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BAROMETER AND WEATHER GUIDE.

BOARD OF TRADE.

1859.

COMPILED BY REAR-ADMIRAL FITZROY, F.R.S.

THIRD EDITION.
(WITH ADDITIONS.)

LONDON:
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1859.

Price One Shilling.

Transcriber's Note

Minor typographical errors have been corrected without note. Due to an omission in the original text, the anchor for footnote #4 has been placed in an assumed position.

A brief table of contents, though not present in the original publication, has been provided below:

A contraction of rules for foretelling weather—in accordance with the following pages—is submitted, for scales of common barometers.

RISE	FALL
FOR	FOR
N. Ely.	S. Wly.
NW.-N.-E.	SE.-S.-W.
DRY	WET
OR	OR
LESS	MORE
WIND.	WIND.
————	————
EXCEPT	EXCEPT
WET FROM	WET FROM
N. Ed.	N. Ed.

Add one tenth for each hundred feet above the Sea.

LONG FORETOLD—LONG LAST,
SHORT NOTICE—SOON PAST.

FIRST RISE AFTER LOW,
FORETELLS STRONGER BLOW.

PREFACE. [3]

Many persons have advocated placing barometers at exposed fishing villages; and the Board of Trade has sanctioned the principle of some assistance by Government to a limited extent, depending on the necessity of each case, and other contingencies, such as the care, publicity, and setting of the barometers.

It was thought advisable to substitute a few words on the scales of these instruments in place of those usually engraved (which are not the most suitable), and to compile brief and plain information respecting the use of weather-glasses.

The following pages were prepared; but only the first few were intended particularly for this purpose.

After writing these, it was suggested that some remarks might be added for the benefit of many persons, especially young officers at sea, and the suggestion was complied with; yet not so as to diminish the portability of this compilation, or increase its price.

These remarks, derived from the combined observation, study, and personal experience of various individuals, are in accordance, generally, with the results obtained by eminent philosophers.

The works of Humboldt, Herschel, Dové, Sabine, Reid, Redfield, Espy, and others, are appealed to in confirmation of this statement.

To obviate any charge of undue haste, or an insufficiently considered plan—which may be fairly brought against many novelties—the following testimony to the first published suggestion of such a measure is submitted.

In the First Report of the Committee on Shipwrecks (1843), at pages 1, 2, 3, the following evidence was printed by order of the House of Commons.

> "I think that the neglect of the use of the barometer has led to the loss of many ships. From a want of attention to the barometer, they have either closed the land (if at sea), or have put to sea (being in harbour in safety) at improper times; and in consequence of such want of precaution the ships [4] have been lost, owing to bad weather coming on suddenly, which might have been avoided had proper attention been paid to that very simple instrument. While alluding to the use of barometers, I may remark, that if such weather-glasses were put in charge of the Coast-guard, at the principal stations round the coast, so placed as to allow any one passing by to look at them, they might be the means, not only of preventing ships from going to sea just before bad weather was coming on, but of preventing the great losses of life which take place every year on our coasts (particularly in the Orkney Islands and on the coasts of Scotland and Ireland), owing to fishing vessels and boats going to sea when bad weather is impending. No bad weather ever comes on our

> coasts without timely warning being given by the barometer. The oldest seaman are often deceived by the look of the weather, but there is no instance on record of very bad weather, such as would have involved loss of life to the extent we have heard of in several years, having come on without the barometer having given timely warning. By the very small expense of an establishment of barometers, so placed as to be accessible to any fishermen, boatmen, or others on the coasts, much loss of life, as well as loss of boats, and even shipping, might be prevented.
>
> "What state of the barometer indicates danger?—It varies in different climates according to the range. The range is small between the tropics, but very large in the higher latitudes. In our climate the range is usually about two inches. The barometer falling considerably below its average height is at once an indication that some considerable change is going to take place, and when it falls low, as for instance (in our climate) to near 29 inches, or below 29 inches, a gale is certain to follow.
>
> "Are the Committee to understand that you are of opinion that every ship ought to have a barometer on board?—I think that every ship ought to have either a barometer or sympiesometer, which is an efficient substitute for a barometer.
>
> "Does the barometer show a sudden change of wind as well as the coming on of bad weather? Supposing a gale of wind is blowing, and you are sailing with a fair wind, does the barometer show any change of wind?—Decidedly.
>
> "Supposing the wind was at West-north-west and it shifted suddenly to West-south-west, would the barometer indicate that?—It requires some practice to be able to say *exactly what is likely to take place* after a change in the barometer; but the principal point for a seaman is, that no violent wind will blow without the barometer giving warning. He may not know exactly from what quarter the wind will come, but no strong wind will come on without warning being given.
>
> "You recommend that at the Coast-guard stations there should be a barometer, by means of which people would know when a violent wind was coming on; but as it would not indicate the quarter from which it was coming, [5] would you have the merchant ship always remain in port till the barometer showed fine weather?—Being accustomed to the barometer on our coast, one could tell from what quarter the wind would probably come by the height of the barometer, taken in connexion with its previous height, and the state of the weather, and the strength of winds that had prevailed before. Taking the state of the barometer in connexion with the appearance of the weather one could make a satisfactory conclusion as to the quarter from which any violent wind would come. And the barometer, after very little practice, can be used by any man. There is no difficulty in using it sufficiently to know that danger is coming on; and if danger is coming on, a man refrains, of course, from exposing himself to it; the quarter from which the wind comes being of minor consequence.
>
> "With a North-easterly wind, in this part of the world, the barometer stands, on an average, about half an inch higher than with the same strength of wind from the South-westward. All over the world there is a similar difference proportionate to the range of the mercury for which allowance should always be made in considering the height of the barometer."[1]

In the first Number of Meteorological Papers, published by the Board of Trade, 1857, is the following passage respecting the use of weather-glasses:—

> "The variety of interesting and useful, if not always important, subjects included within the range of meteorology, is not perhaps sufficiently realized in the minds of active participators in the world's stirring work. Irrespective of any scientific object, how much utility is there to all classes in what is commonly called 'weather wisdom'? In our variable climate, with a maritime population, numbers of small vessels, and especially fishing boats, how much life and property is risked unnecessarily by every unforeseen storm? Even animals, birds, and insects have a presaging instinct, perhaps a bodily feeling, that warns them; but man often neglects his perceptive and reasoning powers; neither himself observes, nor attends to the observations of others, unless special inclination or circumstances stimulate attention to the subject. Agriculturists, it is true, use weather-glasses: the sportsman knows their value for indicating a good or bad scenting day; but the coasting vessel puts to sea, the Shetland fisherman casts his nets, without the benefit of such a monitor, and perhaps without the weather wisdom which only a few possess, and cannot transfer to others.
>
> "Difficult as it is to foretell weather accurately, much useful foresight may be acquired by combining the indications of instruments (such as the barometer,

thermometer, and hygrometer) with atmospheric appearances. What is more varying than the aspect of the sky? Colour, tint of clouds, their soft or hard look, their outline, size, height, direction, all vary rapidly, yet each is significant. There is a peculiar aspect of the clouds before and during westerly winds which differs from that which they have previous to and during easterly winds, which is one only of the many curious facts connected with the differing natures of easterly and westerly currents of air throughout the world, which remain unchanged, whether they blow from sea to land, or the reverse.[2] [6]

"Perhaps some of those who make much use of instruments rather undervalue popular knowledge, and are reluctant to admit that a 'wise saw' may be valuable as well as a 'modern instance;' while less informed persons who use weather-glasses unskilfully too often draw from them erroneous conclusions, and then blame the barometer.

"Not only are reliable weather-glasses required at the smaller outlying ports and fishing places, but plain, easily intelligible directions for using them should be accessible to the seafaring population, so that the masters of small vessels, and fishermen, might be forewarned of coming changes in time to prepare for them, and thus become instrumental in saving much property and many lives."

June 1858.

HOW TO FORETELL WEATHER. [7]

Familiar as the practical use of weather-glasses is, at sea as well as on land, only those who have long watched their indications, and compared them carefully, are really able to conclude more than that the rising glass[3] usually foretells less wind or rain, a falling barometer more rain or wind, or both; a high one fine weather, and a low, the contrary. But useful as these general conclusions are *in most cases*, they are *sometimes* erroneous, and then remarks may be rather hastily made, tending to discourage the inexperienced.

By attention to the following observations (the results of many years' practice and many persons' experience) any one not accustomed to use a barometer may do so without difficulty.

The barometer shows whether the air[4] is getting lighter or heavier, or is remaining in the same state. The quicksilver falls as the air becomes lighter, rises as it becomes heavier, and remains at rest in the glass tube while the air is unchanged in weight. Air presses on everything within about forty miles of the world's surface, like a *much* lighter ocean, at the bottom of which we live—not feeling its weight, because our bodies are full of air, but feeling its currents, the winds. Towards any place from which the air has been drawn by suction,[5] air presses with a force or weight of nearly fifteen pounds on a square inch of surface. Such a pressure holds the limpet to the rock when, by contracting itself, the fish has made a place without air[6] under its shell. Another familiar instance is that of the fly which walks on the ceiling with feet that stick. The barometer tube, emptied of air, and filled with pure mercury, is turned down into a cup or cistern [8] containing the same fluid, which, feeling the weight of air, is so pressed by it as to balance a column of about thirty inches (more or less) in the tube, where no air presses on the top of the column.

If a long pipe, closed at one end only, were emptied of air, filled with water, the open end kept in water and the pipe held upright, the water would rise in it more than thirty feet. In this way water barometers have been made. A proof of this effect is shown by any well with a sucking pump—up which, as is commonly known, the water will rise nearly thirty feet, by what is called suction, which is, in fact, the pressure of air towards an empty place.

The words on scales of barometers should not be so much regarded for weather indications, as the rising or falling of the mercury; for, if it stand at *Changeable*, and then rise towards *Fair*, it presages a change of wind or weather, though not so great, as if the mercury had risen higher; and, on the contrary, if the mercury stand above *fair* and then fall, it presages a change, though not to so great a degree as if it had stood lower: besides which, the direction, and force of wind, are not in any way noticed. It is not from the point at which the mercury may stand that we are alone to form a judgment of the state of the weather, but from its *rising* or *falling*; and from the movements of immediately preceding days as well as hours, keeping in mind effects of change of *direction*, and dryness, or moisture, as well as alteration of force or strength of wind.

In this part of the world, towards the higher latitudes, the quicksilver ranges, or rises and falls, nearly three inches—namely, between about thirty inches and nine-tenths (30·9), and less than twenty-eight inches (28·0) on extraordinary occasions; but the usual range is from about thirty inches and a half (30·5), to about twenty-nine inches. Near the Line, or in equatorial places, the range is but a few tenths, except in storms, when it sometimes falls to twenty-seven inches.

The sliding-scale (vernier) divides the tenths into ten parts each, or hundredths of an inch. The number of divisions on the vernier exceeds that in an equal space of the fixed scale by one.[7]

By a thermometer the *weight* of air is *not* shown. No air is within the tube. None can get in. But the bulb of the tube is full of mercury, which contracts by cold, and swells by heat—according to [9] which effect the thread of metal in the small tube is drawn down or pushed up so many degrees: and thus shows the temperature.[8]

If a thermometer have a piece of linen tied round the bulb, wetted enough to keep it damp by a thread or wick dipping into a cup of water, it will show less heat than a dry one, in proportion to the dryness of the air, and quickness of drying.[9] In very damp weather, with or *before* rain, fog, or dew, two such thermometers will be nearly alike.

For ascertaining the dryness or moisture of air, the readiest, and surest method is the comparison of two thermometers; one dry, the other *just* moistened, and *kept so*. Cooled by evaporation as much as the state of the air admits—the moist (or wet) bulb thermometer shows a temperature nearly equal to that of the other one, when the atmosphere is extremely damp, or moist; but lower at other times,—in proportion to the dryness of air, and consequent evaporation, —as far as twelve or fifteen degrees in this climate; twenty or even more elsewhere. From four to eight degrees of difference is usual in England; and about seven is considered healthy for living rooms.

The thermometer fixed to a barometer intended to be used only as a weather-glass shows the temperature of air about it nearly—but does not show the temperature of mercury within exactly. It does so however near enough for ordinary practical purposes—provided that no sun, nor fire, nor lamp heat is allowed to act on the instrument partially.

The mercury in the cistern and tube being affected by cold or heat, makes it advisable to consider this when endeavouring to foretell coming weather by the length of the column.

Briefly, the barometer shows weight or pressure of the air; the thermometer—heat and cold, or temperature; and the wet thermometer, compared with a dry one, the degree of moisture or dampness.[10]

It should be remembered that the state of the air *foretells*, rather than shows present weather (an invaluable fact too often overlooked); that the longer the time between the signs and the [10] change foretold by them, the longer such altered weather will last; and, on the contrary, the less the time between a warning and a change, the shorter will be the continuance of such foretold weather.

If the barometer has been about its ordinary height, say near thirty inches, at the sea level,[11] and is steady, or rising—while the thermometer falls, and dampness becomes less—North-westerly, Northerly, or North-easterly wind—or less wind—may be expected.

On the contrary—if a fall takes place, with a rising thermometer and increased dampness, wind and rain may be expected from the South-eastward, Southward, or South-westward.

A fall, with a low thermometer, foretells snow.

Exceptions to these rules occur when a North-easterly wind, with wet (rain or snow) is impending, before which the barometer often rises (on account of the *direction* of the coming wind alone), and deceives persons who, from that sign only, expect fair weather.

When the barometer is rather below its ordinary height, say, below twenty-nine inches and nine-tenths (at the sea level *only*), a rise foretells less wind, or a change in its direction towards the Northward,—or less wet; but when the mercury[12] has been low, say near 29 inches—the first rising usually precedes, and foretells, strong wind—(at times heavy squalls)—from the North-westward—Northward—or North-eastward—*after* which violence a rising glass foretells improving weather—if the thermometer falls. But, if the warmth continue, probably the wind will back (shift against the sun's course), and more Southerly, or South-westerly wind will follow. "Backing" is a bad sign, with any wind.

The most dangerous shifts of wind, and the heaviest Northerly[13] gales happen after the mercury first rises from a very low point.

Indications of approaching changes of weather, and the direction and force of winds are shown less by the height of mercury in the tube, than by its falling or rising. Nevertheless, a height of about 30 inches (at the level of the sea) with a continuance of it, is indicative of fine weather and moderate winds. [11]

The barometer is said to be *falling* when the mercury in the tube is sinking, at which time its upper surface is *sometimes* concave or hollow. The barometer is *rising* when the mercurial column is lengthening; its upper surface being then, as in *general*, convex or rounded.[14]

A rapid rise of the barometer indicates unsettled weather. A slow rise, or steadiness, with dryness, shows fair weather.

A considerable and rapid fall is a sign of stormy weather and rain. Alternate rising and sinking show very unsettled weather.

The greatest depressions of the barometer are with gales from the S.E., Southward, or S.W.; the greatest elevations, with winds from the N.W., Northward, or N.E., or when calm.

Although the barometer generally falls with a Southerly, and rises with a Northerly wind, the contrary *sometimes* occurs; in which cases the Southerly wind is dry and the weather fine; or the Northerly wind is wet and violent.[15]

When the barometer sinks considerably, high wind, rain, or snow will follow: the wind will be from the Northward if the thermometer is low (for the season)—from the Southward if the thermometer is high.

Sudden falls of the barometer, with a Westerly wind, are sometimes followed by violent storms from N.W. or North.

If a gale sets in from the Eastward or S.E., and the wind veers by the South, the barometer will continue falling until the wind becomes S.W., when a comparative lull may occur; after which the gale will be renewed; and the shifting of the wind towards the N.W. will be indicated by a fall of the thermometer as well as a rise of the barometer.

Three things appear to affect the mercury in a barometer:—

1. The direction of the wind—the North-east wind tending to raise it most—the South-west to lower it the most, and wind from points of the compass between them proportionally as they are nearer one or the other extreme point.

N.E. and S.W. may therefore be called the wind's extreme bearings (rather than *poles*?)

The range, or difference of height, of the mercury, due to change of direction *only*, from one of these bearings to the other (supposing strength or force, and moisture, to remain the same) [12] amounts in these latitudes to about half an inch (shown by the barometer as read off).

2. The amount, taken by itself, of vapour, moisture, wet, rain, hail, or snow, in the wind or current of air (direction and strength remaining the same) seems to cause a change amounting, in an extreme case, to about half an inch.

3. The strength or force alone of wind from any quarter (moisture and direction being unchanged) is preceded, or foretold, by a fall or rise, according as the strength will be greater or less, ranging, in an extreme case, to more than two inches.

Hence, supposing the three causes to act together—in extreme cases—the mercury might range from about 31 (30·9) inches to near 27 inches, which has happened *occasionally*.

Generally, however, as the three act much less strongly, and are less in accord—ordinary varieties of weather (the wind varying as usual—with more or less cloudiness, or rain) occur much more frequently than extreme changes.

Another general rule requires attention; which is, that the wind usually veers, shifts, or goes round, *with the sun*, (right-handed in northern places, left-handed in the southern parts of the world,) and that, when it does not do so, or backs, more wind or bad weather may be expected instead of improvement.

In a barometer the mercury begins to rise occasionally before the conclusion of gale, sometimes even at its commencement, as the equilibrium of the atmosphere begins to be restored. Although the mercury falls lowest before high winds, it frequently sinks considerably before heavy rain only. The barometer falls, but *not always*, on the approach of thunder and lightning, or when the atmosphere is highly charged with electricity.[16] Before and during the earlier part of serene and settled weather, the mercury commonly stands high, and is stationary.[17]

Instances of fine weather, with a low glass, occur exceptionally, but they are always preludes to a duration of wind or rain, *if not both*.

After very warm and calm weather, rain or a storm is likely to occur; or at any time when the [13] atmosphere has been *heated* much above the usual temperature of the season.

Allowance should invariably be made for the previous state of the instrument during some days as well as hours, because its indications may be affected by remote causes, or by changes close at hand. Some of these changes may occur at a greater or less distance, influencing neighbouring regions, but not visible to each observer whose barometer, nevertheless, feels their effect.

There may be heavy rains or violent winds beyond the horizon, out of view of an observer, by which his instruments may be affected considerably, though no particular change of weather occurs in his immediate locality.

It may be repeated, that the longer a change of wind or weather is foretold by the barometer before it takes place, the longer the presaged weather will last; and, conversely, the shorter the warning, the less time whatever causes the warning; whether wind or a fall of rain, hail, or snow, will continue.

Sometimes severe weather from an equatorial[18] direction, not lasting long, may cause no great fall of the barometer, because followed by a *duration* of wind from polar regions:—and at times it may fall considerably with polar winds and fine weather, apparently against these rules, because a *continuance* of equatorial wind is about to follow. By such changes as these one may be misled, and calamity may be the consequence if not thus forewarned.

The veering of the winds is a direct consequence of the earth's rotation, while currents of air from the polar regions are alternating or contending with others from the equator.

The polar currents are cold, dry, and heavy. Those from the equatorial parts of the world are warm, moist, and comparatively light. Their alternate or combined action, with the agencies of solar heat and electricity, cause the varieties of weather that we experience.

It is not intended to discourage attention to what is usually called "weather wisdom." On the contrary, every prudent person will combine observation of the elements with such indications as he may obtain from instruments.

The more carefully and accurately these two sources of foreknowledge are compared and combined, the more satisfactory will the results prove. [14]

A few of the more marked signs of weather—useful alike to seaman, farmer, and gardener, are the following:

Whether clear or cloudy, a rosy sky at sunset presages fine weather; a red sky in the morning, bad weather, or much wind (if not rain):—a grey sky in the morning fine weather; a high dawn, wind; a low dawn; fair weather.[19]

Soft-looking or delicate clouds foretell fine weather, with moderate or light breezes;—hard edged oily-looking clouds, wind. A dark, gloomy, blue sky is windy;—but a light, bright blue sky indicates fine weather. Generally, the *softer* clouds look, the less wind (but perhaps more rain) may be expected;—and the harder, more "greasy," rolled, tufted, or ragged, the stronger the coming wind will prove. Also, a bright yellow sky at sunset presages wind; a pale yellow, wet:—and thus by the prevalence of red, yellow, or grey tints, the coming weather may be foretold very nearly: indeed, if aided by instruments, almost exactly.[20]

Small inky-looking clouds foretell rain; a light scud, driving across heavy clouds, wind and rain; but if alone, wind only.

High upper clouds crossing the sun, moon, or stars, in a direction different from that of the lower clouds, or wind then blowing, foretell a change of wind (beyond tropical latitudes).[21]

After fine clear weather the first signs (in the sky) of change are usually small, curled, streaked, or spotty clouds, followed by an overcasting of vapour, that grows into cloudiness. This murky appearance, more or less oily or watery, as wind or rain will prevail, is a sure sign. The higher and more distant the clouds seem to be, the more gradual, but extensive, the coming change of weather will prove.

Generally speaking, natural, quiet, delicate tints or colours, with soft undefined forms of clouds, foretell fine weather: but gaudy or unusual hues, with hard, definite outlines, presage rain and wind. [15]

Misty clouds forming, or hanging on heights, show wind and rain coming—if they remain, or descend. If they rise, or disperse, the weather will improve, or become fine.

When sea birds fly out early, and far to seaward, moderate wind and fair weather may be expected. When they hang about the land, or over it, sometimes flying inland, expect a strong wind, with stormy weather. As many creatures, besides birds, are affected by the approach of rain or wind, such indications should not be slighted by the observer of weather.

There are other signs of a coming change in the weather known less generally than may be desirable; and, therefore worth notice here.

When birds of long flight, such as swallows and others, hang about home and fly low—rain or wind may be expected. Also when animals seek sheltered places, instead of spreading over their usual range: when pigs carry straw to their sties; and when smoke from chimneys does not ascend readily, (straight upwards during a calm,) an unfavourable change may be looked for.

Dew is an indication of fine weather. So is fog. Neither of of these two formations occurs under an overcast sky, or when there is much wind. One sees the fog occasionally rolled away, as it were, by wind—but not formed while it is blowing.

Remarkable clearness of atmosphere, near the horizon; distant objects, such as hills, unusually visible; or raised (by refraction); and what is called "a good *hearing* day" may be mentioned among signs of wet, if not wind, to be expected.[22]

More than usual twinkling of the stars; indistinctness or apparent multiplication of the moon's horns; haloes; "wind-dogs;" and the rainbow; are more or less significant of increasing wind, if not approaching rain.[23]

Near land, in sheltered harbours, in valleys, or over low ground, there is usually a marked diminution of wind during part of the night—and a dispersion of clouds. At such times an eye on an overlooking height may see an extended body of vapour below; which the cooling of night has rendered visible.

Although the preceding remarks are probably sufficient for their principal purpose—these pages may fall into the hands of persons familiar with the subject, to whom the following observations may be addressed, as some of the *reasons* for what has been so briefly, if not too positively outlined. [16]

As the mercurial column rises with increase of pressure by the atmosphere, and descends when the pressure diminishes, it indicates a greater or less accumulation of air, which, like other fluid, such as water (when heaped above its average level or reduced below it, from whatever cause),—will have a tendency to fall or rise till the general equilibrium is restored. An observer may be under the centre of such accumulation or depression, he may be more or less distant from it, though within the influence of whatever horizontal movement of air may be caused by such temporary increase or diminution of pressure. Hence the barometer shows, and generally foretells, changes of wind; but as complications always occur, and as changes are of greater or less extent, affecting or extending through a wider or more limited area, accompanied by hygrometric and electrical alterations, it is extremely difficult at times to say beforehand what particular change of weather is to be expected, and at what interval of time; although after the event the correspondence of barometric changes with those of the weather can be readily traced. However, notwithstanding occasional perplexity, the general character of weather during the next few days may be predicted by an observer who understands the nature and use of this instrument and the thermometer, and has watched them in the few immediately preceding days.

In endeavouring to foretell weather, the general peculiarity should always be remembered, that the barometric column usually stands higher with easterly than it does with westerly winds; and with winds from the polar regions higher than with those from the direction of the equator. Hence the highest columns are observed with north-east winds in northern latitudes, and with south-east in the southern hemisphere.

In middle latitudes there is an average difference (unreduced or observed height as read off) of about half an inch, other things being similar, between the heights of the mercury with North-easterly, and with South-westerly winds.

The steadier the column, or the more gradually it moves, the more settled in character will the weather be, and conversely: because it shows a quiet settled state of the atmosphere; or, if otherwise, the reverse. In the tropics, when the barometric column moves contrary to its usual [17]
daily motion, inferior weather may be expected (temporarily), because the usual air currents are disturbed.

This regular movement, whether tidal, or otherwise connected with the sun's influence—sensible in tropical latitudes, but more or less masked elsewhere—amounts to nearly two-tenths of an inch near the equator, the highest being at about nine, and the lowest near three o'clock.

Some movements of the atmosphere may be illustrated by reference to the motion of water drawn off from a reservoir by a small opening below; or by similar *upward* draught through a syphon; or by a gradual pouring in at the upper surface.

From a slight motion at the commencement, affecting only that portion of the fluid adjoining either of those places of diminution or repletion, gradually all the water becomes influenced and acquires more or less rapid movement. But suppose a long reservoir or canal of fluid which has two such points of exhaustion or two of such repletion (as imagined above), and that one of either is near each end of the vessel. If each aperture be opened at the same moment, equal effects will be caused in each half of the fluid towards either end of the vessel, but in the middle there must be a neutral point at which the water falls, yet has no horizontal motion. The converse takes place in raising the level. And in the case of fluid drawn off or diminished in weight at one end while increased by repletion at the other, the *whole* body of water will move similarly to that in the former vessel, but unequally. Hence it is evident, that before horizontal motion occurs, an augmentation or a diminution of pressure must take place somewhere more or less remote; and so it is with the lighter fluid atmosphere,—which has centres, lines, or areas of depression towards which currents flow.

Such considerations show in some degree why the barometric changes usually precede, but sometimes only accompany, changes of weather: and, though very rarely, occur without any sensible alteration in the wind current of the atmosphere. An observer may be near a central point towards which the surrounding fluid tends,—or from which it diverges. He may be at the very farthest limit of the portion of fluid that is so influenced. He may be at an intermediate point —or he may be between bodies of atmosphere tending towards opposite directions.

It has been said, that "a whirlwind which sets an extended portion of the atmosphere into a state
of rapid revolution diminishes the pressure of the atmosphere over that portion of the earth's [18]
surface, and most of all at the centre of the whirl. The depth of the compressing column of air will, at the centre, be least, and its weight will be diminished in proportion to the violence of the wind." Yet this has been controverted with respect to the *general* effect of air in horizontal motion, and the depth of the column in question.

Certainly there are two kinds of whirlwinds—one caused by rarefaction, tending to lighten vertical pressure under the vortex, though not, perhaps, under all the current drawn towards it; and the other, a consequence of opposing winds, which occasion huge eddies or whirlwinds of compression.

Some whirlwinds are accompanied by rushes from the upper atmosphere, from the colder regions, which, mingling with warmer and moister air near the sea, cause dense clouds. About their centre it sometimes happens that the barometer falls as much as two or three inches, showing a diminution of atmospheric pressure by nearly a tenth part; when it should be expected, from physical considerations alone, that very dense clouds would be formed.[24]

The column of mercury falls about one tenth of an inch for each of the first few hundred feet above the sea level, but varying when it becomes much more elevated.[25] Due allowance, therefore, should be made in observing, when on high land.

The tides are affected by atmospheric pressure, so much that a rise of one inch in the barometer will have a corresponding fall in the tides of nine to sixteen inches, or about one foot for each inch.[26]

Vessels sometimes enter docks, or even harbours, where they have scarcely a foot of water more than their draught; and as docking, as well as launching large ships, requires a close calculation of height of water, the state of the barometer becomes of additional importance on such occasions.

To render these pages rather more useful at sea, in *any* part of the world, a few words about squalls and hurricanes are here offered to the young seaman. [19]

Generally, squalls are preceded, or accompanied, or followed by clouds; but the very dangerous "white squall" (of the West Indies and other regions), is indicated only by a rushing sound, and by white wave crests.

"Descending squalls" come slanting downwards, off high land,[27] or from upper regions of atmosphere. They are dangerous, being sometimes violently strong.

A squall cloud that can be seen through or under is not likely to bring, or be accompanied by, so much wind as a dark continued cloud extending beyond the horizon. How the comparative hardness or softness of clouds foretells more or less wind or rain, was stated in pages 13 and 14.

The expressions "hardening up," "softening," or looking "greasy," are familiar to seamen: and such very sure indications are the appearances so designated, that they can hardly be mistaken.

The rapid or slow rise of a squall cloud—its more or less disturbed look—that is, whether its body is much agitated, and changing form continually, with broken clouds, or scud, flying about—or whether the mass of cloud is shapeless and nearly quiet, though floating onwards across the sky—foretells more or less wind accordingly.

An officer of a watch, with a good eye for clouds and signs of changing weather, may save his men a great deal of unnecessary exposure, as well as work, besides economising sails, spars, and rigging.

In some of the "saws" about wind and weather, there is so much truth that, though trite and simple, their insertion here can do no harm.

Adverting to the barometer:—
When rise begins, after low,
Squalls expect and clear blow.
Or:—*First* rise, after very low,
Indicates a stronger blow.
Also:—Long foretold, long last:
Short notice, soon past.
To which may be added:—In squalls—
When rain comes before wind,
Halyards, sheets, and braces mind.
And:—When wind comes before rain, [20]
Soon you may make sail again.

Also, generally speaking:—
When the glass falls low,
Prepare for a blow;
When it rises high,
Let all your kites fly.[28]

To these short expressions—well known, in practice, to the experienced; a very concise but sure rule may be added, for avoiding the central or strongest part of a hurricane, cyclone, typhoon, tornado, or circling storm.

With your face towards the wind, in North latitude, the centre of the circling, or rotatory storm, will be square to your right. In South latitude, square to your left.

The apparent veering of the wind, and the approach or retreat of the dangerous central circle, depend on your position in the curvilinear whirl or sweep.

Draw a circle;—mark the direction of the rotation or circulation, by an arrow with the head towards the left hand (against the movement of a watch's hands) in North latitude; but towards the right (or with the hands of a watch) if in South latitude. The direction of the wind, and the bearing of the centre, show your position in the meteor, for such it is, though perhaps hundreds of miles in diameter; and the veering of the wind, or the contrary, and its change in strength, will show how the meteor is moving bodily—over an extensive region, revolving horizontally—or inclined at a certain angle to the horizontal plane.

If the observer be stationary, in North latitude, and the centre pass on his polar side, he will experience a change of wind from Southward by the West towards North; but if it pass between him and the Equator, the change will be from Southward by the East towards North; but otherwise in South latitude, as his place in circles sketched will show more clearly than words. The roughest sketch or diagram, indicating the various directions of wind, and the course of the meteor's centre, will show more plainly than descriptions—which must necessarily vary with each case, and are tedious. [21]

Cyclonology, or really meteorology, is simple enough in these great characteristic effects; but their causes must be the philosopher's study, rather than that of the young practical seaman.

Were it not for this reflection, one might endeavour to show how all the great Easterly trade winds—the no less important anti-trades,[29] or nearly constant Westerly winds,—and their complicated eddying offsets, are all (on greater or smaller scales) breadths, or zones of atmosphere, alternating, or circulating, or crossing (superposed or laterally)—between which, at distant intervals, occur those strong eddies, or storms, called hurricanes—typhoons—tornadoes—or cyclones.

The great easterly and westerly movements—so clearly shown by philosophers to be the consequences of cold polar currents of air—warm equatorial currents—and diurnal rotation of the earth;[30] are grand ruling phenomena of meteorology—to which storms, and all local changes, occurring but occasionally, are subordinate and exceptional. Further investigations into electrical and chemical peculiarities will probably throw additional light, perhaps the strongest, on meteorological science.

In the previous observations, general reference has been made to mercurial barometers of the ordinary kind; but, excepting the construction of the instruments themselves, those observations apply to all barometers, wheel—aneroid—or metallic—and likewise, of course, to the sympiesometer, which is a modified barometer. But as these four last-mentioned instruments are scarcely so familiar as the simplest form of barometer, it may be useful to add a few words about each of them.

The Wheel barometer has a syphon tube, partly filled with mercury, on which, at the short or open end of the tube, a float moves, to which a line is attached that moves a wheel, carrying an index.[31]

Aneroid barometers, if often compared with good mercurial columns, are similar in their indications, and valuable; but it must be remembered that they are not independent instruments; [22]
that they are set originally by a barometer,[32] require adjustment occasionally, and may deteriorate in time, though slowly.

The aneroid is quick in showing the variation of atmospheric pressure, and to the navigator who knows the difficulty, at times, of using barometers, this instrument is a great boon, for it can be placed anywhere, quite out of harm's way, and is not affected by the ship's motion, although faithfully giving indication of increased or diminished pressure of air.[33] In ascending or descending elevations, the hand of the aneroid may be seen to move (like the hand of a watch), showing the height above the level of the sea, or the difference of level between places of comparison.[34]

The principle on which it is constructed may be explained in a few words, without going into a scientific or too minute detail of its various parts. The weight of a column of air, which in a common barometer acts on the mercury, in the aneroid presses on a small circular metal box, from which nearly all air is extracted; and to this box is connected, by nice mechanical arrangement, the hand visible over the face of the instrument. When the atmospheric pressure is lessened on the vacuum box, a spring acting on levers, turns the hand to the left, and when the pressure increases, the spring is affected differently, the hand being turned to the right. It acts in any position, but as it *often varies several hundredths with such a change*, it should be held uniformly, while read off.

The known expansion and contraction of metals under varying temperatures, caused doubts as to the accuracy of the aneroid under such changes; but they were partly removed by introducing into the vacuum box a small portion of gas, as a compensation for the effects of heat or cold. The gas in the box, changing it bulk on a change of temperature, was intended to compensate for the effect on the metals of which the aneroid is made. Besides which, a further and more, reliable compensation has lately been effected by a combination of brass and steel bars.[35]

Metallic barometers (in *outer* shape and size like aneroids) have not yet been tested adequately in very moist, hot, or cold air for a sufficient time. They, as well as sympiesometers, are likewise dependent or secondary instruments, and liable to deterioration. For limited employment, when sufficiently compared, they may be very useful, especially in a few cases of electrical changes not foretold or shown by mercury. [23]

The Sympiesometer is considered to be more sensitive than the marine barometer, falling sooner, and rising earlier: but this is partly in consequence of the marine barometer tube being contracted, to prevent oscillation or "pumping." In the sympiesometer a gas is used, which presses on the confined surface of the liquid with an uniform pressure at an equal state of temperature. The liquid is raised or depressed by an increase or diminution in the density of the atmosphere, and change of temperature is allowed for, by the sliding scale of the instrument being always set to agree with the height of the mercury in the attached thermometer, bringing the *pointer* on the sliding scale of the sympiesometer to the same degree on the inverted scale (over which it slides) as is indicated by the thermometer. The height of the fluid, as then shown by the sliding scale, indicates the pressure of the atmosphere.

As the instrument is delicate, great care should be taken, in carrying or handling, to keep the top always upwards, and to exclude casual rays of the sun, or a fire, or lamp.

Oil sympiesometers seem to be affected more than mercurial, or others, and much more than the barometer, by lightning or electricity. That they, and the hermetically sealed "Storm Glasses," are influenced by causes besides pressure and temperature, appears now to be certain.

The daily movement of the barometer may be noted (in a form or table of double entry) at the time of each observation, by a dot at the place corresponding to its altitude, and the time of observing; which dot should be connected with the previous one by a line. The resulting free curve (or zig-zag) will show at a glance what have been the movements during the days immediately previous, by which, and not merely by the last observation, a judgment may be formed of the weather to be expected.

Such a diagram may be filled up by *uncorrected* observations, its object being to serve as a weather guide for immediate use, rather than for future investigation. If closely kept up, it will [24] prove to be of utility, and will in some degree reward the trouble of keeping a regular record. For purely scientific objects much more nicety and detail are required.

Hesitation is sometimes felt by young seamen, at first using the vernier of a barometer, for want of some such familiar explanation as the following:—

The general principle of this moveable dividing scale is, that the total number of the smallest spaces or subdivisions of the vernier are made equal, taken altogether, to one less than that number of the smallest spaces in an equal length of the fixed scale.

For example: ten spaces on the vernier being made equal to nine on the scale, each vernier space is one tenth less than a scale space; and if the first line or division of the vernier agree exactly with any line of the scale, the next line of the vernier must be one tenth of a tenth (or one hundredth) of an inch from agreement with the next *scale* division; the following vernier line must be two hundredths out, and so on: therefore, the number of such differences (from the next tenth on the scale) at which a vernier line agrees with a scale line, when set, is the number of hundredths to be added to the said tenth; (in a common barometer, reading only to hundredths of an inch).

The vernier of a barometer reading to thousandths of an inch, is on a similar principle, though differently divided. In this application of it, generally, twenty-five vernier spaces equal twenty-four of the scale spaces, which are each half a tenth, or five hundredths of an inch; therefore, the difference between one of the vernier and one of the scale is two-tenths of a hundredth, or two thousandths of an inch [25)·050(·002].

This is the usual graduation of scientific barometers; but for ordinary purposes, as weather-glasses, a division, or reading, to the hundredth of an inch is sufficient.

When set properly, the vernier straight edge, the top of the mercury, and the observer's eye, should be on the same level; the edge (or pointer) just *touching*[36] the middle and uppermost point of the column.

Great care should be taken to look thus square, or at right angles to the scale. [25]

Light, or something white, at the *back* of the tube, assists in accurately setting the vernier, and may be shifted about to aid in reading off.

The Aneroid has been recommended, in these pages, as a weather-glass; but it may increase its usefulness to append a table for measuring heights (approximately) by this, or any barometer, which can be compared with another, or itself, at a higher or lower station.

If the measure of a height rather greater than the aneroid will commonly show, be required, it may be *re-set* thus—When at the upper station (*within its range*), and having noted the reading carefully, touch the screw behind so as to bring back the hand a few inches (if the instrument will admit), then read off and start again. *Reverse the operation when descending.* This may add some inches of measure *approximately*.

In the following Table, the difference between the number of feet opposite the height of a barometer, at one station, and that at another station, is their approximate difference of height.

TABLE. [26]

Barometer Inches.	Height in feet.	Barometer Inches.	Height in feet.	Barometer Inches.	Height in feet.
31·0	0	26·8	3829	22·7	8201
30·9	85	26·7	3927	22·6	8317
30·8	170	26·6	4025	22·5	8434
30·7	255	26·5	4124	22·4	8551
30·6	341	26·4	4223	22·3	8669
30·5	427	26·3	4323	22·2	8787
30·4	513	26·2	4423	22·1	8906
30·3	600	26·1	4524	22·0	9025
30·2	687	26·0	4625	21·9	9145
30·1	774	25·9	4726	21·8	9266
30·0	862	25·8	4828	21·7	9388
29·9	950	25·7	4930	21·6	9510
29·8	1038	25·6	5033	21·5	9632
29·7	1126	25·5	5136	21·4	9755
29·6	1215	25·4	5240	21·3	9878
29·5	1304	25·3	5344	21·2	10002
29·4	1393	25·2	5448	21·1	10127
29·3	1482	25·1	5553	21·0	10253
29·2	1572	25·0	5658	20·9	10379
29·1	1662	24·9	5763	20·8	10506
29·0	1753	24·8	5869	20·7	10633
28·9	1844	24·7	5976	20·6	10760
28·8	1935	24·6	6083	20·5	10889
28·7	2027	24·5	6190	20·4	11018
28·6	2119	24·4	6297	20·3	11148
28·5	2211	24·3	6405	20·2	11278
28·4	2303	24·2	6514	20·1	11409
28·3	2396	24·1	6623	20·0	11541
28·2	2489	24·0	6733	19·9	11673
28·1	2582	23·9	6843	19·8	11805
28·0	2675	23·8	6953	19·7	11939
27·9	2769	23·7	7064	19·6	12074
27·8	2864	23·6	7175	19·5	12210
27·7	2959	23·5	7287	19·4	12346
27·6	3054	23·4	7399	19·3	12483
27·5	3149	23·3	7512	19·2	12620
27·4	3245	23·2	7625	19·1	12757
27·3	3341	23·1	7729	19·0	12894
27·2	3438	23·0	7854	18·9	12942
27·1	3535	22·9	7969	18·8	13080
27·0	3633	22·8	8085	18·7	13219
26·9	3731				

MARINE BAROMETER, [27]

ADOPTED BY

HER MAJESTY'S GOVERNMENT,

On the recommendation of the Kew Observatory Committee of the

British Association for the Advancement of Science.

THIS instrument should be suspended in a good light for reading, but out of the reach of sunshine or the heat of a fire or lamp. It should be as nearly amidships, and exposed as little to sudden changes of temperature, gusts of wind, or injuries, as possible. In a ship of war it should be below the lowest battery or gun-deck. Light should have access to the back of the tube, to admit of setting the index so as to have its lower edge a tangent to the surface of the mercury—the eye being on the same level, which is known by the back and front edges of the index being in one line with the mercury surface. White paper or card will reflect light for setting the vernier correctly. The height of the cistern above or below the ship's water-line should be ascertained, and entered on the register.

It is desirable to place the barometer in such a position as not to be in danger of a side blow, and also sufficiently far from the deck above to allow for the spring of the metal arm in cases of sudden movements of the ship.

If there is risk of the instrument striking anywhere when the vessel is much inclined, it will be desirable either to put some soft padding on that place, or to check movement in that direction by a light elastic cord; in fixing which, attention must be paid to have it acting only where risk of a blow begins, not interfering otherwise with the free swing of the instrument: a very light cord attached above, when possible, will be least likely to interfere injuriously.

The vernier, as usual in standard barometers, reads to the two thousandth (·002) part of an inch. Every long line cut on the vernier corresponds to ·01 part; each small division on the scale is ·05; the hundredth parts on the vernier being added to the five when its lower edge is next above one of the short lines; or written down as shown by the figures on the vernier only, when next above [28]
one of the divisions marking tenths.

In placing this barometer, it is only necessary to fix the instrument carefully, as indicated in the above directions, and give a few gentle taps with the fingers on the bottom, to move the mercury. Without further operation it will usually be ready for observation in less than an hour.

When moving the barometer, or replacing it in its case, the mercury should be allowed to run gently up to the top of the tube, by holding the instrument for a few minutes inclined at an angle. The vernier should be brought down to the bottom of the scale. No other adjustment for portability is required. During carriage, it ought to be kept with the cistern end uppermost, or lying flat, the former position being preferable.

If the mercury should not descend at first by a few gentle taps, use sharper (but of course without violence), by which, and two or three taps, with the finger ends, on the tube—between the scale and the tangent screw—the mercury will be made to begin to descend.

In reading off from a barometer, it should hang freely, not inclined by holding, or even by touch.

Sometimes, though rarely, at sea the mercury seems *stopped*. If so, take down the instrument (after *sloping*), reverse it, tap the tube gently while the cistern end is upwards, and then replace as before.

TESTING BAROMETERS, HYDROMETERS, AND THERMOMETERS.

In the year 1853 a conference of maritime nations was held at Brussels, on the subject of meteorology at sea. The report of this conference was laid before Parliament, and the result was a vote of money for the purchase of instruments and the discussion of observations, under the superintendence of the Board of Trade. Arrangements were then made, in accordance with the views of the Royal Society and the British Association for the Advancement of Science, for the supply of instruments properly tested.

In the barometers now in general use by meteorologists on land, the diameters of the tubes are nearly equal throughout their whole length, and a provision is made for adjusting the mercury in the cistern to the zero point, previous to reading the height of the top of the column. The object of the latter arrangement, it is well known, is to avoid the necessity of applying a correction to [29]
the readings for the difference of capacity between the cistern and the tube. At sea, barometers of this construction cannot be used. Part of the tube of the marine barometer must be very much contracted to prevent "pumping," and the motion of the ship would render it impracticable to adjust the mercury in the cistern to the zero point. In the barometer usually employed on shore, the index error is the same throughout the whole range of scale readings, if the instrument be properly made; but in nearly all the barometers which have till recently been employed at sea, the index correction varies through the range of scale readings, in proportion to the difference of capacity between the cistern and the tube. To find the index correction for a land barometer, comparison with a Standard at any part of the scale at which the mercury may happen to be, is generally considered sufficient. To test the marine barometer is a work of much more time, since it is necessary to find the correction for scale readings at about each half inch throughout the range of atmospheric pressure to which it may be exposed; and it becomes necessary to have recourse to artificial means of changing the pressure of the atmosphere on the surface of the mercury in the cistern.

The barometers intended to be tested are placed, together with a Standard, in an air-tight chamber, to which an air pump is applied, so that, by partially exhausting the air, the Standard can be made to read much lower than the lowest pressure to which marine barometers are likely to be exposed; and by compressing the air it can be made to read higher than the mercury ever

stands at the level of the sea. The tube of the Standard is contracted similarly to that of the marine barometer, but a provision is made for adjusting the mercury in its cistern to the zero point. Glass windows are inserted in the upper part of the iron air-chamber, through which the scales of the barometers may be seen; but as the verniers cannot be moved in the usual way from outside the chamber, a provision is made for reading the height of the mercury independent of the verniers attached to the scales of the respective barometers. At a distance of some five or six feet from the air-tight chamber a vertical scale is fixed. The divisions on this scale correspond exactly with those on the tube of the Standard barometer. A vernier and telescope are made to slide on the scale by means of a rack and pinion. The telescope has two horizontal wires, one fixed, and the other moveable by a micrometer, screw so that the difference between the height [30]
of the column of mercury and the nearest division on the scale of the Standard, and also of all the other barometers placed by the side of it for comparison, can be measured either with the vertical scale and vernier or the micrometer wire. The means are thus possessed of testing barometers for index error in any part of the scale, through the whole range of atmospheric pressure to which they are likely to be exposed, and the usual practice is to test them at every half inch from 27·5 to 31 inches.

In this way barometers of various other descriptions have been tested, and their errors found to be so large that some barometers read half an inch and upwards too high, while others read as much too low. In some cases those which were correct in one part of the scale were found to be from half an inch to an inch wrong in other parts. These barometers were of the old and ordinary construction. In some the mercury would not descend lower than about 29 inches, owing to a fault very common in the construction of the marine barometer till lately in general use, that the cistern was not large enough to hold the mercury which descended from the tube in a low atmospheric pressure.

The practice which has long prevailed of mounting the marine barometer in wood is objectionable. The instrument recently introduced agreeably to the recommendation of the Kew Committee, is greatly superior to any other description of marine barometer which has yet been tested, as regards the accuracy with which it indicates the pressure of the atmosphere. The diameter of the cistern is about an inch and a quarter, and that of the tube about a quarter of an inch. The scale, instead of being divided into inches in the usual way, is shortened in the proportion of about 0·04 of an inch for every inch. The object of shortening the scale is to avoid the necessity of applying a correction for difference of capacity between the cistern and the tube. The perfection with which this is done may be judged of from the fact, that of the first twelve barometers tested at the Liverpool Observatory with an apparatus exactly similar to that used at Kew (whence these instruments were sent by railway, after being tested and certified), the index corrections in the two pressures of 28 and 31 inches in three of them were the same; two differed 0·001 of an inch; and for the remainder the differences ranged from 0·002 to 0·006 of an inch. The corrections for capacity were therefore considered perfect, and, with one unimportant exception, agreed with those given at Kew. [31]

In order to check the pumping of the mercury at sea, the tubes of these barometers are so contracted, through a few inches, that, when first suspended, the mercury is perhaps twenty minutes in falling from the top of the tube to its proper level. When used on shore, this contraction of the tube causes the marine barometer to be always a little behind an ordinary barometer, the tube of which is not contracted. The amount varies according to the rate at which the mercury is rising or falling, and ranges from 0·00 to 0·02 of an inch. As the motion of the ship at sea causes the mercury to pass more rapidly through the contracted tube, the readings are almost the same there as they would be if the tube were not contracted, and in no case do they differ enough to be of importance in maritime use.

The method of testing thermometers is so simple as scarcely to require explanation. For the freezing point, the bulbs and a considerable portion of the tubes of the thermometers, are immersed in pounded ice. For the higher temperatures, the thermometers are placed in a cylindrical glass vessel containing water of the required heat; and the scales of the thermometers intended to be tested, together with the Standard with which they are to be compared, are read through the glass. In this way the scale readings maybe tested at any required degree of temperature, and the usual practice is to test them at every ten degrees from 32° to 92° of Fahrenheit. For this range of 60° the makers who supply Government are limited to 0·6 of a degree as a maximum error of scale reading; but so accurately are these thermometers made, that it has not been found necessary to reject more than a very few of them.

Hydrometers are tested by careful immersion in pure distilled water; of which the specific gravity is taken as unity.

In water less pure, more salt, dense, and buoyant, the instrument floats higher, carrying more of the graduated scale out of the fluid.

The zero of the scale should be level with the surface of distilled water, and rise above it in proportion as increase of density causes less displacement.

The scale is graduated to thousandths—as far as ·040 only—because the sea water usually ranges between 1·014 and about 1·036. Only the last two figures need be marked.

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FOOTNOTES:

[1] In South latitude the South wind corresponds to our North wind in its nature and effects. The Easterly and Westerly winds retain their respective peculiarities in both hemispheres.

[2] Exclusive of local land and sea breezes of hot climates.

[3] Glass, barometer, column, mercury, quicksilver, or hand.

[4] Or atmosphere, or the atmospheric fluid which we breathe.

[5] Or exhaustion.

[6] A vacuum.

[7] See pages 24 and 25.

[8] Thirty-two degrees is the point at which water begins to freeze, or ice to thaw.

[9] Evaporation.

[10] The two thus combined making a hygrometer: for which some kinds of hair, grass, or seaweed may be a make-shift.

[11] It stands lower, about a tenth of an inch for each hundred feet of height directly upwards, or vertically, above the sea; where its average height, in England, is 29·94 inches (at 32°).

[12] In an Aneroid, a metallic, or a wheel barometer, the hand's motion should correspond to that of mercury in an independent instrument.

[13] Southerly in South latitude.

[14] In the best columns, those of standards for example, no concavity is seen, at any time: but it is otherwise with many barometers, which do show a concavity.

[15] In these cases there is usually a combination or a contest of currents in the atmosphere, horizontally, *or* one *above* the other, or diagonally.

[16] Thunder clouds sometimes rise and spread against the wind (lower-current). It is probable that there is a meeting, if not a contest of air currents, electrically different, whenever lightning is seen. Their concurrence, when the new one advances from *polar* regions, does not depress the barometer, except in oscillations of the mercury, which are very remarkable at some such times.

[17] Aneroids, metallic barometers, and oil sympiesometers, seem to be much more affected than mercurial barometers by electrical changes.

[18] Southerly, in North latitude; the reverse in the Southern hemisphere.

[19] A "high dawn" is when the first indications of daylight are seen above a bank of clouds. A "low dawn" is when the day breaks on or near the horizon. The first streaks of light being very low.

[20] Indications of weather, afforded by colours, seem to deserve more critical study than has been often given to the subject. Why a rosy hue at sunset, or a grey neutral tint at that time, should presage the reverse or their indications at sunrise;—why bright yellow should foretell wind at either time, and pale yellow, wet;—why clouds seem soft, like water colour; or hard edged, like oil paint, or Indian ink on an oily plate;—and why such appearances are infallible signs—are yet to be shown satisfactorily to practical men.

[21] In the trade winds of the tropics there is usually a counter current of air, with light clouds,—which does not indicate any approaching change. In middle latitudes such upper currents are not so evident, except before a change of weather.

[22] *Much* refraction is a sign of Easterly wind. *Remarkable* clearness is a bad sign.

[23] The "young moon with the old moon in her arms" (Burns, Herschel, and others) is a sign of bad weather in the temperate zones or middle latitudes, because (probably) the air is then exceedingly clear and transparent.

[24] Even in ordinary changes of weather it is interesting, as well as useful, to mark the formation or disappearance of clouds, caused by colder and warmer currents of air mixing: or intermingling.

[25] Depending on pressure and temperature.

[26] Sir James Ross—M. Daussy.

[27] Williwaw (Whirl-awa?) of the old sealers and whalers.

[28] Seamen call the light sails, used only in very fine weather, "flying kites."

[29] Herschel.

[30] Dové.

[31] For a barometer of this kind, Admiral Milne has invented self-registering mechanism, that answers well.

[32] A small turnscrew being applied gently to the screw head at the back. This is often necessary, on receiving or first using an aneroid that has long been lying by, or that has been shaken by travelling.

[33] It is a good weather glass—to be suspended on or near the upper deck, for easy reference;—and is unlikely to be injured by mere concussion of air, or vibration of wood, when guns are fired.

[34] Allowing 0,0011 of an inch for each foot.

[35] The manufacture of these useful auxiliary instruments (all French originally) has increased much latterly: and now the patent has expired. They might be so improved so to be worth more than double their present value.

[36] Like the sun's edge or limb, touching the sea horizon, as seen inverted when using a sextant.

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