began to moderate ;—the wind, in the afternoon getting round to N.W. For about a week, previous to the gale, we had very heavy cold winds varying from N.N.E. to N.N.W., attended by bitter squalls of sleet, hail, and rain, varied in the evenings by displays of most dazzling lightning, although the thunder was slight. On Monday, 24th October, this weather seemed to be breaking up ; the day was fine, with light breezes, and much warmer. The morning of Tuesday, 25th, was also fine, with sunshine, and a light breeze from east ; but by noon the sky was completely overcast ; the wind then gradually freshened, but not much until 6 P.M., when the sky became very dense, and it began to blow fresh, the night setting in pitchy dark. About an hour from this time I observed the meteor I have mentioned.”

That this meteor may have been seen, at the same time, in Ireland, the following letter to me shows :—

“ Dublin, November 9, 1859.

“ As I understand that any information respecting the storm of the 25th and 26th ultimo is acceptable to the Board of Trade, I beg to offer the following :—

“ I was at Belmullet, in the north-west part of the county of Mayo, in October. There had been several days of beautifully mild weather up to Wednesday, the 19th ; on the 20th, there was a change in the weather,—some cold showers, and in the evening hail and snow storms, with wind, of short duration. This state of things continued getting worse the mountains in the neighbour-

hood being covered with snow; and on Sunday night the roads were two inches deep in snow where they pass through the Erris mountains. On that evening I saw two balls of fire fall to the earth from one of the snow-clouds. I left that part of the county on the 24th, Monday, and proceeded to Castlebar and Ballinrobe, where, though there had been, as I was informed, some snow, there was none on the ground, but the air was very cold. On Tuesday, 25th, I could perceive nothing at all unusual in the appearance of the weather, till, at half-past seven, when in the neighbourhood of Ballinamar and Ballyporeen, about, I should say, 12 or 14 English miles west of Athlone, the sky being free from clouds, I saw, in the direction of the Pleiades, a meteor. At first, when I saw it, it was about the size of a star of the first magnitude; it advanced swiftly towards me for about four or five seconds, rapidly increasing in size, and appeared to be coming so straight towards where I was that it created alarm; the colour was an intense white light, similar to the electric spark. At the end of the first four or five seconds it changed colour to a bright ruby red, and it seemed (but of this I could not speak positively) then both to change its course and to lose its velocity; while the red colour remained was not more than one-and-a-half to two seconds. It then burst into about, I should suppose, 15 or 16 bright emerald green particles, which, after remaining visible for about two more seconds, disappeared altogether. I saw nothing more that night. I arrived at Athlone about 12 o'clock, and up to that period the sky was quite clear and calm, and there was not the slightest appearance of storm. I was much astonished to hear, on my arrival in Dublin, on the night of Wednesday, 26th, of the violent storm that had taken place on the coast of Wales.

"From the fact of the meteor appearing to come so directly towards me at first, I should find great difficulty in giving a correct sketch of it. I think after it changed its colour it seemed to have decreased in diameter, and to have taken more the form of a current than a solid substance. I am sure the whole duration was not more than ten seconds, or less than seven.

"I should say the direction from where I was,—say 12 English miles, as a crow would fly, west of Athlone,—was about north-west or north-north-west.

"Of course it is impossible for me to say at what distance it was from me; but if any other of your correspondents observed it, some idea of its distance from the earth might be arrived at. It was the most beautiful meteor I ever saw, and, with the exception of one I witnessed in the day-time, a few years ago, in Oxfordshire, which passed south over Southampton, and I believe the whole of France, I have never seen one so large as it appeared towards the end of the period of white light.

"I could not but think that the fall of the meteor had some connexion with the storm.

THOS. T. CARTER."

Numerous other instances of a similar kind have been mentioned; but none so marked and definitely recorded have as yet reached the writer of this report.

One fact more, of a magnetic character, should be noted, before changing the subject. In page xxxi it is said that Mr. Cromwell Varley, the well-known electrician, informed me he had observed high winds, or rain, follow disturbances of electric currents along the telegraphic wires. On one such occasion, a *very marked* one, in 1861, he kindly wrote to me; and two days afterwards there was a *particularly* heavy gale of wind.

SECTION 2.

Water.—Temperature.—Pressure.—Wind.

Few Londoners have yet forgotten the state of the Thames in 1859. Deficiency of water supply during 1858 and 1859, and great evaporation, (often to *fourteen* degrees of thermometrical difference in Mason's hygrometer,) caused a condition of its liquid excessively disagreeable to eye and nose, if not actually pestiferous.

Everywhere a want of water was felt, and this had been of considerable duration. In August the heat reached 92° (in places where usually summer heat is not above 80°), and the temperature of evaporation was 78°, by the same hygrometer.

Hail and snow in the north, clouds and rain in the south, prevailed before the "Charter" gale; and this wintry weather, on the 21st of October, seems the more remarkable as so rapidly following very warm if not hot weather.

It happened that the late Mr. Laird, who made several notes of this and following days, was in the North of Ireland, near Garron Tower, on the 21st. It was exceedingly cold, the air remarkably transparent, and the Scotch mountains so distinct that every one noticed their extraordinary visibility. There was much vivid lightning to the southward.

Writing about these same days, the lamented Captain Boyd said,—“On the 19th I was at Belfast, oppressed with heat, in close weather, with small rain. It was like a muggy May day. The next three days I was travelling along the east coast, cut to the vitals by a piercing north wind, with snow and hail squalls.”

The barometer continued to fall. Near London that night the temperature was only 22°,* a degree of cold not often exceeded during a whole winter, and, on this occasion, the more remarkable, from its sudden succession to very mild, if not warm weather.

On the 22d there were northerly, mixed with westerly winds—great variations of temperature—within narrow geographical limits, and barometers still low.

On this day a friend told me his barometer had fallen very much, and asked what it could be for, as the weather seemed fine.

* In Onslow Square.

I replied, "We shall hear of much wind and snow in the north, "the thermometer is so low." That very evening I met some relations, just arrived from Yorkshire, whose journey had been delayed on the railway by a very heavy fall of snow, with a strong north-east gale.

On the 23d much mixture, or contest of air currents was evident, the temperature being even lower (only 18° that night near London), and the barometer remaining low, but unsteady.

The differences of temperature between the east and west coasts of England were very remarkable on these days.

On October 24th, with a low barometer and excessive differences of temperature, (in very limited spaces) there was not much wind, or horizontal movement of air currents. The barometer was low, and almost equally low, therefore generally expressive of an extensive "area of depression," a *comparative* vacuity, or diminution of *tension*, necessarily to be filled, or equilibrated, by supplies, or by pressure, from other regions. If this were considered as an extensive, but shallow basin—a lagoon, as it were, on a vast scale, into which two streams are admitted from opposite directions—one having the start of the other—their effects and motions might be rather analogous to the recorded movements of the truly *fluid*, however highly *elastic* air.

On this day, the 24th, it blew hard along the coast of Portugal, from the southward, but no evidence has been obtained of any storm, or cyclonic commotion at that time in the Atlantic, to the southward or westward of the British Islands,—no proof of a cyclone having originated considerably to the south-westward, and having travelled across much of the ocean.

It was blowing strongly, from the northward, to the west of Ireland, on that same day (24th), but no ship reported a storm, on that or the previous two days.

As far as hitherto ascertained, the gale of October 25 and 26 appears to have had its commencement near the Bay of Biscay, and its conclusion about Norway or the Baltic.

During the night of the 24th and in the morning of October 25th, there was no evidence of a storm moving towards England. During the previous days there was a preponderance of northerly wind (polar currents) over and near the British Islands. There was no cyclonic commotion of any kind to the westward or southward. It is very important to mark these facts,—because ideas have prevailed that all cyclones crossing our islands have travelled far—even across the Atlantic, from the south-west. Plausible theories, and elaborate diagrams have been published,—intended to show how cyclones had travelled—not only across the Atlantic Ocean from near the West Indies, but (having there altered their course, or recurved,) actually all the way from the coast of Africa.*

That such storms do travel, like eddies in water, a considerable

* Redfield's track of the storm of September 1853, and other tracks shown by Sir William Reid, in his invaluable works.

distance, during two, three, or four days, has been demonstrated; but any further extension of their progress has not hitherto been satisfactorily proved.

Consecutive storms, at the meetings of main currents, in zones of latitude, at certain periods, have had appearances of continuity. The familiar instance of the *Charles Heddle* has so often been adduced as proof of continuing circuitous action, or gyration, that it may seem injudicious to doubt the *evidence*; but knowing how frequently circuits, or cyclones, succeed each other, *rapidly*; and how unreliable are some of the earlier logs of events in a storm, written after its cessation, especially respecting directions of wind and courses steered, when waves and storm blasts were the guides, not the oscillating compass, (if indeed *that* had not been washed away, as in the *Charles Heddle's* case); it does not appear accordant to experience, and enlarged acquaintance with the subject, to imagine that such atmospheric eddies are, *sui generis*, erratic, and so considerably independent, as to cross a wide ocean.

At midnight of the 24th and very early on the 25th, a ship named *Alipore** was between 46° and 47° N. lat., 13° and 14° W. long. crossing the Bay of Biscay, and, therefore, to the south-west of the British Channel. She had the barometer *then* at 28.98 with the wind at N.N.E. (true) blowing hard. Clearly (by our charts) there was no storm then to the westward of her. It was on the other side, but near. Its central part was at the entrance of the channel, not far from the Land's End. The *Alipore* had come from the south-west. No cyclone or strong wind had passed her from the southward. She *met* a north-east gale. The *Alipore* could not have overtaken a cyclone, supposing it moving only fifteen miles an hour to the north-eastward, bodily. Had it travelled from far westward, or south-westward, it must have overtaken, and passed that ship. Another ship, the *Neihar*, passed down channel, to sea, on the days immediately preceding the 25th. She met no storm. A ship belonging to Mr. Laird met none.† More “crucial” instances could not be desired.

In the morning of the 25th, there was a strong gale from south-west to south-east, over Portugal, Spain, France, and England. This was a warm, and very wet wind, which did not raise the then low barometer. Fog, dense clouds, or heavy rain prevailed. At this time a northerly and cold wind was blowing in the Atlantic, and soon it contended against the warm, wet, southerly wind, from which its chilling influence caused the precipitation, or deposit, of vapour, in fog, or rain. Both these winds were then blowing towards (afterwards around) that area, of the region near, in which the barometrical depression was greatest.

At this time, in Ireland, at Kingstown, there was a very dense fog,—so dense that (said Captain Boyd) “although I fired full

* Belonging to Mr. Lindsay, M.P.

† See page xlvii.

“ charges from guns on the seaward side, the packet (for whose
 “ guidance into port I intended them) though not more than a
 “ mile distant, only heard a few. The fog-bell was heard by her,
 “ only as the fog ‘lifted’ for a time, when she was about half
 “ a mile from the bell. In the afternoon it cleared to a fresh
 “ north-east wind. Not till near midnight had we the gale, fierce
 “ and startling, at the ship.” “The tide was unusually high.
 “ The weather had been singularly ominous and threatening for
 “ some days; so baffling also as to perplex the oldest and most
 “ weatherwise pilots.”*

The Channel squadron, under Admiral Elliot, not far from the Eddystone, had a strong south-east gale all the earlier part of the 25th, but about three in the afternoon the wind ceased, and the sun shone, though the sea continued “towering up and breaking.” The barometer, on board, was then 28.50. Suddenly, in less than half an hour, (the barometer *having* begun to rise) a blast swept furiously over the ships, from north-west; and during the next three hours it blew with the force of a hurricane. *There*, then, at three o’clock, was a lull, or vortex, of the storm, occasioned by an opposition of contrary currents of wind. At half-past five that afternoon, Mr. Laird was in a railway train near Reigate, that was struck so forcibly by a violent squall from *south-east* that he “thought the train would be capsized.” It was so very sudden, and heavy, that every one was alarmed.

According to the most reliable accounts the central area, where the barometer fell lowest, and *towards* which the winds blew, while distant, and around when near, was over Cornwall at about three o’clock in the afternoon of the 25th, and over Lincolnshire at nine next morning, having thus advanced about 250 miles towards the north-east (true) in eighteen hours, *averaging*, therefore, 14 miles an hour *over land*.

During the advance of the central area (a varying space, in which there was heavy rain but very little wind,) from Cornwall to Lincolnshire, all places south-eastward of the line between them (axial line of the progression shown by charts, or axis of the cyclone), had a storm veering from south-eastward, through the south to south-west, west, and north-west; while all those places north-westward of the axial line of progress found the same

* Captain Boyd adverts to a very dense fog. Sir W. Snow Harris quotes,—

“When morning mists come *from* the hills,
 And the huntsman’s horn is free,
 Fine weather reigns:—but, woe the time,
 When the mists are *from the sea*.”

Pressure of westerly winds, and a low barometer, raise the sea level, temporarily, round the British Islands. North-easterly winds, and high barometer, have a contrary effect, driving the surface water, bodily, seaward, towards the ocean, from comparatively shallow “soundings.”

Before a gale is felt, its advent is often signified on the shore, or at Light-ships, (such as those of the Kish, Cockle Gat, &c.,) by the undulation or swell that sets in, caused by the then distant gale. From Valentia I have been telegraphically warned of a coming gale, by heavy swell on the shore a day before the wind commenced.

storm veer round from south-eastward, through east, north-east north, and to the north-westward.

This is beautifully proved by facts, as to general limits and direction; but no proof is given of the contour outline of that area, which, probably, varied considerably as it passed over Cornwall, near the Welsh Mountains, or across the Midland Counties. Excessive quantities of rain fell on the south-east side of, and within the area, as it progressed north-eastward. Comparatively little or none on the north west side of that *central space*.

So limited was the actual gyration, that it only extended to Kingstown, hardly to Dublin, and did not affect France, beyond a few miles inland. Thus its diameter scarcely reached 400 miles at the utmost, but often was nearer 300, (as the charts show,) and therefore while there was a storm from every point of the compass, around the progressive vortex above mentioned, the greater part of Ireland, especially its west coast, and the west of Scotland, had but little wind. The weather there was actually fine.

While there was an area of extreme barometrical depression about Cornwall, the Channel, and the "edge of soundings" towards the Bay of Biscay, there were two strong currents of wind advancing towards that place, one from the northward, and another, *then* strongest, along Portugal and across France from southward. Their encounter occurred near the channel entrance, and from that time, on the 25th, the two bodies of atmosphere that had been drawn towards the same place, to restore due equilibrium, mutually pressed on to maintain advance, while their place of gyration, an immense eddy, was forced north-eastward by the overpowering mass and momentum of the southerly (or tropical) current. But this eddy, or cyclone, commenced on the 25th, and had almost expended its energy on the 27th, near the coast of Norway, having lasted between two and three days, as a definite and (mathematically proved) continuous circulation, or circuit. While the central area was moving north-eastward, from 10 to 20 miles an hour, the sensible velocity of wind, estimated, (by comparisons with measured pressures and *practical experience*, not only then but at other times), could not have been less than 60 nor much more than 100 miles an hour. Probably at the strongest part, on the south-east side of the circuit, the velocity was about 80 miles, added to near 20 for the cyclone's advance, making 100, while on the other side about 60 was the utmost.*

It has been observed that places in Scotland had no remarkable wind during the night of the 25th. When it blew hardest on the northern coasts of Britain, from the eastward, on the 26th, there was but little wind in the British Channel or Ireland. This shows, in connexion with the facts immediately

* With many *exceptions*, caused by local circumstances, and by the very *varying* effect of heavy gales; owing to the great *elasticity* of air, to its eddyings, and to numerous obstacles to the wind's swift advance horizontally. Remarkable streams, or rather thread-lines of force have been noticed at Observatories, especially by Dr. Robinson, of Armagh, whose anemometrical investigations, in conjunction with those of Dr. Lloyd, have been so valuable to their followers.

preceding the circular or gyratory movement which commenced near Cornwall, that the nearest quantities of air were pressed by ordinary dynamical laws towards the place of deficiency, and that the two great normal movements of atmosphere, from and towards the pole, were immediately affected by the local and temporary disturbance of equilibrium.

CHAPTER VII.

FURTHER REMARKS ON THE CHARTER STORM.

It may be useful to reconsider the progress of this storm with reference to the condition and circumstances of surrounding regions.

It has been noted that the west coast of Ireland, and a large proportion of that island, were not affected at all. Scotland was not reached on the 25th, but was so subsequently. Neither the *Alipore*, nor a ship sailing *from* the Channel,* (on the 23d,) nor any other vessel, felt its influence *before* the 25th.

As the *Neikar* left Channel soundings on the 23d, having been off Scilly on the 21st, she must have crossed any cyclone advancing from the south-westward, or from the Atlantic Ocean.

One of Mr. Laird's African vessels sailed from Liverpool on the 24th. No storm was encountered. Only strong northerly winds were found, as she went to the westward, southward. But the barometer was generally low, over at least a thousand square miles of sea and land, and had become so gradually during many previous days,—about a week, indeed.

The *lowest* point then reached, however, was not nearly so low as has been *known*, nor was it even equal, in depression, to that caused by the subsequent storm, of November 1st†, which may have been caused by the rapid shift to the *northward*, and by so much polar current resisting the southerly mass.

On board the *Alipore* 28·98 inches was the lowest registered pressure. The Channel squadron noted 28·50. In London, at my house, the mercury was rather below 29 inches, (reduced to sea level and 32°,) rain being incessantly heavy, and wind violent from southward all the earlier part of the night.

At this time the *Royal Charter* was making way round Anglesea, close in shore, to her fatal anchorage, on the north side of that island; where the full force of next day's tempest, from the northward, was felt, and that *doubly* powered ship, of iron, which had circumnavigated the globe, was destroyed, with nearly all on board, in one short hour, about seven in the morning. With her power of steam, in addition to that of sails in perfect order, a few hours on the starboard tack, with but little way, would have saved her. So much, at such a time, depends on individual judg-

* *Neikar*, of Hamburgh, Captain Brolin.

† Piddington, India, 26·47 inches? Clouston, Orkneys, 27·45 inches. Howard, London, 27·73 inches. Reid, West Indies, 27·00 inches. Daniell, Chiswick, 28·60 inches. *Recent* observations in the North Atlantic, in 48° lat., with Kew barometers, have been as low as 28 inches.

ment. Another ship but a few miles off, a wooden sailing ship, not a steamer, the *Cumming*, and several smaller vessels, acted thus—stood to the westward—and not one was wrecked, nor even injured materially.

Unfortunately many cases might be cited of a similar nature, in other storms, where accidents, heavy expenses, or great losses, have been traced to similar errors in judgment.

It has been supposed by many persons, and asserted authoritatively in public prints, that if warnings had been given from Lighthouses, or salient points on the coast, the *Royal Charter* might have been saved.

Now, it is extremely desirable to separate what is practicable, and may be accomplished, under any or some conditions, from that which is only supposed to be so, yet so much wished for, that the means of effecting the object are over estimated.

The *Royal Charter* could not have made (seen) the land in time, or sufficiently plain, to make out a signal. It was raining and dark on that afternoon and evening. Holyhead, the high mass of land behind it, and bright lighthouse lights, were distinguishable, but nothing more.

No warning signal from the land could *then* have averted the consequences of erroneous management.

That ship had excellent instruments on board when she left her last port—they *should* have given sufficient notice—but had they not been there, or had their indications been unheeded, those of the heavens should not have been disregarded—overlooked they *could* not have been from any ship—and *were* not by the *Cumming*, or by numerous coasters.

While the storm was most violent against Anglesea Island, its force was not excessive at Liverpool. The strongest part of the north-west side of the cyclonic circulation did not sweep over that town till shortly before noon of the 26th. Mr. Hartnup wrote to me, “The storm on the 25th and 26th of October did not reach Liverpool till about 12 hours subsequent to the wreck of the *Royal Charter*.”

“We had at the Observatory, Liverpool, light winds until 9 A.M. on the 26th, when the gale first reached us. At 11.45 A.M. the extreme pressure was 28 lbs. on a square foot, and the greatest horizontal motion, measured hourly, was 57 miles between noon and 1 P.M. The direction of the wind being N.N.W.” (true*).

The greatest force recorded at Liverpool, was 42 lbs. to the square foot, in December 1852, when the velocity was 70 miles an hour. At Lloyd’s, a pressure of 38 has been noted by a similar instrument (in February 1860), and during the St. Kilda storm of October 1860, the force was 28 lbs. At Lord Wrottesley’s observatory, on the summit of a rising ground in Staffordshire, no pressure has been noted exceeding 16 lbs. on the square foot,

* At the Liverpool Observatory, on one of the northern quays of the Mersey, there are local circumstances common to valleys or low places near heights, influencing the direction as well as strength of wind.

since his lordship first placed an anemometer there ; being a remarkable instance of the modifying effect of certain local circumstances, or an inland position. That, generally speaking, (allowing such *exceptions* as those of local storms or whirlwinds, as, for example, those of Calne, and Clifton,* in 1859), there is much less strength of wind, continuously, in inland places, is shown by the full regular growth and rich foliage of trees, in contrast to the stunted, inclined, and scantily leaved trees of a sea coast, exposed to prevailing winds.

A letter from Dublin said, "In England you have had this " tremendous gale (October 25–26.) Here it was not felt. The " barometer fell much, but nothing followed."

Captain McKillop, R.N., informed me that "during the gale " which swept the coast of England and Wales, when the *Royal " Charter* was lost, a dead calm, and a sharp frost of unusual " severity for the country (Ireland), was experienced along the " coast, from Westport to Galway, the wind going round from " north-east to south-east ;—when the frost ceased, and a most " unusual quantity of rain fell, with light variable winds from " south to west."

A vessel returning from Iceland † had heavy gales from N.N.E (true) between October 23d and 28th. This was in latitude 64° to 61°, and longitude 28° to 23°. On the 24th, 25th, and 26th, the wind's force was stated at 10 to 11.‡ During the *whole* of the time, when variable or southerly winds prevailed, eastward of Ireland, as well as while the polar current alone was felt between Ireland and the Baltic, across France to Spain, and in the eastern Atlantic,—during the whole of this time, the expeditionary vessel *Wyman*, employed by Colonel Shaffner to explore a submarine track for his intended telegraphic communication, was in northerly (or polar) winds, on four days extremely strong, with a high barometer.

On the 28th the barometer had risen considerably in general, but not to its normal or par height.§ Winds were variable, and temperatures extremely so. Much rain fell.

On the 29th there was a local cyclone apparently at the meeting of northerly and southerly currents of wind, near the east coast of Scotland in the North Sea. This had not travelled. It grew and then diminished in one locality. There was much variation in the temperatures of even neighbouring places, showing great mixture of air currents. There was little wind, and that very variable—in many places from the *land to the sea*—the land having been considerably chilled by previous northerly winds, by rain and evaporation, while the sea retained nearly uniform, and, at that time of year, rather high comparative temperature (October 30).|| With barometers everywhere low, and falling,

* Mr. Burder's account.

† The bark *Wyman*, Captain Baker, with Colonel Shaffner.

‡ In her log, kept carefully.

§ Near thirty inches (29.94 to 30.00).

|| Averaging then 48°.

ominous skies and increasing warmth, with south-easterly winds approaching towards the north-east, it was seen that another gale might be expected immediately; and next day, 31st, it commenced in Ireland, having been felt heavily in the Atlantic, at a considerable distance, previously.

On the 1st of November, this storm's centre crossed Ireland, the north of England, and then, on the 2d of November, appeared to diminish rapidly in its strength as it overspread the North Sea, progressing towards Denmark. A more distinctly marked cyclone than this as it appears demonstrated on our charts, it is hard to imagine. That it existed three days is proved, and that its central area progressed eastwards about fifteen miles an hour, on an average, cannot be far from the truth. The barometer fell before this storm, considerably lower than it did before its more generally remarked precursor, and the thermometer was much higher. These indications showed preponderance of the southerly (tropical) element over that from the polar direction; and that the meeting, place of gyration, or node, was therefore further toward the north.

That its direction of progress should have been nearer eastward, across the British Isles, instead of more northerly (in consequence of such southern predominance) may have been a consequence of the Scottish mountains, three to four thousand feet high, impeding such a course as would have been taken across open sea.

At the Board of Trade, at Kew, and at Brompton, the lowest barometrical reading in the night of the 31st October, or morning of November 1st, was 28·80, the thermometer in open air being then 50. It has been stated that *there* the lowest on the night of the 25th was 29·00 (sea level and 32°), and the temperature then 25°. Two aneroid barometers, considered to be good instruments, near Lake Windermere, fell to 28·09 and 27·70 (approximately reduced to sea level) the night of the 31st. The first of these showed 28·77, nearly (reduced) the night of the 25th of October.*

On the 29th, Colonel Rogers' barometer had fallen to 28·42, and at 11 P.M. on the 31st to 28·27; but nothing of consequence followed besides rain; no strong wind. At eight next morning his barometer showed 28·09, and at 3 P.M. the sky had cleared, the glass was rising; Windermere had felt no storm, and did not experience any strength of wind afterwards. This is by no means a singular case, but is quoted here as one of the well-marked exceptional anomalies that occurred during this storm of November 1st as well as that of the 25th October, on which occasion, also, Lake Windermere escaped undisturbed. Colonel Rogers said of that time (Tuesday night 25th October):—"My aneroid fell to 28·60† at night. Rain fell, but no remarkable wind occurred. It was fresh and gusty, but at no time severe."

* From Captain Hemming, H.I.C.S., Colonel Rogers, and Captain Crowe. Reduced to sea level and 32°. 156 and 200 feet, having been estimated as their respective elevations.

† 28·77 reduced to mean sea-level, or *half-tide* height, and to the freezing point of Fahrenheit.

Similar exceptions occurred in Ireland, Wales, and Scotland; in some degree resulting, probably, from the sheltering or deflecting effects of high land, but chiefly from the very diversified action of violent winds, expanding and expended, in some places, and so extremely compressed (as it were) and elastic at others, that heavy weights are lifted, large trees snapped asunder, or laid prostrate, and strong buildings unroofed.

SECTION 2.

Gale of 31st October and 1st of November.

On the 31st October, there was a circulation of wind around a place about two hundred miles west of Ireland; barometers indicating very diminished pressure everywhere, but particularly to the south-westward of Ireland, and thermometers showing great differences of temperature. Extreme cloudiness, much fog, and a good deal of rain prevailed during the 30th and 31st. It became evident that a southerly gale was impending. Barometers near London fell to 28·76 at midnight of the 31st, the thermometer, exposed, being then 50°. (Near Lake Windermere 28·09 was the reduced height, soon after that time.)

A steamer, in the Channel, on her passage to Cork, during this night (31st), and the following day, thus describes the weather:—

“On Monday (31st) and Tuesday following, I had a very severe gale in the English Channel:—Noon, October 31st, wind S.E. fresh, dark gloomy weather, barometer 29·0° falling. At 4 h. P.M. increasing wind with rain at times. Barometer falling, dark and cloudy weather at 9 h. P.M. In a heavy arched squall of both wind and rain, attended with vivid flashes of lightning, the wind changed to W.N.W. Midnight, blowing severe gale from west, with low white haze, over which showed a clear sky. At 1 h. 30 m. A.M., the appearance of the western horizon was like thick smoke, the stars visible to the eye like balls of fire through the black haze, very vivid lightning from the same quarter.”

“Barometer then down to 28·50°. There was at this moment a lull, and the wind felt quite warm; (I have felt a heated wind similar in the West India hurricanes, also in the tropical belt of calms during heavy squalls, more particularly when accompanied by lightning, near the Line;) a fierce gale then commenced, the ship could not be steered, and fell off broadside to wind and sea (then running very high), and rolling the lee paddlebox nearly under water; the gale so continued unabated till daylight of Tuesday, with fierce gusts. On the horizon a white haze was visible about masthead high, partly drift or water blown up from the surface. With this appearance the gale lasted all the day, till at 4 h. P.M. I perceived a lull, and found the barometer inclined to rise. At 6 h. P.M. between fierce squalls, and lulls at intervals, the gale moderated to a strong wind, with sea decreasing.”

A letter from Bute Docks, Cardiff, stated:—“The gale of the 1st of November began here at noon of the 31st. The wind

“ was then east, (magnetic). It veered round to the S.S.W. blowing heavily. At midnight it was W.S.W. (S.W. true), with loud thunder and lightning, and terrific squalls, with heavy rain; and so it continued till after noon of the 1st, when the gale abated *here*. The heaviest of it was from W.S.W. (S.W. true).”

At Dublin and at Kingstown at 10 A.M. on the 31st, it was blowing strong from the north-east, at sunset a gale from E.S.E. with rain,* at 11 P.M. from north-west, with a great deal of lightning, and at 10 A.M. on the 1st from west.

It blew hard all the morning of the 1st; a good barometer in Dublin fell to 28·010, at 8 A.M. while the wind was west.†

At Liverpool the extreme pressure shown by the Observatory wind plate was only 14lbs. on a square foot. This was at 8 A.M., the wind being then W.S.W. true, (west magnetic). The utmost hourly horizontal motion that day was but forty miles, showing that the greatest force of that gale did not reach the entrance of the Mersey.

At this time the Wyman, chartered by Colonel Shaffner for exploring a northern submarine line, was near 62° latitude, and 18° longitude, in a very heavy south-easterly gale.

The much lamented Captain Boyd told me that the night of the 29th was fine at Kingstown; on the 30th the weather was gloomy and threatening, on the 31st a strong gale was blowing from north-east, while at Cork he heard it was south-east (magnetic.) Between 3 and 4 P.M. on that day the barometer fell, at Kingstown, from 29·30 to 29·00 in less than one hour, the wind being south-westward—the tides much affected.

On November 1st at 2 A.M. the barometer at Kingstown showed 28·50 afloat. Heavy north-west gales followed at Cork, likewise thunder, with lightning and rain. The chart shows a very remarkable rotation of wind around the Solway Firth and the “Merse” of Berwick. That circuit or gyration had progressed across the north of Ireland from at least two hundred miles to the westward (as several ships’ logs prove) and diminished or dispersed towards the Baltic, apparently; but its exact direction and condition, after reaching the North Sea, facts are yet wanting to demonstrate accurately.

SECTION 3.

Resulting Impressions.

The general impressions caused by this investigation seem to be principally, that,—

1. The gyratory movements of wind, usually called cyclones, are consequences of the meeting of great air currents.

2. When so caused, in any part of the world, they rotate, as eddies, during a certain time, more or less limited, not exceeding

* E.N.E. ?

† If a hundred feet above the sea level, this would be about 28·10 inches.

four complete days and nights without interruption, but usually a much shorter period.

3. Cyclones originate on one side of the Atlantic, and traverse to the other, is a fallacy arising out of an *insufficiency of facts*, and consequent erroneous combination of the details of various consecutive gyrations, *since* proved to be *frequent*.

4. When such an atmospheric commotion happens, it is not usually an isolated occurrence, but one of many such, similar in nature and origin, though unequal in extent, duration, and force; not taking place at exactly the same time, necessarily, but prevalent in a certain zone or region of the world during a few days, or weeks, or a season.

5. The conflicting action of two currents, opposed in much peculiarity, as well as in *direction* (a feature connected with electricity?) not only originates a cyclone, but tends to continue its striking qualities of a wet warm side, and a dry cold one, owing to the continued access and addition of air from each of the currents (between which is the eddy), as place is made by immense precipitation of vapour, in rain, hail or snow, supplied from the vaporous side, as speedily as precipitated, or absorbed by the chilling and drying influence of the antagonistic current from a polar direction.

6. These cyclones originating in *opposition* of currents otherwise caused, are different from local whirlwinds, occasioned by rarefaction, or by *electrical* action, as in sand columns (of the desert)* and water-spouts.

7. When opposing currents meet, their masses must *continue* in motion a certain time, either rotating, or ascending, or going onward horizontally in *combination*.

8. Masses of air, either of polar or tropical origin, so to speak, *returning*, when driven back by stronger opposition, at first, and for a certain time, retain the characteristics of their peculiar and very different natures.

9. And—that a new feature has been noticed, as follows:—

The researches and investigations of Beccaria, Quétélet, De Saussure, Faraday, Crosse, Delmann, Thomson, and others, showed some time ago, that during the prevalence of northerly (polar) currents of air, electricity (positive or plus) was more or less active, or developed. That in the contrary, southerly (tropical) current, there was no such action, no electricity in *excess*, no positive or plus, and but little, if any, minus electrical evidence.

Having often noticed effects on certain instruments, used as weather-glasses, that did not seem to be caused by pressure, or solely by temperature, by dryness, or by moisture; having found that these alterations happened with electrical atmospheric changes that were not always preceded or accompanied by movement of mercury in a barometer, and that, among other peculiarities, increase or diminution of wind in the very “heart” of the trade

* Baddeley's Whirlwinds and Dust-storms of India, &c.

winds, caused effects, while the mercurial column remained unaltered, or showing only the slight intertropical diurnal change (as regular there as a clock.)*) I had long felt sure that *another* agent might be traced.

More than a century ago what was called a "storm glass" was sold in this country. Who was the inventor is very uncertain.

Since 1825 I have generally had one or more of these glasses, as curiosities rather than otherwise, for nothing certain could be made of their variations until lately, when it was proved, at least to my own conviction, that if fixed, undisturbed, in free air, not exposed to radiation, fire, or sun, but in the ordinary light of a well-ventilated room, or outer air, the chemical mixture in a so-called storm glass varies in character with the *direction* of the wind, not its force, *specially* (though it *may* so vary, in *appearance* only) from *another* cause, *electrical tension*.

As the atmospheric current veers toward, comes from, or is *approaching* only from the polar direction, this chemical mixture † (microscopically watched) grows like fir or fern leaves, hoar frost, or crystallizations.

As it tends to the opposite quarter, the lines or spikes,—all regular, hard, and crisp features, gradually vanish. Before and in a continued southerly wind the mixture sinks gradually downwards in the vial, till it becomes shapeless, like melted sugar.

Before, or during the continuance of a northerly wind (polar current) the crystallizations are beautiful; (if the mixture is correct, the glass a *fixture*, and duly *placed*. The least motion of the liquid disturbs them. The glass should be wiped clean now and then, gently, if exposed to rain, or dust.

While *any hard* or *crisp* features are visible below, above, or at the top of the liquid (where they form for much north wind) there is plus electricity in the air; a *mixture* of polar current co-existing in that locality with the opposite, or southerly. When nothing but soft, melting, sugary substance is seen, the atmospheric current (feeble or strong, as it may be), is southerly, unmixed with, and uninfluenced by the contrary wind.‡

By repeated trials with a delicate galvanometer, applied to measure electrical tension in the air, I have proved these facts, and now find them useful for aiding, with the barometer and thermometers, in forecasting weather.

Temperature affects the mixture much, but not solely; as many comparisons of winter with summer changes of temperature have fully demonstrated.

* Humboldt's "Personal Narrative."

† Camphor—nitrate of potass and sal ammoniac—partly dissolved by alcohol, with water, and air, in a hermetically sealed glass vial.

‡ A confused appearance of the mixture, with flaky spots, or stars, in motion, and less clearness of the liquid, indicates south-east wind, perhaps a gale.

CHAPTER VIII.

INDUCTIONS FROM FACTS—CONSIDERATIONS IN CONSEQUENCE.
METEOROLOGICAL DYNAMICS—FORECASTING WEATHER.

WE have ascertained that in our latitudes there is a continuous alternation of air currents—each specifically different, and denoting approach by marked characteristics : and we have proved by successive series of simultaneous statical observations, over a wide range,—embracing Scotland, Ireland, all England, and adjacent islands,—that while these alternating or circuitously moving currents are thus incessantly passing—the whole body of atmosphere filling our temperate zone is moving gradually towards the east—at an *average* rate of about five geographical miles an hour.

During strong westerly winds this eastward motion is greatly increased ; and in easterly gales it is proportionally diminished, as measured by its passage along a horizontal surface of earth or ocean. Knowing these circumstances, and having accurate statical observations, of these various currents, at selected outlying stations,—showing pressure, (or tension), temperature, and relative dryness, with the direction and estimated horizontal force of wind at each place simultaneously, the dynamical consequences are already measurable approximately, on geometrical principles ; and, judging by the past, there appears to be reasonable ground for expectation that, soon, meteorological dynamics will be subjected to mathematical analysis and accurate formulas. The facts now weighed and measured mentally—in what may be correctly called “ forecasting ” weather—are—the direction and force of *each* air current, or wind—reported telegraphically to the central station in London, from many distant stations ; their respective tension and temperature, moisture or dryness, and their changes since former recent observations.

These show whether any or either movement or change is on the increase, or decrease—whether a polar current is moving *laterally* off—passing from our stations towards Europe—or approaching us from the Atlantic—whether moving *direct* towards the south-westward with great velocity or slow progress. If moving *fast*, in the direction of its length, it will approach England more from the east—its speed *direct* being twenty to fifty or eighty miles an hour—while its *constant* lateral or easterly tendency (like a ship’s leeway, in a current) being only five miles an hour is then insensible to us—(though clearly deducible from other facts ascertained), and is so much in alteration of actual *direction*, as well as of what would *otherwise* be the velocity of the polar current.

With the opposite principal current—the equatorial or south-westerly, more briefly and correctly *tropical*—similar but opposite results occur—the direct motion from a south-westerly quarter is *accelerated*—sensibly to our perception—by *part* of the *eastward* constant (about five miles hourly)—and, therefore a body of air approaches us *sooner* (other things being equal) from the westward, than it does from the eastward.

To seamen accustomed to navigate in ships making leeway—while in currents setting variously over the ground—such movements, complicated as they may appear, are familiar. Questions relating to composition and resolution of forces—current and tide sailing, allowances for drift, heave of sea or swell, and ordinary leeway—enter into every midshipman's examination, before obtaining a Lieutenant's commission.

Two other remarkable features ought to be pointedly remarked here not merely because they have not been previously described, but because their consideration is necessary in this new and interesting kind of dynametry. One is the disposal or progress of two bodies of air united, or mixed, or contiguous to each other, after their meeting—either directly opposed or at any angle—on the earth's (or ocean's) surface. They do not vanish:—They cannot go directly upwards—against gravitation;—Westward they cannot generally go when there is collision or meeting, because the momentum, elasticity, and extent of the tropical “anti-trade”^{*} usually overpowers any direct polar current, or rises over it, and more or less affects the subordinate below, by the friction of its eastward pressure. Downward there is no exit—eastwardly (towards the east) the accumulating air must go—and this tendency continued causes the *varieties* of wind from the westward—being more or less mixed—more or less purely polar or tropical as either one prevails in combination.

The other point, to be noted, is:—After a body of air has passed, and gone to some distance southward, or northward, it may be stopped by an advancing and more powerful mass of atmosphere which is moving in a direction contrary to, or diagonally across its line of force. If their appulse be gradual and gentle, only a check occurs—and the weaker body is pushed back until its special qualities, respecting temperature and moisture, are so masked by those of its opponent as to be almost obliterated. But, if these currents meet with energy—at very different temperatures and tension, rapid changes are noticed as the wind shifts—and circuitous eddies, storms or cyclones occur.

Otherwise—when their meeting is, as first mentioned, *gradual*—there is the *return* of a portion of either current (which previously prevailed) either direct or deflected—deflected even through more than one quadrant of a circle—by its advancing opponent—and retaining for some considerable time its own previous characteristics.

Thus we have, for short times, cold dry winds from the southwest, instead of the usual warm and moist ones:—or winds of this latter kind from the north, instead of cold ones. The circuitous tendency of air in motion—and the numerous impediments to its horizontal progress, such as land, ranges of mountains, hills or even cliffs—induce many a deviation from normal directions, extremely puzzling to the student of this subject; but so retentive is air of its tension and temperature, for a time, that, like currents

^{*} Sir John Herschel's excellent term.

in the ocean, each may be traced by its characteristics as long as within our island web of stations. When the polar current is driven back by a tropical advancing from a southerly direction gradually—their action united becomes south-easterly (from the south-eastward), and as the one or other prevails, the wind blows more from one side of east or from the other.

Time is required to produce motion in the air—horizontally—*time* is indispensable for its gradual cessation from movement. *Statical* effects are noticed, at observatories—or by careful observers anywhere—hours, or days, before dynamical consequences occur.

SECTION 2.

American Facts and Views.—Weather Maps.—Forecasting Weather.

Remarkably in corroboration of views expressed in these pages, are the following extracts from Professor Henry's letter to General Sabine, dated Smithsonian Institution, July 1, 1861.

Although the American meteorologist has treated his subject under a different aspect, the facts stated have value from another point of view. He has had wavelike undulations in mind, where others may trace continuous horizontal motions of air.

"We are making good progress in collecting materials for studying the peculiarities of the climate of this country, as well as some of the general laws of the changes of the atmosphere.

"Our system of telegraphing the weather during the last winter was a source of great interest. * * * *

"When our reports are full, particularly from points directly west of this city (Washington), we scarcely ever fail to be able to foretell, for nearly a day in advance, the state of the weather.

"We have two classes of storms, one of the cyclone character, which follows the general direction of the Gulf Stream, overlapping our coasts, and the other the ordinary storm common to the temperate zone. The latter come to us from the west, and may be traced in their course from the foot of the Rocky Mountains to the Atlantic seaboard. We have found that they enter the United States from the British possessions about 110° of west longitude, then spread southward and eastward, so as, in some cases, to cover the whole of the portion of our territory east of the Rocky Mountains.

"We have now about 500 observers, and can readily trace the course of a disturbance of the atmosphere from the place of its beginning to that of its termination (provided that the latter is on the continent). We find that not only do the storms of wind and rain come from the west, and enter our territory from the north at the point above named, but also the cold and warm *spells* (periods).

"The early and late parts (of the storm) traverse the country in the form of a long wave extending from north to south, and moving eastward. When this wave arrives at a given meridian during night, a killing frost extends along a wide band of country from north to south, in some cases for more than 1,000 miles, while in an east and west direction not more than 50 or 100 miles.

“At first sight it may appear somewhat strange that our warm spells should begin at the N.W. point of our map, but when we reflect that the south wind is warm and light, and that probably it is in all cases a wind of aspiration, the solution of the phenomenon is not difficult. A rarefaction probably takes place in the north, which draws into it the air next to it on the south, and this again gives motion to the portion of air still further south, and so on until the current reaches the Gulf of Mexico, while at the same time the same heated air from the south is wafted eastward by the prevailing westerly upper current of the temperate zone.”

The facts thus recorded at the Smithsonian Institution, appear to be in accordance with those general results, and views, usually received, on this side of the Atlantic, by those who concur, as to broad principles, with Dové, Herschel, Lloyd, Robinson, Sabine, and Daniells.

The long narrow currents traced in their lateral as well as longitudinal motions over America, are paralleled in Western Europe, in the Atlantic, in the Pacific, and in the great South Sea. Similar streams, but *inelastic*, exist in the ocean.

How far ranges of mountains may act in causing an *apparent* difference at Washington between cyclones and other storms, *said to be different* in character, it would be tedious to show here. Where no such impediments exist, as in the Southern Ocean, clear of all land, all storms, indeed all winds, are cyclonic, or circuitous, although their sweep is sometimes so large as to out-reach ordinary ranges of observation ; in which case, at any one place, they may seem to be “straight lined.”

Various suggestions have been made with a view to exhibit daily, by maps, useful facts respecting weather ; but, in this country, the expense of making, transmitting, and publishing *enough, and sufficiently soon*, to be really valuable, has impeded actual organisation of any system better than that established by the Board of Trade, which includes only twenty selected stations.

The printing, publishing, and quick circulation of such ever-varying data as *daily maps* must have, requiring from 70 to 100 distinct symbols or types, and a key to them (more or less at hand), *for the public*—are practical obstacles, irrespective of expense, hardly to be overcome by individual means, or even by a private association.

As an endeavour to give some premonition of weather expected during the next day or two, has been commenced publicly ; it may be useful to explain here what is actually attempted, as well as the principles by which the *forecasts* are regulated daily, if not twice a day, and modified or entirely altered on each occasion, as may seem advisable, according to the latest telegrams.

“What sort of weather will there be *to-morrow* ?” may be asked :—and to such a question an answer *may* now be given approximately for any place, or for *districts*, such as the following :—

1. North Britain (including from the Moray Firth to the middle of Northumberland).

2. Ireland—generally.
3. Central (Wales to the Solway).
4. East Coast (from Northumberland to the Thames).
5. South England (from the Thames round to Wales).

As space is very limited, and as *some* words are used in *different* senses by different persons, extreme care is taken in selecting those for such brief, general, and yet *sufficiently definite* sentences, as will suit the purpose.

Such words as are on *published* scales of force, or nature of wind and weather, are *generally* understood, and therefore used in preference to others.

In saying, on any day, what the probable character of the weather will be to-morrow, or the day after, at the foot of a table showing its observed nature that very morning,—a limited degree of information is offered, for about two days in advance, which is as far as may be yet trusted generally, as an average, though at times a longer premonition *might* be given, with sufficient accuracy to be of *occasional* use.

Minute, or special details, such as showers at particular places, or merely local squalls, are avoided; but the general or average characteristics, those expected to be principally prevalent (with but few exceptions) the following day, and the next after it, including the nights, not those of the weather actually present, are *cautiously* expressed, after careful consideration.

It may now be seen, after many months' trial, whether tolerably correct forecasts of ordinary weather can be formed here *sooner* than at distant, *isolated* places, where the published *general* Reports arrive a day or two later; and whether they are practically useful as conclusions available for the public.

Ordinary variations of *cloudiness*, or clear sky, or rain, of a *local*, or only temporary character, are not noticed usually.

A broad general *average*, or *prevalence*, is kept in view, referring to a day, or more, in *advance*, and to a *district*, rather than only to *one* time or place.

The great practical difficulty is in separating the effect, on the mind, of present states of air, weather, and clouds, from abstract considerations of what may be *expected* on the morrow, or next following day.

When in doubt, distrusting the indications, or inferences from them (duly considered on purely scientific principles, and checked by experience) the words "*Uncertain*," "*Doubtful*," &c., may be used, without hesitation.

As meteorological instruments usually foretell important changes, by at least a day, or longer, we have to consider what wind and weather may be expected from the morning observations, compared with those of the days immediately previous, as indicative of the morrow's weather, and of the day after, at *each* place, to take an *average* of those *expectations*, for each district, collectively, *in groups*; and then to estimate dynamical effects.

Thus a barometrical height of 29.50, with about 60 degrees of temperature, may indicate (if continued a certain time) fresh south-west wind and mild air, probably cloudy, perhaps rainy;

being the general accompaniments of such weather, in autumn or spring : and at those seasons (*intermediate ones*) about 30·50 inches, with 50 degrees, or *less*, would foretell, and accompany north-easterly wind, dry weather, and usually a clear sky. Again, a high or rising barometer in the north-west, with low or falling temperature ;—while in the south and east the pressure is low or diminishing, indicates a north-west wind—either extending *generally*, or checked and deflected, according to the diminution or increase of the temperature in the south-east. Heights of barometers, changes of temperatures,—dryness or the contrary,—rainfall or snow,—and electrical signs,—all affect the dynametry of this subject.

Outline maps, with moveable windmarkers, and cyclone glasses or horns, are useful in forecasting weather : and full consideration should be given to the probable position, direction, extent, and degree of progress of that central area, or node, round which the principal currents usually circulate, or turn, as they meet and alter, combine with, or succeed one another.

Here dynamical considerations, with comprehensive comparisons of statical facts are most important ; and to treat them even approximately well, with such quick despatch as is requisite, demands aptitude and experience.

Those who are most concerned about approaching changes, who are going to sea, or on a journey, or a mere excursion ; those who have gardening, agricultural, or other out-door pursuits in view—may often derive useful *cautionary* notices from these published *expectations* of weather—although (from the nature of such subjects) they can be but *scanty*, and imperfect, under present circumstances.

Objection has been taken to such forecasts, because they cannot be always exactly correct,—for all places in one district. It is, however, considered by most persons that general, comprehensive expressions, in aid of local observers, who can form independent judgments from the tables and *their own instruments*, respecting their immediate vicinity, *though not so well for distant places*, may be very useful, as well as interesting : while to an unprovided or otherwise uninformed person, an idea of the kind of weather thought *probable* cannot be otherwise than acceptable, provided that he is in no way *bound* to act in accordance with any such views, against his own judgment.

Like the storm signals, such notices should be merely *cautionary*—to denote anticipated disturbance *somewhere* over these islands,—without being in the least degree compulsory, or interfering arbitrarily with the movements of vessels or individuals.

Certain it is, that although our conclusions may be incorrect—our judgment erroneous—the laws of Nature, and the signs afforded to man, are invariably true. Accurate interpretation is the real deficiency.

CHAPTER IX.

ARRANGEMENTS IN OFFICE. PRESENT AND FUTURE DUTIES.
ESTIMATE OF EXPENSE.

25. HAVING endeavoured to explain in the previous chapters on what meteorological basis our operations are sustained, I would now, Sir, request attention to the more official and financial part of my report.

26. In this place it may be proper to sketch our arrangements and method of executing not only those general duties for which we were appointed, but others, that have arisen out of them perhaps more rapidly than was anticipated.

27. The attendance here is necessarily continuous—between ten and six o'clock daily, for some—from eleven to five for others—of the ten persons employed; only two of whom are yet on the regular establishment of the Board of Trade.

28. Meteorological telegraphy is satisfactorily attended to by *three*, who, also, are assiduously engaged in extracting and reducing various meteorological observations, collected on an extensive scale, therefore needing much time for discussion and preparation for printing.

Due attention is given to records, stores, correspondence, and translation, as well as to charge of the instruments. Two youths carry out our weather reports, or telegrams, and are otherwise actively employed in searching for papers, extracting, and copying.

29. Consequent on the progress made, and the results gradually developed, arrangements for weather reporting increased in extensiveness, as has been shown, but the actual time now occupied by meteorological telegraphy is comparatively small, although we are in daily communication with twenty home stations—and with Paris, for six on the Continental coasts.

30. The organisation effected is shown by the “Instructions for Meteorological Telegraphy,” and by the correspondence which follows in the Appendix.

31. Kew verified instruments were intrusted to the care of clerks in charge of selected telegraph stations, by arrangement with the Directors of the Electric, the Magnetic, and the Submarine Telegraph Companies. Very satisfactorily those telegraphists acquired the duties asked for, then perfectly new, which are now continued with extremely creditable regularity and precision.

32. From the commencement in September 1860, no break, or interruption, not only of telegraphic but harmonious written intercourse, has occurred. The directors of those great companies have liberally reduced their tariff charges by one-third—in favour of our public communications, and have authorized reasonable precedence for our messages along their lines.

33. Being fully convinced that the importance, nationally considered, of this system of weather reporting—hitherto experimental—deserves support as a permanent institution—I ventured to submit to you, Sir, the following financial estimate.

34. In 1860—for the financial year 1861–2 the sum proposed to be voted by Parliament for “Meteorological Observations” was 2,800*l.*, which, with 900*l.* provided for salaries and printing, under other heads (Board of Trade and Stationery Office), made a total or gross sum of 3,700*l.*—for all purposes of this office—including an *experimental* commencement of meteorological telegraphy.

35. The expense of this new undertaking was first estimated at 100*l.* monthly—and that estimate was found to be sufficient until the last quarter of the financial year 1860–1.

36. Nearly at that time (February 1861) the *cautionary signals* were first employed—and so well were they found to answer even on the very limited scale tried during the next few months—that in August following an extension of the system was organised by telegraphic communication from outlying stations—by more extended telegraphic *cautions*, and by daily “*forecasts*” of weather, regularly sent—entirely at the expense of the Board of Trade—to all the principal newspapers—which asked to be supplied with them, besides Lloyd’s, Liverpool, and Glasgow Underwriters’ associations. Since that time the Admiralty have directed the Coast-guard to co-operate wherever practicable—adding thus about eighty places of storm warning to the fifty previously in communication.

37. These important additions have not caused nearly so great an additional expense as might have been anticipated, because the Telegraph Companies have very liberally reduced their charges on meteorological telegrams for Government, by one-third, in general (and—in the case of Heligoland—one-half), while authorizing *precedence* on the wires, of all ordinary *private* telegraphy.

38. The result is that the system, at present considered to be working *satisfactorily*—can be continued in a similar manner—without asking for a larger increase to the meteorological vote than 900*l.* above *last year*; or 4,600*l.* instead of 3,700*l.*

39. The gross sum for meteorological observations in			
1862–3 being thus estimated at	-	-	-£4,600
Of which is provided for salaries at Board of Trade, 440 <i>l.</i> ,			
and by Stationery Office, for printing forms, books,			
papers, tables, charts, &c., 360 <i>l.</i>	-	-	- 800
			<hr/>
Leaves to be provided	-	-	-£3,800
Which will be required for—			
Salaries	-	-	- £800
Agencies	-	-	- 50
Special printing	-	-	- 150
Opticians	-	-	- 100
Carriage, packing, and all contingencies	-	-	- 100
			<hr/>
			£1,200
Meteorological telegraphy	-	-	- 2,600
			<hr/>
1 February 1862.	Total	-	-£3,800

40. This estimate shows the heads under which this sum may be divided; but it is to be said that the great expense of supplying *sets of instruments*, gratis, to merchant ships, has almost ceased; because ample results of that judicious annual expenditure, first authorized in 1854, are now in this office, sufficient to occupy all at present employed here during several years. To continue accumulating would tend to overwhelm.

41. Many of these instruments are now employed at telegraph stations—others are still on board a gradually diminishing number of selected ships, and a few are at maritime positions.

42. In addition to these scientific results, the stimulus that has been given to careful observation and record, the information that has been diffused in the mercantile marine—and the consequent direct advantage—in a national point of view—are now well known to have been very beneficial.

43. But having thus shown the way—and demonstrated its advantages—it may remain for others to follow, for their own advantage chiefly, by supplying themselves similarly with instruments, books, and forms—aided, perhaps, by advice—and occasional publications from this department,—but not otherwise continuing chargeable to the public purse.

44. In a scientific point of view, what has been accumulated here, since 1854, may be fully tabulated, discussed, and utilised—it is respectfully submitted, before overloading our shelves, and our minds, with materials increasing continually without advantage.

45. One of the greatest evils of meteorology hitherto has been the practice of incessantly making observations—without very definite objects in view—with the somewhat vague hope that eventually they might become of value; and the natural consequence has been, voluminous records exceeding the grasp of any genius and industry, however combined in individuals.

CHAPTER X.

NATURE AND EXTENT OF RESULTS ATTAINED—CONTEMPLATED PROCEEDINGS—CONCLUSION.

46. THE general effect of this branch of the Board of Trade, among maritime communities of this country and other nations, may be mentally realized by considering the great distribution of instructive publications—the large supplies of forms, with ample directions—and the liberal loans of valuable instruments, gratuitously, to such numbers of able and exemplary officers.

47. These aids have not been confined to British ships, and a considerable demand for our publications has been made by Agents of other countries, in some of which the more popular ones, such as the Barometer Manual; Passage Tables, with directions; and Compass pamphlets, have been translated. A general communication of all our principal publications has been made

regularly among scientific men, and establishments on the Continent,—in America, and elsewhere—assisted greatly by the facilities so kindly afforded to this department by the Government offices.

48. With your permission, Sir, I will now offer remarks on the new, and, as many persons say, important experiments in meteorological telegraphy, instituted under the Board of Trade.

49. In stating the *direction* of wind, distinction must be drawn between the true and the magnetic, as they differ from two to three points of the compass, between the British Channel and the Hebrides; and some observers are not aware that only *two* directions are attempted to be indicated by the cautionary signals. One, when the apex of the cone is upwards, expressing from north polar direction—a gale—from what seamen and meteorologists understand by the polar quarter—as opposed to the tropical or equatorial—which is shown by a cone pointed *downwards*.

50. Each of these so-called quarters is, practically, a semicircle:—one from W.N.W. (true) to E.S.E. : by the north—and the other from E.S.E. (true) to W.N.W. by the south.

N.N.E. and S.S.W. (N.E. and S.W. magnetic) were well termed by Dové the “wind-poles,” as they are the extremes of axial lines, common to all circuits of wind, and having very marked opposite peculiarities, besides mere direction of progress.

51. How connected with magnetism, electricity, and those mysterious “earth currents” which seem to affect north-east and south-west directions, may, before long, be proved by those eminent men who are now investigating this interesting question.

52. Besides an oversight in taking the exhibition of a “north or south cone,” to mean that a gale might be expected from *due north*, or *due south*—and from those points *only*—(although fully explained in the directions sent everywhere round the coast), too little notice may be taken of the fact that no storms are *steady*, or blow long from *one point*—certainly seldom six hours.

53. Seamen know well the marked characteristics of these two great divisions of wind, in all parts of the world, and do not care to calculate the *intermediate* changes, or combinations, to two or three points. They want to know the *quarter* whence a gale may be expected—whether northerly or southerly.

54. Then, as to time. Every seaman will admit, that however useful, and therefore desirable, it would be to know exactly the *hour* of a storm’s commencement—as our acquaintance with meteorology does not enable such times to be fixed—the next best thing is to have limits assigned for extra vigilance and due precaution, which limits are clearly stated in all the printed popular instructions, to be from the *time* of hoisting the signal until *two* or *three days afterwards*.

55. But, say some, and justly—are ships to remain waiting to avoid a gale that, after all, may not happen? Are fishermen and coasters to wait idle and miss their opportunities? By no means. All that the cautionary signals imply is,—“Look out.”

“Be on your guard.” “Notice your glasses and the signs of the weather.” “The atmosphere is much disturbed.”

56. In order to elicit general *opinions*, from known authorities, for comparison with the statistical accounts—letters were addressed to the following places :—Liverpool, Glasgow, Hull, Southampton, Plymouth, Aberdeen, North Shields, Sunderland, Hartlepool, Deal, and Dundee. And, afterwards, a circular was sent to each of the places under-mentioned, namely :—Lloyd’s, Aberdeen, Glasgow, Leith, Greenock, Berwick, Maryport, Whitehaven, Holyhead (Superintendent of Packets), Milford, Llanelly, Swansea, Cardiff, Newcastle-on-Tyne, Sunderland, Scarborough, Bridlington, Hull, Lynn, Yarmouth, Hastings, Brighton, Portsmouth (Commander-in-Chief), Southampton, Portland, Plymouth (Commander-in-Chief), Falmouth, Penzance, Leith, Portrush, Belfast, Kingstown, Galway, Queenstown (Commander-in-Chief), Ardrossan, Cork, Dublin, London, Cowes, Newport, Dover, Southsea, Ramsgate, Rye, and Liverpool Exchange, as well as local authorities.

57. From all these various quarters only *three* replies are decidedly unfavourable to the warning signals as hitherto tried; seven are qualified answers—expressing no decided view—and all the others gave either unqualified favourable opinions, or amplified their expressions of approval by various reasons sufficiently cogent. These decidedly favourable statements were 46 in number.

58. It would unnecessarily occupy time to offer even extracts, here, from the letters of approbation,—I will therefore confine myself to answering *material* objections.

59. To most of the remarks, in objection to such signals; as stated in the seven qualified answers, I have already replied, in anticipation, but there are two, very apposite questions, as yet unnoticed here sufficiently. One asks,—“How can it be known whether a late, or a night signal, applies to that night—or to the following day, or later?” The reply is,—The *local* weather—sunset and sunrise signs—(well known to some, though unheeded by many) and glasses—barometer and thermometer, on the spot. Attention being aroused, the fishermen will not start so early as in the dark long before sunrise, or even daybreak. The coaster will look to his *deck load*, ground tackle, and other precautions; as he starts at the destined hour: and even powerful steamers, having only a short run to make across a comparatively smooth sea—will make all snugly secure—and then exercise special vigilance, knowing that in the vicinity there is or will be bad weather, although it *may* not extend so far as, or contract its circuit to, the very locality then occupied by them.

60. Many remarkable instances have occurred, which show the value of such warnings, or cautionary notices. Some have been published in newspapers, and need not be repeated here; others have been communicated only by private letters; and one or two of them may be properly mentioned now.

61. Admiral Evans wrote that on one evening, after a warning had been given at Liverpool, such a sudden (though brief) storm

swept over the Mersey as would have done much harm, had not the harbour-master made due preparations, because of the signal.

62. A gentleman intending to cross the Irish channel with an invalid lady, was warned to *wait*, though the weather *then* looked beautiful in London. That night it blew a "hurricane" on the west of Ireland, and a gale in the Irish Sea, which lasted the following day.

63. Three ships of war were lying in Plymouth Sound, ready to sail for the West Indies. They waited two days, being cautioned, and then put to sea, in the intervening lull (as it happened), between two gales, the first of which was blowing while they were detained; and the second was a violent cyclone, that crossed France, the Netherlands, and Denmark, of which the northern semicircle swept our south and south-eastern coasts, but was *just avoided* by Her Majesty's squadron, or, rather, utilised by them, as they steered to the westward, nearly before its easterly wind, for some hours, and so passed out clear into the Atlantic.

64. Full warning was given along our eastern coasts, of that storm, in which the Prussian corvette "Amazon" was totally lost; and so struck were the Prussian authorities by the facts of that period—taken in connexion with other known cases—that an official application was soon afterwards made to the Board of Trade for information, with the view of enabling a similar system to be organized in the Baltic, communicating, if possible, with England.

65. Perhaps it may here be said, in passing, that the writer has been honoured by visits, for inquiry into this system, from French, American, Dutch, Belgian, Danish, Austrian, Spanish, Portuguese, and Norwegian authorities, all of whom have been supplied with the Board of Trade publications.

66. Probably, Sir, your own estimate of the subject may be influenced, and not unduly, by knowing that Sir John Herschel, and the Astronomer Royal, the President of the Royal Society, and the first Irish and Scotch meteorological authorities, have written to me, expressing their favourable and very encouraging opinions; while the most eminent continental meteorologist, Dové, has honoured the productions of this department of the Board of Trade, by dedicating his last and best work (on the atmosphere and its storms), to his English follower, *here*.

67. Reverting to a few more instances of useful cautionary signals, it may be noticed, that on the 12th of November 1861, a warning was sent to Yarmouth, in the afternoon. Being nearly dusk—and having then no night signals—nothing was done till next day, *after all* the fishing boats had gone far out to sea—having started very early in the morning. That afternoon there was a storm; and to save their own lives, the fishermen were obliged to cut from and abandon some 40,000*l.* worth of nets and gear. Night signals might have saved that loss, and the imminent risk of many lives. Those means are ready now.

68. On Friday the 7th of March—the warning drum was hoisted all day at Plymouth. *Saturday* was so fine, in *appearance*,

that the caution was not appreciated, and mackerel boats went to a distance—as usual. That afternoon *another* signal was made—South Cone under drum—to show that a heavy southerly gale was coming soon. It was a *beautiful* afternoon. No one anticipated the sequel, except those who, spider like, could “feel along the lines.” Before midnight there was a storm—which lasted much of the next day. One of the boats was lost with eight men. “A more *dangerous* gale had not been known,” was written to me by an officer of experience and good judgment. But I will not here quote more of this nature. In the Appendix are some valuable opinions in the letters of unquestionably good authorities.

69. It is very remarkable that the only objectors, by letter, to the warning signals, are some of the residents at a few contiguous ports in the North; namely, Newcastle-on-Tyne, Shields, Sunderland, and Hartlepool. As the signals have been communicated to Hartlepool, at the special request, *officially*, of the local authorities;—as Sunderland has never had them,—and as Newcastle is so far inland that probably they would not have been sent there—had application been made—it does appear that there is some local view of the whole subject—different entirely from that prevailing at other ports in Great Britain and Ireland. Certainly there are peculiar provisions in those places near Newcastle (formerly treated as creeks of that *chief* port), such as insurance; pay by voyage; and short trips by steam-powered traders, which should not be interfered with, undoubtedly, by any such signals, not *compulsory* in their character. But a signal expressing only “look out” can never be injurious when *understood*. Moreover, I have reason to think that the cards of explanation had not been circulated duly at those places.

70. If it were not for the consideration that *lives* cannot be *replaced* by insurance, like property,—to withdraw the signals and instruments from Shields and Hartlepool, would be an easy step; but even Newcastle, the principal objector, approves of the “records” (reports) and wishes them to be continued (at North Shields).

71. Perhaps sufficient thought has not always been applied to the consideration of mere pecuniary *loss* by wear and tear, risk, accident, delay, and demurrage,—caused by a gale at sea;—balanced against the results of waiting for a tide or two, perhaps *once in two months*, when cautioned by a storm signal.

72. But be this as it may, with coasters, short traders, or even screw colliers—the question is entirely different with ordinary over-sea or foreign going ships—especially when starting from a southern, or from a western port. To such vessels a gale in the channel, or even during the first day or two after clearing the land, must always be very prejudicial. Officers and men are mutually strange. Things are not in their places: often not secured—and the ship perhaps is untried at sea.

73. Of course, however, these remarks are inapplicable to fine first-class ships—and to powerful, well managed steamers, which are independent of wind and weather, and start at fixed hours.

74. And now, Sir, in conclusion, I venture to submit, that the balance of facts is so decidedly in favour of these cautionary signals,—of the weather reports and of the forecasts—that they may be placed on a permanent basis: and that their execution may form a part of the regular duties of the Meteorological Department of the Board of Trade.

I have the honour to be, Sir,

Your obedient servant,

To the Right Honourable

ROBERT FITZROY,

T. MILNER GIBSON, M.P.,

Rear-Admiral.

President of the Board of Trade.

N.B.—*Notwithstanding the extremely stormy weather that has prevailed in the North Sea during the first three months of 1862, the coasts of Durham and Northumberland have had a fortunate immunity from shipwreck, there having been no serious shipping disasters upon that line of coast since November 1861.—("Times," March 29, 1862.)*

APPENDIX.

REPLIES TO INQUIRIES.

DEAR SIR,

20, Water Street, Liverpool, 4th March 1862.

CAPTAIN SPROULE read to the Council of the Mercantile Marine Service Association at their meeting yesterday your letter to him of the 25th of February regarding the opinion entertained by the shipmasters of the port of the practical value of Admiral FitzRoy's storm signals.

I am to acquaint you that several members of the Council stated that, from their own experience, they were able to speak highly of the value of the signals, and further, that it is the opinion of the Council that a knowledge of their value is rapidly gaining ground in the service.

The Council feels that the importance of these signals cannot be too strongly impressed upon shipowners and shipmasters, and considers that every method should be adopted to make them known to all who are likely to be affected by them.

I am, &c.

BEN. J. THOMSON.

PORT OF GALWAY.

Custom House, 6th March 1862.

A STATEMENT of the result of experiments with reference to telegraphic signals sent from the Board of Trade to this port from the 13th September 1861 to the 21st February 1862.

Questions.

Answers.

Have the storm warnings been generally correct in being followed by a storm or bad weather?

Yes, generally so, to the extent of two-thirds of the warnings or more, viz., out of 23 warnings, 16 were correct.

Have they been correct in respect of time of storm?

Yes; except on 21st and 24th September, 12th and 13th November, 13th December, and 11th January last.

Place where it is felt?

Galway and vicinity.

Direction of winds?

Varying from E.S.E. to N.W. or N., but generally from S.S.W. to N.W.

Are they trusted by the seafaring men of the port?

Yes; no seafaring man would now think of unmooring ship after seeing signal hoisted.

Are they found to be practically useful?

Yes; as implied in previous answer.

ALEX. THOMSON, Col., Rec.

Custom House, Whitehaven, 6th March 1862.

Questions.

Answers.

Have the storm warnings been generally correct in being followed by a storm or bad weather?

Yes.

Have they been correct in respect of time of storm, place where it is felt, direction of wind?

Nearly so.

Are they trusted by the seafaring men of the port?

By most of them.

Are they found to be practically useful?

Yes.

I have, &c.

JOHN FOGGO, Col.

SIR,

Custom House, Lynn, 5th March 1862.

IN furnishing the following replies from this locality to the questions put in your circular letter of the 4th instant, the low flat surface of the surrounding country should be kept in mind.

First Question.—With one or two exceptions, they have been followed by high winds.

Second Question.—The storm has generally been simultaneous with the hoisting of the signals, or very shortly afterwards, not exceeding six hours. The direction of the wind has not invariably answered the prediction, but the tendency has been very generally towards the point predicted.

Third Question.—The interest taken in them by the seafaring men cannot be doubted.

Fourth Question.—Their practical utility, from the replies given to the foregoing questions, I think, must be admitted.

Barometrical indications have hitherto been almost unheeded (in many instances entirely unknown) by our coasting captains; but I feel confident the more they are understood, the more they will be appreciated by those very captains whose interests are so deeply concerned.

The whole system is calculated to engage all those feelings which excite us to commiseration and to seek for prevention of sad calamity to a large portion of our fellows in pursuing their hazardous calling. From May last to this time the signals have been worked here by the Customs' staff without one farthing of expense locally, and we are therefore aware of the great interest captains of vessels take in their warnings.

I am, &c.

JAS. TURNER, Collector.

SIR,

Local Marine Board, Glasgow, 5th March 1862.

I AM directed by the Chairman to acknowledge receipt of your communication of the 3rd instant with reference to the attempt which is being made to caution the maritime community against the occurrence of stormy weather, which will be laid before this Board at the first meeting.

In the meantime, I am to state that the apparatus for exhibiting the signals to the public has only been erected here during the last fortnight, and consequently there has not been sufficient experience to enable satisfactory replies to the queries in your communication to be obtained.

A copy of the communication has been handed to Captain Small, and he has been requested in future to note how far the weather here may be in accordance with the predictions.

I find from Captain Small that several seafaring men have expressed to him the service which they have received from such signals at Dublin and elsewhere. This was previous to the apparatus being erected here.

From inquiries which I have made at the Underwriters' Association and among the shipowners here, I do not think any one among their members has kept a record testing the accuracy of the predictions.

I have, &c.

J. MUIRHEAD, Secretary.

Custom House, Newport, Mon.,
5th March 1862.

SIR,

IN reply to yours of the 4th instant, I beg to state that, having made inquiry from parties who would be likely to afford me correct information on the subject of your communication, I am enabled to answer in the affirmative to the several questions set forth in your letter.

A copy of barometer card received.

I am, &c.

R. CULLUM, Collector.

SIR,

Custom House, Berwick, 6th March 1862.

IN reply to your letter of the 4th instant, calling for replies to the questions as subjoined regarding storm signals, I beg to report, after consulting with the coast-guard officer, as follows:—

Questions.	Answers.
Have the storm warnings been generally correct in being followed by a storm or bad weather?	That the warnings have, in some cases, been followed by storms or bad weather, but not "generally."
Have they been correct in respect of—	These questions I have no accurate data for answering, and the inspecting commander of the coast-guard, who forwards the regular returns on Wr. 25, as required, states that he has no record of them, but as an approximation the same answer may be given as to the preceding one, viz., that they have been correct in "some cases."
Time of storm?	There are still doubts entertained by the seafaring population of their accuracy, but, in a few instances, vessels have been delayed on account of the warnings being given; and the fishermen, who are subject to more danger from the frailty of their vessels, I believe, pay more attention to the warnings than others. Masters of large craft, however, go to sea in many cases when the warning has been given.
Place where it is felt?	
Direction of wind?	
Are they trusted by the seafaring men of the port?	The answer to this question hangs, in a great measure, on the reply to the foregoing, and I am too diffident in my judgment of such matters to hazard an explicit rejoinder.
Are they found to be practically useful?	I am, &c. HENRY GATES, Collector.

SIR,

Custom House, Maryport, 6th March 1862.

I HAVE to acknowledge the receipt of your letter of the 4th instant, containing certain questions having reference to storm warning signals.

I may state that the first telegram was received here on the 13th September last. Previous to that date, however, the seafaring part of the population at this place had manifested considerable interest in the readings of the barometer (supplied by Government), as notified from time to time on an index board attached to the front of this office, and in the tabulated records of these, and other particulars respecting the weather, kept by me; the cautionary warnings were, therefore, received with a faith which a previous introduction to the science of meteorology had created.

The answers follow this.

1st. The storm warnings have generally been followed by a storm or bad weather. On several instances when the north cone was hoisted, Maryport has been exempted from strong winds from the quarter indicated, although these have prevailed on the east coasts of England and Ireland. I believe those escapes from dangerous polar winds are due to the shelter the high lands to the north-east affords, which has the effect of throwing the wind over our heads. This was manifested in the memorable and disastrous gale of the 9th February 1861, which was only experienced in its intensity, as the large fleet which sailed from hence got clear of the English land.

2nd. The signals have generally been correct in respect of time, place, and direction of wind. On one or two occasions the gale (from the south) was raging when the telegram was received.

3rd. The warnings are trusted by the seafaring men, and especially by those belonging to the port.

4th. The warnings are generally acknowledged to be practically useful. There is a class of vessels employed in the carriage of coals between this port and the Irish coast that require the most favourable weather throughout the

voyage. It was for the benefit of the seamen navigating those that I solicited and had the warnings sent here, and I am satisfied that their use has been most beneficial.

I am, &c.

HENRY LINDSAY, Collector.

SIR, Local Marine Board, Belfast, 6th March 1862.

I AM directed by the Local Board to acknowledge your letter of the 3rd instant, respecting the storm signals at this port, and to state that, both from observation and inquiry of those capable of judging, this Board is enabled to speak most favourably of those signals, and is also of opinion that night signals should be in use as well as the day.

Answers to the queries sent will be found on another page of this letter.

I have, &c.

W. SKINNER, Sec. to Board.

Questions.

Answers.

Have the storm warnings been generally correct in being followed by a storm or bad weather?

Yes.

Have they been correct in respect of time of storm? Place where it is felt? Direction of wind?

Generally correct if wind from the southward; sometimes late when wind from the northward.

Are they trusted by the seafaring men of the port?

Yes, very generally.

Are they found to be practically useful?

Yes.

SIR, Custom House, Penzance, 6th March 1862.

IN reply to your letter of the 4th instant respecting the storm warning signals, I beg leave to reply to the questions proposed in the order in which they stand, viz. :—

Questions.

Answers.

1. Have the storm warnings been generally correct in being followed by a storm or bad weather?

Yes.

2. Have they been correct in respect of time of storm?

Yes, generally so.

3. Place where it is felt? Direction of wind?

Mount's Bay and Penzance; from W.S.W. to S.E.

4. Are they trusted by the seafaring men of the port?

I believe so.

5. Are they found to be practically useful?

Yes.

I am, &c.

W. H. HOLMES, Collector.

SIR, Pembroke Yard, 6th March 1862.

I BEG to acknowledge the receipt of your letter of the 4th instant respecting storm signals, with enclosed copy of barometer card, and requesting answers to the following questions :—

Questions.

Answers.

Have the storm warnings been generally correct in being followed by a storm or bad weather?

I have only received two telegrams on this subject, one dated 4th July 1861, from the Admiralty, viz. :—"A gale from S.W. and afterwards "N.W. is expected by Meteorological Department, "Board of Trade." No storm or bad weather followed.

Questions.

Answers.

One dated 17th February 1862, from Admiral FitzRoy to telegraphist, Milford, viz.:—"Inform Superintendent of Dockyard and Coast Guard that South Cone is hoisted where ready." Strong breezes from S.E. had been blowing previously, and continued for about two days after.

Have they been correct in respect of time of storm?
 Place where it is felt?
 Direction of wind?
 Are they trusted by the seafaring men of the port?
 Are they found to be practically useful?

I am unable to give replies to these questions. As I was not furnished till last week with the barometer card and particulars of the system, it has not yet been carried into execution, but preparations are being made for doing so.

I propose to adopt it at St. Ann's Head, and the signalman of the telegraph station to attend to it there, as I consider such information would be very useful to vessels in the Channel passing the Head.

Arrangements might be made at Milford with the Custom House Office to hoist the signals there, which could be seen by vessels at anchor inside the haven, where the information would be serviceable.

There are no Coast Guard men at St. Ann's Head, nor at Milford. The nearest Coast Guard station to the former place is nine miles distant, and to the latter place three miles, viz., Hobb's Point.

I am, &c.

W. RAMSAY,

Captain Superintendent.

SIR,

Lloyds (E.C.), 6th March 1862.

I AM instructed by the Committee for managing the affairs of Lloyds to acknowledge the receipt of your letter of the 3rd March, enclosing copy of the barometer card and storm warning signals, which have been in use during the past year, and inquiring what has been the general result as far as the Committee's knowledge goes.

In reply, the Committee direct me to acquaint you that the storm warnings have not been in use a sufficient time at this establishment to enable them to form any opinion on the subject, but the subscribers take a great interest in the matter; and the Committee will be much pleased if, after a longer observation, they should feel able to offer an opinion.

I have, &c.

JOHN POLITO.

SIR,

Custom House, Swansea, 6th March 1862.

WITH reference to your circular of the 4th instant, directing me to report, for the information of the Board of Trade, the result of the experiments of the storm signals in operation at this port in the changes of the weather, from the telegrams occasionally received from the Meteorological Department, I beg to state—

- 1st. That the storm warnings received have been generally correct, in being followed by a storm or bad weather.
- 2nd. That for the most part they have been correct in respect of time of storm.
- 3rd. That the place where it has been felt in this district is the Bristol Channel.
- 4th. That the direction of the wind has been mostly south and S.E.
- 5th. That the seafaring men at this port consider the warnings generally correct.
- 6th. That as far as this port is concerned, the warning signals are found to be practically useful.

I am, &c.

THOS. FERRIS, Collector.

SIR, Local Marine Board, Shipping Office, Leith,
7th March 1862.

IN reply to your letter of the 3rd instant, and by direction of the Local Marine Board of this port, I herewith transmit an extract of their minutes of meeting on this date in reference to the storm signals and their efficacy.

I am, &c.

THOMAS THOMPSON, Secretary.

(Extract.)

At a meeting of the Local Marine Board, held at Leith on the 7th March 1862,—

PRESENT :

Messrs. George A. McLaren.

„ James G. Thomson.

„ John K. Wishart.

Messrs. Mungo C. Gibson.

„ Thomas Lindsay.

Mr. McLaren in the chair.

The following business was brought before the meeting :—

A letter from the Board of Trade, of 3rd instant, addressed to the Secretary, Local Marine Board, Leith, with copy of the barometer card, explaining the nature of the storm signals used :—

“ And as the Board of Trade are now anxious to learn the result of these experiments, they will be obliged if the Local Marine Board will favour them with such answers as they can give to the following questions :”—

Questions.	Answers.
Have the storm warnings been generally correct in being followed by a storm or bad weather?	Yes.
Have they been correct in respect of time of storm?	Generally.
Place where it is felt?	Outside entrance of the Firth of Forth, about Dunbar.
Direction of the wind?	North-easterly.
Are they trusted by the seafaring men of the port?	Generally, although the home trade steamers sail at their appointed times.
Are they found to be practically useful?	Yes, and particularly so by the fishermen.
Time of storm?	Not ascertained.

I have, &c.

GEORGE A. McLAREN, Chairman.

(Extracted by Thomas Thompson, Secretary.)

SIR, “ Victory,” at Portsmouth, 7th March 1862.

REFERRING to your letters of the 6th instant, I beg leave to answer the questions therein set forth as follows :—

Questions.	Answers.
1st. Have the storm warnings been generally correct in being followed by a storm or bad weather?	Generally so.
2nd. Have they been correct in point of time of storm? Place where it is felt? Direction of wind?	Generally so.
3rd. Are they trusted by the seafaring men of the port?	The captains of men-of-war would rely chiefly on their own observations. I have no means judging of others.
4th. Are they found to be practically useful?	Yes, I should say so where there are no barometers, or where there are barometers and no persons who well understand that instrument.

Questions.

Answers.

5th. What is the opinion entertained generally in this neighbourhood respecting the "forecasts" of weather?

I have no means of knowing.

6th. Do I gather from others, and do I concur in a wish that they should be continued, or, on the other hand, does it appear rather expedient that they should be discontinued?

The answer to No. 4 question will apply to this. I see no reason why they should be done away with, nor have I heard any one express an opinion to that effect.

I have, &c.

H. W. BRUCE,
Vice-Admiral, Commander-in-Chief.

SIR,

Underwriters' Rooms, Liverpool, 7th March 1862.

I AM directed by the Committee for managing the affairs of the Liverpool Underwriters' Association to state, in reply to the inquiries contained in your letter of 3rd instant, that, while much interest has been felt here in the experiment which has been made by the Board of Trade in giving cautionary or warning storm signals, no record of the general result, so far as Liverpool is concerned, has been kept at these rooms. Reference has, however, been made to the registers kept at the Liverpool observatory, and it has been found that stormy or strong winds have generally attended or followed the exhibition of the warning signal, and that few, if any, strong winds of considerable duration have been experienced except at these times.

Many of the seafaring men of this port are said to have been misled by the signals, through not understanding that they were cautionary merely, and objections have been made to them in consequence; but so far as this Committee can judge, they believe these signals to be useful when taken with the limitations so clearly pointed out on the barometer card which accompanied your letter.

The utility of the signals at any station, more especially at a large port like Liverpool, would no doubt be much enhanced if, as pointed out in the barometer card, local arrangements were made for getting information from neighbouring stations; for example in the case of Liverpool, if reliable data were simultaneously reported from Ormshead, Holyhead, Dublin, Fleetwood, and Whitehaven.

I am further directed by the Committee to express the hope that the experiment which has been tried during the last twelve months may not be judged too severely by the test of immediate and practical results. This time appears too short for trying a matter of so much general interest, and the collateral as well as the direct results should, it is thought, form an element in the consideration of this question. It should also be remembered that the experiment is one which can only be fairly tried by the aid of Government.

THOMAS COURT, Secretary.

SIR,

Custom House, West Hartlepool, 7th March 1862.

WITH reference to your letter of the 4th instant, on the subject of Admiral FitzRoy's storm signals, I beg to state, so far as I am able to do so, in reply to the questions put, that the signals alluded to have been generally followed by bad weather, but on many occasions they have not been correct, either as to time of storm or direction of wind; and they do not appear to be yet much trusted to by the seafaring men of the port, nor considered by them as of practical utility.

I am, &c.

J. MACKENZIE, Collector.

SIR,

Custom House, Ardrossan, 7th March 1862.

IN reply to your letter of the 4th instant, I beg to submit the following replies to the questions it contains, the result of my own observation and of the coast-guard officers who have charge of the signals.

The storm warnings have been generally correct in being followed by a storm or bad weather. They have been generally correct also in respect of the time

of storm occurring here from 8 to 12 hours after receipt of a telegram to hoist the signals; and in reference to the place where it is felt and the direction of the wind, a similar result has been observed. The seafaring men of the port in almost all cases are guided by them, and I have no hesitation in saying that they are found to be practically very useful to mariners.

I am, &c.

G. H. MAY, Collector.

SIR,

Custom House, Yarmouth, 8th March 1862.

IN reply to your letter of the 4th instant, relative to the storm warning signals, I beg to transmit on the other side hereof answers to the questions contained therein, for the information of the Board of Trade.

I have, &c.

WILLIAM MACLEAN, Collector, &c.

Questions.

Answers.

Have the storm warnings been generally correct in being followed by a storm or bad weather?

In most instances during the earlier portions of year they have, but latterly the weather here, particularly with the south cone, has not been such as to cause apprehension.

Have they been correct in respect of time of storm, place where it is felt, and direction of wind?

This question appears in part to be replied to by the first answer, the circuits of the southerly and westerly gales during the latter part of last year not generally having extended to this port; but on the occasions in which they reached this, the wind usually rose for a short time only on the third day, or about sixty hours after the warning signal had been hoisted, and in some instances the worst of the weather had been experienced previous to the warning signal.

Are they trusted by the seafaring men of the port?

There are different opinions on this point, but I believe the prevailing one to be that ultimately they will become very useful. The plans are considered to require further development.

Are they found to be practically useful?

On this point also there are divers opinions. When the warning signal is hoisted the fishing vessels, in some cases, have refused to proceed to sea, although no local circumstances appeared to indicate danger or to warrant apprehension of bad weather. And as these voyages often do not exceed 24 hours' duration, much time and profit are lost. Others think that the signals have a tendency to make the mariners timid. And there appears also a wish to have the time of the expected storm more defined. For instance, a vessel whose destination might be reached in 20 hours, if in a direction contrary to that from whence the storm is anticipated, might make her voyage, whilst delay would be the cause of the storm overtaking her. This actually occurred to two vessels which were ready to sail from this during last autumn. The one that pushed on notwithstanding the storm signal being up reached her destination in safety; the vessel which delayed to sail and put to sea afterwards was caught in the storm and was lost. I must, however, especially remark one way in which these warning signals appear to be extremely useful, and that is, although the masters of vessels may put to sea, yet knowing that a storm is pending, they are careful to see that all is right or snug before retiring to rest at night, and are in a measure prepared to jump on deck on the first symptoms of bad weather. The telegraphist informs me that he has many personal applications from masters of vessels for information and advice relative to these signals, which he considered will ultimately be of great value to the seafaring community.

SIR, Custom House, Llanelly, 8th March 1862.

WITH reference to your letter of 4th inst. I beg to report,—

1st. The storm warnings have been generally correct.

2nd. They have been most correct in—

- (1.) Time of the storm.
- (2.) Place where it is felt, and
- (3.) Direction of wind.

3rd. They were not at first much trusted, but they are now very much relied on by the seafaring men of the port.

4th. They are found to be practically very useful.

I am, &c.
R. V. INNES, Collector.

SIR, Custom House, Southampton, 8th March 1862.

IN answer to your letter dated the 4th instant, requesting replies to a series of interrogatories desiring to learn the result of the storm warnings exhibited from time to time at the telegraph signal station at this port, I beg leave to furnish such answers on the other side hereof as my own observations, and the information I have derived from experienced persons, nautical and others, enable me.

I am, &c.
J. R. BEAUMONT, Collector.

Questions.

Answers.

Have the storm warnings been generally correct in being followed by a storm or bad weather?

As far as my observation has gone, and from inquiries I have made, I believe such to have been the case.

Have they been correct in respect of time of storm, place, and direction of wind?

I have reason to believe almost invariably so.

Are they trusted by the seafaring men of the port?

They are highly appreciated by all, and are to a considerable extent relied upon, by the masters of sailing vessels especially.

Are they found to be practically useful?

The great bulk of the traffic of this port being carried on by a large class of steam ships, nearly all of which carry mails, the fixed time of sailing is rigidly observed, notwithstanding the storm signals give warning of dangerous weather. With sailing vessels, as I learn from the best authority, a growing confidence pervades the commanders, who have on several occasions been beneficially influenced by the signals.

J. R. BEAUMONT, Collector.

SIR, Admiralty House, Devonport, 9th March 1862.

I HAVE to acknowledge the receipt of a communication from the Marine Department of the Board of Trade, dated the 6th inst., in which I am requested to state, for the information of that Board, what is the opinion entertained generally in this neighbourhood respecting these "forecasts" of weather, and cautionary or storm warning signals; and further, if I gather from others, and if I concur myself in a wish that they should be cautioned, or, on the other hand, does it appear rather expedient that they should be discontinued.

I readily comply with this request, and beg to state that, so far as I have been made aware of the opinions of this neighbourhood, I think it very generally favourable to these warning signals. Seafaring people are proverbially averse to novelties, but already some of the oldest and most obstinate of them begin to look with some degree of confidence to the display of the cone and drum. It is evident that the power to make a correct forecast of the weather, "its time of storm," "where it will be felt," and "the direction of the

wind," must, *as yet*, be very imperfect, and somewhat uncertain; but I entertain no doubt that, with further experience and close observations, a very great improvement in accuracy, and consequently in value and importance, will be attained.

The signals transmitted to Plymouth during a great portion of last year have been remarkably near the truth; and I may give as a practical illustration of this, the fact that on Friday last we had *strong gales*, the *drum hoisted*. Yesterday (Saturday) it was moderate in the morning, so much so that H.M.S. St. George was brought from the Sound into Hamoaze; at 4 h. 26 m. p.m., telegram to Plymouth, "Hoist south cone under drum."

It continued moderate and fine weather until between 9 and 10 p.m., when it commenced blowing *strongly*, with heavy squalls from the south, and *at this moment* (10 a.m.) it is blowing a *hard gale of wind* from the S.S.W., and I do not recollect to have seen a heavier sea on the breakwater than we have just now.

In conclusion, I will only add that I should very deeply regret the discontinuance of these storm warnings, and that I believe many of the most intelligent people of this neighbourhood would participate in that regret.

It is at every man's option to regard or to *disregard* these signals, but if persevered with, their value and importance, as an aid to the preservation of life and of property, will be (perhaps gradually, but ultimately generally) acquiesced in and gratefully acknowledged by "those who go down to the sea in ships, that do business in great waters."

I am, &c.

HOUSTON STEWART,
Vice-Admiral and Com.-in-Chief.

SIR,

Custom House, Lowestoft, 10th March 1862.

I AM unable to answer the queries contained in your circular letter of the 4th inst. relative to the storm warnings, in consequence of there being *not* any signal drums provided for the purpose at this port.

I am, &c.

M. ROBERTSON, Collector.

MY DEAR SIR,

Custom House, Deal, 17th February 1862.

As Admiral FitzRoy's storm signals have never been published or made generally known at Deal, the boatmen, and others interested in the matter, have not had an opportunity of judging of their correctness, or how far they can be relied on with advantage. I regret exceedingly, therefore, that I am unable, from inquiries, to furnish you with any information on the subject. It has, however, been intimated to me that one of Admiral FitzRoy's barometers would be of very great service placed in some central part of Beach Street for public inspection, and as the Customs watch-house is well situated for such a purpose, I think, in the event of the Board of Trade ordering one to be supplied, that it could not be fixed at a more convenient place; besides which, notice of approaching storms could be signalized to vessels passing through or anchoring in the Downs from our flagstaff, one of the highest and most conspicuous in the town.

I remain, &c.

JOHN D. A. DUMARESQ.

SIR,

Custom House, Falmouth, 11th March 1862.

IN reply to your letter of the 4th instant, relative to the storm signals in use, I have the honour to report, for the information of their Lordships, that the master, mariners, and pilots of this port have hitherto placed but little confidence in them. This may be in some measure accounted for by the tenacity with which seafaring men cling to their own experiences of atmospheric influences, and also by the fact that the signals have only been "occasional," sometimes preceding a storm, at other times hoisted when it is subsiding, and instances have occurred when the signal has been hoisted in fine weather, I am therefore of opinion that the utility of the signals has yet to be established. If seafaring men and pilots are expected to rely upon them, they should precede

every storm, and correctly indicate its direction. In this locality, situate as it is between two seas, storms are sudden and violent, possibly the outer edge only of a "cyclone" is felt, of which but little previous warning might exist here, and none, perhaps, 100 miles inland.

The theory has been of material benefit, and has excited that amount of attention which its importance deserves. Whether, if the signals were under local management, to be hoisted under certain and indisputable conditions, they would have the confidence of the public, may be for consideration.

There can be no doubt that the valuable barometers which are distributed around the coasts of the United Kingdom will be always made use of and be appreciated; but uncertain warnings have a tendency to frighten the timid and to be an excuse for the lazy to remain in port when they may be losing a fair wind.

I am, &c.

J. HUGHES, Collector.

SIR, "Hawke," at Queenstown, 11th March 1862.

WITH reference to the letters addressed to me from the Board of Trade on the 6th instant, on the subject of storm signals, I have the honour to state that my residence at Queenstown is of too short a duration to enable me to give an opinion on the usefulness of the storm signals at this place.

The winds here appear to me to be much influenced by the tides, and are frequently very different both in strength and direction from what they are found to be outside the harbour.

The "Revenge" and "St. George" left Queenstown on Thursday, 27th February, for Plymouth, the wind from the eastward; both ships experienced a heavy gale, and the "St. George" put into Scilly; during the same gale one of the Cork passenger boats suffered very much from its violence in her cargo, yet during the period of this gale in the Channel the force of the wind at Queenstown was from two to three.

I think, however, that the system of "storm signals" should be continued, in order to give it a fair trial.

I have, &c.

ROBT. SMART, Rear-Admiral.

SIR, Custom House, Cowes, 11th March 1862.

HAVING made every inquiry on the subject of your letter of 4th instant, I beg to report that in some instances it has been blowing very hard just previously to the telegram being received, occasionally at the time it was received, at other times (perhaps in a majority of cases) the signals have been correct as to time, and within a point or two in the direction of the wind, varying from S.S.W., &c., and in a few instances from an opposite quarter.

The signals are not generally trusted by the seafaring men at Cowes, who seem much wedded to notions they have gained by a long experience in watching the local indications of the weather.

If the wind is fair for them to proceed on their voyage, and a storm signal was hoisted, indicating a storm from an opposite direction, it is my opinion the masters of the vessels would not be influenced by it, but would proceed to sea.

The storm warnings cannot, therefore, at present be considered practically useful; eventually they may become so if the seafaring men find them to be correct as to time and the direction of the wind, &c.

I am, &c.

W. DREW, Collector.

SIR, Custom House, Dover, 11th March 1862.

IN return to your letter of the 4th instant, enclosing copy of the barometer card, and requesting answers to certain questions respecting the storm signals, I now beg to give (on the other side) replies thereto.

I am, &c.

G. SAUNDERS, Collector.

Questions.	Answers.
Have the storm warnings been generally correct in being followed by a storm or bad weather?	Yes.
Have they been correct in respect of time of storm?	Generally so.
Have they been correct in respect of place where it is felt?	Generally so.
Have they been correct in respect of direction of wind?	Generally so.
Are they trusted by the seafaring men of the port?	By the fishermen, but not so much by masters of colliers and other coasters.
Are they found to be practically useful?	Yes.

COPY of REPORT on STORM WARNING SIGNALS from Inspecting Commander, Coast Guard, Southsea.

Questions.	Answers.
Have the storm warnings been generally correct in being followed by a storm or bad weather?	Certainly.
Have they been correct in respect of,—	
Time of storm?	In most cases.
Place where it is felt?	Portsmouth.
Direction of wind?	South, south-west, south-east.
Are they trusted by the seafaring men of the port?	Yes, certainly more so than some months back.
Are they found to be practically useful?	To ensure efficiency the signal warnings I consider should be hoisted at lighthouses, so that ships in channel as well as those in port should be warned. The signal warnings I consider of the utmost importance, particularly in ports where large fleets of coasters and fishing smacks resort, this class of vessels having no kind of indicator on board.
	E. F. K. WASEY, I. C.

SIR,

Custom House, Portsmouth, 11th March 1862.

HEREWITH I transmit replies to the several queries contained in your circular dated the 4th instant.

I am, &c.

WM. J. REDPATH, Col.

Questions.	Answers.
Have the storm warnings been generally correct in being followed by a storm or bad weather?	Yes.
Have they been correct in respect to time of storm, place where felt, duration of wind?	They have been generally correct in all these particulars.
Are they trusted by the seafaring men of the port?	They were at first looked upon with indifference, but in consequence of their accuracy there is now a considerable amount of reliance placed on them.
Are they found to be practically useful.	They are, and of the utmost importance to coasters and fishing vessels, which rarely have any indicator on board.

SIR, Local Marine Board Shipping Office, 2, Deane Street, Cork,
11th March 1862.

I AM directed by the Local Marine Board to acknowledge the receipt of your favour of the 3rd instant, requesting them to answer certain questions relative to the working of storm signals at this port.

The Board not having taken very particular notice as to the results, instructed the shipping master to make such inquiries as would enable them to answer the queries required, which I now forward.

Questions.	Answers.
Have the storm warnings been generally correct in being followed by a storm or bad weather?	They have.
Have they been correct in respect of time of storm?	Generally.
Direction of wind?	Very correct.
Are they trusted by the seafaring men of the port?	By the majority.
Are they found to be practically useful?	They are.
	I have, &c.
	JOHN H. HALL, Secretary.

SIR, Local Marine Board, Aberdeen, 12th March 1862.

I AM directed by the Local Marine Board of this port to acknowledge receipt of your communication of the 3rd instant, respecting Admiral FitzRoy's storm warning signals, and requesting replies to certain questions on the subject; and I am instructed to state that so far as the members of this Board have learned from personal observation, and otherwise, the warnings at Aberdeen have been generally followed by a storm or bad weather, if not always in this immediate locality, at least in neighbouring localities.

The time has also been generally correct, and likewise the direction of the wind. Many of the more intelligent of the seafaring population pay great attention to them, and have a certain amount of confidence in them. They have frequently been found useful, and will, in the opinion of this Board, be found more so as they come to be better understood.

The Local Marine Board have much pleasure in observing that the signals are about to be restored to their former conspicuous position in the middle of the harbour.

I have, &c.
JAMES F. KELLAS.

COPY of REPORT on STORM WARNING SIGNALS from the Inspecting
Commander, Coast Guard, Berwick.

Questions.	Answers.
Have the storm warnings been generally correct in being followed by a storm or bad weather?	Mostly so.
Have they been correct in respect of—	} On the whole the result very satisfactory.
Time of storm?	Not always.
Place where it is felt?	Not always.
Direction of wind?	Not always.
Are they trusted by the seafaring men of the port?	Yes, when supported by barometer indications they certainly render the men most cautious.
Are they found to be practically useful?	Yes, most decidedly so.

COLIN CAMPBELL KANE, Inspecting Commander.

12th March 1862.

SIR,

Custom House, Cardiff, 13th March 1862.

IN answer to your letter of the 4th instant, requesting, for the information of your Board, certain information as to the result of the experiments of the storm warning signals, I beg to say that prior to December last this matter was not in any way brought under my notice. Communications from the office in London to hoist signals, &c., were, I think, made to Commander Durnford, Dock Master, at the pier head, so that I have no record to supply any of the information required up to that period.

On the 11th December last I forwarded my first form Wr. 25, and I have forwarded three reports subsequently, and beg to subjoin all the information it is in my power to give in answer to your queries.

Had I have been aware that such a report would have been required of me, I would have noted down particulars at the time of each warning signal report being returned, which I will do for the future.

I am, &c.

T. S. MILLER, Collector of Customs.

Questions.

Answers.

Have the storm warning signals been generally correct in being followed by a storm or bad weather?

Yes; during my record two cases out of four, one of them to a degree most marked.

Have they been correct in respect of—

Time of storm?

Yes; within the 72 hours.

Place where it is felt?

Yes.

And direction of the wind?

Yes.

Are they trusted by the sea-faring men of the port?

Yes, generally very much so; particularly by the superior class of masters of vessels. Some treat the matter with indifference.

Are they found to be practically useful?

I can hardly answer this. I have no doubt, as far as the short observation of the effect produced here has been known to me, much property and probably many lives have been saved.

SIR,

Bridlington Quay, 13th March 1862.

IN reference to your letter of the 4th instant, containing questions relative to the storm signals, I beg to send the enclosed replies to the best of my belief.

Questions.

Answers.

Have the storm warnings been generally correct in being followed by a storm or bad weather?

Generally.

Have they been correct in respect of—

Time of storm?

Generally.

Place where felt?

Generally.

Direction of wind?

Generally.

Are they trusted by the seafaring men of the port?

At first they were not; but I think they are gaining confidence in them.

Are they found to be practically useful?

I should say they are.

I have, &c.

HUGHES HICKS, I.C.

SIR,

Shipping Office, Newcastle, 14th March 1862.

IN acknowledging the receipt of your letter of 3rd March, enclosing a barometer card, together with certain questions which you did me the honour to ask me to move the Local Marine Board to answer to the best of their ability, such questions all bearing upon the use or otherwise of "the storm warnings," introduced in 1861.

I have the honour to send you the answers to each question proposed to the consideration of this Local Board, together with their concluding remark on the system of record upon which such "storm warnings" are based; the whole being unanimously agreed to at a very full meeting of the Board held in this office yesterday, 13th inst.

In conclusion, I beg you to excuse the delay which has occurred in replying to your letter, and to be assured that

I remain, &c.

ROBERT JOBLING,
Secretary to the Local Marine Board.

Questions.

Answers.

Have the storm warnings been generally correct in being followed by a storm or bad weather? By no means "generally," only very partially so.

Have they been correct in respect of time of storm? No.

Place where it is felt? Direction of wind? No record.

Are they trusted by the seafaring men of the port? No.

Are they found to be practically useful? No.

The Local Marine Board, however, highly approve of a record being kept, as is now done under the orders of Admiral FitzRoy.

SIR, Local Marine Board, Plymouth, 14th March 1862.

I AM directed by the Plymouth Local Marine Board to acquaint you, for the information of the Lords of the Committee of Privy Council for Trade, that, speaking as well from the individual knowledge of some of the members of the Board as from information which the Local Board has upon inquiry been able to obtain, the following answers appear to be applicable to the questions contained in your letter of the 3rd inst., respecting the storm signals which have been lately exhibited at this port, viz :—

Questions.

Answers.

Have the storm warnings been generally correct in being followed by a storm or bad weather?

They have been generally correct.

Have they been correct in respect of—

Time of storm?

Answering this question with relation to the time of storm mentioned in the printed card as occurring in some part of the next nights and two or three days, and this port as the place where felt, the answer as to each part of this question would be in the affirmative, and that occasionally storms have followed within a very short time after the hoisting of the signals.

Place where it is felt?

Direction of wind?

They are not as yet universally relied on, not having been in use sufficient time to convince all that they may be trusted.

Are they trusted by the seafaring men of the port?

Are they found to be practically useful?

They are so in many instances, and the Local Board expect they will be more so when it is found from experience that they may be relied on.

With reference to the storm signals, an instance occurred here on Sunday last. On the previous day the weather was fine, and several mackerel boats went out to sea in the morning; late in the afternoon the storm signals, drum and cone with point downwards, were hoisted; in the night the gale came on and blew very violently, and on Sunday morning there was a storm from the south-west, and a heavier sea than has been known for a great many years in Plymouth.

It was with difficulty the mackerel boats got back to port, and one, driven out of her course, was upset and foundered close by the breakwater, and all hands were lost. The mackerel men in the port say if the signals had been up in the morning they would not have gone to sea.*

I have, &c.

JOHN KELLY, Secretary.

SIR,

Admiralty Office, Holyhead, 14th March 1862.

WITH reference to your two letters of the 6th inst., requesting information on the subject of *storm warning signals*, I have the honour to observe that after diligent inquiry amongst the seafaring community of this port, I am led to believe that their opinions on this subject are as follows:—

1. That the storm warnings have been generally correct in being followed by a storm or bad weather.

2. That they have been generally correct in

Time of storm,
Place where it is felt,
Direction of the wind.

3. That they are trusted by the general run of the seafaring men of the port, but the hovellers and beach-men form a notable exception to this, as these people consider the signals to be perfectly useless. It may be observed that the more merchant ships are compelled to put back into port the greater the profit of this class, and as these signals certainly tend to prevent vessels from going to sea unless when the weather is likely to be fine, and thus their return to port is infrequent, it may be that diminished pecuniary gains may have something to do with this opinion. I have reason to think this to be the case.

4. They are found to be practically useful.

On several occasions, and especially twice this month, no bad weather has followed the exhibition of these signals, but the newspapers of the following days have shown that a storm has been raging within a comparatively short distance of us, or the packets have made known its prevalence in the channel.

I gather that there is a general wish that these signals should be continued, a wish in which I concur.

I am, &c.

BENJAMIN P. PRIEST,

Commander R.N., conducting the Packet Service,
and Queen's Harbour Master.

COPY of REPORT on STORM WARNING SIGNALS from Inspecting Commander, Coast Guard, Bridlington Quay, Yorkshire.

Questions.	Answers.
Have the storm warnings been generally correct in being followed by a storm or bad weather?	Generally.
Have they been correct in respect of time of storm, place where it is felt, direction of wind?	Generally.
Are they trusted by the seafaring men of the port?	At first they were not, but I think they are gaining confidence in them.
Are they found to be practically useful?	I should say they are.

DOUGLAS HERBERT, Inspecting Commander.

13th March 1862.

* The warning drum *was* shown there, in several places, from *noon till dusk* on the previous day, namely, Friday, the 7th.—R.F.

COPY of REPORT ON STORM WARNING SIGNALS from Inspecting Commander, Coast Guard, Greenock, N.B.

Questions.	Answers.
Have the storm warnings been generally correct in being followed by a storm or bad weather?	Yes.
Have they been correct in respect of—	
Time of storm?	Yes.
Place where it is felt?	Yes.
Direction of wind?	Generally.
Are they trusted by the seafaring men of the port?	By the majority, yes; others are sceptical.
Are they found to be practically useful?	To the best of my belief they are.

J. C. CAMPBELL, Inspecting Commander.

12th March 1862.

SIR,

Custom House, Rye, 15th March 1862.

WITH reference to your letter of the 4th instant, missent to Hastings, with regard to the experiments made to caution the maritime community against the occurrence of stormy weather.

I have made every inquiry of the fishermen and others at Hastings, and I beg to report in answer to your questions that the warnings have been generally correct.

Questions.	Answers.
2ndly. Time of storm?	Occasionally late.
3rdly. Place where felt?	Hastings.
4thly. Direction of wind?	Generally southerly.
5thly. Are they trusted by the seafaring men of the port?	Not at first, but are more trusted now.
6thly. Are they found to be practically useful?	Yes.

I am, &c.

J. K. GROOM, Receiver of Wrecks.

SIR,

Custom House, Scarborough, 17th March 1862.

I BEG herewith to return the most correct answers to questions contained in a letter dated 4th instant, from my Lords of the Privy Council for Trade, as from my full inquiry I have been enabled to obtain, respecting the "*storm warning signals*;" observing that the signals at present erected at this port from *their situation* cannot advantage any but vessels in the harbour about to proceed to sea. The letter, with answers thereon, enclosed.

I am, &c.

J. P. HAYTON, Collector.

Questions.	Answers.
Have the storm warnings been generally correct in being followed by a storm or bad weather?	In general correct, but sometimes at a distance from Scarborough.
Have they been correct in respect of time of storm, place where it is felt, direction of wind?	No means of sending in a return, as there is no record.
Are they trusted by the seafaring men of the port?	To a certain extent.
Are they found to be practically useful?	Yes; I am informed that they have prevented vessels proceeding to sea before a coming storm.

SIR,

Custom House, Holyhead, 17th March 1862.

IN reply to your letter of the 4th instant, I beg to state that after making every possible inquiry I am of opinion—

That the storm warnings have been *generally* correct in being followed by a storm or bad weather.

That they have been correct in respect of time of storm, place where it is felt, and direction of wind.

Also that they are trusted by the seafaring men of the port, and are found to be practically useful.

I must, however, state that the above opinion is not entertained by the hobblers and boatmen of this place, and can only account for their objections by the fact that in consequence of bad weather being foretold by the signals vessels do not so frequently attempt to leave the refuge harbour, and therefore their services are not so often required.

I must also state that, *generally*, the signals arrive here after the commencement of bad weather, and that in the two last cases no bad weather was experienced at this place after the signals were hoisted.

In conclusion, I may remark that the storm warnings are particularly useful in a harbour of refuge like the one we have here, where so many vessels are assembled waiting for fine weather.

I am, &c.

E. B. CUNNAH, Deputy-Receiver.

COPY of REPORT on STORM WARNING SIGNALS from the Inspecting Commander, Coast Guard, Brighton, Sussex.

Questions.

Answers.

Have the storm warnings been generally correct in being followed by a storm or bad weather?

Not generally correct.

Have they been correct in respect of—

Time of storm?

Correct on the 7th and 8th March, being followed by a gale on the 9th from daylight until midnight.

Place where it is felt?

Coast of Sussex.

Direction of wind?

From the southward.

Are they trusted by the seafaring men of the port?

Yes.

Are they found to be practically useful?

Not yet.

15th March 1862.

JAS. P. THURBURN,
Inspecting Commander.

Local Marine Board, Sunderland,
19th March 1862.

SIR,

IN reply to your letter of the 3rd inst., making inquiries as to the storm warnings, I am instructed to say that the signals have not been established at this port, but judging from the telegrams as reported through the ordinary channels of intelligence the Board are of opinion that the storm warnings have *not* been followed by weather in such accurate accordance therewith as to give to them practical utility.

Yours, &c.

ROBT. BROWN, Secretary.

COPY of REPORT on STORM WARNING SIGNALS from the Inspecting Commander, Coast Guard, Kingstown, near Dublin.

Question.

Answer.

Have the storm warnings been generally correct in being followed by a storm or bad weather?

Yes.

Questions.	Answers.
Have they been correct in respect of—	
Time of storm?	Usually.
Place where it is felt?	Dublin Bay.
Direction of wind?	Usually very correct.
Are they trusted by the seafaring men of the port?	Yes, by merchant vessels; but not by fishing vessels.
Are they found to be practically useful?	I consider them to be useful.

Questions replied to in an accompanying letter from chief officer of Kingstown Station.

17th March 1862.

LOFTUS ROBINSON.

SIR,

Kingstown Station, 11th March 1862.

I BEG to furnish you with the information (as far as it is in my power) required in Board's letter of the 7th inst., respecting the storm warning signals. The signals have been in general, with few exceptions, followed by a storm or bad weather, and in general bad weather has been experienced within 76 hours after the signal has been made, and on some occasions the gale has been on when the signal arrived. Kingstown and Dublin Bay the places felt. In some instances the direction of the wind has been very correct. Respecting the attention paid to them by seafaring men of the port, those who are employed fishing do not in general pay attention to those signals, except the weather at the time is threatening; but coasting and other trading vessels in general act with caution when the signal is made, and on the whole I consider them to be useful, although in some instances coasting vessels would have lost a good sum if they had acted upon the signal.

I have, &c.

H. WITHECOMBE, Com. Officer.

SIR,

Local Marine Board, 71, Cornhill, 21st March 1862.

I AM directed to acknowledge the receipt of your letter of the 3rd instant, accompanying a copy of the barometer card with signals now in use, and in compliance with your request this Board, while stating that they have not watched the matter so closely as to enable them to give exact dates when the predictions have proved true, or the reverse, beg to give the following general answers to the queries of the Board of Trade.

In reply to the first question—

Questions.	Answers.
Have the storm warnings been generally correct in being followed by a storm or bad weather?	The Board would answer in the affirmative.
2nd. Have they been correct in respect of time of storm?	Yes, generally so.
3rd. Place where it is felt?	Generally correct.
4th. Direction of wind?	Generally correct in this particular also.
5th. Are they trusted by the seafaring men of the port?	The Board are of opinion that the seamen of the port of London have not yet paid much attention to these predictions; partly, because the transition from the docks to sea is not so immediate as at most other ports, and also because the practice of making public official predictions of wind and weather is of recent date.

Question.

6th. Are they found to be practically useful?

Answer.

This Board feel convinced that these notices conducted as they are must daily increase in usefulness; but as some persons may be alarmed at the word "dangerous," and make it an excuse for inaction, the Board beg to suggest that the words "unsettled weather, with high winds," would be enough to ensure extra vigilance and caution, and that the word "dangerous" be used only when there appeared a certainty of something unusually severe occurring.

I have, &c.

JOHN DOMETT.

SIR,

Local Marine Board, Dundee, 21st March 1862.

I AM directed by this Local Marine Board to acknowledge the receipt of your letter of the 3rd instant, on the subject of the storm signals which have recently been adopted with a view of warning mariners as to approaching storms, and requesting the Local Board to report the results of the experiments which have been made.

And I am directed by the Local Board to state in reply that Admiral FitzRoy's apparatus is only now in the course of being established at Dundee; but that as soon as it has been completed and tested the Local Board will have much pleasure in reporting the results.

I have, &c.

J. JECKS, Secretary.

SIR,

Local Marine Board, Port of Shields,
22nd March 1862.

I AM directed by this Board to acknowledge the receipt of your letter of the 3rd instant, enclosing a copy of the barometer card of the storm signals used for indicating anticipated changes in the weather, and requesting answers from the Local Board to certain questions as to the results of the system of storm signals.

In reply I am directed by the Board to forward the following as the results of their experience and inquiries on this subject so far as relates to the port of Shields, viz. :—

1. That the storm warnings have not been generally correct in being followed by a storm or bad weather.

2. They have not been correct in respect either of the—

Time of storm,

Place where it is felt, or

Direction of wind;

but, on the contrary, they have been generally incorrect, with some few exceptions.

3. They are certainly not trusted by the seafaring men of the port, although they occasion to a certain extent a feeling of uncertainty and uneasiness.

4. They are not found to be practically useful, but have often caused unnecessary delay and inconvenience, both to owners and seamen, without any corresponding good result.

I am, &c.

THOS. C. LIETCH, Secretary.

SIR,

Local Marine Board, Hull, 24th March 1862.

I AM directed by the Chairman of this Board to acknowledge the receipt of your letter of the 3rd instant, relative to storm signals, and in reply thereto to state that at a meeting held this day the Board expressed its unanimous opinion that gales of wind from the quarters indicated have generally followed

the announcement by signal, but that little notice appears thus far to have been taken of the signals by ships frequenting or vessels belonging to the port; that such warning, however, would have the effect of precautions being taken accordingly.

I am, &c.

CHAS. MARSHALL, Secretary.

SIR,

Dublin Local Marine Board, 25th March 1862.

YOUR letter of the 3rd instant was duly laid before the Dublin Local Marine Board respecting the storm warning signals, and after making every inquiry, they direct me to make the following answers to the queries required by my Lords of the Privy Council for Trade:—

Questions.	Answers.
1. Have the storm warnings been generally correct in being followed by a storm or bad weather?	Yes.
2. Have they been correct in respect of—	
Time of storm?	No.
Place where it is felt?	No.
Direction of wind?	No.
3. Are they trusted by the seafaring men of the port?	Not generally.
4. Are they found to be practically useful?	Somewhat. They are particularly observed by sailing vessels. All parties express a desire that they should be continued.

I am, &c.

R. McLEAN, Capt. R.N., Hon. Sec.

SIR,

Liverpool, 22nd February 1861.

YESTERDAY about 3 p.m. we were warned by telegram of an impending gale, and about high water (8.40 p.m.) it burst upon us like a thunder clap. It began at S.W., but did not go further round than W.N.W. Fortunately it did not last much over an hour, or the damage would have been serious. As it was, most of the ships in the river dragged—and, but for the assistance of steam, several would have fared badly. One drove on the south landing stage and did herself and it some damage.

I took the precaution to circulate the warning as widely as possible, which was the means, perhaps, of preventing some accidents.

GEORGE HAMLIN.

To Rear-Admiral Evans.

Plymouth, 27th March 1862.

“The storm signals shown here have astonished everybody; and I have constant applications to explain how coming storms can be predicted with such great accuracy.”

W. SNOW HARRIS.

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