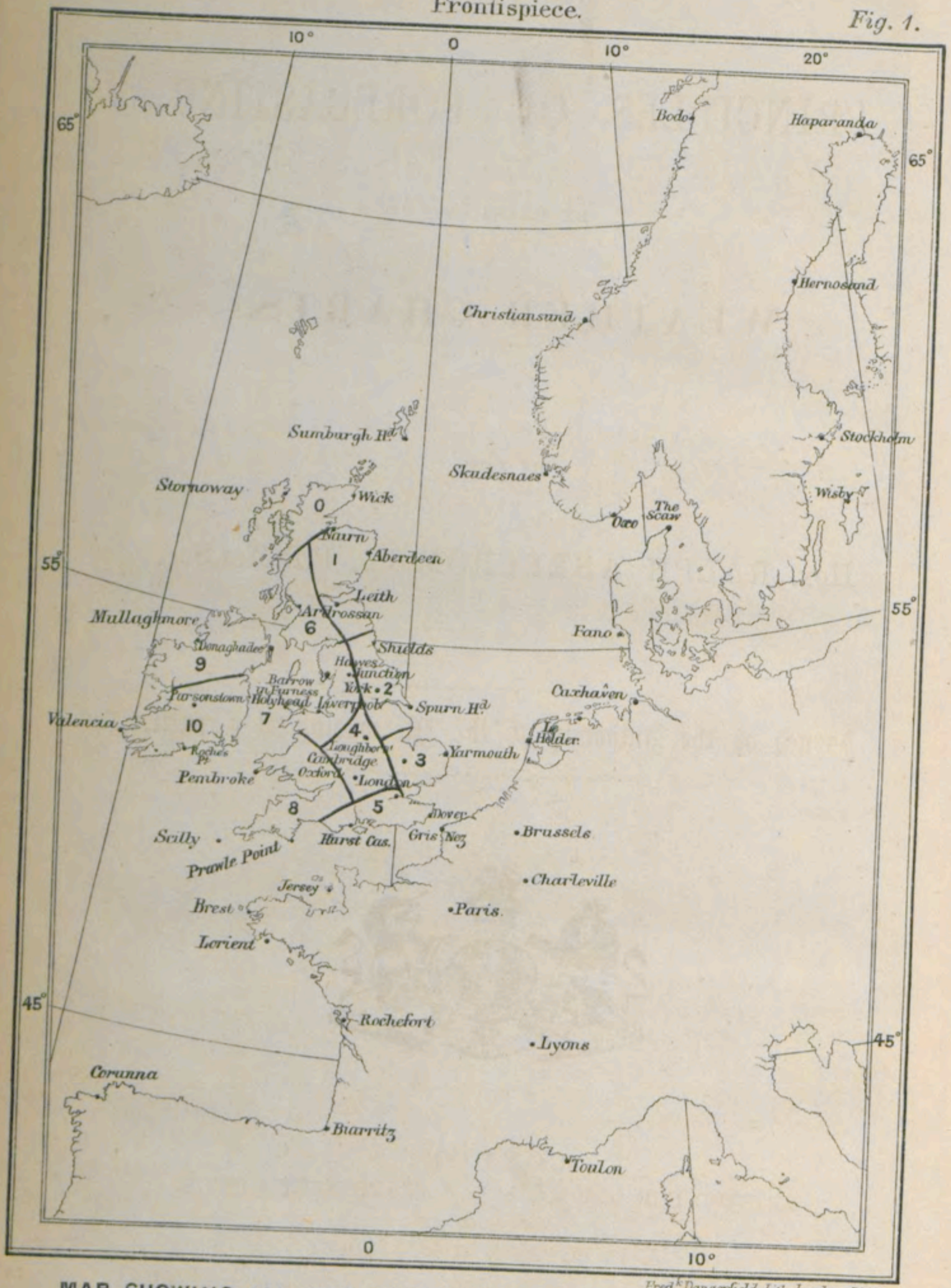
Frontispiece. *Fig. 1.*



MAP SHOWING ALL THE STATIONS REPORTING BY TELEGRAPH DAILY TO THE METEOROLOGICAL OFFICE, FROM JULY 1ST TO DEC. 31ST 1883. & ALSO THE 11 FORECASTING DISTRICTS.

Official, No. 60.

PRINCIPLES OF FORECASTING

BY MEANS OF

WEATHER CHARTS.

BY THE

HON. RALPH ABERCROMBY, F.R.MET.SOC.

Issued by the Authority of the Meteorological Council.

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PREFACE.

THE following work has been undertaken at the request of the Council of the Meteorological Office.

No attempt has been made to treat any branch of the subject in detail. The object has rather been to lay before the public a sketch of the subject as a whole; giving principles only, and endeavouring to explain the methods of preparing weather forecasts and issuing storm warnings.

Where the author has availed himself of the writings of others, he has endeavoured, as far as possible, to give references to the originals.

He is indebted to Mr. R. H. Scott, the Secretary of the Meteorological Council, not only for much assistance in supplying materials and references which were required, but more especially for the help obtained from an unpublished draft of a portion of a "Barometer Manual," compiled by him for the Office in 1877. From this he has extracted several paragraphs relating to wind gradients, &c.

The greater part of the work is however new, and several investigations, such as those relating to the classification of weather into types, and to the occurrence of periodical weather changes, &c., have been undertaken expressly for this publication.

It must also be understood that the Meteorological Council, although authorizing the publication of the work, accept no responsibility for the opinions it contains, which are therefore to be regarded as those of the author alone.

London, May 7th, 1883.

NOTE.—Owing to the serious and prolonged illness of the author, this work has necessarily been passed through the press without having the advantage of his final revision, and there are some passages which, though obscure, it has not been thought desirable to modify.

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PRINCIPLES OF FORECASTING

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WEATHER CHARTS.

CHAPTER I.

SYNOPTIC CHARTS.

The earliest stage of Meteorology in every country has always been the collection of popular weather prognostics, referring to the appearance of the sky or the movements of animals; and everywhere these observations lead to a considerable success in forecasting weather. For the last 150 years the indications of the barometer, as observed by each solitary observer, have been added in all civilized countries to the older weather lore, and with increased power of forecasting. But within the last 25 years a new method has been introduced of combining on a chart the observations made at the same instant at a large number of places, especially with regard to the relative height of the barometer. These maps are called synoptic charts, and round them a totally new science has grown up, which has developed a vastly increased power of forecasting. The problem of forecasting weather by means of prognostics and the observer's own barometer will always be of value at sea and in rural places, but will only be casually alluded to in this work.

Our object is to place before the reader, in an elementary form, a brief account of the modern method of forecasting weather by means of synoptic charts; and though the general principles laid down hold all over the world, the details will refer to Great Britain only. It may also be remarked that the whole system of synoptic forecasting, as this may be called, depends entirely on the observed association of different sets of phenomena, and is totally independent of any theory of atmospheric circulation.

Synoptic charts are so called from a Greek word meaning "*a general view,*" that is, over a large tract of country, and those prepared at the Meteorological Office are constructed in the following manner. Every morning at 8 o'clock punctually, telegraphic reports are sent up to London from about 50 stations in the United Kingdom, giving the height of the barometer and thermometer, with the direction and force of the wind, together with the actual state of the weather. Practically the weather changes are so rapid that these reports must be sent by telegraph to be of any use.

Here is a portion of such a report :—

Stations.	Barometer at 32° F. and Sea Level.	Temp. in Shade.	Wind. Direction.	Wind. Force (0 to 12).	Weather.
Pembroke -	29·62	46	W.N.W.	5	bc
Scilly - -	29·71	48	N.W.	6	c
Prawle Point -	29·67	46	W.N.W.	4	bc
Hurst Castle -	29·56	44	N.W.	4	b
Dover - -	29·43	45	W.	5	b
London -	29·48	44	W.N.W.	2	bc
Oxford - -	29·56	42	N.W.	4	b
Cambridge -	29·39	44	S.W.	2	b
Yarmouth -	29·28	42	W.S.W.	5	cq
The Helder -	29·25	45	W.S.W.	5	r

A blank map is then taken, and the first thing done is to mark at each station the height of the barometer. Lines are then drawn through all those places where the pressure is equal. If two stations have exactly the pressure required, they are simply joined, but if neither has the pressure wanted, we draw a line between them so as to divide the distance proportionally. Thus from the data just given, if we wanted to draw the line of 29·5 inches, we should have to draw it proportionally between London, where the pressure is 29·48 inches, and Oxford, where it is 29·56 inches, and it would pass much nearer London. Lines so drawn are called "isobaric lines" or shortly "isobars," from two Greek words signifying "equal weight," because they pass through places where the barometric pressure is equal. They are by far the most important element in forecasting, and the greater portion of this work will be occupied in showing the relation of wind and weather to the different shapes which these lines assume.

After the isobars, the direction of the wind is marked by arrows, which are always supposed to fly with the wind and have a number of "fleches" proportional to the force of the wind.

The force of the wind is estimated by the Meteorological Office on what is universally known as "Beaufort's scale." On this system all possible forces or velocities are estimated on an arbitrary scale of 0–12, or from calm to hurricane force. The intermediate numbers refer to the number of knots that a man-of-war can make per hour, or the extent of canvas which the wind permits her to carry. The scale is as follows; and we have added in the last column the estimated equivalent velocity in miles per hour of the arbitrary numbers in the first column, being that adopted in the Meteorological Office.

BEAUFORT'S SCALE.

				Velocity of wind in miles per hour.
0	Calm.			3
1	Light air -	Or, just sufficient to give steerage way.		8
2	Light breeze -	Or, that in which a well-conditioned man-of-war, with all sail set, and clean full, would go in smooth water from -	1 to 2 knots.	13
3	Gentle breeze -		3 to 4 knots.	18
4	Moderate breeze		5 to 6 knots.	23
5	Fresh breeze -	Or, that to which she could just carry in chase, full and by - - - -	Royals, &c.	28
6	Strong breeze -		Single-reefed topsails, and topgallant sails.	34
7	Moderate gale -		Double-reefed topsails, jib, &c.	40
8	Fresh gale -		Triple reefed topsails, &c.	48
9	Strong gale -		Close-reefed topsails, and courses.	56
10	Whole gale -	Or, that with which she could scarcely bear close-reefed main-top-sail and reefed foresail.		65
11	Storm - -	Or, that which would reduce her to storm-stay-sails.		75
12	Hurricane -	Or, that which no canvas could with-stand.		90

Then the weather is marked. In this country a system of abbreviations is used known as Beaufort's notation, which is—

- **b** blue sky.
- **c** detached clouds.
- **d** drizzling rain.
- **f** fog.
- **g** dark, gloomy.
- **h** hail.
- **l** lightning.
- **m** misty (hazy).
- **o** overcast.
- **p** passing showers.
- **q** squally.
- **r** rain.
- **s** snow.
- **t** thunder.
- **u** ugly, threatening.
- **v** visibility, unusual transparency.
- **w** dew.

Lastly, the readings of the thermometer are marked, and lines are drawn through those places where the temperature is equal, just as was done for pressure; these lines are called "isotherms," that is, lines of equal heat. They play, at present, a very small part in forecasting. The chart is then complete.

We shall next proceed to point out the relation which the examination of a very large number of similar maps has shown to subsist between the wind and weather and isobars.

CHAPTER II.

GRADIENTS AND WIND.

First, as regards the direction of the wind. In few cases is the wind exactly parallel to the isobars, but is inclined at an angle of about 30° to 40° to them, while the relation relatively to the adjoining areas of high and low pressure is given by the following rules.

The general rule is:—

Stand with your back to the wind and the barometer will be lower on your left hand than on your right.

Thus the wind may be expected to be:—

Easterly, when the pressure is higher in the north than in the south.

Southerly, when pressure is higher in the east than in the west;

Westerly, when pressure is higher in the south than in the north;

Northerly, when pressure is higher in the west than in the east.

The relation between wind and pressure is traceable in several older writings, but the credit of having persistently urged it, until it has met with general acceptance for all winds, is due to Professor Buys Ballot, of Utrecht, after whom it is generally called Buys Ballot's Law.

Next, as to the velocity of the wind. This has been discovered to depend, at least in a great measure, on the amount of the difference of barometrical readings over a given distance.

It is obvious to every one that the steepness of a slope is measured by the proportion between its vertical height and its horizontal length, and engineers measure slopes in this way, and speak of the steepness of a slope, or of the gradient as 1 in 60, 1 in 100, &c.

Thus we get the idea of a gradient, but barometric gradients are not referred to the same units of scale in the vertical and horizontal directions as are those of engineers for railroads. The vertical scale is expressed in units of barometrical readings, and the horizontal scale in units of geographical measurement.

The use of the term "gradient," as applied to differences of atmospheric pressure, first suggested by Mr. T. Stevenson, C.E., of Edinburgh, has been generally adopted in this and other countries. In the Meteorological Office the gradients are now expressed in decimal parts of an inch of mercury per 15 nautical miles, or about 17 common miles. This proportion was chosen for the sake of conformity with the French scales. A hundredth of an inch is nearly equal to a quarter of a millimetre, so that the definition given above is nearly exactly equivalent to stating that the gradients are given in millimetres per 60 nautical miles, or 1° of latitude.

From the gradients thus estimated conclusions as to the probable force and direction of the wind are drawn. It is found, for instance, that the force of the wind will not generally exceed the figure 5 or 6 on Beaufort's scale, a "fresh" or "strong" breeze, unless the gradients be as high as ·02 inch; and that practically no storm of serious extent is ever felt over the United Kingdom unless there be a barometric difference exceeding half an inch between two of our stations. This, however, does not preclude dangerous squalls or blasts associated with thunderstorms.

Gradients, as thus measured, are rarely higher than ·04 or ·05 inch in our islands, though much higher values than these are occasionally recorded in very severe storms.

In a general way we may define gradients as slight or moderate when below ·01 inch, and steep when above ·02 inch.

In the following table the observed mean velocity for different gradients at Kew is given:—*

Gradients per 15 Nautical Miles.	Wind Velocity in Miles per Hour.	Gradients per 15 Nautical Miles.	Wind Velocity in Miles per Hour.
In. 0·002	5·0	In. 0·017	15·0
·005	7·0	·020	16·5
·007	7·5	·022	19·1
·010	9·2	·025	22·0
·012	11·6	·027	22·2
·015	12·6	·030	25·5

Observe particularly that the difference of the barometer readings at two places, divided by the number of fifteens in the distance in nautical miles between them, does not give the gradient, unless

* Whipple, "Barometric Gradients," &c., Q. J. Meteor. Soc., Vol. VIII., 1882, p. 198.

the line joining them happens to be square to the isobars—a mistake which is often made. For instance, in Fig. 2, if the

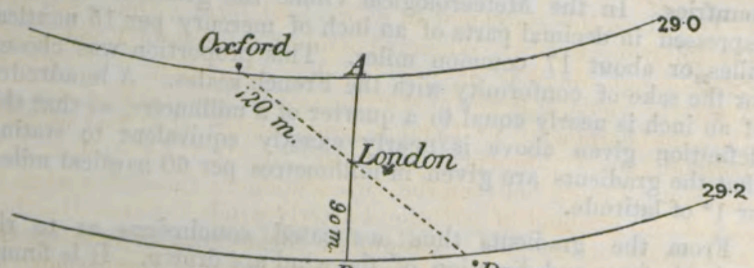

Fig. 2.

difference of pressure between Dover and Oxford, 120 miles apart, is two tenths of an inch, $\frac{0\cdot2 \times 15}{120} = \frac{0\cdot2}{8} = 0\cdot025$, is not the true gradient over London. This would be found by drawing a line A B through London, square to the isobars, and measuring its length, 90 miles, on the scale of the map, when the true gradient would be $\frac{0\cdot2 \times 15}{90} = \frac{0\cdot2}{6} = 0\cdot033$ inch.

By combining the idea of gradient with what we have before stated as to the relation of the wind's direction to the isobars, we can now explain the meaning of the expression, that in a certain chart we have gradients of such an amount for such a particular wind.

For if the wind is nearly parallel to the isobars, then it must be nearly perpendicular to the gradient. For example, in Fig. 3, we

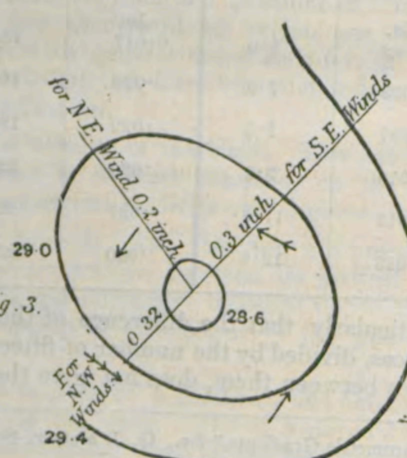

Fig. 3.

find a gradient of 0·3 inch for South-east winds on the north-east side; a gradient of 0·2 inch for North-east winds on the north-west side; and of 0·32 inch for North-west winds on the south-west side.

To reduce this statement to a practical form we may put it in the following words. When it is said that between London and Scarborough there is on a given day a gradient of ·025 for Westerly winds, it is meant that the isobars lie west and east, and that the barometer in London reads higher than that of Scarborough, by a difference amounting to ·025 for each unit of 15 nautical miles between the two stations. Similarly, when we speak of a gradient of ·015 for Easterly winds between Holyhead and Brest on another occasion, we mean that isobars on that occasion were also lying west and east, but that the barometrical reading at Holyhead was higher than that at Brest, and that the difference amounted to ·015 per 15 nautical miles. Note that in both instances, stations have been selected which were north and south of each other, so as to be at right angles to the isobars.

Observation shows that the relation of wind to gradient can only be approximately stated, and that it is not the same in all parts of the world; for it has been clearly proved by the investigations into the meteorology of the Equatorial region of the Atlantic, which have been carried on in the Meteorological Office, not only that the total difference in the barometer readings over the Trade Wind zones is much less than would be observed here for winds of the same force as the Trade Winds, but also that there is a marked difference in this respect even between the two Trade Winds in the Atlantic.

In this country this relation is subject to several sources of variation, the most important being, that for any given gradient, winds from North and East points are stronger than those from South and West points at these stations, by 20 or 30 per cent. In forecasting, therefore, gradients that would only cause a strong breeze with West winds would give a gale with East winds.

An instance in point, as regards West winds, is to be found in gradients during the gale of January 8, 1870, during which the reading at 8 a.m. at Brest was 29·38 ins., and that at Penzance at the same hour was 29·19 ins. The difference between these readings is 0·19 in., and the resulting gradient is ·025 in. per 15 nautical miles. The actual winds reported that morning were West-south-west 9 from Brest, South-west 10 from Penzance, and West 11 from Plymouth. Here, then, a heavy Westerly gale accompanied a steep gradient from Penzance to Brest.

The converse conditions, accompanying an Easterly gale, were observed May 14, 1869, when the reading at 8 a.m. at Penzance was 29·92 ins., and at Brest was 29·68 ins. The resulting gradient is ·032 in. per 15 nautical miles, and the gales reported were East 8 at Penzance and Plymouth, and South-east 9 at Cape Clear.

These examples show that the force of the wind in the English Channel did not bear the same proportion to the gradient on the two occasions cited, and if space permitted, abundant instances of similar discrepancies might be adduced.

Besides this, we also find that for the same gradients there is more wind in summer than in winter, and more by day than by night.

The former is called the seasonal, and the latter the diurnal variation; and though both are of great scientific interest, they are of slight importance in forecasting, and will not be again referred to in this work.*

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* For further details, see Ley on "The Relation of Gradient to Force of Wind," Q. J. Meteor. Soc., Vol. III., p. 437; Abercromby on "The Diurnal Variation of Wind and Weather," Q. J. Meteor. Soc., Vol. VIII., p. 213.

CHAPTER III.

ISOBARS AND WEATHER.

In the foregoing pages we have described the principal relations which observation has established between wind and isobars, and have seen that the force depends only on the closeness, and the direction on the lie or trend of the isobars. But when we come to the relation of weather to isobars, we discover that the shape or configuration of the lines is of primary importance. Although the shape of the isobars is perpetually changing, we find that a few well-defined forms are always reproduced. To seven of these conventional names have been given, which we will now proceed to describe in detail. They are—

1. The cyclone, an area of low pressure, bounded by circular or oval isobars.
2. The secondary cyclone, or shortly "secondary," a small circular depression, subsidiary to the foregoing.
3. The V-shaped depression, an area of low pressure bounded by V-shaped isobars, something like a secondary, but differing from it in many important particulars.
4. The anticyclone, an area of high pressure, bounded by circular or oval isobars.
5. Wedge-shaped isobars, an area of high pressure bounded by isobars converging to a point like a wedge.
6. Straight isobars, a barometric slope, down which the isobars lie in straight lines.
7. The *col*, or neck of low pressure, lying between two adjacent anticyclones.

Of these the cyclone, secondary, anticyclone, and wedge are by far the most important, and we will now proceed to give the particulars of the weather which characterises each of these shapes of isobars, beginning with the cyclone.

Cyclones.

The details of cyclone weather we shall be obliged to give at some length, for in describing them we shall have to introduce the reader for the first time to some of the leading principles of synoptic meteorology, but when they have once been rightly apprehended, the characteristics of the other shapes of isobars can be given much more briefly.

The following technical terms referring to cyclones may first advantageously be explained—

The centre of the cyclone is the geometrical centre of the innermost isobar, *see* Fig. 7 (p. 14).

The diameter of a cyclone is a line drawn through the centre as far outwards as the curvature of the isobars is distinctly related to the centre, and is often very ill defined, since the influence of the cyclone extends much further in some directions than in others. A cyclone may be of any diameter, from 100 to 3,000 miles. The commonest are between 1,000 and 2,000 miles; and anything less than 1,200 miles across may be called a small one. The diameter is the measure of the size of a cyclone.

The axis of the cyclone is an imaginary line round which the whole air in a cyclone may be supposed to circulate. There is reason to believe that it is not usually vertical to the earth's surface, and that both the inclination and direction of the axis is variable.

The intensity of a cyclone is measured by the maximum steepness of the gradient in any portion of it. If this exceed 0·02 inch per 15 nautical miles, then the cyclone may be said to be of considerable intensity.

By the expression the level of a cyclone is meant the barometrical reading at the lowest point. If the lowest point in the cyclone is above 29·9 inches, we may call it a high-level cyclone; if below that a low-level one.

The path of a cyclone is the path described by the centre. In this country 90 per cent. move towards some point of east, the most frequent direction being about east-north-east.

The velocity of a cyclone is the velocity of the centre. It may be anything from 70 miles an hour eastwards to 10 miles an hour westwards. About 20 miles is a common velocity, but sometimes a cyclone is stationary.

The trough is a line drawn through the centre of the cyclone, generally at right angles to its path, which marks out the position of all the places where the barometer has attained its lowest point. Everywhere the mercury is falling in front and rising in rear of the line, in consequence of the forward motion of the cyclone. This line defines the front and rear of a cyclone.

The right and left sides of a cyclone are the right and left sides to an observer looking in the direction in which the cyclone advances; they are thus relative to the direction of the cyclone path.

The life of a cyclone is measured by the number of days during which it can be traced on synoptic charts. The length of the life may be anything from a few hours to about 20 days. Any cyclone whose life is less than 24 hours may be called short-lived.

Now for the details of wind, weather, temperature, &c. in different portions of a cyclone.

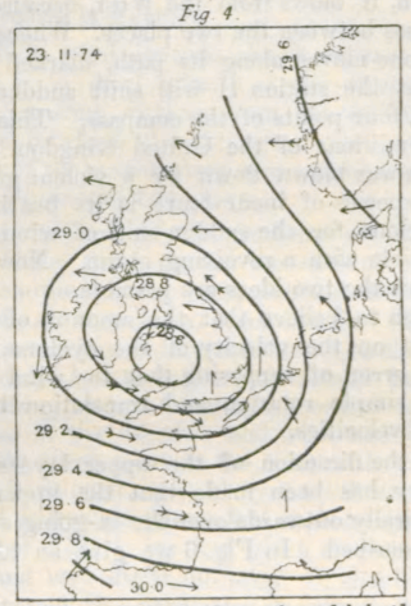
The temperature is always higher in front than in rear: the warm air in front having a peculiar close, muggy character, quite independent of the actual height of the thermometer. The cold air in the rear, on the contrary, has a peculiarly exhilarating feeling, also quite independent of the thermometer.

The front is always very damp, especially the right front, while the rear is dry to a marked degree.

The wind blows round the centre in a direction contrary to the motion of the hands of a watch which is lying horizontally with its face upwards; but as the direction is slightly inclined to the isobars, on the whole the circulation is an in-going spiral. The amount of incurvature is usually greatest in the right front and

least in the rear of the cyclone, so that sometimes the passage of the trough is marked by a sudden shift of wind. In Fig. 4 we

Fig 4.



give an example of a typical cyclone, in which the relation of the wind to the centre is well shown, and in Fig. 5 we give an

Fig 5 28-12-79. 6 P.M.

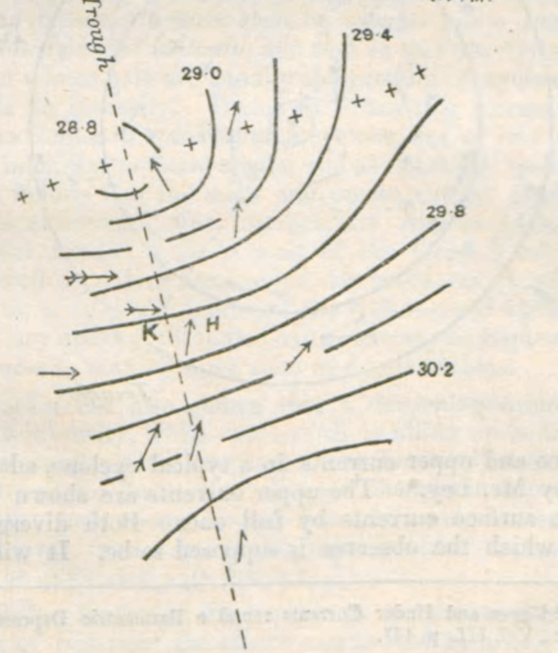


illustration of exceptional incurvature. In the latter instance the wind at the point marked H is almost due South, while at K, some 60 miles off, it blows from the West, because the trough of the cyclone passes between the two places. Whence, it is evident, that as the cyclone moves along its path, marked by the crossed line, the wind at the station H will shift suddenly from South to West, that is, four points of the compass. This diagram gives the synoptic conditions of the United Kingdom 1¼ hour before the Tay Bridge was blown down by a violent gust. The chief interest of this species of incurvature is its bearing on the conception of a cyclone, for the sudden shift of wind was long held to be incompatible with a revolving storm. Now by means of charts we see how the two ideas are possible.

There is reason to believe that the amount of incurvature is partly dependent on the velocity of the cyclone, but the reader must avoid the error of supposing that the wind in a cyclone is compounded of simple rotation and translation by the so-called parallelogram of velocities.

By watching the direction of the upper layers of clouds, the striking discovery has been made that the upper currents in a cyclone move spirally outwards over the in-going surface currents we have just described. In Fig. 6 we give an ideal diagram of

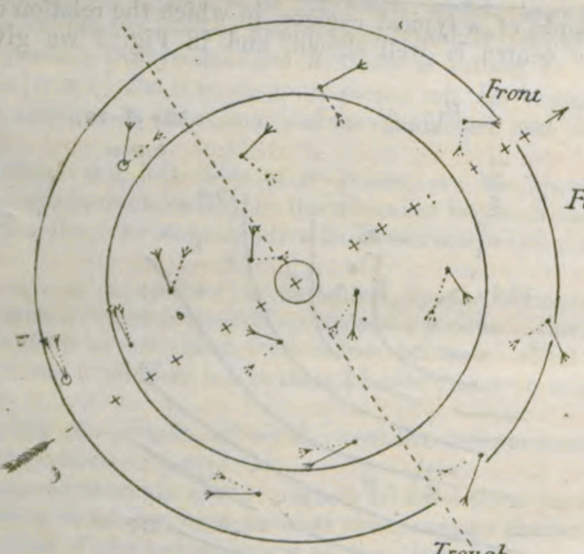


Fig 6

the surface and upper currents in a typical cyclone, adapted from a paper by Mr. Ley.* The upper currents are shown by dotted lines, the surface currents by full ones. Both diverge from a point at which the observer is supposed to be. It will be seen

* Ley, "Upper and Under Currents round a Barometric Depression," Q. J. Meteor. Soc., Vol. III., p. 437.

that, like the surface winds, the direction of the upper current is dependent on the position of the front, that is, of the direction in which the cyclone is moving.

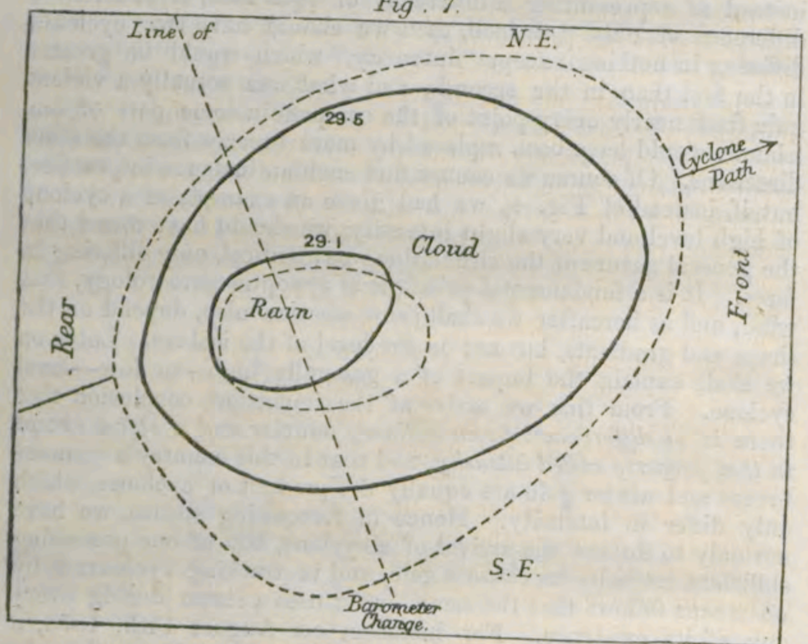
The force of the wind depends almost entirely on the gradients. In the centre it is dead calm, and the steepest gradients are usually found at some distance from the centre. The direction from the centre in which the strongest winds are found, depends on the position of the surrounding areas of high pressure, and will be abundantly illustrated further on.

The relative steepness of the gradients measures the intensity of cyclones. Take, for instance, the cyclone shown in Fig. 4, and conceive another of the same size and shape, moving in the same direction at the same rate, but in which the isobars, instead of representing a difference of $\frac{2}{10}$th inch, represented a difference of only $\frac{1}{10}$th inch, then we should have two cyclones differing in nothing except "intensity," which would be greater in the first than in the second; and what was actually a violent gale from nearly every point of the compass in some part of our islands, would have been replaced by mere breezes from the same directions. Of course we cannot find such an instance in practice, but if, instead of Fig. 4, we had given an example of a cyclone of high level and very slight intensity, we should have found that the general nature of the circulation was identical, only differing in force. It is a fundamental principle of synoptic meteorology, that wind, and as hereafter we shall show weather also, depend on the shape and gradients, but not on the level of the isobars. Later on we shall explain the import of a generally high—or low—level cyclone. From this we arrive at the important conclusion that there is *no difference between ordinary weather and a storm except in that property called intensity*, and that in this country a summer breeze and winter gale are equally the product of cyclones, which only differ in intensity. Hence in forecasting storms, we have not only to foresee the arrival of a cyclone, but of one possessing sufficient intensity to cause a gale, and in tracking cyclones it by no means follows that the same one causes a storm during every day of its existence. For instance, on August 14th, 1873, a cyclone was formed a little west of the Cape Verde Islands, which passed as a hurricane round Bermuda, to Newfoundland by the 27th, after which it crossed the Atlantic and Great Britain as an ordinary cyclone, till it died out in Norway on September 2nd, and gave rise to nothing more than moderate breezes.

Observation has also shown that a deepening cyclone is increasing in intensity, while one which is filling up is decreasing. Whence in watching the progress of cyclones by telegraph, it is very important for forecasting to note changes in depth, as well as any other indications derived from the configurations of the isobars, or even from weather prognostics, which experience has shown to be associated with intensity.

The broadest feature of the weather in a typical cyclone consists of an area of rain near the centre surrounded by a ring of cloud, but both the rain and cloud extend further to the front than to the rear of the centre, as in Fig. 7. When we come, however, to examine the nature of the cloud and rain as well as the general appearance of the sky, we find that the cyclone is also divided into two well-defined halves by the line of the trough. The front may be further divided into the right or south-east and left or north-east fronts, which, though they have much in common, are sufficiently different to be classified separately. They are separated by the line which represents the path of the cyclone; but this line does not mark the position of any great physical change, like the trough, as the weather in either front merges gradually into the other. In Fig. 7 this is shown in a diagrammatic form, with

Fig. 7.



lines marking out the position of the right and left, or south-east and north-east fronts, as well as the front and rear of the cyclone, besides showing the relation of the isobars to the rain and cloud areas. The whole of the front is characterised by warm, close, muggy, and damp weather, with a dirty sky, while the whole of the rear is cool, brisk, exhilarating, and dry, with a hard, firm sky. Coming now to more minute detail, in the left or north-east front, when the steepest gradients are somewhere south of the centre, the first symptoms of the approach of a cyclone are a halo with a gradual darkening of the sky, till it becomes quite overcast, without any appearance of the formation of true cloud; or else, light wisps or barred stripes of cirrus moving sideways appear in the blue sky, and gradually soften into an

uniform black sky of a cumulo-stratus type; nearer the centre, light, ill-defined showers fall from the uniformly black sky, the wind from some point between South-east and North-east blows uneasily, and though the air is cold and chilly, there is an oppressive feeling about it. These appearances continue till the barometer commences to rise, when the character of the weather at once begins to alter. In a cyclone where the steepest gradients are somewhere to the north and east of the centre, the general character of the weather is the same as above described, but is much more intense, the wind rising at times to a heavy gale and the ill-defined showers developing into violent squalls.

In the right or south-east front, when the steepest gradients are to some point south of the centre, which will be seen further on to be the commonest case in this country, the first symptoms are likewise a gradual darkening of the sky into the well-known pale or watery sky, with a muggy oppressive air; or else, as in the north-east front, wisps of cirrus first appear in the blue sky, which gradually become heavier and softer, till the sky is uniformly overcast with a cumulo-stratus type of cloud. Nearer the centre, rain, usually in the form of drizzle, sets in, and the wind, from some point between South-east and South-west, varying in force according to the steepness of the gradients, drives the cloud and rain before it. But this wind differs from that in the other portions of the cyclone, in its way of blowing, and, for the same velocity, does not raise so high a sea, or seem to bear so much down on the surface of the earth. In cases of very great intensity, the rain in this portion of a cyclone may come in showers, or even squalls, but the general character is never lost.

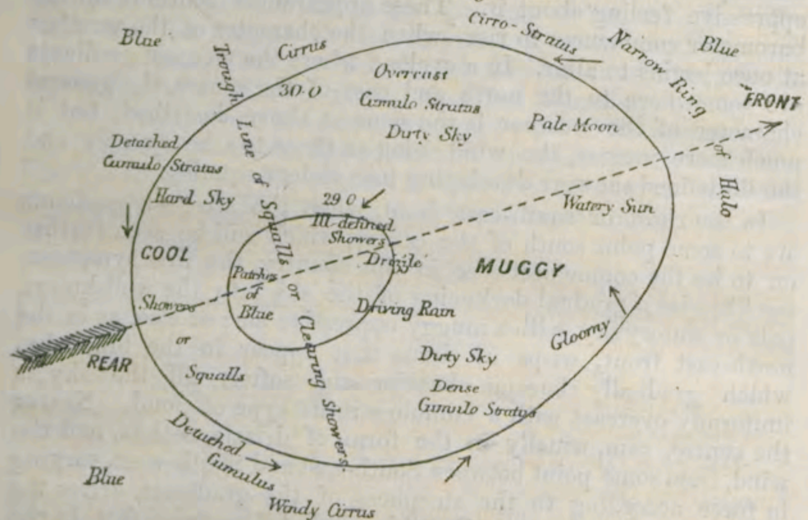
The line of the trough marks out a line of heavy showers or squalls, especially the portion on the southern side of the centre.

The general character of the west, or rear side, is a cool, exhilarating feeling in the air, with a high hard sky, of which the tendency is always to break into firm detached masses of cloud. The rain, which occurs near the centre, is usually in cold, sharp, brisk showers, or hard squalls, and the general hard look of the weather presents a marked contrast to the dirty appearance of the weather which characterises the whole front of a cyclone. Further from the centre showers or squalls are replaced by simply detached masses of cloud, and these finally disappear, leaving a blue sky. The wind, from some point between West and North, blows gustily, and for the same velocity raises a higher sea than a South-west wind, and seems to bear down more on the surface of the water. The whole of the rear of a cyclone partakes of this general character, but the change of weather along the north of a cyclone is not nearly so strongly marked as along the southern portion.

If instead of the general terms "rain," "cloud," &c. used in Fig. 7, we write down in popular language the details of the kind of cloud or sky, with other characteristics of different portions of the same cyclone, as in Fig. 8, we shall find our old friends the

Fig. 8.

Cyclone Prognostics.



popular weather prognostics of ordinary life under a very new guise. We shall see that a large number of well-known prognostics of rain or bad weather are simply descriptive of the weather in different parts of a cyclone, and that they owe their value to their appearance in front of the rainy portion of a cyclone.* Thus a watery sky is a sign of rain, because it is characteristic of the front or east side of a cyclone, and as a cyclone usually travels eastwards, an observer will successively be subjected to the influence of the cloudy and rainy parts of the cyclone before an area of fine weather again reaches him.

We shall refer to the subject of prognostics and their value in synoptic forecasting further on in this work.

Though the general characteristics of a cyclone—warm, muggy, and dirty weather in front; cool, dry, and bright in rear—are invariably maintained, still individual cases vary much in detail.

The sources of variation are so important that it will be necessary to examine them shortly, premising that they only modify, but do not alter, what we have called the general characteristics, and that though we are now referring only to cyclones, these variations apply to every other shape of isobars.

There are six sources of variations which must be mentioned, viz.:—1, the type; 2, the intensity; 3, the size; 4, local variation; 5, diurnal variation; and 6, seasonal variation.

The first source of variation in any cyclone is one which will be hereafter very fully developed, and which depends on the *type of general distribution of pressure to which it belongs.*

* For further details, see Abercromby and Marriott, "On Popular Weather Prognostics," Q. J. Meteor. Soc., Vol. IX., p. 27.

The commonest type of cyclone in this country has the highest pressure some point south of the centre, on which side the steepest gradients are found. In this case the rain and cloud area extends far to the south and south-east of the centre, but comparatively little to the north and north-west, while the hardest weather generally is found to the point of south, where the steepest gradients are. This may be termed the Westerly Type of cyclone, both because the paths of the cyclone run nearly east and west, and because the prevailing winds are Westerly. In another less common type the highest pressure is some point to the north-east of the centre, on which side the steepest gradients are found; in this case the rain and cloud area is very differently shaped from that just described, extending furthest from the centre in the north-east direction, while the hardest or most severe weather is found to the point of north-east, where the steepest gradients are. This may be termed the Easterly Type of cyclone.

It may be well to mention here that it is very rare to find rain at any particular hour over the whole of what is called the "rain area;" but where not actually raining, the sky is overcast and bordering on rain, which is sure to fall some time during the day. Similarly in the area of less cloud, called the "cloud ring," isolated patches of rain are often found developed by local or other circumstances.

The next source of variation depends on the difference of the *intensity* of the cyclone. In cyclones of the same type the weather differs much in "hardness," or "severity," or in "quietness." Thus, in the south-east front the sky may be simply soft and overcast in a cyclone of moderate intensity, but with increased intensity the overcast sky would develope into soft, drizzling rain, or into broken rain, or even into a peculiar class of thunderstorm common on our west coasts in winter, while the wind would vary from a moderate breeze to a gale of any force; but in spite of all these variations there is always the close, muggy atmosphere, and dirty sky characteristic of this part of a cyclone. Again, in the rear, the general character is always a cool, brisk feeling in the air, with a bright and broken sky, which varies according to the intensity, from simple heavy masses of cloud, to hard showers, to squalls, or to hail squalls with thunder and lightning; but no difference of intensity can ever alter the fundamental difference in the general character of the south-east front and the rear portions of a cyclone.

Now it is found from observation that these differences of intensity are directly connected with differences of steepness in the barometric gradients. If, for instance, we take two cyclones, differing in nothing but a greater or less steepness of the gradients, as in discussing wind, the corresponding difference of weather would be shown in a less continuous area of rain near the centre of the second cyclone, in a smaller extension of cloud round the rain, and in a less total rainfall all over the country during the cyclone's passage. Where squalls occurred in the first cyclone, they would be replaced in the second by brisk showers, and the weather generally would be more deficient in these properties to which the words "hardness" or "severity are usually applied.

It is well known that a deepening cyclone is increasing in intensity, while one which is filling up is decreasing, and Professor Loomis has shown that in the United States rain and cloud extend further from the centre in the former than in the latter case, and there is reason to believe the same rule holds good in this country, though it is hard to verify.

A third source of variation depends on *the size and shape of any cyclone*, and is intimately connected both with the type and intensity. In very large cyclones the steepest gradients and the bad weather which accompanies them are always found at some distance from the centre. In small cyclones the heaviest rain usually surrounds the centre, and extends more or less to one side or the other, according to the direction of the nearest area of high pressure, and the steepest gradients.

Another very important cause of modification in weather is *local variation*. It is well known that in any storm, showers, squalls, and thunderstorms are very local, and in some places, either from the contour of the ground or other causes, they are much more frequently developed than in others. Again with the amount of rainfall—the position of ridges of hills, or of the sea, relatively to the prevailing winds, or the presence of lakes and forests as compared with bare ground—all seem to have an important influence over it. So important is the position of the sea, that on our east coasts the worst weather is with Easterly winds, while on our south and west coasts the worst is with Westerly winds.

It is clear that even if we had a thorough acquaintance with all the conditions under which storms appear, it would be quite impracticable so to apportion our warnings that only such ports as were visited by the gales should be warned. A moment's reflection will suffice to show anyone who fancies that warnings should be local and tested by local weather, that by such a system Liverpool would seldom receive a warning for Southerly gales in St. George's Channel. The simultaneous records of the wind at Holyhead and in the town of Liverpool prove that frequently gales of this character blowing at Holyhead are accompanied by light South-easterly breezes in the Mersey, and every warning of such gales sent to Liverpool would be counted as a failure. Warnings are mainly intended to give the seamen information of the weather prevailing outside his port, and which he will have to meet if he sets sail. It is evident, therefore, that any warnings issued should be tested by the continuous records of the weather prevailing on the entire district of coasts where the stations are situated.

So, also, for weather generally. An inch of rain may fall in one part of London and hardly a drop in another, but the general character of showery or thundery weather would be the same in both parts. When, therefore, we forecast weather, it can

only be done in general terms, as even if it were otherwise possible, every few square miles of the United Kingdom would require a separate warning.

A fifth very important source of variation is one known as *diurnal variation*. This term is applied to changes in the amount of wind cloud or rainfall which depend on the time of day. As a rule these changes are so complicated that they cannot be detailed in such an elementary work as the present, so that we must content ourselves with merely stating some important principles connected with them. The simplest conception of diurnal change can be got from the idea that though a day may be described in general terms as "hot" or "cold," still there will be a diurnal range of the thermometer overriding or superimposed on the general temperature of the day. We have already alluded to the diurnal variation of wind, and it may now be stated generally, that every meteorological element has a diurnal variation, that different shapes of isobars have not the same variation, for instance, the diurnal change of weather of a cyclone is almost the converse of that in an anticyclone; but that in every case the diurnal weather modifies, but does not alter, the general character imposed on the weather by the shape of the isobars. The changes of weather due to alterations in the shape of the isobars are called the *general changes*, and it is a fundamental principle of synoptic meteorology that the diurnal variations and general changes are independent, and that the observed weather represents their sum. Therefore, though very interesting from a purely scientific point of view, it follows that this variation plays no part in forecasting.

The sixth and last source of modification is the seasonal variation. In this country, during winter, the cyclones are usually much larger than in summer; and, even in cyclones of about the same size and intensity, the position of the rain and cloud areas is not quite the same. In winter time, the clouds and general appearance of the sky are usually softer than in summer, and the rain is more drizzly and less showery, besides many other smaller differences, which are too well known to require minute description. This variation is an important factor in forecasting.

From all these considerations we conclude that though every detail of weather is subject to assignable laws, the details are so complicated that we can describe the weather associated with any shape of isobars in general terms only.*

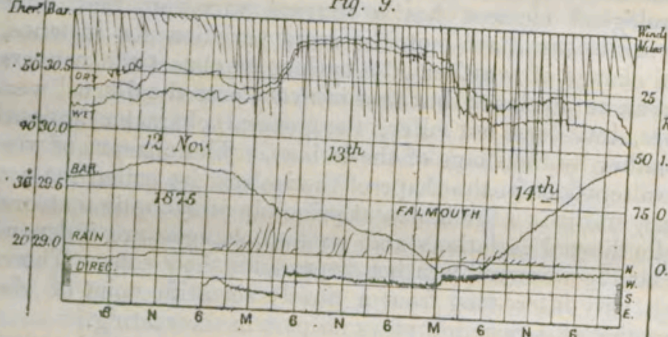
So far we have only dealt with a single synoptic chart, but as the isobars are constantly shifting their position, we see that a series of synoptic charts is simply a series of plans of the changing positions of atmospheric movements. While, therefore, a single chart tells us only about existing weather at a given hour, the comparison of two or more enables the direction, nature, and succession of the ceaseless changes of cyclones to be accurately

* For further details, see Abercromby, "On Cyclone Weather," Q. J. Meteor. Soc., Vol. IV., p. 1; also, "On the Diurnal Variation of Wind and Weather," Q. J. Meteor. Soc., Vol. VIII., p. 213.

followed. As the aim of forecasting is to foretell the weather changes at any one place, we must now endeavour to explain how the movements shown on a series of synoptic charts would be reflected as the sequence of weather at any place.

The method employed, besides noting verbally the succession of physical changes in the appearance of the weather, such as blue sky, halo, cloud, rain, and blue sky again, is to record in a diagrammatic form the changes in the readings of the different instruments which it is thought necessary to observe. The best traces are those obtained from self-recording instruments. The trace given by a barometer is called a "barogram;" that by a thermometer a "thermogram;" while a trace of either the direction or force of wind is called an "anemogram." When two or more of these traces are all combined in one picture, as in Fig. 9, the

Fig. 9.



whole is called a "meteorogram." For the sake of distinctness we also give in Figs. 10 and 11 small charts for a portion of

Fig. 10

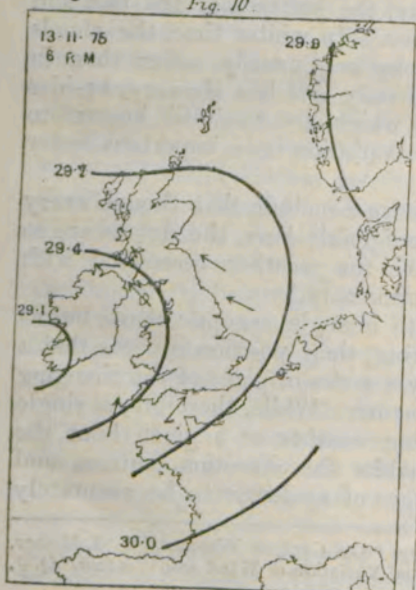
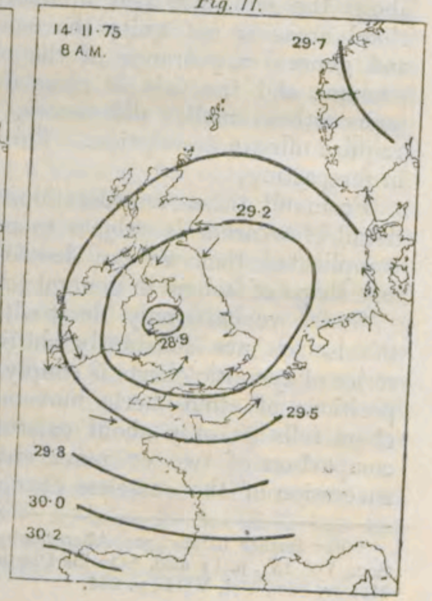


Fig. 11.

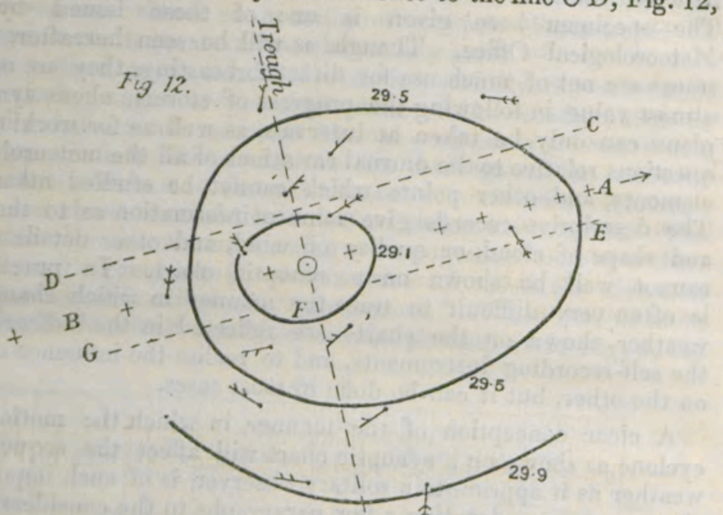


the period contained in the meteorogram, so that the relation between the two kinds of observations may be easily detected. The specimen here given is one of those issued by the Meteorological Office. Though, as will be seen hereafter, these traces are not of much use for direct forecasting, they are of the utmost value in following the progress of storms, whose synoptic plans can only be taken at intervals, as well as for working out questions relative to the diurnal variations of all the meteorological elements, and other points which cannot be studied otherwise. The descriptive records give minute information as to the kind and shape of cloud, or quality of wind, and other details which cannot well be shown on a synoptic chart. In practice it is often very difficult to trace the manner in which changes of weather shown on the charts are reflected in the indications of the self-recording instruments, and to realise the influence of one on the other, but it can be done in most cases.

A clear conception of the manner in which the motion of a cyclone as shown on a synoptic chart will affect the sequence of weather as it appears to a solitary observer, is of such importance that we propose devoting a few paragraphs to the consideration of the diagrams we have just referred to. In Figs. 10 and 11 we give two successive charts of the same cyclone at 6 p.m. November 13th, 1875, and at 8 a.m. November 14th; while above we give in Fig. 9 a meteorogram at Falmouth for three whole days, November 12th, 13th, and 14th, 1875. In Fig. 12 (p. 22) the isobars and wind arrows for the chart in Fig. 11 are given on larger scale.

The first important point to remark is that as the cyclone moves along its path, it carries its own circulation of wind along with it. If then, as in Fig. 12, we draw a line E G passing through F, which represents the position of Falmouth, parallel to A B, the crossed line which marks the path of the cyclone, we shall get the sequence of barometric and wind changes at Falmouth. For instance, starting from E, the barometer would fall till we arrive at the trough, as we see in the right-hand half of the barogram in Fig. 9; after the passage of the trough, the barometer begins to rise. Note, however, the sharp irregular dip of the trace just as the trough passes, for this is most characteristic, and is associated with the squall already mentioned as occurring in this portion of a cyclone. As in this case the gradients are steeper in rear than in front of the cyclone, the rise of the barometer will be more rapid than the fall. Turning now to the wind direction, we see from the chart, Fig. 12 (p. 22), that the wind will be from between South-south-east and South in front of the trough, when it will suddenly shift about six points of the compass to West-south-west, and then veer slowly towards the North-west. All this is well shown in the direction anemogram. Then as to velocity, a glance at Fig. 11 shows that the gradients are less steep in front than in rear, and by reference to the velocity trace, Fig. 9, we see that the greatest velocity of the wind was not attained until after the barometer had begun to rise. If the station had been somewhere north of the cyclone centre, we see by the reference to the line C D, Fig. 12,

Fig 12.



that the shift of wind would have been from South-east by North-east, and North to North-west; also that on either side, the nearer a station is to the centre the greater will be the shift of wind.

On the south side we have seen that the wind shifts in the same direction as the motion of the sun, which is called "veering"; while on the north side it shifts against the sun, which is called "backing."

Turning, now, to the sequence of weather, if we consider how any single station would be affected by the passage of the cyclone in a manner similar to the shifts of wind, we find that the cyclone carries its characteristic weather along with it, and that therefore the sequence to a solitary observer would be from blue sky through a ring of cloud, then through rain, then more cloud, and finally to blue again. We also see that if he was a certain distance from the centre he might only experience a period of cloud without any rain. Returning now to our prognostic diagram, Fig. 8, in which we have generalised the actual cyclone given in Figs. 7, 11, and 12, we see at once that if we draw a section across it south of the centre, as we did for wind, we shall get a sequence of "halo," "gloom," "muggy weather," "uneasy animals," "drizzling rain," "driving rain;" then at the passage of the trough we shall have a squall or shower, then the sky beginning to break, with showers and cumulus cloud till the sky is blue again. These changes were very clearly observed by the author during the passage of the cyclone shown in Fig. 10 over Brighton.

Thus we see that to get an idea of the sequence of weather from a synoptic chart, we must draw a section across a cyclone parallel to the direction of its motion; and that the relation of the two may be expressed in the statement,—a meteorogram or a series

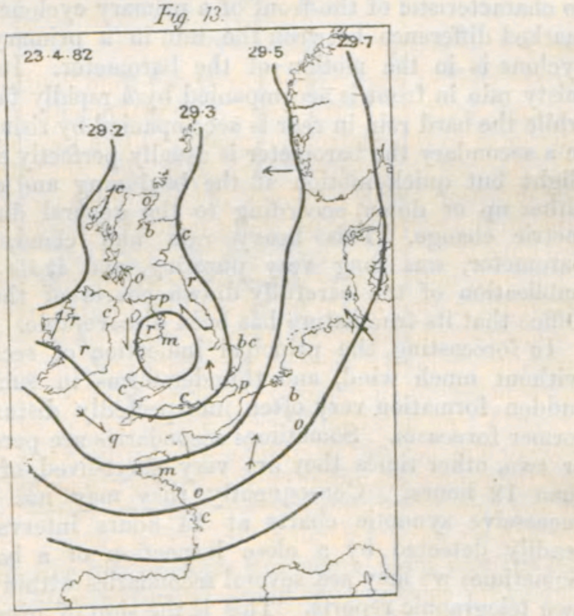
of consecutive observations on the changing physical appearance of the weather at a single place, for any given interval, may be considered as a continuous record *in section* of that weather, while a series of synoptic charts, at definite intervals of time, shows the samechanges *in plan*.

Taking only cyclones, we see that if they remain pretty constant in shape, and move pretty regularly along a given path, then we can forecast the weather which will accompany their passage very accurately. Unfortunately, as a rule, the same cyclone varies very much in shape at different periods of its existence and moves along a very irregular path, at very different rates, so that the forecaster is doomed to many failures and disappointments.

Secondaries.

Coming now to the next shape of isobars which we propose to describe, we find the "Secondary" cyclone as shown in Fig. 13.

Fig 13.



This, it will be seen, consists of a small cyclone formed on the side a larger one which is called the "Primary." Secondaries are almost invariably formed either along the prolongation of the trough a cyclone, or else on that side of the primary which adjoins the nighest adjacent pressure. The most important feature about them is the manner in which they deflect the isobars of the primary, so as to leave an area of slight gradients and light winds, on the side of the secondary next the primary, and a line of steeper gradients and stronger winds on the side furthest from the primary.

Their motion is usually along with, that is parallel to, that of the primary; and they very rarely show any tendency to revolve round the primary. Hence the term "satellite" depressions, which is sometimes applied to them, seems hardly suitable.

In secondary cyclones, as viewed on a synoptic chart, the area of rain and cloud sometimes appears to cover the area of shallow gradients inside the secondary; at other times, the rain especially seems confined to the partial ring of steeper gradients which surrounds the secondary on the side of the nearest area of high pressure. The most striking difference between a secondary and primary cyclone, is the great amount of rain and cloud with absence of wind developed in the former compared with the less rain and cloud, but the stronger wind, developed in the latter. To a single observer the characteristic features of a secondary are an uniformly overcast sky, with a peculiar stagnant condition of the clouds, and a very gloomy appearance and oppressive state of the atmosphere. When the rain comes on it is usually very heavy, and falls straight, and in its general appearance and surroundings, is very different from the driving or drizzling rain, so characteristic of the front of a primary cyclone. Another very marked difference between the rain in a primary and secondary cyclone is in the motion of the barometer. In a primary, the misty rain in front is accompanied by a rapidly falling barometer, while the hard rain in rear is accompanied by rising mercury; but in a secondary the barometer is usually perfectly stationary with a slight but quick motion at the beginning and end of the rain, either up or down, according to the general direction of barometric change. This heavy rain and cloud, with a steady barometer, was long very puzzling, and it is only since the publication of the carefully drawn charts of the Meteorological Office that its true nature has been discoverable.

In forecasting, the principal indication of secondaries is rain, without much wind, and thunderstorms in summer, and their sudden formation very often unexpectedly disturbs and vitiates former forecasts. Sometimes secondaries are persistent for a day or two, other times they are very short-lived, often lasting less than 12 hours. Consequently they may not be observed on successive synoptic charts at 24 hours interval, but they are readily detected by a close inspection of a barographic trace. Sometimes we may see several secondaries within the area of our own telegraphic reports. This is the sign of great intensity, and the indication in such cases is always for wild, broken weather, often with thunderstorms, but not for wide-spread gales.

As an illustration, we give in Fig. 13 (p. 23) for April 23rd, 1882, an example of a very well-developed secondary. We see that there is a large primary off our north-west coasts, which, if unmodified, would have produced strong South-west winds, but owing to the presence of a secondary, with its centre near Liverpool, the wind on the western side of the secondary is reversed into a light North-easterly wind, while on its south-

eastern side the gradients are increased and the wind rises to a fresh gale from South-south-west. The weather symbols explain themselves. With these gradients there would not have been nearly so much rain if the secondary had not been formed.

This is an example of an exceptionally well-developed secondary, but as a rule, they are much more frequently but partially formed, appearing as a mere loop in the isobars. In the example we have given, the relation of the secondary to the primary is obvious, but cases sometimes occur when both are of so nearly the same size that it is hard to say which is which.

V-shaped Depressions.

Allied to secondaries are V-shaped depressions, of which we give an example in Fig. 14. They are so called because the

Fig 14.

isobars enclosing the low pressure run into a point like the letter V. They are generally formed along the southern prolongation of the trough of a cyclone, or in the col or furrow of low pressure which lies between two adjacent anticyclones. Their motion is generally eastwards along with their associated cyclone, but they are very often short-lived, that is to say, they can rarely be traced on two successive charts at 24 hours interval. Not infrequently the V develops into a secondary cyclone, and often much disturbs the forecasts. The most interesting thing about them is that they are entirely non-cyclonic. In front of the trough which forms the bottom of the V, the wind is South-west with driving rain, and very dirty weather; while in rear the wind is North-west with bright sky and detached clouds, but there is no calm spot as in a cyclone, because a V has no centre. The line of the trough, along which the barometer rises, marks out the line along which the weather changes very abruptly, and this change is very often accompanied by a violent squall. The trough is often curved, the convexity being towards the direction of its motion. From what we have already explained, it will be easily seen that the sequence of weather to a single observer would be, from blue sky, through dirt and driving rain with a South-west wind and falling barometer, to a sudden squall; as the wind flies round to the North-west, the sky begins to clear, and the barometer to rise. It should be specially remarked that the rain is almost entirely in front of the trough. Thus while a cyclone has, as it were, a double symmetry, that is to say, one set of phenomena which are symmetrically disposed in front and rear of the trough, and another set, such as wind and rain, which are symmetrically arranged round the centre; a V-shaped depression has only one line of symmetry—the trough—to the front and rear of which alone both wind and weather are related.

In this country the wind in any part of a V-shaped depression very rarely rises beyond the strength of a strong breeze, so that the indications are for moderate to fresh South-west winds and rain, changing suddenly to North-west and clearing up.

As an illustration, in Fig. 14, we see a typical Vdepression at 8 a.m. January 28th, 1878, in which the direction of the wind from South or South-west in front, and West or North-west in rear is clearly shown.

The western edge of the rain area is almost exactly bounded by the trough, and the rain does not extend much in front beyond the well-defined isobars of the V depression.

In very rare cases we find V's in this country, where the front is only cloudy and the line of the trough marks the commencement of rain. As in the commoner case, the rain area is shaped like a portion of a crescent, only it is in rear instead of in front of the trough. The squall which capsized H.M.S. "Eurydice," was associated with the squall of a trough of a V-depression belonging to this rare type. We shall illustrate this in Fig. 36 (p. 56), when we come to discuss types of weather.

Anticyclones.

We now come to by far the most important shape of isobars after cyclones, viz., the anticyclone. This is so called because it is in every way the converse of a cyclone.

While cyclonic isobars enclose an area of low pressure, with rain, and strong winds circulating against the watch hands, the whole system being generally in rapid motion, anticyclonic

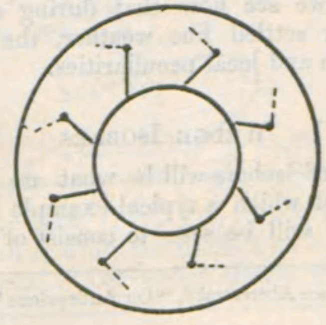
isobars enclose an area of high pressure, as in Fig. 15, which is associated with fine weather, and light winds circulating with the

Fig 15.

watch hands, and the whole system is usually stationary for many days together. These conditions we shall now describe in more detail.

The shape of the isobars is usually circular or slightly oval, and the gradients are always very slight. In the centre there is a dead calm; and while the winds at a distance circulate round the centre in the direction of the watch hands, they are a little outcurved, thus forming another contrast to cyclones, where the wind is always slightly incurved. Equally marked is the circulation of the upper currents. These blow round the centre with a considerable amount of incurvature, as shown in the diagram, Fig. 16, and, like the cyclonic upper currents, they throw much

Fig 16



light on the circulation of the atmosphere, and are useful in explaining many points relative to the motions of clouds. This diagram is adapted from one by Dr. Hildebrandsson, of Upsala. The temperature is always below the average of the season, and though in summer the sun may be very hot, there is always a cold air in the shade, and the nights are chilly.

Extreme dryness is one of the most marked features of an anticyclone.

In anticyclones, viewed on a synoptic chart, the position of blue sky, cloud, or fog seems very capricious, but to a single observer a certain general character is readily perceptible. The constant characteristics of a cold, dry air, and fine, or at least quiet, weather are never lost, but as they are much less marked than those in cyclones, they are more easily masked by diurnal, local, and seasonal variations. Thus in winter there might be thick fog in the valleys, but a clear frosty night on the hill tops; while in summer a misty morning would clear off into a fine day. The calms or light winds also give free play to the radiation of the season; that is, give very hot days in summer and very cold nights in winter. To these characters are applied the terms "radiation weather," and "radiation temperature," which best describe anticyclone weather.

There is no doubt that in this country rain sometimes falls in an anticyclone, and in France it seems to be tolerably common. To a single observer, the rain is usually in slight showers, with rather a high sky, and the general appearance is different from that in either primary or secondary cyclones; the showers are very often accompanied by a slight irregular motion of the barometer, and since of short duration and of small extent, they are probably due to some local disturbance.*

As a general illustration, in Fig. 15 (p. 27) we give a specimen of the weather in an anticyclone on May 17th, 1874. In this diagram it is principally to be remarked that, though the sky is mostly blue, there is cloud and mist in a few places, but which could never practically be mistaken for the kind of cloud or mist that would be marked with the same letters *c* or *m* in a cyclone. Had this anticyclone been formed in winter, the whole of the calm centre where there is marked blue sky would have been enveloped in dense fog.

In forecasting, we see now that during an anticyclone the indications are for settled fine weather, the details depending much on the season and local peculiarities.

Wedge Isobars.

Our next shape of isobars will be what are termed "wedges" of high pressure, of which a typical example is given in Fig. 17. On inspection they will be seen to consist of isobars converging

* For further details, see Abercromby, "On Anticyclone Weather," Q. J. Meteor. Soc., Vol. IV., p. 1.

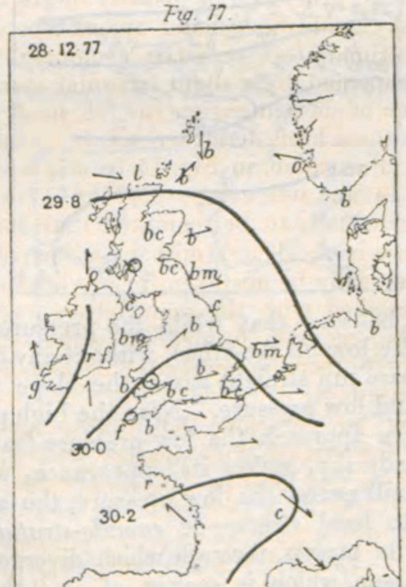
almost to a point, but enclosing an area of high pressure instead of a low one, as in the case of the V's. In every way they are as much the converse of the V's, as anticyclones are of cyclones. These wedges seem to shoot up in front of cyclones and V depressions and to travel along before them.

On the front or east side the weather is very bright, and often gives that extreme clearness or visibility which comes with a blue sky. The wind is North-west and moderate, while the temperature is that due to excessive radiation. According to the season, this gives by day a peculiar burning heat which sometimes precedes rain, and by night white frost, another well-known sign of rain. On the rear or west side, where the barometer begins to fall, the wind turns to South-west, and the sky overcasts in that peculiar manner which first gives a halo, and then gradually becomes black without true cloud as the cyclone approaches. At the extreme north point of the wedge a shower or thunderstorm is sometimes observed.*

Thus, as the wedge travels eastwards, the sequence of the weather to a solitary observer will be from very fine with North-west wind, falling calm, to halo, and gloom with a South-west wind followed by rain and perhaps a gale, if the gradients of the on-coming cyclone are sufficiently steep.

As an illustration, Fig. 17 gives the wind and weather in a wedge

Fig. 17.



at 8 a.m., December 28th, 1877. The rear of a retreating cyclone is seen over the Baltic, while the front of an incoming one appears on the west of Ireland. The wedge almost exactly covers Great

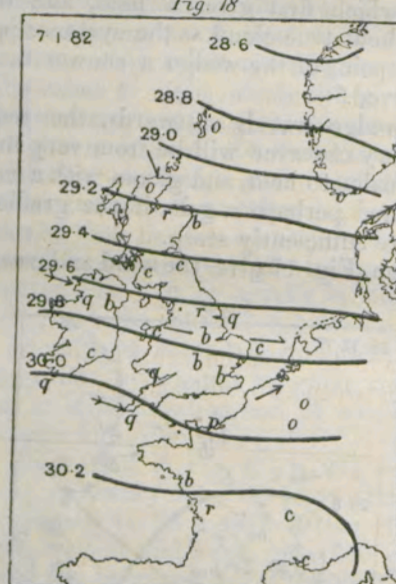
* For further details, see Abercromby and Marriott, "On Popular Weather Prognostics," Q. J. Meteor. Soc., Vol. IX., p. 27.

Britain, but the head of it is slightly curved westwards, so as to embrace the new cyclone. This is often observed, and seems to be a sign of intensity, that is, that the coming cyclone will have steep gradients. On the east side the weather symbols are all for blue sky or fine weather mist, with light West winds, while on the west side we find cloud and rain with South-west winds. Observe how far south the rain extends into the anticyclone over the south of France, for this is very characteristic of wedges.

Straight Isobars.

In the next place, at the edges of anticyclones, on the north side especially, nearly straight isobars are sometimes found, as in Fig. 18.

Fig 18



In them it will be seen that while the pressure is high on one side, it is generally low on the other, without any definite cyclone, and that the isobars run straight across the slope which joins the regions of high and low pressure. Near the high pressure the sky is blue, then as we approach the low pressure feathery cirrus, or some form of windy sky, makes its appearance, with a blustery wind. Getting still nearer the low pressure, the sky is found to be gathering into hard *stratus*, or *cumulo-stratus*, at first with chinks between its masses, through which divergent rays stream down under the sun, which is spoken of as "the sun drawing water." Sometimes, especially in winter, these rays are lurid, and when the gradients are very steep a little rain sometimes falls with straight isobars, generally in light showers, and with a hard sky. In all cases the air is both cool and tolerably dry. The force of wind in them, as well as its direction, depends on the slope and trend of the isobars, and hardly ever rises beyond the strength of a fresh breeze.

Though as a matter of convenience we have described the sequence of weather as we proceed from the high to the low pressure, it must be clearly understood that it does not represent the sequence of weather to a single observer, but rather what the weather will be, simultaneously, in different parts of the country; for instance, that if there is cirrus in London, there may perhaps be lurid sky in Edinburgh.

Straight isobars are never persistent, and the area which they have occupied is usually soon traversed by a cyclone of greater or less intensity.*

For purposes of forecasting the indications, therefore, are for cool, cloudy, unsettled weather, the wind from moderate to fresh according to the gradients, to be followed soon by rain, as a cyclone forms or comes up.

The following is a typical case of straight isobars. In Fig. 18 we give the isobars and weather at 8 a.m., January 7th, 1882. Here we see an anticyclone over the Pyrenees, a small cyclone over Norway, and a barometric slope, marked by straight isobars over our islands. The wind is fresh to strong from about West under the influence of rather steep gradients, while the weather is bright or cloudy with patches of rain and showers. The chart for 8 a.m. the next morning showed the front of a new cyclone approaching our western coasts, bringing rain and fresh gales.

Cols.

Lastly, we have to describe the weather in the neck of low pressure lying between two adjacent anticyclones. In Fig. 19,

Fig 19

* For further details, see Abercromby and Marriott, "On Popular Weather Prognostics," Q. J. Meteor. Soc., Vol. IX., p. 27.

for February 26th, 1879, we give an example of the commonest case which occurs in this country, viz., when one anticyclone lies to the north-east of the other. Under these circumstances a narrow neck of low pressure obliquely lies across Great Britain; to the north-west there are gradients formed for South-west winds, and to the south-east the gradients are for North-east winds. In neither case are they often found steep, while in the middle of the "col" the wind is always light. The weather is always quiet, but variable in appearance owing to the local influence of radiation. The temperature is that due to the radiation of the season, while the humidity is greater than would be found in an anticyclone at the same time of year.

Though their general position is sometimes pretty stationary, the weather in them is rather variable owing to the tendency of the depression which lies on their north-west side to develope a secondary in the "col."

Hence, in forecasting, though we could tell what the weather would be in the "col" at the moment, the future course of the weather is subject to much uncertainty, as we shall explain fully further on when discussing the easterly type of weather.

As an illustration, in Fig. 19 (p. 31) we give the isobars and weather symbols for February 26th, 1879. In this the edge of one anticyclone is seen over Ireland, the edge of the other over Scandinavia, while a "col" is formed between them. On the north-west we find a generally low area, without any well-defined cyclone; while to the south-east a cyclone evidently lies over Southern Germany. Under its influence the gradients for North-east winds are rather steep near Dover, giving overcast and gloomy weather with snow in several places. Within the "col" we find light winds and mostly blue sky; while on the north side, detached clouds or an overcast sky are reported.

This is the commonest class of "col" in this country, but in summer another kind is formed in which one anticyclone lies to the east of the other. Under these conditions the wind is from some point of South on the east side of the "col," and from some point of North on the west side. The weather is calm and stagnant, usually gloomy, and frequently associated with violent thunderstorms. The motion of these thunderstorms is very ill defined, and forecasting becomes very difficult. Though rare in this country, this class of "col" forms an important feature in the meteorology of France, Germany, and the United States.

We have now described the seven leading shapes of isobars found in this country, and there are others less common which need not be described in this work. We may, however, sum up what we have already shown, viz., that isobars take certain well-defined shapes, and that every portion of every shape has a characteristic weather and appearance, the wind being given by certain laws common to all. In fact we may say that *isobars map out the areas of bad or good weather; their shapes giving the weather, and their gradients the wind.*

The question is often asked, What are these shapes of isobars that the forecaster treats as so many abstractions, and to which he assigns different names? This can only be partially answered in our present state of knowledge. We have already shown in our diagrams of the surface and upper currents in both cyclones and anticyclones, that the lines as we observe them are associated with, or are the product of, complex motions and circulations of the atmosphere. The general idea to which we are brought is, that taking the earth as a whole, with a hot equator and cold poles, a circulation is set up, which sometimes takes that form of motion we call a cyclone, sometimes that of an anticyclone, and so on; while the weather is the product of the vertical and lateral movements which constitutes these cyclones, &c. Thus the rain in a cyclone seems due to an ascending current near the centre which must exist, if, as we have already seen, the surface wind is incurved and the upper current outcurved. Similarly the dry, cold, cloudless character of an anticyclone seems due to a descending current, which must exist if the surface wind is outcurved, and the upper current incurved. For the present, however, we prefer to mention those only hypothetically, and to base the whole science of forecasting on pure observation, which we do by merely assigning arbitrary names to the different isobaric shapes, and grouping or classifying the varied phenomena of wind and weather which we find associated with them.

Surge.

We have so far described different shapes of isobaric lines, and the changes of pressure which are observed as they pass over an observer; but we have now to describe a source of fluctuation of pressure, which is totally different from any of these, and to which the term *surge* seems very applicable. The word *wave* would partially express the same thing, but that word has already been applied to so many different meteorological phenomena, it seems better to take the new word, and define a *surge* as a progressive change of level, without a change of shape in the isobaric lines. For instance, the isobaric charts for March 23rd, 1878, showed that a cyclone which was over Finland on the 22nd, had not moved by the 23rd, but, that though its size and shape had little altered, the lowest isobar had fallen about 0·2 inch, from 29·2 inches to 29·0 inches. The actual level of the isobars over Great Britain had diminished rather more, nearly 0·3 inch, the isobars of 29·9 inches and 30·1 inches on the 22nd being almost in the same position as those of 29·6 inches and 29·8 inches on the 23rd. To a single observer this change was shown by a steady fall of the barometer, amounting to 0·3 inch in the 24 hours, and which is evidently totally unconnected with the passage of any cyclone. But by next day, the 24th March, though the Finland cyclone had filled up to the extent of 0·4 inch, its centre bad moved so far westwards, as to cause a fall of the barometer amounting to 0·2 inch. Thus the fall of the barometer on the 23rd was due to surge, while that on the 24th was due to the motion of the cyclone.

So far a surge might be considered only as a deepening cyclone, but under the name of "waves," Birt and others have found a progressive march eastwards of many barometric depressions. In those days isobars were unknown, and little attention has lately been given to the subject.

The great difficulty in handling the subject lies in the impossibility of entirely separating the motion of surging from the motion of individual cyclones. Still the following example will show that there is sometimes a sort of eastward march of surgings, but which can only be roughly defined. In Fig. 28 (p. 50) for November 12th, 1875, we find three principal depressions, one in America, another in Mid-Atlantic, and a third over Russia. By next day, the American has become more shallow, the Atlantic has deepened, and the Russian begun to fill up. On the third day the American cyclone shows signs of the commencement of a fresh increase of depth, the original Atlantic one has increased enormously in depth, while the Russian has almost disappeared. Finally, on the fourth day, Fig. 31, the American depression has increased still further and moved eastwards, while the original Atlantic one, now over the Baltic, is filling up. Thus we see that what we may call the deepening impulse seems to travel eastwards, modifying the cyclones it finds in its course, but at the same time it can hardly be called a true wave in the ordinary sense of the word.

In stationary anticyclones we sometimes find traces of surging, for the actual level often varies from 0·2 in. to 0·3 in., without any material change of shape, and it seems likely that this impulse is propagated in an easterly direction.

It is exceedingly doubtful whether a *surge* of itself gives rise to any characteristic weather, but the influence of *surges* on existing cyclones, or for developing new ones is very great. Defining the portion of a surge in which the barometer falls, as the front; the line along which the barometer turns to rise, as the trough; the line along which it turns to fall as the crest; and the portion where it rises as the rear, in a general way we may say that the front of a *surge* increases the intensity of an existing cyclone, or tends to develope new ones; while the crest diminishes an existing cyclone, and is very prejudicial to the formation of new ones. Hence, in forecasting, it is desirable to watch the appearance and phase of any surging downwards, because even if no cyclone is then visible, it is almost certain that one will form soon; and a cyclone already in existence, which otherwise would not seem to be very dangerous, would, with the case of a rapid surge, be very likely to develope dangerous intensity.

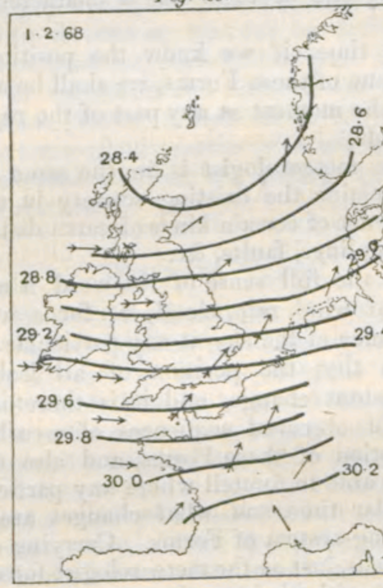
This portion of the subject has not yet been seriously worked out, and is only mentioned here to call attention to the existence

of a phenomenon which may some day play a more important part in forecasting than at present.

Level.

We may conveniently notice here the influence of barometric level on cyclones. It is obvious from the inspection of such a diagram as Fig. 20 that a gale has no necessary dependence on

Fig. 20



the absolute height of the barometer at the place where the gale is felt. Here a South-west wind is blowing at Rochefort, where the barometer is 30·16 ins.; a gale from the same quarter at Plymouth, with the barometer at 29·55 ins., and another at Ardrossan, with the barometer at 28·61 ins.

When we come to discuss weather types we shall find that large areas of low pressure are persistently formed over certain portions of the world, which are not themselves cyclones, but which form the theatre of the incessant formation of cyclones; and the final result to which observation leads us is, that though a low level of pressure does not of itself give bad weather, still it is very conducive to its formation; and conversely, that though a high level need not give fine weather, still it is conducive to the persistence of settled weather. Hence the markings on a barometer scale of "Fair," "Change," "Rain," at 30·0 ins., 29·5 ins., and 29·0 ins. respectively have a certain amount of value.

CHAPTER IV.

WEATHER SEQUENCE.

General Introduction.

We have now described certain well-defined Forms to which almost every configuration of isobars seems referable, and we have also seen that, subject to local, diurnal, and seasonal variations, each part of every one of them has a characteristic wind and weather.

Hence at any time, if we know the position of a system belonging to any one of these Forms, we shall be able to say what the weather is at the moment at any part of the region over which that system extends.

In this case, the meteorologist is in the same position as the geologist who explains the existing scenery in any part of the world by the presence of certain kinds of earth disturbance, known as upheavals, crumplings, faults, &c.

But weather in the full sense of the word is applied as much to the sequence of wind, rain, cloud, &c. for a whole day, as to the actual appearance of the sky at any particular moment.

We have seen that the position of all isobaric Forms is in a state of constant change, and it is therefore obvious that the explanation of observed sequences of weather depends on describing the motion of these Forms, and also that forecasting depends on being able to foretell where any particular Form will be at any particular time, and what changes are likely to take place in any existing system of Forms. Carrying out the analogy to geological methods, just as the meteorologist forecasts the future course of cyclones, with their resultant weather, by the study of their past motions, so the geologist will perhaps some day forecast the future position of new upheavals and crumplings, with the corresponding change of scenery.

If we look at any series of synoptic charts over a large area, the changes are sometimes so complicated as almost to baffle description, and in a case of that sort, though we might be able to explain the sequence of weather at any place, we should be unable to forecast it.

Fortunately for meteorology, this is not usually the case; and in a vast majority of days, we are able to form a very fair estimate of the future weather.

We shall now endeavour to explain the principles which enable us to do so.

We may state at once that there is nothing approaching to any numerical calculation possible in forecasting, but that we find from careful observation of synoptic charts over a very large area, that there is a certain method in weather changes, and that cyclones formed under different surroundings have different ways and courses of their own.

We shall first illustrate the principal kinds or types of weather

which occur in this country; and in doing so, it will be convenient to explain simultaneously both how the changes shown in the charts affect the observed sequence of weather, and how the knowledge of these changes can be utilized in forecasting.

In illustrating these types, we shall carry out the plan adopted throughout this work, which is by far the best adapted to explain such complicated shapes and motions as belong to cyclones—when no two are alike, yet all are cast in the same mould,—viz., to define by well-selected samples, rather than by generalities or averages.

We will, then, give some principles of cyclone motion, and explain the various aids to forecasting that can be derived from different sources, such as prognostics, periodicities, &c. Then after a series of illustrations of successful and unsuccessful forecasts, we shall conclude with some general reflections on the whole subject, and besides detailing the method practically in use for issuing forecasts to the public, we shall mention the present condition and future prospects of the science.

Weather Types.

The general idea of weather types will be readily understood by considering the fact familiar to all observers, that the weather in this country frequently occurs in spells of several weeks' duration, during which there is a remarkable persistence of the general type of weather over-riding both a considerable fluctuation from day to day, and a considerable local variation from place to place.

For instance, the wind will often back to some point of South, with a high temperature, a dull sky and rain, and then veer to some point of West with a cooler air and brighter sky; and after a day or so of fine weather it will back again to the South with bad weather, perhaps this time rising to the intensity of a gale, and subsequently veer towards the West with finer weather, and so on for weeks together.

The changes only vary in intensity and detail, not in general character, while the feel of the weather and the look of the sky remain through all of them what are customarily associated with Westerly winds.

Similarly, the wind will often come persistently from some point of East, fluctuating between South-east for fouler weather, and North-east for finer weather, and back again with many variations for several weeks, during which the predominant features of the weather are always characteristic of East winds. The frequent recurrence of particular types of weather at particular seasons of the year is also a matter of common observation; the North-east winds of March, the cold North winds of the middle of June, and the wet West winds of September are well-known instances.

If we examine a large number of synoptic charts, we soon see that, relatively to Europe, the general position of the great areas of high pressure frequently remained constant for a lengthened period. Further examination shows that the constancy of these positions coincides with persistency of types of weather similar to those above mentioned, the fluctuation of weather in each type being due to the passage of cyclones, while the local variation depends on the exact position of the cyclone centre, and on the innumerable local conditions which modify any general type.

The charts used in this work are principally derived from the French *Atlas des Mouvements généraux de l'Atmosphère* for 1865, which refers to the weather of Europe and the North Atlantic, from the Equator to a line drawn obliquely from Newfoundland to the North Cape of Norway; and Hoffmeyer's charts, extending over Europe, Greenland, the United States, and the Atlantic down to about 40° north latitude; as well as those of the United States Government, which extend over the greater portion of the Northern Hemisphere.

The types may be considered as applying generally to Europe, while the details of weather refer only to Great Britain.

Over the above areas the distribution of atmospheric pressure presents certain constant features; namely,—

1. An Equatorial belt of nearly uniform low pressure.
2. A Tropical belt of high pressure rising at intervals into great irregular elevations or anticyclones.
3. A Temperate and Arctic region of generally lower pressure, but in which occasionally areas of high pressure appear for a considerable period.

The Equatorial belt constantly covers the Sahara and the Amazon Valley, and always narrows over the Atlantic at about 30° West Longitude, where it often does not reach higher than 10° North Latitude. The shape and depth of this area are tolerably constant.

The Tropical belt comprises a region of high pressure, rising at variable intervals into great anticyclones; these anticyclones are usually longest in an east and west direction, and often rise into two or more heads. Their position is generally variable with the exception of one, which is always found over the central Atlantic. This anticyclone forms a very important factor of the weather of Western Europe, and will be constantly referred to as "the Atlantic Anticyclone."

The extension south and west of this anticyclone is tolerably constant, while north and east it is variable, sometimes rising as far as 60° North and stretching over Great Britain and Continental Europe.

Cyclones are rarely, if ever, formed to the south of this anticyclone; sometimes they have their origin on its south-west side, when they work round the anticyclone first towards the north-west, and then towards north-east. These are the West India Hurricanes.

The north side of the anticyclone is the birth-place of innumerable cyclones of every size and intensity, which invariably move towards some point of east, and then play a most important part in the meteorology of Great Britain.

Cyclones are also occasionally formed on the south-east side near Madeira; these either work very slowly round the high pressure to the south-west, or else leave the anticyclone and go east.

The Temperate and Arctic region extends from the tropical high pressure to the pole. Though ordinarily low, the pressure in this region is perpetually fluctuating by reason of the incessant passage of cyclones; yet occasionally persistent areas of high pressure appear in certain portions of it.

With reference to Western Europe, there are at least four well-marked types of weather:

1. The Southerly, in which an anticyclone lies to the east or south-east of Great Britain, while cyclones coming in from the Atlantic either beat up against it or pass towards north-east.

2. The Westerly, in which the tropical belt of anticyclones is found to the south of Great Britain, and the cyclones which are formed in the central Atlantic, pass towards east or north-east.

3. The Northerly, in which the Atlantic anticyclone stretches far to the west and north-west of Great Britain, roughly covering the Atlantic Ocean. In this case cyclones spring up on the north or east side, and either work round the anticyclone to the south-east, or leave it and travel rapidly towards the east.

4. The Easterly, in which an apparently non-tropical anticyclone (or one disconnected from the tropical high pressure belt) appears in the north-east of Europe, rarely extending beyond the coast-line, while the Atlantic anticyclone is occasionally totally absent from the Bay of Biscay. The cyclones then either come in from the Atlantic and pass south-east between the Scandinavian and Atlantic anticyclones; or else their progress being impeded, they are arrested or deflected by the anticyclone in the North-east of Europe.

Sometimes they are formed to the south of the north-east anticyclone, and advance slowly towards the east, or in very rare instances towards the west.

As examples of these type groups, those for the first three months of 1865 are subjoined:—

January 1st to 17th, Westerly type.
18th to 31st, materials insufficient.
February 1st to 12th, Easterly type.
13th to 15th, transitional.
16th to March 6th, Westerly type.
March 7th to 20th, Easterly type.
21st to 27th, Northerly type.
28th to 30th, transitional.

We shall now give details of these types with special reference to the assistance they afford in forecasting, by indicating the probable path of any cyclone. We shall describe their broad general character, and seasonal modifications, together with the signs of intensity, and, when possible, any symptoms of persistence, or of change of type. For the sake of conciseness, we shall assume throughout that when we have mentioned the shape of isobars over Great Britain, we have thereby described the broad features of the wind and weather.

Though the unit components of weather, such as cyclones, anti-cyclones, &c., are considerably modified by the type in which they occur, these variations need not be discussed in an elementary work which deals only with broad principles.*

Southerly Type.

In this the Atlantic anticyclone extends very little to the northward, while a large area of high pressure covers Europe to the east and south-east of the United Kingdom.

The North Atlantic is occupied by a persistent area of low pressure in which cyclones are constantly being formed; these beat up against the high European pressure, and either die out or are repelled.

Sometimes, especially in summer, small cyclones, arising on the easterly side of the area of depression, pass rapidly near the British coasts in a north or north-east direction. In either case it is somewhat rare for the centre of a cyclone to reach over these islands, so that generally Great Britain is under the influence of the rim or edge of either a cyclone or anticyclone.

At other times the Atlantic low pressure extends over Great Britain, driving the high pressure eastwards, without forming any definite cyclone. In this case the indications are for tolerably fine weather and little wind, with a very low barometer: a condition which often excites remark.

In winter the cyclones are usually large, but in summer the general depression of the Atlantic is much less pronounced, while the cyclones are smaller, their centres progress further eastward, and the gradients are less steep. The weather in them is not so dirty, though the air is always close, and the sky is harder than in winter.

This type of weather occurs at all seasons of the year, but is most common and persistent in winter; in fact, the warmth or otherwise of the winter principally depends on the number of days of this type.

The temperature of this type is always high, partly because of the prevailing Southerly winds, and when the cyclones die out, the slight degree of cold which follows is very noticeable. Sometimes a portion of the Russian anticyclone reaches Great Britain, and in winter gives rise to white frost of short duration.

The wind in this type is remarkable for its steadiness and absence of gustiness, except when the intensity is extreme; and for various reasons the gales of wind do comparatively little destruction either on sea or land, considering their force and duration.

V-shape depressions are not common with this type, and they generally appear in the south-east corner of a cyclone. Under their influence, or that of a secondary in the same position, the

* For further details, see Abercromby, "On certain Types of British Weather," Q. J. Meteor. Soc., IX., 1.

isobars over Great Britain often form, roughly speaking, two sides of a square, running nearly east and west, on the south side, with moderate gradients for West wind; and nearly north and south on the east side, with steep gradients for Southerly gales. The indications then are for a sharp Southerly gale, which quickly subsides as the wind shifts rather suddenly to West.

The signs of persistence are only those common to every type, as described hereafter.

Then as to signs of change. This type may merge insensibly either into the Westerly on one side, or the Easterly on the other, the latter change being usually the more abrupt; but it is not possible to give any detailed description of symptoms of change.

To a single observer the sequence of weather in this type is very simple. As atmospheric pressure falls, temperature rises, and the sky grows dirtier, till drizzling rain sets in. The wind from some point of South, having backed slightly, rises in velocity till the barometer has reached its lowest point; as soon as pressure begins to increase, the wind veers a little towards South-west and gradually falls, the air becomes cooler, and the sky begins to clear; but it rarely becomes hard, or contains firm *cumulus*. By next day, perhaps, the same sequence is repeated, varying only in intensity but not in general character, and this alternation often lasts for weeks at a time.

All the above phenomena are evidently due to the passage of portions of extensive cyclones over an observer; but in this type sometimes after the barometer has fallen fast with very bad weather, it suddenly becomes stationary, the weather improves, and the wind falls light; and then after several hours the pressure slowly begins to increase, the air becomes cooler, and the weather clears completely.

This is due to a ring of steep gradients passing over the observer, and then leaving him in the centre of a very large cyclone which gradually disperses.

Now, as to forecasting. It is evident that when a persistent spell of this type is recognised as having set in, the general character of the weather and direction of the wind are at once indicated, so that all that is necessary for storm warnings is to watch for signs of the intensity becoming so great as to give rise to a gale.

An inspection of the illustrative charts will show that the area involved is so large that it is hopeless to trace the cyclones as a whole, but that usually within the area of the British telegraphic reports, and always within the area of the large charts, there are localities to the east or north-east where the pressure is steady. Over the Atlantic great variations occur, and it is therefore necessary first to try and discover the area of steady pressure, and and then to keep a sharp look-out for any rapid fall of the barometer over the west coast of Ireland, which would produce steep gradients and their associated gales.

When once a portion of a ring of steep gradients appears, its progress eastwards must be traced by telegraph, and watch must be kept that there is no giving way of pressure over Scandinavia.

Since the rate of progress of the steep gradients is usually slow and pretty regular, and since, as has been shown above, the direction of the wind with the general character of the weather is subject to little uncertainty, gales of this type are practically forecast with almost greater success than those in any other class.

The following is an illustration of this type of weather:—

In Figs. 21, 22, 23, and 24 are given synoptic charts over a large area for the four days February 25th to 28th, 1874. In all of these pressures under 29·9 inches are marked by dotted lines, so as to indicate the broad features of the distribution of high and low pressure.

In each of these the northern edge of the great Atlantic anticyclone is seen near the Canary Islands or coasts of Portugal, and in all the pressure is high over Russia, but low over the Atlantic. On the 25th a portion of a cyclone, so large as nearly to fill the whole North Atlantic, is seen affecting the British Islands; on the 26th, the cyclone centre seems to have moved somewhat towards the east, and to have become deeper, giving rise to steep gradients with heavy South or South-west gales in Great Britain, while the Russian anticyclone has retreated a little to the east.

Fig. 21

Fig 22

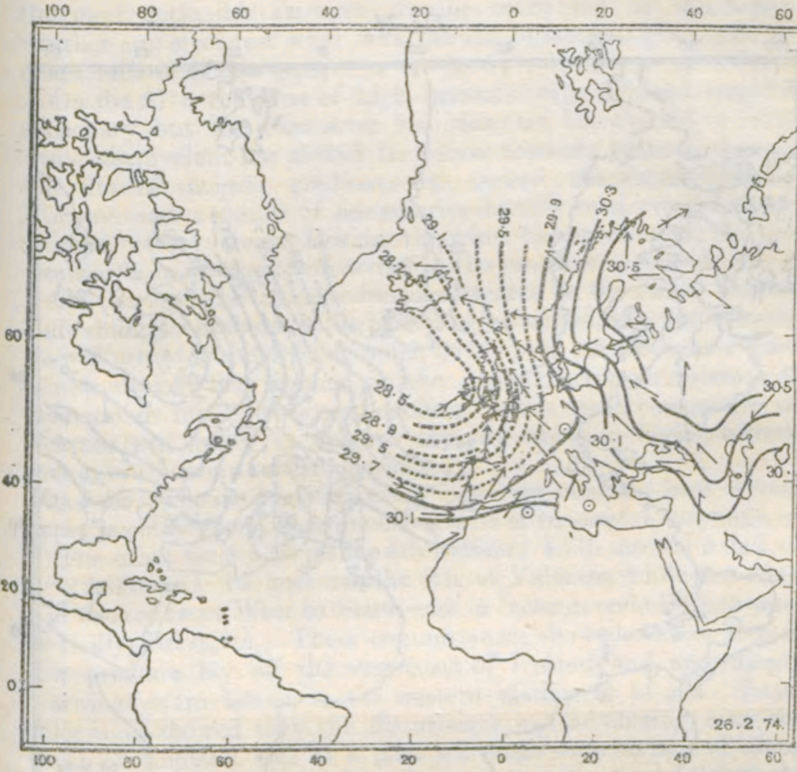


Fig. 23.

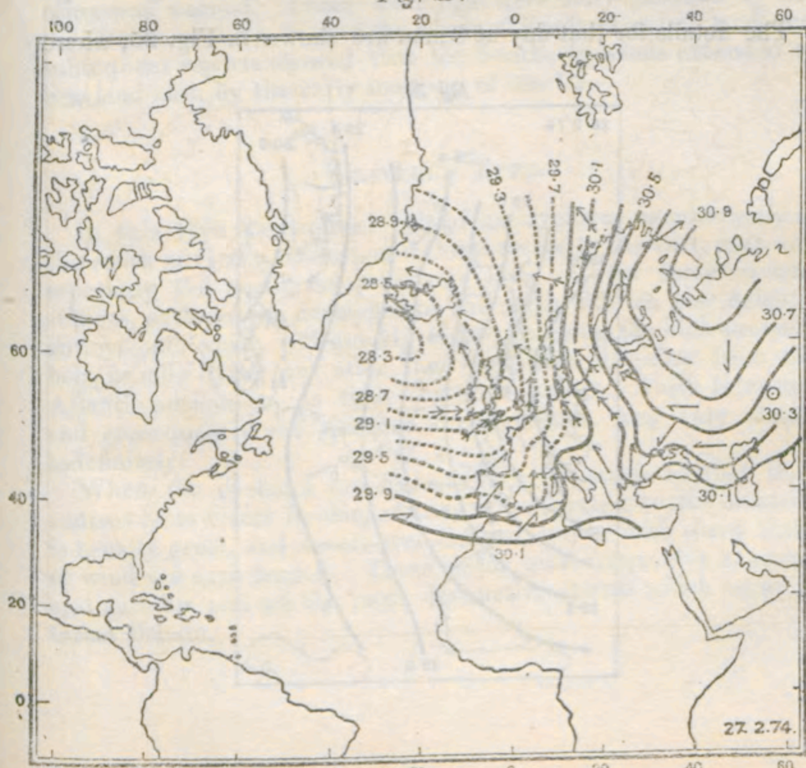
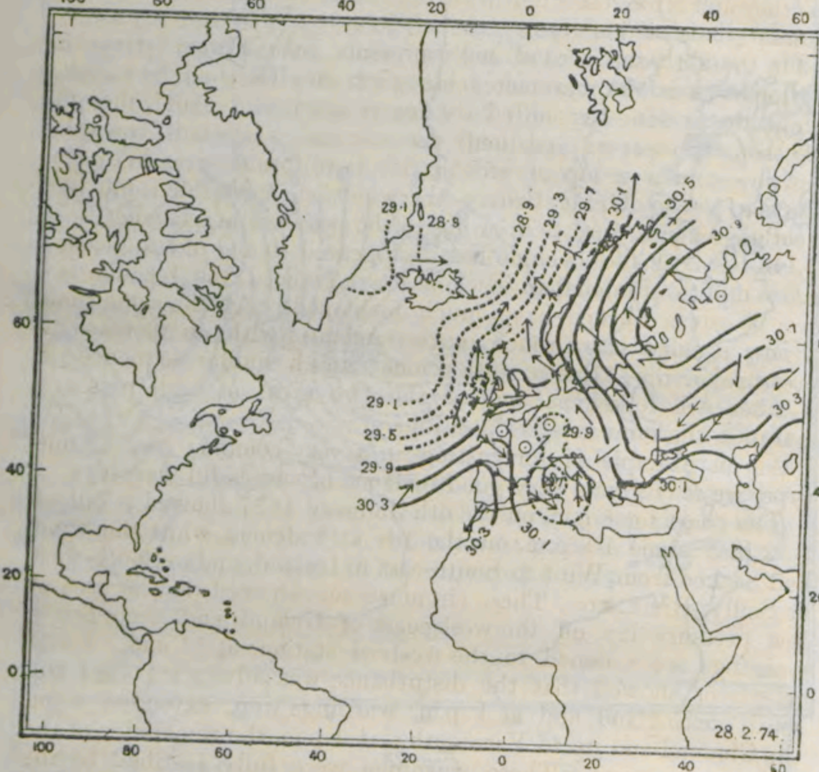
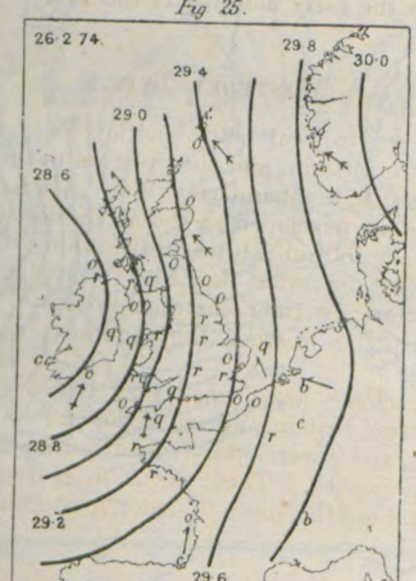


Fig. 24.



The details for that day at 8 a.m. are shown in Fig. 25, where

Fig. 25.



the most noticeable features are the connexion of the worst weather and strongest wind with the rim of steepest gradients, so characteristic of this type.

On the 27th the area of high pressure over Finland remains stationary, but the barometer has risen no less than 0·4 inch, while the cyclone has shifted its course towards Iceland, though the rim of steepest gradients has moved westwards towards Norway, and a group of secondaries have formed over Western Europe. Over Great Britain the wind has moderated, but the weather remains unsettled, owing to the presence of secondaries.

On the 28th the cyclone has disappeared in the Arctic Ocean, and while the Finland anticyclone has advanced, the secondaries over Western Europe have much developed. At the same time a new cyclone has formed in the Atlantic with an increase of pressure in the Atlantic anticyclone; and a similar sequence of weather will follow as long as the two areas of high pressure maintain the same relative positions.

As an example of forecasting in a very common case of this type, we may give a very good instance of successful warnings.

The chart for 8 a.m. on the 6th January 1877 showed a fall of 0·2 inch since 10 p.m. on the 5th at Valencia, while the wind had backed from West to South-east in Ireland, and to South-west at Scilly, Brest, &c. These circumstances showed that an area of low pressure lay off the west coast of Ireland, and accordingly warnings were issued to the western stations at 11 a.m. Later telegrams showed that the disturbance was advancing over the south of England, and at 1 p.m. warnings were extended along the Channel and up to Yarmouth; at 4 p.m. the remainder of the coast was warned. These warnings were fully justified by the occurrence of the gale over the whole of England and Ireland, and subsequent reports showed that the Southerly winds extended to Scotland also, by the early morning of the 7th.

Westerly Type.

In this type the tropical belt of anticyclones is constantly to the south of Great Britain, and the pressure to the east, west, and especially the north, comparatively low. Under these circumstances, cyclones are developed on the north side of the Atlantic anticyclone, which roll quickly eastwards along the high-pressure belt, usually dying out after they have been detached from the Atlantic anticyclone in their eastward course. Their intensity, and consequently the weather they produce, may vary almost indefinitely.

When the cyclones are formed very far south, so that their centres cross Great Britain, and are of moderate size, the intensity is usually great, and severe well-defined storms with sharp shifts of wind are experienced. These occur most frequently in spring and autumn, and are the most destructive storms which occur in Great Britain.

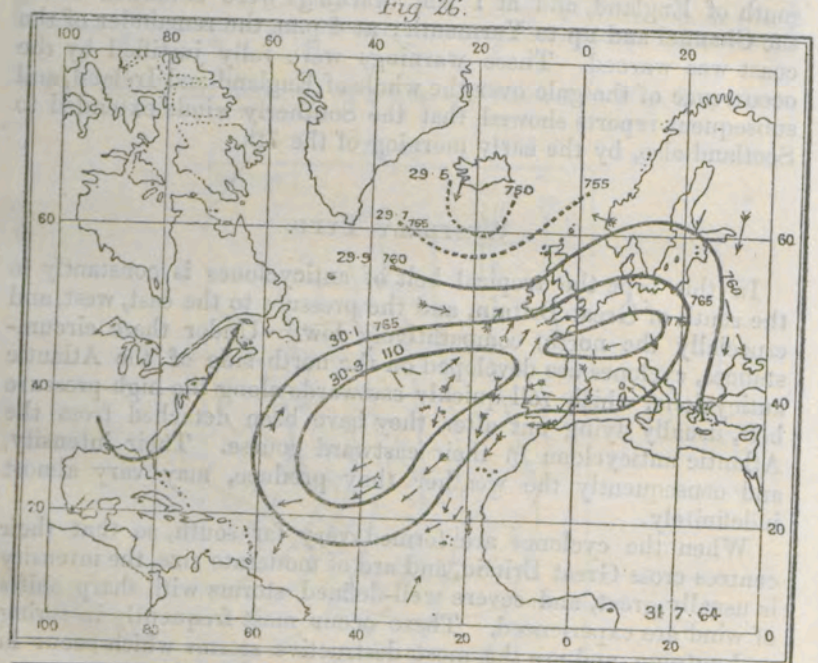
Another intense form is found in a series of small, short-lived, quick-moving cyclones and numerous secondaries, without very steep gradients, during which the indications are for rainy, broken weather, rather than for storms. This phase is common at all seasons of the year.

In another modification, while the pressure is low to the north, and the isobars run nearly due east and west, the whole of the Arctic area of low pressure surges southward with an exceedingly ill-defined cyclone, bringing a rim of steep gradients along the edge of the Atlantic anticyclone, and across Great Britain, in a manner analogous to a phase of Southerly type, before explained. The indications then are for rain, and Westerly gales with very little shift of wind. This phase belongs almost exclusively to the winter months.

But the commonest modification at every season, and that which forms about 70 per cent. of our weather, is when the intensity is moderate, and the cyclone paths are so far to the north of the British Islands that the wind merely backs a point or two from South-west as the cyclone approaches and veers a point or two towards the West as the cyclone passes, the general direction of the wind being between South-west and West, without rising to the strength of a gale, while rain is moderate in quantity.

Sometimes in summer a prolongation of the Atlantic anticyclone covers the southern portion of Great Britain, and cyclones of small intensity and far north, just influence the northern counties, as in the chart, Fig. 26, for August 31st, 1864.* Then

Fig 26.



* This figure is taken from Marié Davy's, "De la Prévision du Temps."

the intensity is too small to develope rain, but only cloud in the middle of the day, so that fine dry weather is indicated. This phrase, when very prolonged, may give rise to drought. In the chart there is a very typical "Col" developed over the Bay of Biscay. During the course of the day this gave rise to severe thunderstorms in the west of France.

The general temperature accompanying this type is about the average of the season, a little warmer in front of the cyclone, and a little colder in the rear. In winter, however, a great prevalence of this type gives an open season, as the high wind prevents frost, unless the cyclones are so far north that the influence of the Atlantic anticyclone is felt. In summer, on the contrary, if the type be intense, the temperature is below the average, from the excess of cloud hiding the sun.

Another important consideration as regards temperature is the locality of the normal cyclone path. The difference of temperature just north and south of a cyclone centre is very marked, so that when the cyclone passes further south than ordinary, the temperature of the region lying between the usual and actual path is greatly lowered.

Now, as to signs of persistence. It has already been shown that a wedge of high pressure indicates a continuance of the same sequence of cyclones. Many years ago Mr. Buchan observed that when the temperature does not fall as much as usual in rear of a cyclone, another almost immediately follows; while M. Marié Davy has pointed out that when the cyclone centre moves along a V-shaped path, as in Fig. 27, that also indicates a new cyclone with fresh bad weather.

Fig 27

Then, as to signs of change. This type merges almost insensibly into the Southerly, on one side, and into the Northerly on the other. Unfortunately, no certain symptoms can be detailed formally, but the appearance of a secondary on the south-west or west side of a cyclone ordinarily precedes an irruption of the Northerly, while a very deep surge sometimes precedes the commencement of the Easterly type.

To a single observer the principal peculiarity of this type lies in the variable wind and weather. In the Southerly type an observer only gets, as it were, the front of a series of cyclones, while in this type he gets the characteristic weather of both front and rear. In the former condition the worst weather is always in front; while in this the worst often occurs in rear, after the pressure has begun to increase.

In some of the synoptic charts it will be seen that there is a small area of steepest gradients to the south-west of the centre, where the high pressure closes up in rear of the cyclone. In this type, too, the characteristic squall during the passage of the cyclone's trough is most frequently observed.

In forecasting during the prevalence of this weather the chief difficulty arises when the intensity is so great that the cyclones form and disperse rapidly, or two or three secondaries merge into one large cyclone. In these cases, though the general indication is for broken weather, the details for any one locality cannot be given with certainty.

Another case of doubt, over a small area, arises when a well-defined cyclone is approaching Ireland, so far south that its centre will cross Great Britain. The difficulty then is, that though the wind and weather to the north and south of the centre can be prognosticated accurately, there is always considerable uncertainty as to the exact course of the centre, so that the belt of country between the track expected by the forecaster and that actually taken, may receive a forecast exactly opposite to what occurs. An example of this will be given later on.

As an example of the westerly type we will describe the period February 26th–28th, 1865, which may be taken as illustrating that kind of intensity which produces broken weather without very steep gradients. On the morning of the 26th the Equatorial low pressure occupied its usual place, into which the North-east and South-east Trade Winds blew; an area of high pressure covered the United States; the Atlantic anticyclone stretched from the West Indies to Poland, its head of highest pressure being near the Azores; while the edge of another anticyclone was near Moscow. The segment of a cyclone skirted the north of Norway; there was one small secondary near Denmark, and a V-shaped depression lay over Great Britain. Further westward three inflections were found on the north side of the Atlantic anticyclone.

The winds to the north of the Atlantic anticyclones were generally Westerly, modified, by their position relative to the cyclones and secondaries, and moderate to strong in force.

The weather was rainy or overcast at almost all the British stations, owing to the presence of the V-shaped secondary.

On the 27th the positions of the Equatorial low pressure and the Tropical high pressure were but slightly changed, but the cyclone over Norway had descended towards the south-east, partly by amalgamation with the V-shaped depression, while the secondary observed near Denmark still lay over the Baltic. Great Britain was covered by a projection of the Atlantic anticyclone forming the wedge-shaped projection of high pressure so characteristic of an advancing cyclone of this type. The three inflections to the westward had merged into two and increased in intensity.

The winds still retained their modified Westerly set, while the weather over Great Britain was either clear or slightly clouded.

On the morning of the 28th the Equatorial low pressure over the centre of the Atlantic had fluctuated considerably, and an inflexion appeared in it over Bermuda, which by next day developed into a cyclone moving north-eastwards. High pressure still covered the United States and had advanced over Newfoundland; while the Atlantic anticyclone, much diminished in size and height, still had its centre over the Azores. The high pressure over Russia had disappeared; the Norwegian cyclone had moved on to the White Sea; while the depression noticed the previous day over the Mid-Atlantic had developed into a cyclone of considerable intensity with its centre over Scotland, accompanied by a group of secondaries. The wedge in front of the cyclone had advanced to Norway. The winds still retained their modified Westerly direction, but were much increased in force over Southern Britain, owing to the steeper gradients. The weather was rainy in the English Channel, and on the western coast.

The foregoing example illustrates the Westerly type, when of moderate intensity, and also the relation of the Atlantic anticyclones, and of the Trade Winds to our weather; but we will now give an illustration of great intensity, and though the charts do not give the Equatorial pressures so fully, they give the Polar pressure much better, and also illustrate the enormous scale on which weather changes take place.

In Figs. 28–31 we give charts of isobars for the four days, November 12th—15th, 1875. In all four we note high pressure over the Southern part of the North Atlantic, over Central Siberia, and over Greenland. The theatre of cyclone action lies between these regions.

In Fig. 28 one huge cyclone, distorted by numerous secondaries, covers the whole of Europe, and extends from Egypt on the south to Spitzbergen on the north, say 3,500 miles; a large secondary lies south of Ireland; a double-pitted cyclone covers the Central Atlantic; while a well-defined cyclone is leaving the American Continent, apparently followed by another, now lying over Hudson's Bay.

By next day, November 13th, the European cyclone has much diminished, both in size and intensity, and gathered itself up into two distinct pits; while the Iceland secondary has moved northwards and became a primary. One pit of the Atlantic cyclone has shrunk into a secondary, while the other with increased

Fig. 28.

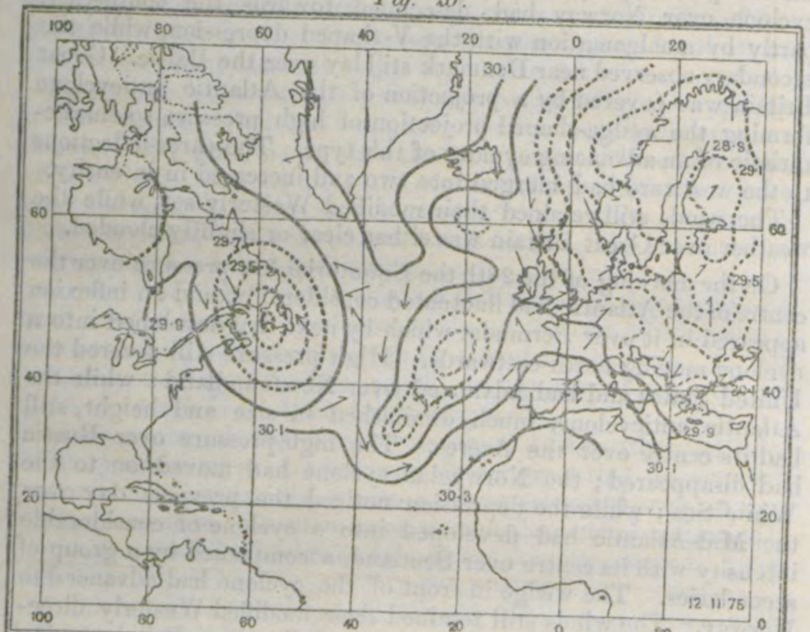


Fig. 29.

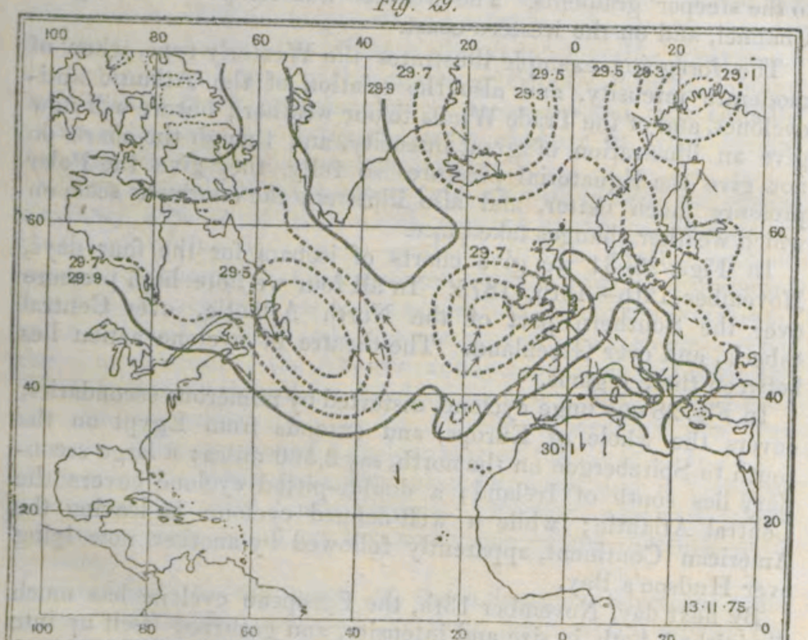


Fig 30.

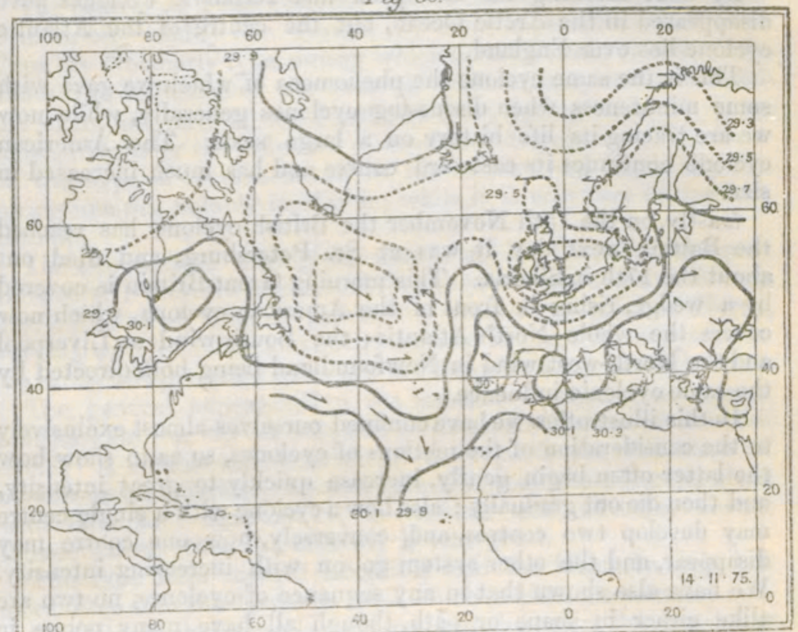
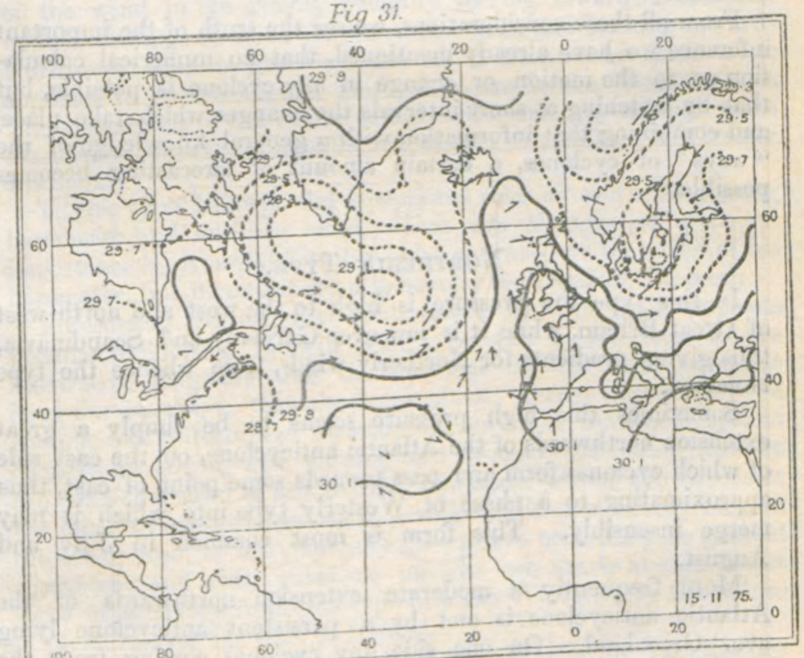


Fig 31.



intensity has moved towards the north-east, so as to touch Great Britain, and a well- defined wedge has formed in front of it. The American cyclone has commenced its course across the Atlantic, while the Hudson's Bay cyclone appears to have filled up.

By next morning the European and Icelandic cyclones have disappeared in the Arctic Ocean, but the centre of the Atlantic cyclone lies over England.

This is the same cyclone the phenomena of which we gave with some minuteness when discussing cyclones generally, while now we are tracing its life history on a large scale. The American cyclone continues its eastward course and has much increased in size.

Lastly, on the 15th November the British cyclone has reached the Baltic; next day it was at St. Petersburg, and died out about the 17th in Siberia. This morning Great Britain is covered by a wedge, rising in front of the American cyclone, which now covers the whole North Atlantic; the South wind at Liverpool and the North-west wind in Newfoundland being both directed by the same cyclonic influence.

In this illustration we have confined ourselves almost exclusively to the consideration of the motions of cyclones, so as to show how the latter often begin gently, increase quickly to great intensity, and then die out gradually; also how a cyclone with a single centre may develop two centres, and, conversely, how one centre may disappear, and the other system go on with increasing intensity. We have also shown that in any sequence of cyclones, no two are alike either in shape or path, though all have many points in common.

From all these considerations, we see the truth of the important inference we have already mentioned, that no numerical calculation as to the motion or change in any cyclone is possible, but that by watching at short intervals the changes which take place, and combining that information with a general knowledge of the "ways" of cyclones, a certain amount of forecasting becomes possible.

Northerly Type.

In this type the pressure is high to the west and north-west of Great Britain, while it is low over Germany and Scandinavia, thus giving gradients for Northerly winds, from whence the type is named.

Sometimes this high pressure seems to be simply a great extension northwards of the Atlantic anticyclone, on the east side of which cyclones form and pass towards some point of east, thus approximating to a phase of Westerly type into which it may merge insensibly. This form is most common in July and August.

More frequently a moderate extension northwards of the Atlantic anticyclone is met by a persistent anticyclone lying over Greenland. On one side any cyclones coming from the American continent are arrested by the belt of high pressure thus formed. On the other side, a large area of low pressure lies over northern and central Europe, which is the theatre of the formation of an incessant series of cyclones.

The centres of these cyclones always lie to the east of Great Britain, but modify our weather by their approach or recession. Thus the Northerly type, during which Great Britain is constantly under the influence of the rear of cyclones, may be considered the exact converse of the Southerly type, during which it is as constantly under the influence of the front of cyclones. This form of the type is most common in the winter, and especially the spring months, notably in March; while it is very rare during the autumn.

The temperature during this type is always low, from the prevalence of Northerly winds, and for the same reason, the air is very dry. The wind remains persistently from some point of North, varying with the inflections of the isobars. In practice, the gradients are rarely steep, so that gales are not frequent while this type lasts.

The general appearance of the weather is hard, with a great tendency in the sky to break into detached masses of *cumulus* cloud. A notable characteristic of the type is the formation of numerous secondaries. In them the sky would be overcast, often with rain, and occasionally, in summer and autumn, violent thunderstorms when the intensity is very great.

This type often merges insensibly into the Westerly type, but more often into the Easterly, with which it often alternates.

To a single observer the most marked feature is the constancy of the wind in the North, generally veering towards North-east with increasing cloud as the barometer falls, and backing towards North-west with brighter weather as it rises; but there is no approach to such a regular shift as occurs in the Westerly type. The appearance of the sky is usually hard, and any rainfall takes the form of showers or squalls, rather than of a drizzle or a steady downpour.

To this type belongs the exceptional case of rain with a rising barometer and an East wind, which was thought of sufficient importance by Admiral FitzRoy to be engraved on the scales of his barometer, but its explanation is beyond the scope of this work.

Forecasting during the continuance of this type presents peculiar difficulties. It will readily be seen by reference to the illustrative diagrams that the cyclones of this type are most irregular in shape, that they are almost always distorted by a complicated collection of secondaries, and that the whole system changes by surging and forming new secondaries, rather than by the definite motion of any existing cyclone. Hence the forecaster has much to contend against, in giving details of weather; but, on the other hand, he can generally give pretty accurately its general character; and while gales are rare, he can nearly always detect signs of a change from this type into the Westerly, by the failure of pressure over the west of Ireland.

The following example will illustrate the leading peculiarities of this type. We have chosen it to illustrate one of the most characteristic features of a persistent type of weather, viz., its apparent failure for a day or two and then its re-establishment with increased intensity.

In Figs. 32–35 we give synoptic charts for the period, May 7th–10th, 1874. In all of these the pressure is high over the whole North Atlantic, and low over Europe.

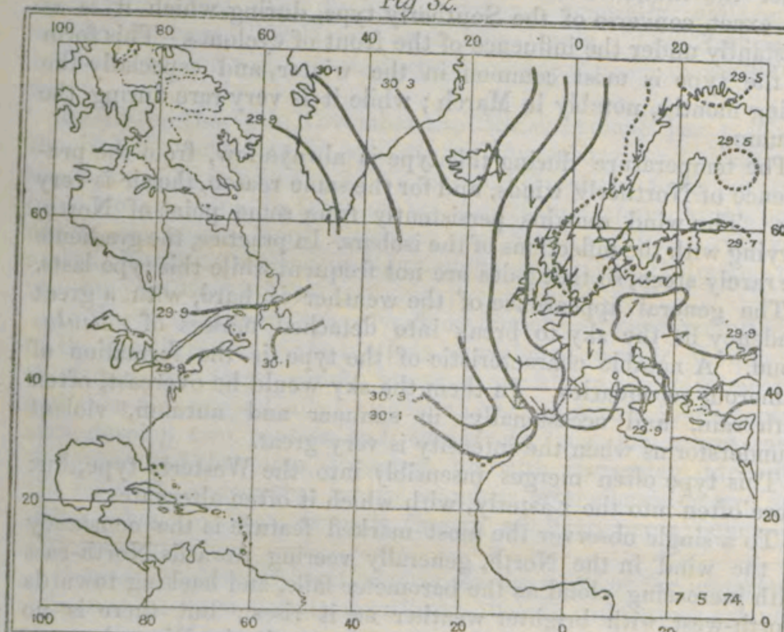


Fig 32.

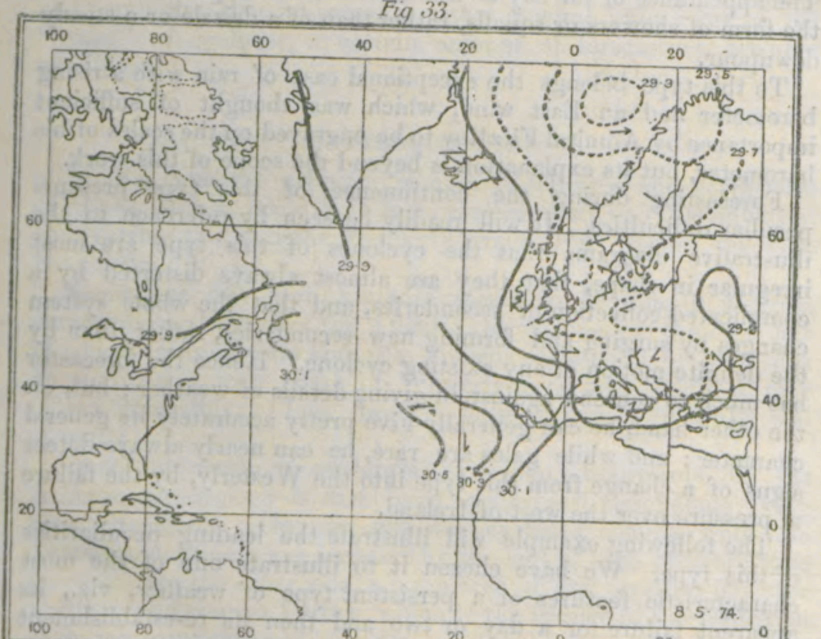


Fig 33.

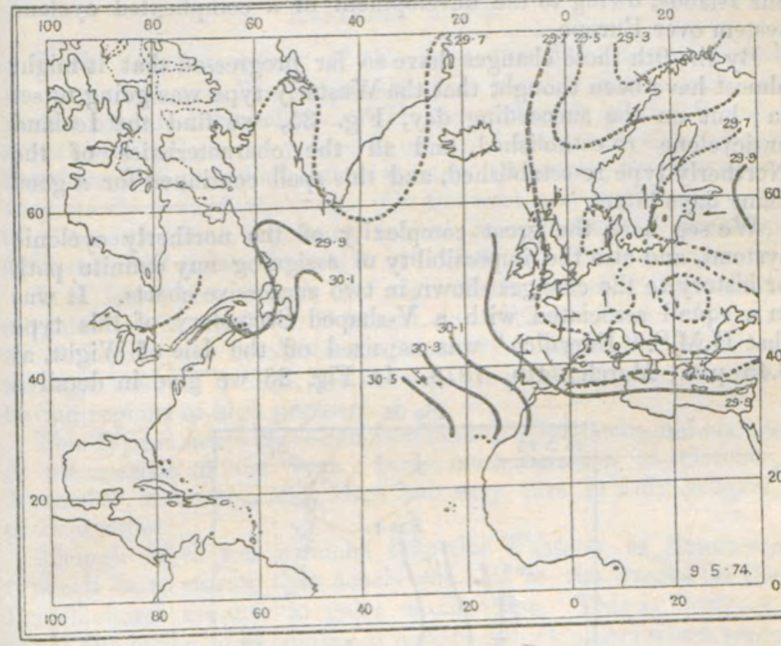


Fig 34.

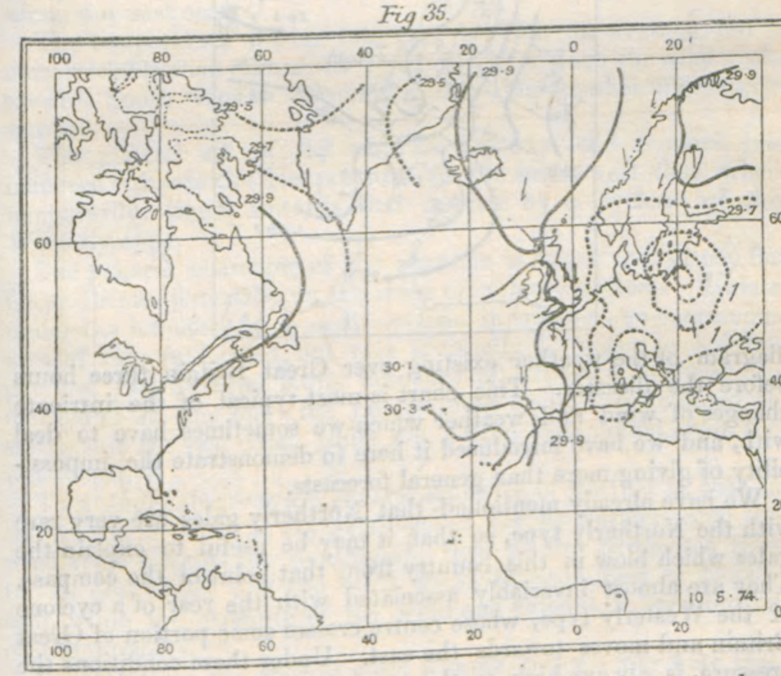


Fig 35.

On the 7th of May, besides the normal Atlantic anticyclone, another well-pronounced one lies near Iceland; by next morning the latter has nearly disappeared, and pressure has decreased over our Islands, owing to the development of a complicated cyclone system over Europe.

By the 9th these changes have so far progressed that it might almost have been thought that the Westerly type was going to set in; but on the succeeding day, Fig. 35, we find the Iceland anticyclone re-established, and all the characteristics of the Northerly type re-established, and this spell continued for a good many days later.

We see here the great complexity of the northerly cyclonic systems, and also the impossibility of assigning any definite path or history to the changes shown in two successive charts. It was in a squall associated with a V-shaped Secondary of this type that H.M.S. "Eurydice" was capsized off the Isle of Wight, at 3.45 p.m., March 24th, 1878. In Fig. 36 we give in detail a

Fig 36

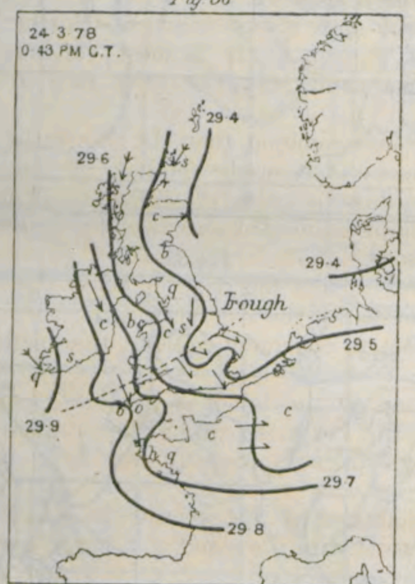


diagram of the weather existing over Great Britain three hours before the disaster. This chart is most typical of the intricate changes of wind and weather which we sometimes have to deal with, and we have introduced it here to demonstrate the impossibility of giving more than general forecasts.

We have already mentioned that Northerly gales are very rare with the Northerly type, so that it may be useful to explain the gales which blow in this country from that point of the compass. They are almost invariably associated with the rear of a cyclone of the Westerly type, whose centre crosses some portion of Great Britain and moves towards the east. Under these conditions the pressure is always high to the west, so that steep gradients are formed for North winds. These Northerly gales have in most cases been preceded by a gale from the South-east or South-west.

Easterly Type.

In the commonest form of this type, the Atlantic anticyclone is very small and lies far south, while another anticyclone lies persistently over Scandinavia. On the south side of the Scandinavian anticyclone, a cyclone is usually formed over Central and Southern Europe, which either remains stationary, or else moves very slowly towards the west. On the west and south-west side of the anticyclone, cyclones formed in mid-Atlantic press up against it, and either die out, or are rebuffed.

In a less common form, the edge of the Atlantic anticyclone stretches as far north as Portugal, and cyclones coming in from the Atlantic pass across Great Britain in a south-east direction, through the col which lies between the Atlantic and Scandinavian regions of high pressure.

This type is much more common than the Northerly, and occurs at all seasons of the year. It is most common in October, November, February, and May, but very rare in July, August, or September.

Though much less common than the Westerly or Southerly types, it is so stormy that nearly one half of the wrecks on the British shores are due to gales of this type. This is, however, partly due to the large number of unseaworthy Colliers which trade along our east coasts.

The temperature during this type is below the average, but is more variable than that of the Northerly; for when the wind veers towards South from an oncoming cyclone, the weather always gets warmer.

The general set of the wind is Easterly, and is much less incurved towards the low pressure to the south-west than when temporarily drawn towards that quarter by a cyclone of the Westerly type.

The general character of the weather is black and bitter, for Great Britain is usually on the slope of a large cyclone. Unless under the influence of a small cyclone in summer, no continuous area of rain is formed, but rain is usually developed in isolated patches. In no type is the influence of exposure to the sea so marked as in this one: the rain is often exclusively confined to stations on the east coast, while not a drop falls inland or on the west coast.

To a single observer the general sequence of weather is, that as the barometer falls the sky gets blacker, the air warmer, and the wind veers towards the South-east: then as the barometer rises the air gets colder and the wind backs towards East or North-east, while the strength of the wind and amount of rain depend on the intensity.

In most cases the shift of wind is small, but we may note that the wind veers for an oncoming cyclone, instead of backing, as in the Westerly type. This is because the cyclone centres are always towards some point south of the observer.

This type sometimes persists for two or three weeks on end, but no definite symptoms of a change of type can be given. It often succeeds the Northern type, and sometimes the two types alternate with one another. At other times the Scandinavian anticyclone lies so far to the south that this type merges insensibly into the southerly.

Forecasting in this type presents the greatest difficulties, from the ill-defined manner in which the changes take place, for if it is almost impossible to follow the changes in two charts at 24 hours interval, after we know what has occurred, how much more difficult is it to forecast the appearance of the second chart from an inspection of the first one only?

To illustrate this type we shall first give an example showing the relation of the Scandinavian to the Atlantic anticyclone.

In Figs. 37–40 we give charts for February 8–11, 1865, so as to show an irruption of pressure from the north-east and the accompanying changes in the Atlantic.

In Fig. 37 we find all the characteristics of the Westerly type, as far as regards the Atlantic anticyclone, with a series of cyclones on its northern side: but an area of high pressure has begun to form over Scandinavia, so that the weather over Great Britain is fine, with North-east and North winds. An area of low pressure, doubtfully a true cyclone, lies over the Mediterranean, while one well-defined cyclone lies to the north of the Azores, and another appears over Canada.

Fig 37.

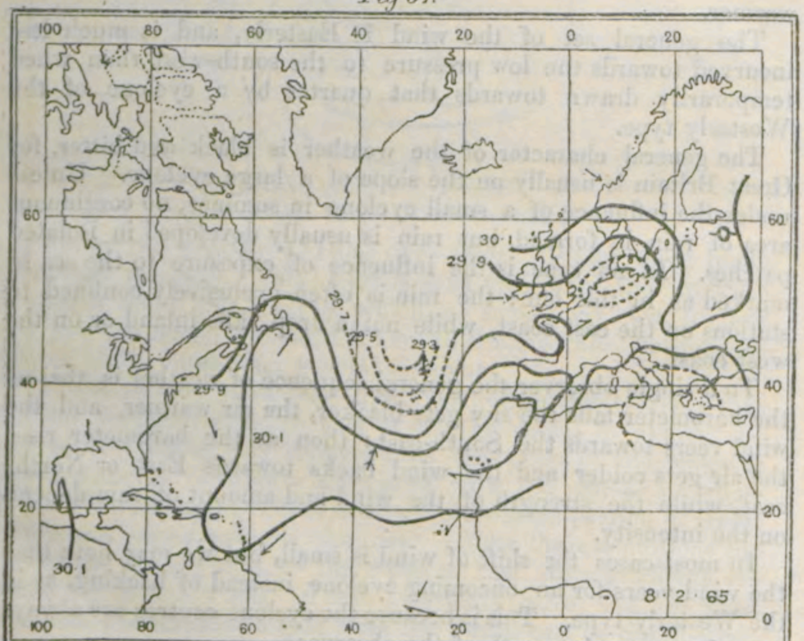


Fig 38.

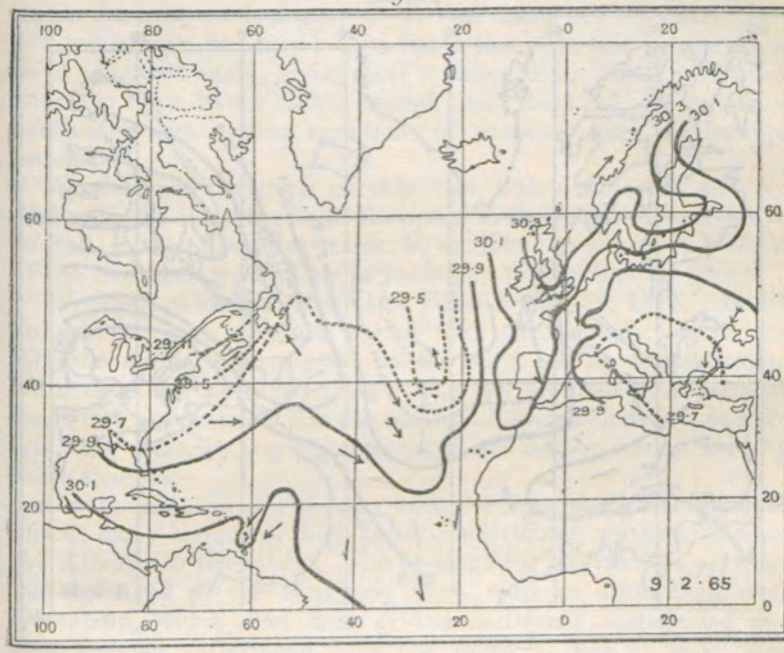


Fig 39.

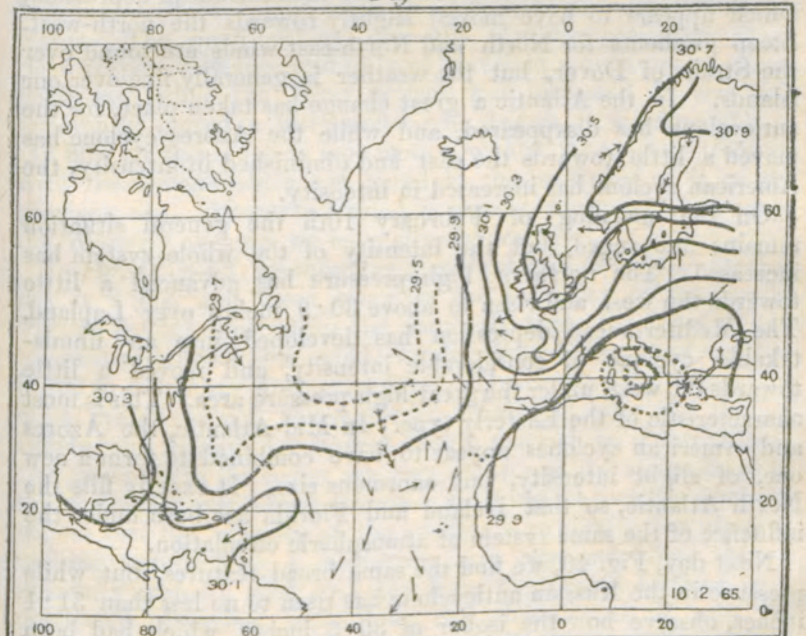
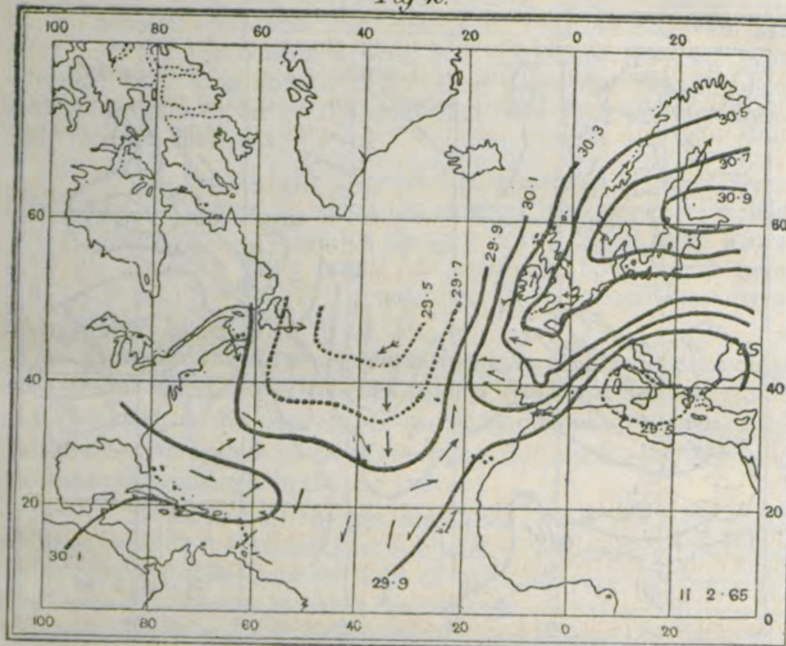


Fig 40.



By next morning, Fig. 38, "a wedge" projects from the northern area of high pressure over the whole western coasts of Europe, so as to form one side of the Mediterranean depression, which appears to have moved slightly towards the north-west. Steep gradients for North and North-east winds are found over the Straits of Dover, but the weather is generally fine over our islands. In the Atlantic a great change has taken place, for the anticyclone has disappeared, and while the Azores cyclone has moved a little towards the east and diminished in intensity, the American cyclone has increased in intensity.

On the morning of February 10th the general situation remains unchanged, but the intensity of the whole system has increased. The northern high pressure has advanced a little towards the west, and risen to above 30·9 inches over Lapland. The Mediterranean depression has developed into an unmistakable cyclone of considerable intensity, and moved a little towards the west, under the great high-pressure area. This is most characteristic of the Easterly type. In Mid-Atlantic, the Azores and American cyclones appear to have combined to form a new one, of slight intensity, but enormous size. It exactly fills the North Atlantic, so that Ireland and Florida are both under the influence of the same system of atmospheric circulation.

Next day, Fig. 40, we find the same broad features, but while pressure in the Russian anticyclone has risen to no less than 31·1 inches, observe how the isobar of 30·3 inches, which had been advancing from the north-east, has now been driven back by the mid-Atlantic cyclone, so that rain with a South-west wind has set

in on the west of Ireland. If we had continued our charts for a few more days, we should have found that soon this isobar would have advanced again, giving finer weather and a South-east wind, and then been driven back a second time, this kind of alternation continuing with endless variations of detail, so long as the type lasted.

We shall now describe another case, which, though it does not deal with the relation of the European to the Atlantic anticyclone so well as the preceding example, exhibits the nature and origin of the Northern anticyclone as belonging to the Arctic regions.

We shall take the four days, February 25–28, 1875. In all, an area of high pressure rested over Scandinavia, while the Atlantic anticyclone reached so far north as to suggest some features of the Northerly type. The low pressure area between these two anticyclones was the theatre of cyclone activity, and we will now describe how the weather in our islands was affected by these changes.

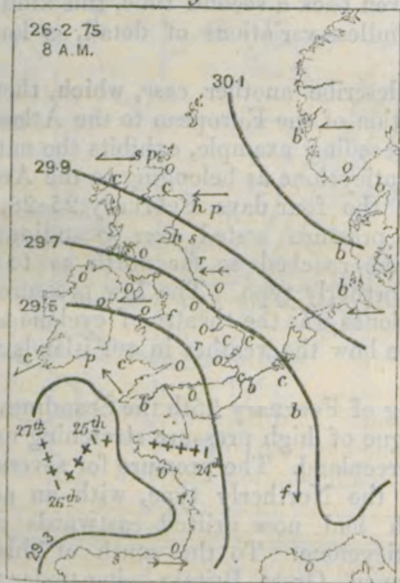
On the morning of February 25th the Scandinavian anticyclone almost met a tongue of high pressure stretching northwards from the Atlantic to Greenland. The pressure for several days previous had belonged to the Northerly type, with an anticyclone over Greenland, which had now drifted eastwards and joined the Scandinavian anticyclone. To the south of this at least four cyclones were formed, Great Britain being under the influence of one whose centre lay off Brest.

By next day, the 26th February, the Scandinavian anticyclone had increased in height, while the Atlantic one retreated southwards. The small cyclones over the Mediterranean and Black Seas respectively appeared to have travelled a little to the east or north-east, while the Brest cyclone had increased in size and apparently moved a little westwards, though it is impossible to say how far this is due to true motion, or how far to its coalescence with the cyclone which was found to the westward of it on the previous day. However formed, it presented a great contrast to the Westerly cyclones we have already described.

In Fig. 41 (p. 62) we therefore give the details of weather for that day at 8 a.m., and these being for the same day of the year as Fig. 25 (p. 44), illustrating the Southerly type, the effect of any seasonal variation is eliminated, and the whole difference of weather is due to difference of pressure type. The centre of the fragment of a cyclone which covers Great Britain is over the Bay of Biscay, and its path for several days is marked by a dotted line; the gradients in the centre are very slight, and the steepest are to the north-east over Great Britain. Looking at weather symbols, we see that the intensity of the cyclone is so slight, that there is nothing approaching a continuous rain area anywhere, but a generally overcast area stretches from the centre furthest in a north-east direction, while here and there spots of rain are developed. In our own islands, the rain is almost exclusively on the coasts exposed to the East wind, while on our west coasts the sky is only overcast or broken.

The large charts for that day showed an intense cyclone on the American seaboard, and a "col" of pressure in mid-Atlantic.

Fig. 41.



On the morning of the 27th, the Scandinavian anticyclonic had formed two heads, and stretched a little further over Great Britain; the cyclone systems over Europe had shrunk in size, while the American cyclone had increased very much.

Finally, by next day, the 27th, the Scandinavian anticyclone has increased in size, but diminished in height, while the European cyclone systems have travelled a little towards the east. By these changes the barometer had risen over Great Britain, and the wind backed more to North-east for finer weather. The alterations on the American coasts were very typical, for while the cyclones there appeared unable to pass through the Atlantic "col," a secondary from them had been projected partially between the great anticyclones, with a great increase of pressure in the tropical Atlantic. When a "col" lies over Great Britain, a similar change is often observed.

The "cols" which occur with this type are about the most difficult configuration of isobars from which a meteorologist can be asked to issue a forecast, as in our present state of knowledge we can give no certain indication whether an incoming cyclone is going to pass through the "col" or be deflected by it.

For instance, on the 27th March 1879 the charts showed a cyclone passing towards south-east between the Scandinavian and Atlantic anticyclones, the centre lying near Brest. Next day the cyclone had made some forward progress, a "col" covered Great Britain, and the front of another cyclone is seen to the south of Ireland. This, it might have been thought, would have taken the

same course of the preceding one, viz., through the "col," but by next morning it had been deflected to the north-east, but a secondary lay over the North Sea, stretching towards the "col."

Fluctuation.

Before leaving the subject of types, it will be well to explain more fully the significance of the terms Fluctuation, Persistence, Intensity, Recurrence, and Dependence, which have been so often used.

In the first place, it must be clearly understood that though a well-defined type is very distinct, there are a large number of transitional forms which it is almost impossible to classify. Thus we have shown that the Westerly type merges almost insensibly into the Northerly, when the cyclones move towards the south-east, while the Northerly and Easterly frequently alternate for a day or two at a time. Similarly, the Easterly and Southerly, and still more the Southerly and Westerly, are often separated by imperceptible shades of difference; but in no case can one type merge into the one opposite to itself.

By the term "Fluctuation" applied to the weather in type is meant that, though the weather may be good or bad or vary in many ways, still a general character and sequence in the changes is discernible as above explained. This is partly due to the high pressure keeping the same quadrant of the cyclones pretty constantly over the same place, and partly to the successive repetition of the same types. In fact, the leading idea of type is sequence, and it is from this conception that such a classification derives its greatest value.

Persistence.

By the term "Persistence" is meant a condition of things during which in spite of fluctuation, the general distribution of pressure, on which the character depends, remains constant, and in this property of types we find the explanation of many phenomena of weather, and of many popular weather prognostics.

For instance, a period of cold weather in winter may be produced by the persistent influence of either the Northerly or Easterly type; or if only for two or three days, from the wedge-shaped area of high pressure between two cyclones. So also a drought may be induced either by a persistent anticyclone, or else by the Westerly type when the intensity is slight, and the cyclone centres are far north; while long-continued rain may accompany almost any persistent type if the gradients be steep.

Then, as to weather prognostics. It is a well-known saying, that "When grouse come down into the farmyards it is a sign of snow." The birds are driven down in search of food by the excess of snow already existing on the moors, and so far the prognostic would refer to the past, rather than to the future; but by the principle of persistence, the type which has already given so much snow may be expected to continue for some time, and therefore more snow may be expected. In Germany there is a similar proverb "Fresh snow, fresh cold."

In like manner the prognostics "When a river like the Tweed rises without any rain having fallen," or "Irregular tides are signs of rain," have a significance for the future; for though both are caused by past bad weather at a distance, yet the persistent type will almost certainly sooner or later bring more bad weather over the place of observation.

On the same principle, the prognostic "Breakers in-shore with-" out wind are a sign of storm," holds on the east coast as well as on the west, but for a different reason. On the west coast the breakers have sometimes run on ahead of the cyclone which raised them, but on the east coast this does not occur, as, practically, all cyclones move towards some point of east. Nevertheless, though the storm which raised the waves has never affected the place where they occur, still it is extremely probable that another of the same series will do so, therefore the prognostic is good, though less certain than on the west coast.

By persistence, also, is explained what is termed "a feeding storm," or a "laying storm." In winter, when snow falls in fine flakes, especially with a North-east wind, it is called a "feeding storm," since it is premonitory of a spell of frost and snow. This is true, because the fine snow comes usually with the first small cyclone of a persistent Northerly or Easterly type, whereas a heavy fall of snow in large flakes may occur in rear of a westerly cyclone if sufficiently intense.

It is also manifest that the principle of persistence has an important bearing on forecasts. Unfortunately, though such types are common, it is not yet possible to define any certain indications of change from one to another. One sign of persistence may, however, be mentioned which rarely fails.

Sometimes a type apparently fails for a day or two, but then is re-established with great intensity. When this occurs, its continuance for a considerable time may safely be predicted. For instance, with the easterly type a small cyclone frequently passes rather far to the east, and the wind shifts to the South-west with increased warmth, but when this dies out the Easterly type is re-established in full force. In these cases the appearance of the weather is sometimes very characteristic, for though the wind is West, the look of the sky is that of an East wind, and so obvious is this, that the people say popularly "that the East wind has not gone yet."

Intensity.

We have already explained the term "intensity" as applied to single cyclones, and shown how it is measured by the gradients and how weather is influenced by it.

We have also shown what an important element in forecasting intensity is, and what a valuable clue we can sometimes get to

an increase or decrease of intensity by watching atmospheric surges.

But there is another form of intensity, which is essentially one of "type," and which refers to that sequence or succession of weather to which the term "broken" would be applied.

From synoptic charts, broken weather is found to be either the product of small quick-moving cyclones, which only exist a very short time, or of frequent secondaries; in contradistinction to the weather produced by large low-gradient cyclones, moving slowly and lasting some days, which would be associated with more settled weather.

The relation between these two kinds of intensity is analogous to the relation between single heavy gusts of wind and numerous short puffs, for both of these are signs of atmospheric disturbance, though they proceed from different causes.

The explanation of a few prognostics is afforded by their dependence on intensity of type. For instance, sheet lightning in the early morning during winter, on the western coasts especially, is a sign of bad weather, and so is the occurrence of hail squalls instead of rain squalls at the same season. Reference to synoptic charts shows that both are associated not only with steep gradients during their occurrence, but also that they take their place in a series of violent cyclones.

Recurrence.

By "recurrence" of type is meant the tendency of certain kinds of weather to recur about the same season of every year.

The following may be considered a preliminary, and very incomplete list of such types for Great Britain :—

January 14th to 20th, a great barometric surge. February 7th to 10th, a spell of cold weather associated with the Northerly type. This is the first of a series of six cold and three hot periods observed by Mr. A. Buchan, and described by him.* The method adopted by him was to note the irregular flexures in the general sweep of the annual temperature curve. He found their recurrence so regular that he says, "During the last 50 " years some of them appeared every year between the dates " specified, and none failed to make their appearance on more " than five years." He also noticed that during the cold periods the pressure was higher to the north of Scotland, and lower to the south, and that during the warm periods pressure was higher over Scotland than in places to the north.

March.—The proverbial East winds of this month are mostly due to the Northerly type, the winds being really North-east. The occurrence of Equinoctial gales about the 21st of the month is occasionally noticed. They are sometimes of the Easterly type, but more frequently of the Westerly.

April 11th to 14th, a cold spell. Buchan's second period, which he has identified with the popular "weather saw" of the

* Journal of the Scottish Meteorological Society, Vol. II. (new series), pp. 4, 41 and 107.

"borrowing days." These are three cold days which March is said to borrow from April, allowing for the difference of the old and new style of reckoning the calendar.

May 9th to 14th, a cold spell. Buchan's third period. This is the most celebrated of the cold periods, as it occurs over all Europe, and has been the subject of many wild theories. The saints to whom these days are dedicated in the German calendar have been popularly called "the Frost Saints." This cold spell is also known as "Maedler's cold days," from the name of an investigator.*

June, a cold spell in the second or third week is associated with the Northerly type. June 29th to July 4th, a cold spell; Buchan's fourth period.

July 12th to 15th, a warm period; Buchan's first. July 15th, St. Swithin. The popular legend of this saint, and other rainy saints like St. Méchard, receives an easy explanation from synoptic charts. Roughly speaking, the weather at the end of July is influenced by one of two types; either the Westerly of considerable intensity, which would be rainy, or the Northerly type, which would be dry. If, then, there is either a rainy or a dry spell about the 15th, similar weather may be expected to last for some time after, if not for 40 days.

August 2nd to 8th, a wet period; the "Lammas floods" of Scotland. 6th to 11th, a cold period; Buchan's fifth. 12th to 15th, a hot period; Buchan's second.

September.—The Easterly and Northerly types are rare during this month; the Equinoctial gales, when these occur, are almost invariably of the Westerly type. About the 30th a fine period is experienced for a few days, the "Indian summer" of North America.

October.—About the second or third week a spell of the Easterly type of moderate intensity is common. 18th; a fine quiet period about this time, "St. Luke's summer."

November 6th to 12th, a cold spell; Buchan's sixth, associated with the Northerly type. The 11th is "St. Martin's little summer," popularly considered in the Mediterannean to be a period of warm, quiet weather. About the 12th to the 15th, a great atmospheric surge.

December 3rd to 9th, a warm period; Buchan's third.

The question now arises, how far the knowledge of recurrent types can be utilised in forecasting? The whole subject of meteorological periodicities will be discussed further on in this work, but the result can be mentioned here, that though the forecaster is not justified in stating that any periodic change will occur absolutely, still when about the time of its usual recurrence the synoptic charts show signs of the expected type, then the forecasts for a few days ahead can be issued with greater confidence.

For instance, suppose that about the 6th of November the charts begin to show traces of the Northerly type, then, but not before, there would be good grounds for saying that a period of cold weather, which usually occurs at this season, has already set in, and may be expected to last for five or six days. The forecaster is thus enabled to issue a forecast much longer ahead than he can as a rule safely attempt.

* For some interesting details, see W. von Bezold. "Die Kälte-rückfälle, in Mai." Abhand. K. Bayer, Akademie der Wiss., II. Cl. XIV. Bd. II. Abth.

It may be remarked that though the recurrent types here given apply in detail only to Great Britain, yet in the main they pertain to the whole of Western Europe, and that the principle of recurrence holds all over the world.

Dependence.

By "dependence" of type is meant the supposed connexion between the occurrence of any particular type at one season of the year, and the recurrence of it, or of another type, as a consequence at another season. For instance, it is very commonly believed that if Easterly winds prevail about the time of the Spring Equinox, then a great preponderance of Easterly winds may be expected during the rest of the year.

Similar beliefs, such as the dependence of cold winters on hot preceding summers, are very common in all weather lore.

Now with regard to the first-mentioned saying about the Equinox, there are undoubtedly a sufficient number of instances to account for the saying. Put into the language of types and synoptic charts, it means that if the Easterly type happens to prevail at the spring Equinox, then there will be an unusual tendency of that type to occur during a great portion of the year.

Though so widely held, it cannot be said that there is any one such saying which has been conclusively established, but even if it were, we may confidently say that the same argument would hold for recurrence as for dependence, viz., that even if the principle does exist, we can make no use of it in forecasting from day to day, since its influence can be so easily overridden by more powerful causes.

Weather of no Type.

So far our illustrations have been chosen to exhibit the four commonest types of cyclone motion which occur in Western Europe, but we shall now describe a single example of a spell of weather which does not belong to any of them.

We shall consider the four days, February 8–11, 1874.

The general features of the period were the passage of an anticyclone from Greenland to Switzerland, but it is particularly interesting, both as showing a case of transition from the Northerly to the Westerly type, and from the manner in which it illustrates the recurrence of the cold February period we have just described.

On February the 8th an anticyclone lay over Iceland, which on the previous day was found on the east coast of Greenland. Over Spain a wedge of high pressure projected northwards, and the presence of a cyclone near Copenhagen suggested all the features of the Northerly type. The winds and weather over our islands were those due to the "*col*" lying between the two high pressure areas.

By next day, however, the Iceland anticyclone had moved south-eastwards, so as partially to cover Great Britain; by the 10th its centre was over the North Sea; the following day over Germany, with steep gradients for South-east winds over Ireland.

Some features of the Westerly type now presented themselves, and the chart for the 12th showed that the centre was then over Switzerland, and that all the characteristics of the Westerly type had made their appearance.

In weather of this sort, the forecaster is at a great disadvantage, for moving anticyclones are so rare in this country, that it is impossible to generalise on them, in contrast to the cases of cyclone motion we have given so fully.

Before proceeding further with the subject, it may be well to consider what we have learned from the type charts besides the existence of types at all. In the first place, we have shown in the most complete manner that weather is the product of the varying position of cyclones and anticyclones, and that every known case of weather can be explained by reference to them, or to allied isobaric forms.

We have also made it very evident that if cyclones only moved in tolerably well-defined paths, and remained steadily of any regular shape, then weather forecasting would be one of the most definite and simple of sciences, and that the most minute details, both of the appearance of the sky, and the sequence of weather, could be announced with the greatest certainty.

But unfortunately this is not the case. We have demonstrated that, on the contrary, not only are the paths most irregular in their courses, but that from the tendency of two cyclones to coalesce, there is often the greatest difficulty in saying what the path or history of any cyclone has been.

We have also seen that following the history of any existing form of isobars is only a small part of the forecaster's duty, and that a great deal of his work consists in endeavouring to estimate what new changes or formations are likely to take place.

It is also very clear that, though the general fact that a falling barometer indicates bad weather is undoubtedly true, because it is associated with the formation or increase of a cyclone, still the changes which give rise to such an apparently simple phenomenon, are really very complex.

CHAPTER V.

WEATHER FORECASTING.

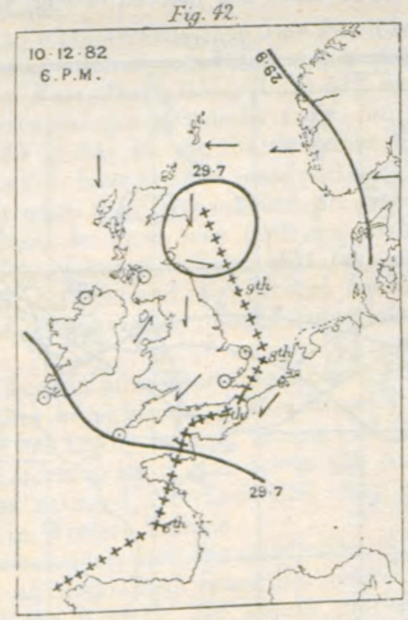
So far we have only explained the nature of weather and weather sequence, and only incidentally alluded to forecasting proper, so that we must now go more minutely into that portion of the subject. We have already mentioned that the greatest assistance the forecaster has, is the recognition of certain types of weather; but we shall now give some of the general principles of cyclone motion and weather changes on which he has to fall back when he cannot recognise any known type. We shall then explain the use of various aids to forecasting, and conclude with some detailed examples of successful and unsuccessful forecasts.

Cyclone Paths.

In the first place, as the motion of cyclone centres is always towards some point of east, except in certain cases of the Easterly type which we have already explained, in an uncertain case we may always assume some Eastward drift.

Another very noticeable point about cyclones, is the tendency of their centres to follow a coast line rather than to strike inland. Also when they do cross the land, they seem to take by preference the lines of valleys or at all events of lowest ground, which seem to be lines of least resistance to cyclone motion. In this country cyclone centres have a tendency to pass up channel, or round the north-west coasts of Ireland and Scotland; and when they cross

Fig. 42.



the country they frequently select the line of the Caledonial Canal, or the line of the Forth and Clyde Canal. As an example, in Fig. 42, for December 10th, 1882, at 6 p.m., we give an example of a cyclone centre working up channel, and then along the east coast of England, so that the centre seems to hug the shore, but to avoid passing over the land. Though these cases do often occur, still the knowledge of the fact is of but little use in forecasting, for the centres often take other paths, and it is only in very rare cases that the knowledge is of any practical use.

Storms Crossing the Atlantic.

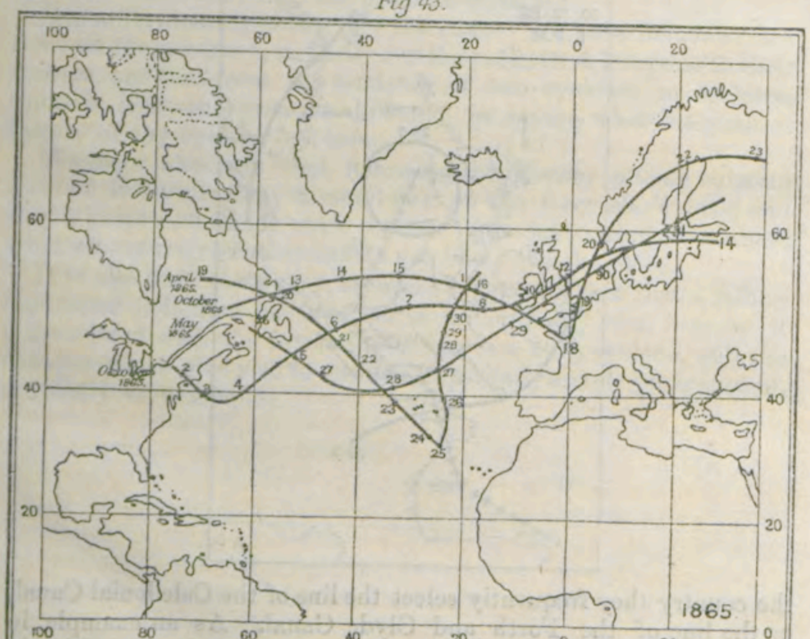
Public opinion has been much fascinated by the discovery that occasionally cyclonic storms have been traced from America across the Atlantic to the coasts of Europe, and exaggerated hopes have been entertained of thus issuing Storm Warnings to Great Britain several days in advance. We propose, therefore, to devote a few paragraphs to the consideration of this subject.

First, as to the number which actually do cross, their tracks, and their time of passage. In the year 1865, as far as the French charts show, that is to say a little north of 50° lat., only four were traced as follows :—

Date.	Distance traced.	Days in Transit.
1865, April 19–May 1 -	Traced from Labrador to Ireland - -	12
„ May 26–31 -	„ Gulf St. Lawrence to Finland -	5
„ Oct. 2–14 - -	„ Cape Cod „ „ -	10
„ „ 13–23 - -	„ Newfoundland „ „ -	10

The tracks of all of these are marked in Fig. 43, which shows

Fig 43.



at a glance that their paths were so different, and their rates of progress so irregular, that any attempt to forecast British weather from the mere knowledge of the fact that a cyclone has left the United States and gone into the Atlantic Ocean, must end in disastrous failure.

In the year 1874, the following six were traced by Professor Loomis, the greater number probably by means of Hoffmeyer's charts, giving observations up to lat. 70° N. :—

Date.	Distance traced.	Days in Transit.
1874, March 1–5 - -	Traced from Hudson's Bay to North Cape -	4
„ April 14–17 -	„ „ „ to Norway -	3
„ „ 16–23 -	„ Gulf of St. Lawrence „ „ -	7
„ May 23–30 - -	„ „ „ „ „ -	7
„ Aug. 1–4 - -	„ „ „ „ North Cape	3
„ „ 12–17 - -	„ Hudson's Bay „ Norway -	5

In this case the passages are a little less irregular than in the year just described, but still they have no definite feature.

Some recent years, for which more complete materials exist, have given larger numbers, and one or two cyclones have even been traced from the Pacific coast to Russia. But in many cases there is much uncertainty as to how far the cyclone which reaches us is really the same one which left the United States. When a cyclone which has left Canada combines with another which has come up from Bermuda, how are we to identify the resulting depression with either?

Turning, now, to what we may learn from the illustrations already given as to the more ordinary course of cyclones which affect the United States, in Figs. 28 to 31 (pp. 50–51), we see a cyclone leaving Nova Scotia and going partially across the Atlantic; while in Figs. 32 and 33 (p. 54) we see the commonest case of all, in which cyclones, which have crossed some portion of the American continent, die out when they have reached the Atlantic seaboard.

Besides all these, we have seen cyclones originating in mid-Atlantic, which have become so large that they completely filled that ocean, both Europe and the United States being simultaneously, instead of successively, under the influence of the same cyclone.

We must also bear in mind that even when a centre crosses, we have no cognizance of either the size or intensity of the cyclone. A cyclone which has hardly brought rain in Canada may develop into a dangerous storm in its course across the Atlantic; while a storm which has ravaged Newfoundland may give rise to a moderate breeze in Western Europe.

From all these considerations the conclusion is inevitable, that though there is an undoubted connexion between the weather on both sides of the Atlantic, the nature of the changes are so complicated and variable, that no practical use can be made of the knowledge for forecasting purposes without observations over the intervening ocean.

Unequal Change of the Barometer.

So far, then, as general knowledge of cyclone motion is concerned, we see that pretty nearly all it enables us to do is to say that, except during the Easterly type, the motion of a depression will be towards the east; but we have already shown that there are a great many weather changes which are not associated with well-defined cyclones, and that even when they are, the changes are on so large a scale that we cannot trace them on a small area. This brings us to what is practically the forecaster's greatest stand-by when he has no definite isobaric shape to trace, viz., to watch over his limited area of observation where the barometer is falling, and where it is stationary or rising. By combining these changes, with the existing shape of the isobars, he can usually determine whether the wind will increase in force; and also whether the weather is likely to improve or otherwise, for, we have shown that in a general way, increasing gradients are associated with weather getting worse. He is also enabled by this means to form an opinion whether an anticyclone is likely to break up, or as to the likelihood of any other very great change. We shall defer our illustrations of this subject till we have explained the system on which the United Kingdom is divided into districts for forecasting purposes.

Periodicities.

We have already alluded to the question of periodicities when speaking about recurrent types of weather, but it will now be convenient to discuss the subject a little further, with special reference to the case of the supposed connexion between sun-spots and weather, concerning the value of which most exaggerated ideas have been circulated. The best method of explaining the true nature of all meteorological periodicities will be to take the most obvious one—the daily range of temperature—and then from a consideration of its nature, we shall be enabled to understand the value in weather forecasting both of annual periodicities and of those of longer period.

In Fig. 44, where we give thermograms at Stonyhurst for

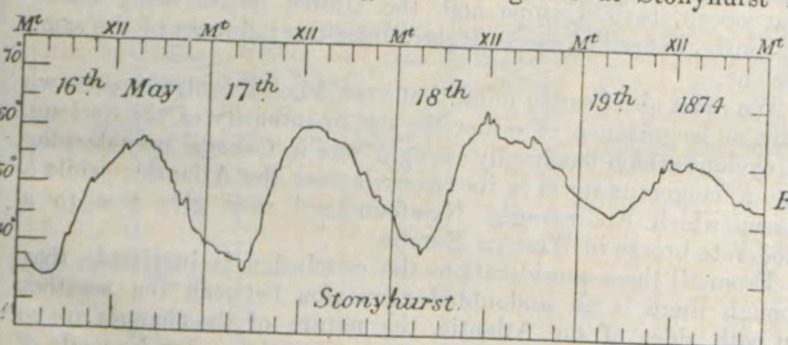


Fig. 44

the four days May 16th–19th, 1874, we have a very fair specimen of the variation of the thermometer on a fine day in England.

A chart for May 17th is given in Fig. 15 (p. 27) as illustrating anticyclone weather. We see that the temperature is usually highest about 1 p.m., and lowest about 4 a.m. But how should we fare if we attempted to say that on every day it will be hottest at 1 p.m. and coldest at 4 a.m.? Look at the thermograms in Fig. 45 for December 7th–10th of the same year. On the first

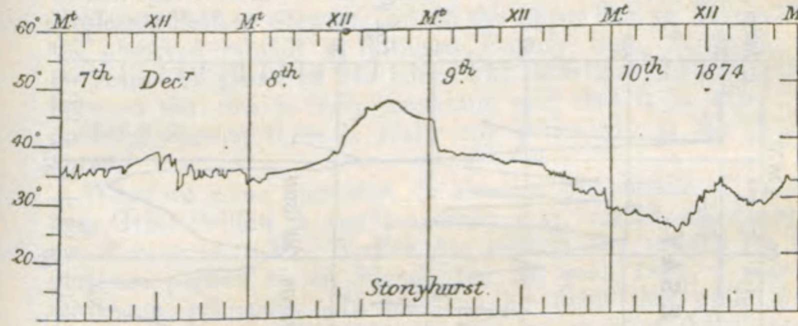


Fig. 45.

day the *minimum* is at 2 p.m. and the *maximum* about noon, the whole curve being the result of a dull, cloudy, day with cold showers. On the next day the thermometer rises till about 6 p.m. and then falls so continuously for the next 48 hours, that during the 9th December there is hardly any hour which is not colder than the preceding one. To explain this apparent anomaly, we must describe the charts for December 8th and 9th, 1874, at 8 a.m. In the first a cyclone was coming on, which accounts for the rise of temperature seen in the thermogram for that day; while in the next chart it was seen that Stonyhurst was under the influence of the rear of the same cyclone, which accounts for the great cold, that was sufficient to override the diurnal variation. On the last day of our thermogram we see that after the mid-day maximum the thermometer rose again to an equal height, under the influence of another oncoming cyclone.

Considering, then, all these illustrations, it is evident that the observed temperature is the result of a number of different causes, and that because on any particular day we do not find the ordinary maximum, it does not prove that there is no such thing as a solar diurnal variation, but only that the power of the sun has been overridden by stronger influences. For instance, in this country during the summer months, the diurnal variation of temperature is always greater than what we may call the general changes from cyclonic or other causes. At that season we always find the nights colder than the days, however irregular the curves may be. In winter, on the contrary, as we have just seen, the general changes are so much stronger than the diurnal that the nights are sometimes hotter than the days. The same argument holds good for every other diurnal variation.

With respect to annual variations, we have already shown, when speaking about weather types, that we cannot assert absolutely that any periodicity will recur every year at the same time, but that when it does return, and we recognize its nature, then, and not till then, can we utilise it to give greater certainty to our forecasts.

Sun-Spots and Weather.

Now, with regard to cycles of longer period, the only one which

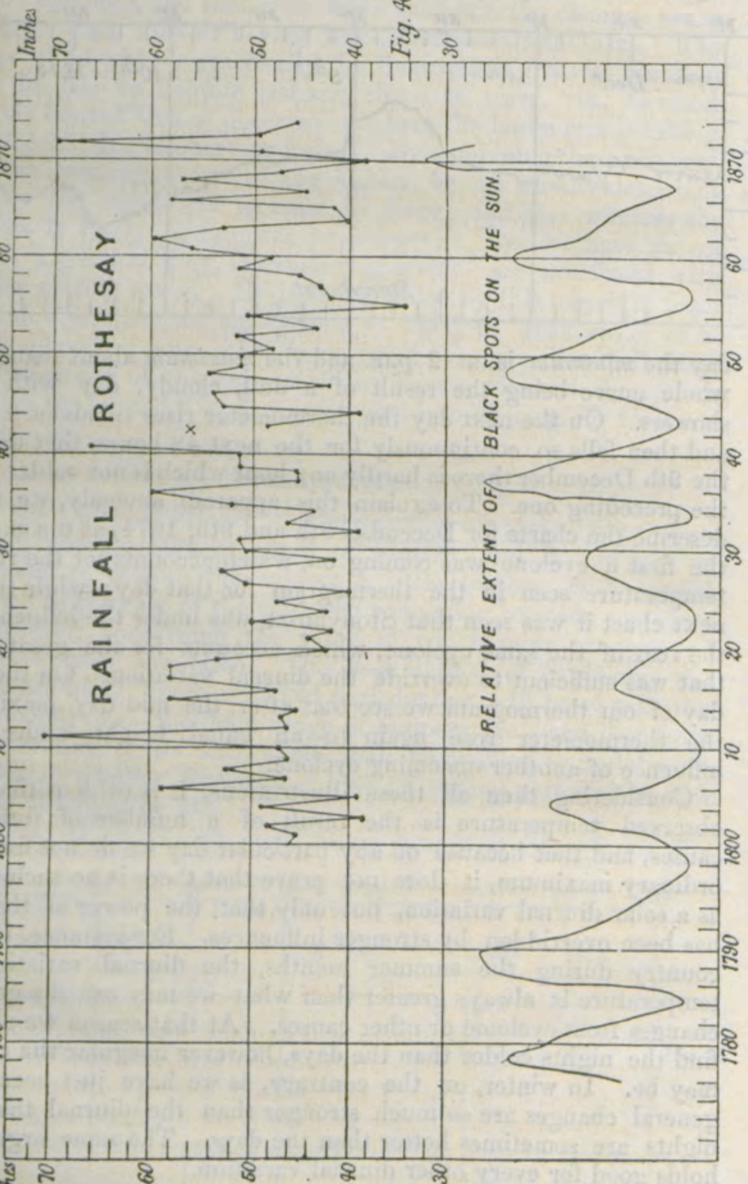


Fig. 46.

has attracted much attention, is a supposed relation between sun-spots and weather, especially with rainfall. The nature of the

cycle is said to be that the maximum of solar spots has a period of about 11·1 years pretty certainly, and that there is an ill-defined maximum of rain with the same period, which falls a year or two behind the solar maximum.

To enable our readers to judge of the amount of connexion, in Fig. 46 we give on the lower line a diagram of the relative number of sun-spots, from Wolff's and other observations, as given by Professor Balfour Stewart, and on the upper line we have added the observed rainfall at Rothesay, County Bute, Scotland, for 80 years. A glance at this curve will show that the connexion between the two is very uncertain, and that it is extremely doubtful whether there is really any periodicity in the rainfall curve.

When we come, moreover, to examine the details of rainfall over Great Britain in any maximum year, similar uncertainties are discovered. Mr. Buchan has plotted the rainfall for the northern portion of our islands, for the year 1872, a year or maximum sun-spots. In his map he finds that while near Aberdeen the rainfall was 75 per cent. in excess of the average, the amount near Cape Wrath, about 100 miles distant, was below the average.

But even supposing that the existence of this periodicity was ever clearly established, what use could we make of it in forecasting? It is very obvious that we could not predict an increase of rain even in a general way, and that even if we could, we should be unable to say where it would fall, speaking only of yearly totals.

Still less, when we come to predict the weather for any particular day, can we avail ourselves of even a well-defined periodicity. It is obvious, from all the illustrations we have given already, that when we have to determine the probable course or intensity of any cyclone, such knowledge would be of no assistance to us.

Other stations have given signs of a more likely connexion between sun-spots and rainfall than Rothesay, and it is probable that if curves of the number of rainy days in a year, instead of the quantity of rain were employed, any relation between the two might be more clearly shown. But even if such a connexion should be ever fully established, it is evident that the knowledge would be of little service in forecasting.

Statistics.

A similar line of argument will explain why we are unable to use average values or any statistical results in weather forecasting. We have already explained why such a curve, as that for mean temperature, does not enable us to forecast the fluctuations of the thermometer for any single day, and when we apply average values to the motions of isobaric lines, the impossibility of using statistical results is even more obvious. For instance, we have seen that the motion of a cyclone may vary from 70 miles an hour eastwards to 10 miles an hour westwards. In some cases, by taking each depression on its own merits, we can form a very good opinion of the probable course, but the mean velocity of British cyclones, 20 miles an hour east, is only the arithmetical sum of all that have been observed, and represents no physical law, nor any number which can be used in forecasting.*

Prognostics.

We shall now discuss the relation of popular weather prognostics to modern synoptic methods, as it is a point of great importance. We will show both the relation of the old and new meteorology, and explain how well-known sayings can now be utilised for synoptic forecasting. We have already seen, in Fig. 18 (p. 30), that prognostics are merely the detailed description of the appearance of the sky in different parts of a cyclone, and further on we have shown that every shape of isobars has a set of prognostics belonging to itself. This is the fundamental principle of all synoptic meteorology. Theoretically, then, when the isobars are well defined, we ought to be able to write down the prognostics which might be visible, but practically we cannot do so completely; and also theoretically, all that any prognostic does, is to enable a solitary observer to identify his position in any phase of atmospheric circulation. The mere observation of the prognostic can give little or no clue to the probable path of the cyclone; that depends on the position of the surrounding areas of high pressure, and can be judged by synoptic charts alone.

On the other hand, there are sometimes cases of isobars which have no well defined shape, but with which thunderstorms or heavy showers often occur. These, as is well known, only affect the barometer slightly, but are abundantly forewarned by the commonest prognostics, and as the rainfall is usually heavy in them, the failure of the forecast which omits to notice them is very conspicuous. The scope of this work precludes us from entering into the complicated question of the non-cyclonic rainfalls in this country. It will be enough to state that the prognostics which precede them are those associated with broken weather, such as bright sun-rises or heavy clouds banking up without a fall of the barometer, rather than the muggy, dirty weather of a cyclone front. The warning they give is also much shorter, rarely more than three or four hours, if so long.

We shall now illustrate all these points. First, for a prognostic and synoptic forecast both succeeding. Turning to the cyclone shown in Fig. 11 (p. 20), the author observed a very well-defined halo of 46° diameter at Brighton about 6 p.m. the previous evening. The prognostic held good in this instance, because a halo is characteristic of the front of a cyclone, and here the cyclone pursued the ordinary course towards some point of east. The

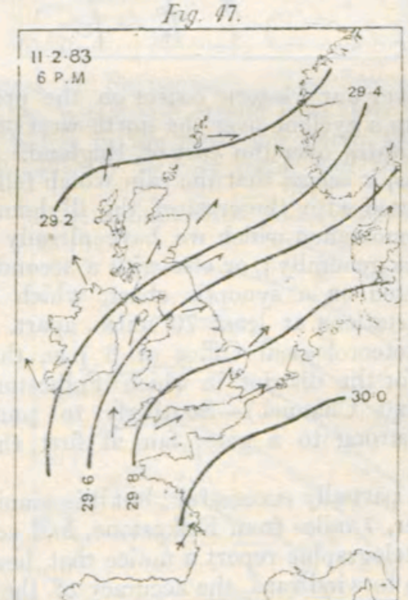
* For further details of the application of statistics to synoptic meteorology, see Abercromby, "On the Application of Harmonic Analysis to the Reduction of Meteorological Observations, and on the general Methods of Meteorology," Q. J. Meteor. Soc., Vol. IV., p. 141.

Meteorological Office also warned all coasts successfully of a South-westerly gale, because the charts indicated an approaching cyclone of the Westerly type and of great intensity.

But then for a halo failing when a synoptic forecaster might have succeeded. On February 5th, 1883, at Folkestone, the writer saw a halo off and on, from 9.30 a.m. to 4 p.m., and this was due to the front of the cyclone which is seen lying off our north-west coasts in the 8 a.m. chart. The whole of that day and night, as well as the succeeding day, was very fine, so that the prognostic might seem to have failed. Before the days of synoptic charts, this is all that we could have said about the matter, but the chart for 6 p.m. the same day showed that, owing to the increasing pressure over the North Sea, the cyclone we saw at 8 a.m. had not been able to move in its usual eastward course. In this case, though the synoptic forecaster can explain the failure of the prognostic, he would not have been able to state at 8 a.m. that rain would not have fallen in that part of England, for the isobars then presented the difficult case of a "col."

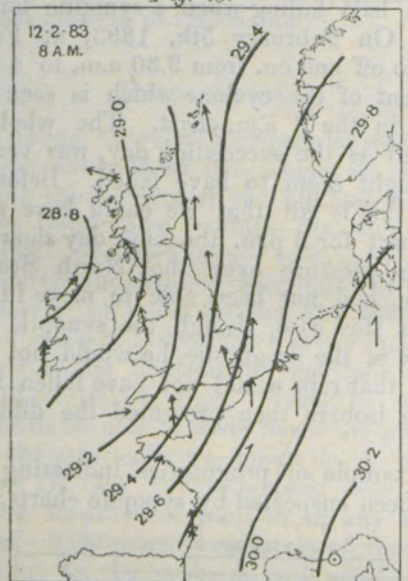
Next as an example of prognostics indicating rain, when it would not have been suspected by synoptic charts, in Fig. 47 we

Fig. 47.



give a chart for February 11th 1883, at 6 p.m. In it the edge of an anticyclone lies over the south-east of England, and the weather there was generally fine. At Folkestone, however, after a wildish day, but while the barometer was rising, a brilliant halo of 46° diameter was observed at 4 p.m.; a pale sunset followed. A little after 6 p.m. the clouds showed evident signs of rain, which fell heavily from 7 to 10.30 p.m., during the crest of the barometric trace which began to fall just afterwards. By 11.50 p.m. the stars were shining, but next day was warm, squally, and threatening. In the chart for the morning of February 12, Fig 48, the low

Fig. 48.



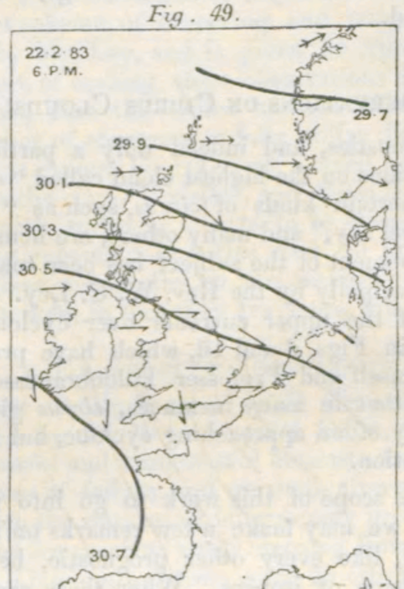
pressures lying over our western coasts on the previous evening have gathered into a cyclone over the north-west of Ireland, with almost straight isobars over the east of England. Combining all these observations, it seems that the rain which fell at Folkestone was either associated with the crest of the ill-defined wedge seen in Fig. 47, a phenomenon which we have already noticed when describing wedges generally; or else with a secondary so small as not to be detected on a synoptic chart, which was based on observations at stations at least 70 miles apart. The forecast issued by the Meteorological Office at 6 p.m. that evening, the 11th February, for the district in which Folkestone lies, was:—5, S. (London and Channel.)—Southerly to south-westerly or westerly winds, strong to a gale; fair at first, then very rainy, and squally.

This was only partially successful; but it is manifest that if the observer at Dover, 7 miles from Folkestone, had sent up with his ordinary 6 p.m. telegraphic report a notice that heavy rain clouds were banking up to windward, the accuracy of the forecast would have been much increased.

Lastly, as an example of the failure of a prognostic when synoptic charts succeeded. In London at 4 p.m. on the 22nd of February 1883, a solar halo was visible, though the surrounding clouds were not threatening. By 6 p.m. the sky was nearly blue, and the night and all next day were very fine. Here an observer, who had only prognostics to guide him, might have expected bad weather, but a synoptic forecaster could not have made such a mistake. A glance at Fig. 49 for 6 p.m. that evening will show

that the halo was due to the presence of a very small secondary, hardly indicated on the chart except by the deflection of the wind

Fig. 49.



to the north-west at Portsmouth. The forecaster, with a full knowledge of the prognostic, would have seen at once that with the barometer rising in the west and north, there could be no danger of bad weather in any form, and the chart shown in

Fig. 50.

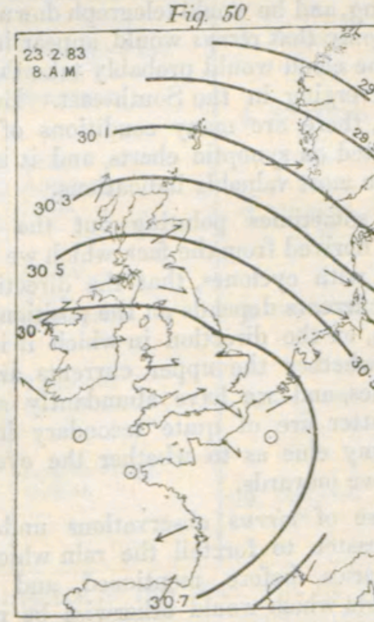


Fig. 50 for 8 a.m. the next morning, shows that an anticyclone had stretched over England from the west. The forecast issued by the Meteorological Office was: "District 5, England, S. (London and Channel), North-westerly and perhaps Northerly airs and light breezes; dry and colder, with local fogs," and was thus abundantly justified.

Observations on Cirrus Clouds.

Allied to prognostics, and indeed only a particular case of them, are observations on the highest cloud called "*cirrus*."

The forms of certain kinds of *cirrus*, such as "mare's tails," "wisps," "mackerel sky," and many others, are household words; but a great development of the subject has been made during the last few years, principally by the Rev. W. C. Ley. By studying the movements of the upper currents over cyclones and anticyclones, shown in Figs. 6 and 16, which have practically been worked out by himself and Professor Hildebrandsson, of Upsala, he has discovered that in many instances, *cirrus* gives very early intimation not only of an approaching cyclone, but in some cases of its probable motion.

It is beyond the scope of this work to go into the details of the subject, but we may make a few remarks on the principles involved. *Cirrus*, like every other prognostic, bears a definite relation to some shape of isobars. When these are well defined, *cirrus* tells us little that we do not know before; in fact in most cases we could forecast that *cirrus* would make its appearance in certain districts. For instance, if at 8 a.m. a wedge just covers the United Kingdom, the sky over the Eastern counties would be cloudless. A synoptic forecaster would see that a cyclone was certainly approaching, and he would telegraph down to an observer in that district not only that *cirrus* would appear in the course of the day, but that the cloud would probably take the form of long parallel stripes converging in the South-east. But, as we have already mentioned, there are many conditions of rain which are very slightly indicated on synoptic charts, and it is in those cases that *cirrus* gives the most valuable indications.

The power of sometimes pointing out the direction of a cyclone's motion is derived from the fact, which we have explained fully when dealing with cyclones, that the direction of both the surface and upper currents depends on the position of the front of the cyclone, that is, on the direction in which it is going. It is, however, doubtful whether the upper currents are of more use than the lower ones, and we have abundantly shown that the direction of the latter are of quite secondary importance. In neither have we any clue as to whether the cyclone will stand still, die out, or move onwards.

The greatest use of *cirrus* observations undoubtedly is in assisting the forecaster to foretell the rain which occurs with the small secondaries before mentioned, and to give more precision to forecasts which would otherwise be rather vague, as for generally unsettled weather, &c.

The importance of these observations is, however, so great, that the Meteorological Office have been endeavouring for the last three or four years to organize a system of *cirrus* observations. A very perfect scheme of observing and telegraphing has been worked out by Mr. Ley, and is given in Appendix I. Unfortunately, the art of making these observations is so difficult and incommunicable, that the Office has not been able to find a sufficient number of observers to fully utilize the method; besides, the observations cannot be taken at a fixed hour, when wanted, but only when the *cirrus* is visible, and there is great difficulty in finding men with sufficient leisure to be always on the look out. It is also very important to notice that no prognostic or *cirrus* observation gives much clue to the intensity of the cyclone in which it is observed, in fact they are more valuable for rain than for wind.

Examples of Forecasting.

We shall now explain in more detail the actual nature of the forecasts issued by the Meteorological Office, and give examples of both successful and unsuccessful forecasts, so as to illustrate the different sources of failure, and we shall afterwards indicate the means by which the number of failures may probably be reduced.

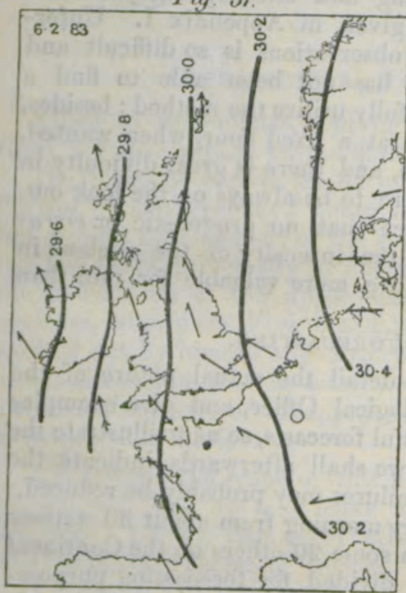
Observations are received every morning from about 30 stations in the United Kingdom and from some 20 others on the Continent of Europe. These islands are divided for forecasting purposes into 11 districts. Their position, and the names of the stations in each, are given in the following table —

Names of Districts.	Names of Stations.	Names of Districts.	Names of Stations.
0. Scotland, N.	Sumburgh Head. Wick. Stornoway.	5. England, S.	London. Dover. Hurst Castle.
1. Scotland, E.	Nairn. Aberdeen. Leith.	6. Scotland, W.	Ardrossan.
2. England, N.E.	Shields. York. Spurn Head.	7. England, N.W.	Hawes Junction. Barrow-in-Furness. Liverpool Observatory (Bidston). Holyhead.
3. England, E.	Yarmouth. Cambridge.	8. England, S.W.	Pembroke. Prawle Point.
4. Midland Counties.	Loughborough. Oxford.	9. Ireland, N.	Donaghadee. Malin Head. Mullaghmore. Belmullet.
		10. Ireland, S.	Parsonstown. Valencia. Roche's Point.

In the frontispiece of this work will be found a map showing the position of every station, and marking the limits and numbers of the different districts.

Our first illustration will be a successful forecast of a common winter gale. In Fig. 51 we give the chart from which forecasts had to be issued at 8 a.m., February 6th, 1883. We see in it at once the commonest features of the Southerly type of weather, with the pressure high over Scandinavia and low over the west of Ireland, while the isobars run nearly due north and south. Southerly gales have already commenced in the west and north, while fine weather prevails over our south and east coasts. We also note that, while the barometer is rising over Norway, it is falling, but only slowly, over our western coasts. Now, from all that we have already explained as to the nature of this type, it is evident that there is no fear of the depression crossing England so as to bring any great change of wind, but that the gradients will get steeper for Southerly winds with bad weather, and that probably our south and east coasts will not be affected. Then, as to storm warnings, all the north and west (Districts 0, 1, 6, and 9,) were already warned, but as the south of Ireland, District 10, will be affected by the increasing gradients, warnings were necessary for it also.

Fig. 51.



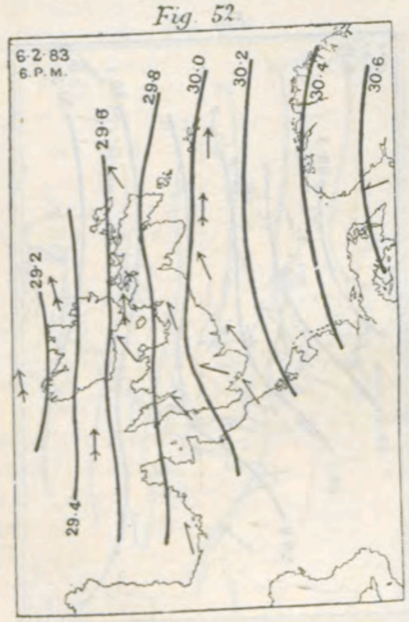
Hence the following forecasts were issued to the different districts :—

FORECASTS for the 24 hours ending at Noon on the 7th February 1883.

Districts.	Forecasts.	Districts.	Forecasts.
0. SCOTLAND, N.	Southerly strong winds and gales; cloudy generally with some rain.	6. SCOTLAND, W.	South-easterly and southerly strong winds, perhaps a gale; fair to cloudy, and unsettled.
1 SCOTLAND, E.	Do. do.	7. ENGLAND, N.W.	Do. do.
2. ENGLAND, N.E.	South-easterly winds, moderate inland, strong on coast; fair generally.	8. ENGLAND, S.W.	South-easterly and southerly winds, increasing; cloudy.
3. ENGLAND, E.	Do. do.	9. IRELAND, N.	South-easterly and southerly winds, increasing to a gale; cloudy, unsettled; some rain.
4. MIDLAND COUNTIES.	Same as No. 5.	10. IRELAND, S.	Do. do.
5. ENGLAND, S. and the Channel.	South-easterly and southerly winds, moderate or fresh: fair generally.	WARNINGS -	The south cone is still up in Districts 0, 6, 9, and parts of 1 and 7, and has been re-hoisted this morning in district 10.

By looking at the chart, Fig. 52, for 6 p.m. on the same day, we find that the above anticipations have been completely verified.

Fig. 52.



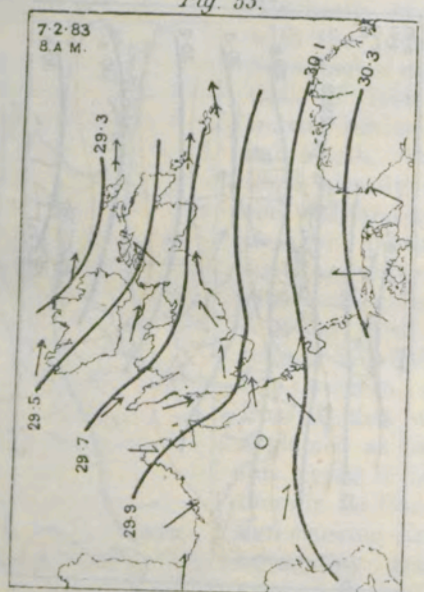
Wind and rain have increased in the west and north, but in south-east England the weather remains fine. In his journal, at Folkestone, in District 5, on that day, the author finds the following entry: "6th Feb. 1883. Cold, dry, very fine and bright; "wind south-east, fresh." Hence the forecasts were a complete success.

In selecting the example we had, however, an additional object, viz., to illustrate what we have laid down relative to the use of periodicities in forecasting. We have already mentioned that the period, February 7–10, is one of recurrent cold weather, and we have given a detailed illustration of the recurrence of a cold type on those days in 1865, Figs. 37–40 (pp. 58–60). Whence, if the forecaster had trusted blindly to periodicities, he would have made a complete failure. On the other hand, had he seen on this day traces of either the Northerly or Easterly types setting in, the knowledge of the periodicity would have been of great use to him.

Returning now to our last chart, Fig. 52, the forecast issued from it was equally successful, but by next morning a complication had set in, which caused a partial failure in the predictions for that next day. This is an instructive instance of a very common source of failure, viz., the occurrence of secondaries and the sudden dying out of a cyclone. In Fig. 53 (p. 84) we therefore give a chart for 8 a.m. February 7th, 1883. Here we find the same broad features of the Southerly type as on the preceding day, but the Scandinavian anticyclone has been driven a little back, while the main depression has advanced a little to the north-north-east, and a well-defined secondary lies over Central England.

In consequence of these changes, the wind has moderated everywhere except in the north, and the weather improved, except

Fig. 53.



where influenced by the secondary. The barometer was also rising fast in the south-west.

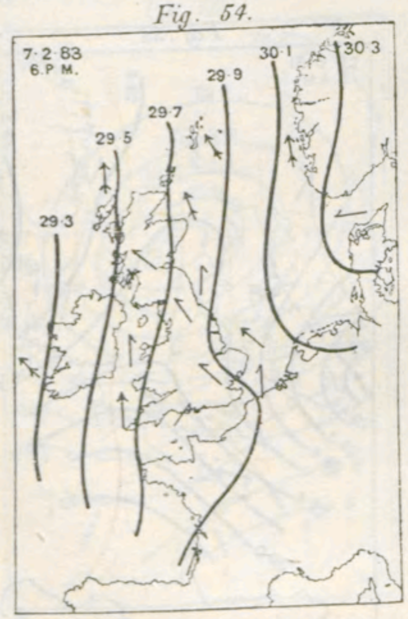
The forecasts for the day were issued on the supposition that these changes would continue in the same direction; that is that the cyclone and secondary would move off in a north-north-east direction, with better weather in the north, but that the weather generally, especially in the west, would be wet and unsettled. On these grounds the following was issued:—

FORECASTS for the 24 hours ending at Noon on the 8th February 1883.

Districts.	Forecasts.	Districts.	Forecasts.
0. SCOTLAND, N.	Southerly gales, moderating gradually; dull and rainy to fair.	6. SCOTLAND, W.	South-easterly to southerly winds, fresh; cloudy, some rain.
1. SCOTLAND, E.	Do. do.	7. ENGLAND, N.W.	Do. do.
2. ENGLAND, N.E.	South-easterly gales to southerly strong winds; dull and rainy to fair.	8. ENGLAND, S.W.	South-westerly winds, moderate or fresh; fair to cloudy and unsettled.
3. ENGLAND, E.	Do. do.	9. IRELAND, N.	Southerly and south-westerly winds, fresh or strong, changeable; some rain.
4. MIDLAND COUNTIES.	Same as No. 5.	10. IRELAND, S.	Do. do.
5. ENGLAND, S.	South-easterly to southerly or south-westerly winds, moderate to fresh; fair on the whole.	WARNINGS -	The south cone was hoisted yesterday on all coasts, but has been lowered this morning in Districts 5 and 8.

Turning now to Fig. 54, where the chart refers to 6 p.m. on the evening of the same day, we find that the cyclone in the

Fig. 54.



north-west has died out, and a fresh depression appeared in the south-west so that the isobars had recovered their north and south trend, while the secondary had moved a little to the east-south-east.

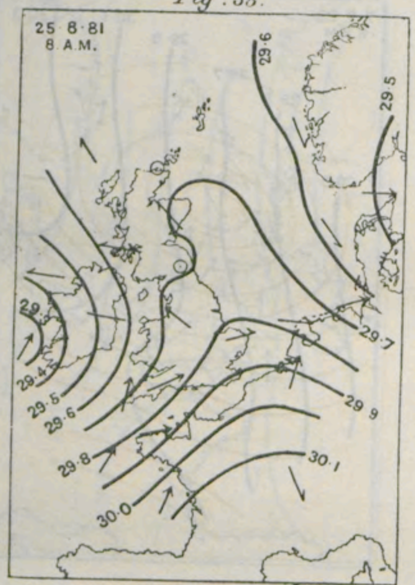
In consequence of this, though the broad features of South to South-west winds with unsettled weather were justified, the details in the different districts were only partially verified.

Thus, in the extreme north, the gale, instead of abating, continued, though the direction was given correctly. The rest of Scotland, Districts 1 and 6, and north-east of England received good forecasts, as the changes above described did not affect them. The Midlands and south of England were well forecasted as regards direction and force of the wind, but badly as regards weather, for the secondary moved slowly over these districts instead of passing away as anticipated. Thus, at Folkestone, the author finds the general weather for the day recorded thus: "Warm, dull, rain in the forenoon; wind South, moderate to fresh." Lastly, in the western districts, the prediction for wet and unsettled weather was justified, but the gale which set in at Valencia was not announced. The warnings were correctly kept up on the north and west coasts, and correctly lowered in the south and south-west of England, but erroneously kept flying in the east of England.

Our next illustration will be that of a well-defined cyclone, crossing our islands, which will show another class of difficulty.

The chart, Fig. 55, is for August 25th, 1881, at 8 a.m. In it we find the ordinary characteristics of a well-defined cyclone, of the Westerly type, which is likely to cross our islands, for we see another

Fig. 55.



cyclone disappearing over the Baltic, and a typical wedge between them.

So far there is little doubt that the cyclone is going to move towards some point of east, but there is always some uncertainty as to what precise point. In this case the following forecasts were issued on the supposition that it would move nearly due east, and will be readily understood by reference to what we have said about shifts of wind under the head of cyclones:—

Forecasts for the 24 hours ending at Noon on August 26th, 1881.

Districts.	Forecasts.	Districts.	Forecasts.
0. Scotland, N.	South-easterly to easterly or north-easterly winds, light to fresh; becoming overcast gradually and then rainy.	6. Scotland, W.	Same as Nos. 0 to 2.
1. Scotland, E.	Do. do.	7. England, N.W.	Southerly (S.E.-S.W.) winds, freshening; rainy. Wind perhaps shifting northward later on.
2. England, N.E.	Do. do.	8. England, S.W.	South-westerly winds, strong; squally; rainy; unsettled.
3. England, E.	South-westerly and southerly winds, increasing in force and veering again towards W.; much rain; very unsettled.	9. Ireland, N.	Easterly to north-easterly winds, moderate; rainy.
4. Midland Counties.	Do. do.	10. Ireland, S.	Same as No. 8.
5. England, S.	Do. do.	Warnings	South cone is flying in Districts Nos. 5 and 8.

Now, turning to Fig. 56, we see that the cyclone has moved on towards east-north-east, with increased intensity, and that therefore, though on the whole the forecasts were very accurate, the districts lying between the actual and expected path of the cyclone received a forecast, right as regards weather and force of wind but wrong as regards direction and shift of the wind. In the diagram, Fig. 57, the districts which were thus

Fig. 56.

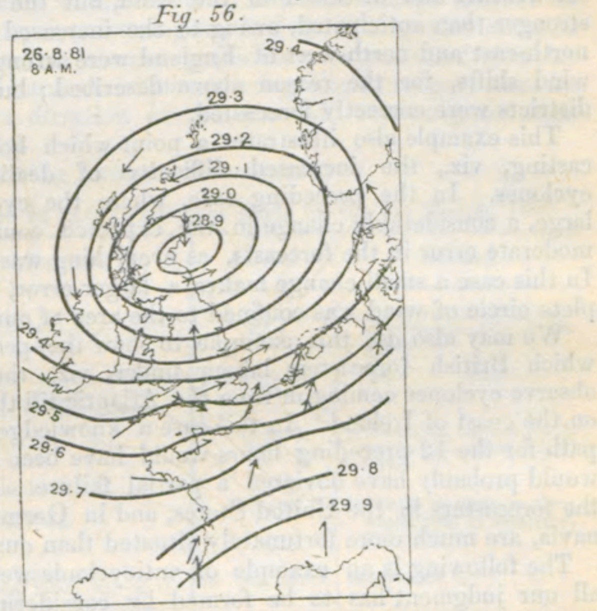


Fig. 57

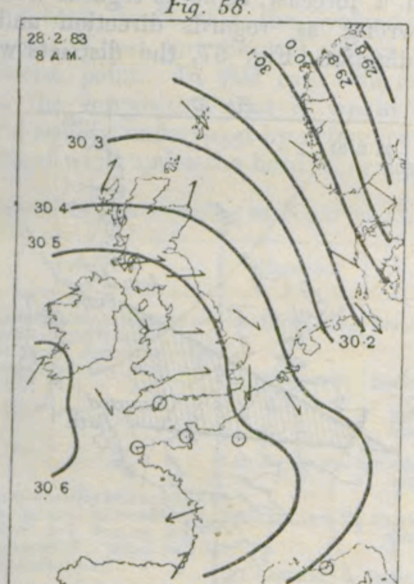
affected are shown by shading. Taking the details of the eleven districts, the north and east of Scotland were correctly warned for weather and direction of the wind, but the wind was much stronger than anticipated, owing to the increased intensity. The north-east and north-west of England were wrong as regards the wind shifts, for the reason above described; but all the other districts were correctly forecasted.

This example also illustrates a point which holds in all forecasting, viz., the increased difficulty of dealing with small cyclones. In the preceding case, where the cyclone was very large, a considerable change in the expected course made only a moderate error in the forecasts, as everything was on a big scale. In this case a small change makes a larger error, because a complete circle of wind was confined to the area of our own islands.

We may also use this example to show the peculiar difficulty which British forecasters labour under, viz., their inability to observe cyclones coming in from the Atlantic till they are actually on the coast of Ireland. In this case a knowledge of the cyclone path for the 12 preceding hours would have been invaluable, and would probably have obviated a partial failure. In this respect the forecasters in the United States, and in Germany or Scandinavia, are much more fortunately situated than ourselves.

The following is an example of anticyclonic weather, in which all our judgment has to be formed by considering the relative position of the districts where the barometer is rising and of those where it is falling. In the Fig. 58, for February 28th, 1883, at 8 a.m

Fig. 58.



we see an anticyclone lying over the greater portion of the United Kingdom, while a cyclone is disappearing over the Baltic. At the same time, while the barometer is rising slowly over Ireland

and the south-west of England, it is falling slowly over the north of Scotland. Thus, on the whole, we may assume that the anticyclone will spread a little eastwards, and that though there is no trace of any new cyclone coming on, still the falling barometer in the north will produce steeper gradients with unsettled weather. The difference of barometric change being slight, no gale need be expected, and the direction of the wind will obviously be from north-west to west.

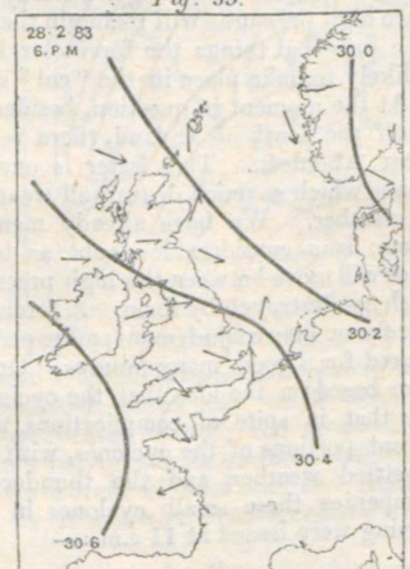
Hence the following forecasts were issued:—

FORECASTS for the 24 hours ending at Noon on the 1st March, 1883.

Districts.	Forecasts.	Districts.	Forecasts.
0. SCOTLAND, N.	Westerly to north-westerly winds, freshening; cloudy; cold showers.	6. SCOTLAND, W.	North-westerly winds, light or moderate; fair on the whole.
1. SCOTLAND, E.	Westerly to north-westerly winds, moderate; fair to unsettled, and showery.	7. ENGLAND, N.W.	Do. do.
2. ENGLAND, N.E.	Do. do.	8. ENGLAND, S.W.	Westerly and north-westerly winds, light; cloudy; local fogs.
3. ENGLAND, E.	Same as No. 5.	9. IRELAND, N.	Westerly or north-westerly winds, light or moderate; dull; misty.
4. MIDLAND COUNTIES.	Same as No. 5.		
5. ENGLAND, S.	Westerly and north-westerly winds, light; fair on the whole, but dull and misty at times.	10. IRELAND, S.	Same as No. 8.
		WARNINGS -	None issued.

Looking at Fig. 59 for 6 p.m. the same day, we see that these indications were successful in every district, for while in the

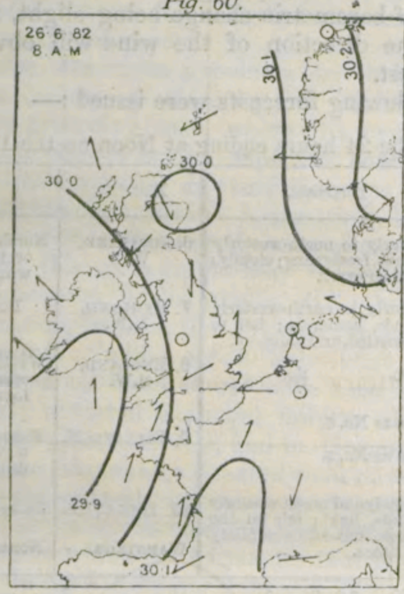
Fig. 59.



north and east the weather is rainy and unsettled, it remains fine in the south and west.

We will now give an example of the difficulties which surround the forecaster when he has to deal with the ill-defined and short-lived depressions which are formed in a "col." In the chart, Fig. 60, for June 26th, 1882, at 8 a.m. the principal feature is the high

Fig. 60.



pressure over Scandinavia, with a projecting wedge over the Pyrenees. From our general knowledge, we may expect that in the main these two high pressures will maintain their same relative positions, and the principal things the forecaster has to consider are the changes likely to take place in the "col" of low pressure between them. At the moment in question, besides an irregularly shaped cyclone off the south of Ireland, there is a small high-level cyclone near Aberdeen. This latter is one of the short-lived small cyclones which so much disturb all weather predictions in this type of weather. We have already mentioned that in similar cases, there is a considerable doubt as to whether the system of cyclones will move between the high pressures, or else be deflected and perhaps destroyed by them. A forecaster is obliged in these cases to rely on his own judgment and experience, but must always be prepared for a good many failures. On this occasion the forecasts were based on the idea that the cyclones would not pass through, so that in spite of complications, we should only experience the front portions of the cyclones, with East or South-east winds, unsettled weather, and the thunder which almost invariably accompanies these small cyclones in summer time. Hence the following were issued at 11 a.m.:—

FORECASTS for the 24 hours ending at Noon on June 27th, 1882.

Districts.	Forecasts.	Districts.	Forecasts.
0. SCOTLAND, N.	Calms or Easterly airs; fair to cloudy, and unsettled.	6. SCOTLAND, W.	Easterly winds, light; fair on the whole.
1. SCOTLAND, E.	Do. do.	7. ENGLAND, N.W.	South-easterly winds, light or moderate; cloudy.
2. ENGLAND, N.E.	Southerly winds, light; cloudy at times and perhaps thunder.	8. ENGLAND, S.W.	Southerly to south-westerly breezes, moderate; cloudy and showery to fair.
3. ENGLAND, E.	Do. do.	9. IRELAND, N.	South-easterly and easterly winds moderate; fair generally.
4. MIDLAND COUNTIES.	Same as No. 5.	10. IRELAND, S.	Do. do.
5. ENGLAND, S.	Variable or southerly breezes, light; cloudy generally, and thunder in some places.	WARNINGS -	None issued.

Turning now to Fig. 61 for 8 a.m. the next morning, the 27th, we see that, contrary to expectation, the two cyclones have

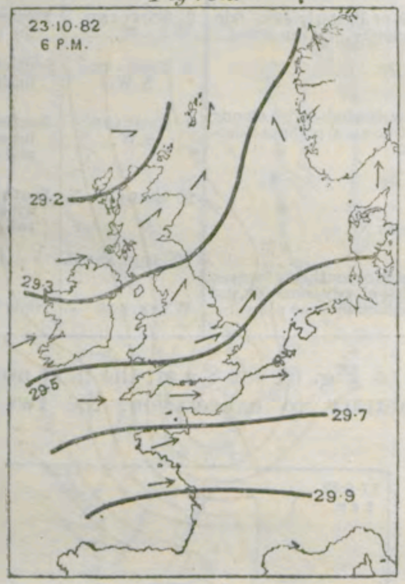
Fig. 61.

coalesced to form a single system, and passed between the two areas of high pressure, so as now to lie with its centre over Denmark. Consequently, though the prognostications for rain and thunder were very generally verified, the shifts of the wind from East to North-west in Scotland, and from South-east by South to West or North-west over England, were not correctly indicated.

Our last illustration will be that of a kind which fortunately rarely occurs, viz., the sudden formation of a cyclone in an unexpected position, which entirely upsets all forecasting. In

Fig. 62 we give a chart for 6 p.m. October 23rd, 1882. In it we see the most familiar features of the Westerly type of weather, and

Fig. 62.



though the barometer was falling over the Bay of Biscay and rising over Scotland, there was no reason to expect that the ordinary sequence of that kind of weather would be disturbed, that is to say, that West and South-west winds, with rather showery weather, would prevail. Accordingly the following forecasts were issued:—

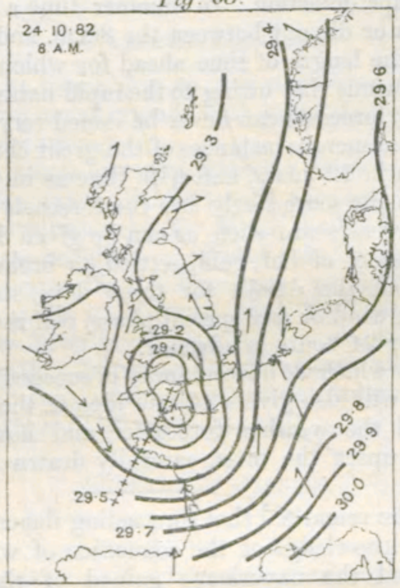
Forecasts of Weather for October 24th, 1882. (Issued at 8.30 p.m. the previous day.)

Districts.	Forecasts.	Districts.	Forecasts.
0. Scotland, N.	South-westerly breezes, fresh or moderate; showery.	6. Scotland, W.	Same as No. 0.
1. Scotland, E.	South-westerly breezes; moderate; some showers, with bright intervals.	7. England, N.W.	Same as No. 0.
2. England, N.E.	Do. do.	8. England, S.W.	South-westerly winds, fresh to strong; showery.
3. England, E.	Same as No. 5.	9. Ireland, N.	Wind returning to south-west, and freshening; weather showery.
4. Midland Counties.	Same as No. 1.	10. Ireland, S.	Do. do.
5. England, S.	Westerly and south-westerly breezes, light to fresh; fine and cold at first, some local showers later.	Warnings -	None issued.

When we come to look, however, at Fig. 63 (p. 93), the chart for 8 a.m. the following morning, we find that a small well-defined

cyclone had formed during the night over the English Channel, which moved during the day towards north-north-east, and thereby produced continuous rain with complete shifts of the wind through

Fig. 63.



180° in many parts of the country, so that the forecasts issued were a complete failure.

It may be well to consider how failures of this sort may be guarded against. The answer undoubtedly is, by taking observations at shorter intervals than 14 hours, as on this occasion. On this particular night a halo—a sure sign that the cyclone had begun to form—was seen near London at 10 p.m.; and it is therefore certain that if the observations could have been taken at 11 p.m. or midnight, such a complete failure might have been avoided.

General Remarks.

We may conclude this portion of the work by a few reflections on forecasting generally.

In the first place, we may remark that the meteorological changes are so rapid that they can only be traced by means of electric telegraph, and that the expense is therefore so great that this problem can only be efficiently handled by a Central Government Office.

Then as to the amount of detail which is possible, it is manifest that in may cases of small disturbances the minor features, such as squalls, thunderstorms, &c., are so local, that even if it were possible to define their range accurately, every few square miles of the United Kingdom would require a separate forecast. Whence we may say that it is only the general character of the weather which can ever be forecast, and that, roughly, the larger the scale of the disturbance, the more likely are the forecasts to be successful. These minor features are also usually short lived, so that the more frequently the observations are taken, the more unlikely is a storm to escape detection. In summer time a small storm may sometimes form or die out between the 8 a.m. and 6 p.m. reports.

Then, as to the length of time ahead for which forecasts can be issued. It is obvious that owing to the rapid nature of all meteorological changes, forecasts can never be issued very long in advance. We have given numerous instances of the great changes which may take place even in 12 hours, and with time as in detail, the larger the disturbance the more likely are the forecasts to be successful. The longest forecasts are such as can be given in general terms, like the continuance of hot, cold, settled, or broken weather for a day or two; but the details for these days, such as the exact strength of the wind or any special phase, can rarely be given for more than 12 or 24 hours in advance.

The examples which we have adduced of successful and unsuccessful predictions will also give a certain idea of the great difficulties which surround the weather forecaster, and how very little will mar or totally upset the most carefully drawn deductions from synoptic charts.

It will also be remarked that forecasting depends on no theory whatever; the knowledge of the connexion of wind and weather with isobars and the experience gained of their changes and motions are entirely the result of observation. The names which we have applied to the different shapes of isobars, such as cyclones, anticyclones, &c., are purely conventional terms to denote the given shape, and have no connexion with any theory of cyclonic motion, or of the circulation of the wind.

It will also be very apparent that the British forecaster labours under peculiar difficulties from his geographical position. Situated on the most outlying portion of Europe, and in the very track of storms which almost always advance from the westward, he has no intimation of an approaching cyclone till it is actually on him. In the United States and in Germany they are more fortunate. For instance Hamburg often receives timely warning from our Office. "In the year 1869, 23 storms were felt in Hamburg, and "of these 22 had previously passed over some part of the United "Kingdom."*

It will also be very evident from the examples we have given that owing to the nature of weather changes, no calculation can be used, and that the average or mean value of any meteorological quantity affords no clue towards estimating the probable change in any existing system. In fact Meteorology is not an exact, but an observational science like Geology or Medicine; and just as however accurately the symptoms or treatment of any malady may be described, the skill to recognise and the judgment to treat must rest on the ability of the physician, so in meteorology, however carefully the relation of weather to isobars may be defined, and the nature of their changes described, the judgment, which experience alone can give, to enable a warning to be issued, must ever depend on the professional skill of the forecaster.

* R. H. Scott, "Weather Charts and Storm Warnings," p. 130.

Present Results.

It will now be interesting to give some idea of the amount of success which at present attends both every day weather forecasts, as well as storm warnings.

The 8 a.m. forecasts are very carefully checked in the Meteorological Office, for every district; each forecast being considered under the separate headings of "Wind" and "Weather," and the amount of success or failure is divided into four degrees, complete success, partial (more than half) success, partial failure, and total failure. In practise it is found that the per-centage of any degree varies but little from year to year, so that the subjoined summary of weather forecasts for the year ending March 31st, 1882, may be taken as a fair sample of the results usually attained by the Meteorological Office:—

Summary of Results.

District.	Per-centages.				Total Per-centage of Success.
	Complete Success.	Partial Success.	Partial Failure.	Total Failure.	
Scotland, N.	39	42	14	5	81
Scotland, E.	35	43	15	7	78
England, N.E.	32	46	17	5	78
England, E.	33	44	17	6	77
Midland Counties	31	46	18	5	77
England, S.	35	46	14	5	81
Scotland, W.	30	44	19	7	74
England, N.W.	32	44	17	7	76
England, S.W.	34	42	18	6	76
Ireland, N.	36	44	14	6	80
Ireland, S.	35	41	16	8	76
Summary	34	44	16	6	78

By this it will be seen that the complete or partial successes amount to 78 per cent., varying from 74 per cent. in the west of Scotland to 81 per cent. in the north of Scotland and south of England. The full details are given in Appendix IV.

Besides the daily forecasts, the Meteorological Office have since 1879 issued special warnings during the time of the hay harvest. By reference to the subjoined table, giving the results for the same year as the last table, it will be seen that the mean result is 76 per cent. of success, but that they vary from 64 to 83 per cent., which is much more than the daily forecasts :—

SUMMARY of RESULTS, 1881-82.

Districts.	Names of Stations.	Percentages.				Total Percentage of Success.
		Complete Success.	Partial Success.	Partial Failure.	Total Failure.	
SCOTLAND, N. - -	Golspie and Drynie - - -	32	40	26	. 2	72
SCOTLAND, E. - -	Glammis and Longniddry - -	21	62	13	4	83
ENGLAND, N.E. -	Morpeth and Ulceby - - -	22	42	31	5	64
ENGLAND, E. - -	Thorpe and Rothamsted - -	35	49	12	4	84
MIDLAND COUNTIES -	Cirencester and Gerrard's Cross -	34	50	16	–	84
ENGLAND, S. - -	Maidstone and Downton - -	33	50	14	3	83
SCOTLAND, W. - -	Drymen, Islay, and Stranraer - -	28	48	20	4	76
ENGLAND, N.W. -	Leyburn and Prescot - - -	28	46	22	4	74
ENGLAND, S.W. -	Bridgend (Glamorgan), Falfield, Clifton, and Glastonbury.	29	43	24	4	72
IRELAND, N. - -	Antrim, Hollymount, and Moynalty -	23	46	26	5	69
IRELAND, S. - -	Moneygall, New Ross, and Ardfert Abbey.	30	44	23	3	74
	Mean for all districts -	92	47	21	3	76

The Report of the Office for the year ending March 31st, 1882, goes on to say, at page 14 :—

"The final result of the checking shows that the general percentage of success for that year (1881) is precisely the same as in 1880, but that the proportion of *completely* successful forecasts, as distinguished from those which are only partially successful, is decidedly smaller than it was in 1880.. This is especially the case in "Scotland, E." and "England, N E." The percentage of success in "Ireland, N." was materially reduced by the very low values attained at Hollymount, co. Mayo, and as the reports of the weather received from that locality are confirmed by the regular weather charts, it appears that for the western part of the district the forecasts were by no means successful.

"The largest percentage of complete success was reached in "England, E.," the Midland Counties, and "England, S."

"In a communication to the Meteorological Office, Mr. J. R. Mitchell, of Drynie, Inverness, stated that the forecasts that year were remarkably correct; and, similarly, Colonel Turbervill, of Bridgend, Glamorganshire, reported that they were so fully

appreciated by the farmers in that neighbourhood, that he determined to continue the telegrams at his own expense at the time of wheat harvest."

The reason of the less satisfactory results obtained during the hay harvest will be readily understood from what has been previously explained relative to the very local character of many of the rains which occur in summer time. These are the rains associated with small secondary depressions, which are always difficult to forecast.

Then, as to the results obtained with Storm Warnings, as distinct from Daily Weather Forecasts. The Report just quoted goes on to say at page 15 :—

"In Appendix II. will be found the names of the stations which are furnished with signals for storm warnings, in accordance with Circular 717 of the Board of Trade, issued in February 1874.

"These stations were, at the end of March 1881, 136 in number, situated :—

"Sixty-eight in England, 13 in Wales, 35 in Scotland, 14 in Ireland, 3 in the Isle of Man, and 3 in the Channel Islands."

The Report further says at page 77 :—

"The testing of the warnings is conducted in the following manner :—The intelligence issued is compared with the weather experienced on the coasts, as indicated by the various self-recording anemometers, by the telegraphic reporters, and by the several gentlemen who have volunteered to observe for the Meteorological Office.

"In order to render the information in the possession of the Office as to the weather experienced on our coasts still more complete, the Meteorological Council make application to the various lighthouse boards, and obtain from them the original log books from some of the most exposed lightships and lighthouses.

"The coasts are sub-divided into nine districts, as will be seen in the table. Two large tracts of coast are entirely omitted, the west of Ireland from the Shannon to Malin Head, and the west of Scotland from the Mull of Cantyre to Cape Wrath. No warnings are issued to any place within the limits indicated, except to Galway, and the amount of information as to the weather received from the omitted tracts of coast is, as yet, very scanty.

"It should be remembered that in analysing the reports, all observations of the wind in which the force *exceeded* 7 (a "moderate gale") or the velocity exceeded 40 miles an hour, have been quoted as instances of the occurrence of a gale ; but it has not been considered that the signal was hoisted late or was hauled down too soon, unless the force of 9 (a "strong gale") or the velocity of 50 miles an hour, was reached prior to the issue of the order to hoist, or subsequent to the issue of the order to lower.

"In the summaries all cases in which the signal has been shown to be late by a single report either of force 9, or of a velocity of 50 miles an hour, have been specially noted."

The results of the comparison for the year 1880 are shown in the following tables :—

RETURN of the RESULT of the COMPARISON between the WARNINGS issued and the WEATHER experienced in 1880.

Coasts.	Total No. of Orders to hoist and repetitions.	Warnings justified by subsequent Gales, Force 8 and upwards.	Warnings justified by subsequent strong Winds, Forces 6 and 7.	Warnings not justified by subsequent Weather.	Warnings late, Force 9 reached at two Stations before issue.	Warnings partially late, Force 9 reached at one Station before issue.	Warnings in Error owing to Telegraphic mistakes.	Storms for which no Warning was issued.
IRELAND, S. -	48	30	11	6	—	1	—	Jan. 1, Jan. 30, May 26, Aug. 7.
IRELAND, E. -	46	20	18	7	—	1	—	Feb. 29.
SCOTLAND, E. -	38	24	7	4	1	2	—	Jan. 1, Jan. 2, Jan. 30, March 1, May 26, Oct. 31, Dec. 10, Dec. 23 p.
SCOTLAND, W. -	37	19	11	6	—	1	—	March 1, May 26, Dec. 10.
ENGLAND, N.W. -	36	20	3	8	1	4	—	March 1, Nov. 14, Dec. 24 p.
ENGLAND, W. -	51	26	17	8	—	—	—	Nov. 23.
ENGLAND, S. -	61	38	16	4	1	2	—	Feb. 7*, Feb. 18, March 2, Sept. 18, Nov. 25, Dec. 29.
ENGLAND, S.E. -	26	10	6	3	—	—	—	—
ENGLAND, E. -	47	33	7	6	—	1	—	Jan. 2†, March 1†, Dec. 8†.
Totals - -	390	227	96	52	3	12	—	
Per-centages -		58·2	24·6	13·3	0·8	3·1	—	

* Storms on the S. Coast marked thus were only felt at the entrance to the Channel.
† Storms on the E. Coast marked thus were only felt on the north-east coast of England.

The following table contains a comparative statement of the storm warnings and the results in 1880 and in the 10 preceding years :—

Years.	Total No. of Warnings issued.	Warnings justified by subsequent Gales.	Warnings justified by subsequent strong Winds.	Total Warnings justified.	Warnings not justified by subsequent Weather.
1870	349	46·7	21·7	68·4	22·4
1871	299	46	17·7	63·7	22·0
1872	379	61	19·5	80·5	11·9
1873	250	45·2	34·0	79·2	16·8
1874	317	45·4	32·8	78·2	16·4
1875	248	41·1	35·1	76·2	21·0
1876	265	61·1	21·5	82·6	11·7
1877	475	53·3	25·9	79·2	16·4
1878	485	56·7	20·8	77·5	17·9
1879	509	50·5	25·1	75·6	20·6
1880	390	58·2	24·6	82·8	13·3

The great jump in the number of successful warnings in the year 1872 is due to the commencement of observations and warnings at 6 p.m. in addition to those at 8 a.m. This was first

initiated by the desire of and at the expense of the "Times" newspaper.

In Appendix III. will be found opinions respecting the value of Storm Warnings.

FUTURE PROSPECTS.

Having already detailed the present condition of weather forecasting, as far as regards the percentages of successes, we shall now devote a few paragraphs to the consideration of what prospect there is of increasing the number of successful predictions. To do so we shall briefly sketch several lines of research which promise useful results, but which have not yet been sufficiently investigated to enable us to form a definite opinion of their value.

We have already shown how often we are dependent on a knowledge of the difference of rate at which the barometer is rising or falling in different districts. At present we take the differences between the present readings and that at the preceding report; that is, at an interval of 12 or 14 hours. There is no doubt that during such a long interval many minor changes may escape detection, and that if we could have the barometric difference for a shorter period, we should be in a better position to consider its import.

Moreover, we have seen that the barometer may rise or fall from a variety of different causes, and when we look at any barogram we find that the curves of rise or fall differ very much in small details, and it seems more than probable that some day we may be able to derive far more information from barograms than we do at present.

Again, though we have shown that Great Britain is at a great disadvantage as regards some other countries in respect to tracing cyclones before they arrive at our coasts, still there seems to be a great field of research open in the study of the relation of the pressure to leeward of an advancing cyclone to its future path. The most casual inspection of the charts which have already been given will show that when a cyclone is once formed its path is far more controlled by the pressure which lies in front of it, than by any other consideration. The study of these relations, therefore, specially concerns British meteorologists, and we are firmly convinced that much progress is possible in that direction.

The importance of the four great types of weather which have been described has been previously pointed out, but it is extremely probable that further research may prove the existence of sub-types which will remove many difficulties which are at present apparent, by showing real differences to exist where now we only see uncertainty.

We have already alluded to the advantage to be obtained by the receipt of reports at shorter intervals than 12 hours, and though the difficulties and expense, both of sending up the observations and distributing the information derived from them, are at present great obstacles there is no doubt that when they can be overcome, great improvement will result from more frequent observations.

We have also pointed out the assistance which may sometimes be derived from the use of popular prognostics in conjunction with synoptic charts, and also from the observation, not only of the appearance, but also of the motion of cirrus clouds in upper currents. So far, however, the principal use of observations on cirrus is to increase our knowledge of the mechanism of a cyclone, that is, to show the nature of the complex circulation which makes up that kind of depression. But there is another view which is supported by some evidence. In thunderstorms we often find a very complete circulation of wind under an upper current which remains constant throughout the storm, and in almost every case the storm moves in the direction of this upper current. Now, it has been suggested, that in the case of ordinary cyclones, the circulation is confined to the lower strata only, and that there is an upper current which gives the drift of the cyclone as a whole. Even if this is the case, however, it is quite certain that such an elevated current can rarely be observed, and of course the term "upper current" is a very vague one, and really means clouds at almost any height above the surface.

Allied to cirrus observations are records derived from high-level stations. Like cirrus, their greatest value is in giving the mechanism of atmospheric circulation, and in some respects they are not so valuable as cirrus. It is obvious that when a surface wind meets an obstacle, such as a mountain, a portion of the current must be deflected upwards, and that the wind and moisture which we measure on the top of the hill by no means represent the condition of the atmosphere as it would be over an undisturbed level surface.

It is evident, therefore, that even within sight, there are many lines of research which will probably improve our power of weather forecasting, and as the history of all science points to the fact that research always leads to greater results than were expected, we are fully justified in the belief that within ten or twenty years the proportion of successful forecasts will be considerably increased.

CHAPTER VI.

STORM WARNINGS.

So far we have explained both what weather is, and the principles on which it can be forecast; we shall now conclude with a detail of the machinery practically used by the Meteorological Office in the issue of forecasts and storm warnings for our coasts. A map showing the Reporting Stations and the eleven Forecasting Districts, for January 1, 1885, forms the Frontispiece (Fig. 1).

The operations connected with the preparation and issue of the Daily Weather Report, Forecasts, and Storm Warnings are described as follows. Report for the year ending March 31st, 1882, Appendix VIII.:—

"The Office receives, when the telegraphic communications are perfect, 53 reports every morning, 13 every afternoon (except on Sundays), and 19 each evening. The interruptions which occur during the winter in the communication with Sumburgh Head and Stornoway are of a serious description, both cables being sometimes broken for several months. The suspension of the afternoon reports on Sundays is due to the fact that almost all the telegraphic circuits are closed at the hours at which the messages would be transmitted.

"The foreign reporting stations, 23 in number, extend along the entire western coast of the Continent, from Christiansund in lat. 63° N. to Corunna in lat. 43° N., and include four stations on the coast of the Baltic, and one in the Mediterranean. The information is received in accordance with various arrangements made with the meteorological organisations in France, Holland, Germany, Denmark, Norway, and Sweden.

"At the British stations the morning observations are taken at 8 a.m. Greenwich time, and most of the telegrams arrive in London at about 9 o'clock, when the Intelligence Department of the Post Office extracts from them the portions required for its wind and weather reports. They are then transmitted to the Meteorological Office by its private wire, where the majority of them usually arrive between 9 a.m. and 10 a.m.

"As fast as the reports come in the information is entered on a chart, which shows for each station at 8 a.m. the barometrical and thermometrical readings, with their respective alterations during the preceding 24 hours, the direction and force of the wind, and the state of the weather, together with any changes of importance which may have been noticed in the course of the preceding day. From this chart, which is preserved in the Office, other charts are then drawn for publication in the newspapers, as described further on.

"If necessary, telegraphic intelligence of storms or of atmospherical disturbance is immediately sent to our own coasts and to foreign countries. A brief telegraphic *resumé* of the weather is despatched shortly after 11 a.m. to the harbour authorities in Jersey and also to the Marine Ministry in Paris, by which Department it is afterwards transmitted to Florence for the benefit of the Italian Naval Service. Another telegraphic message of about 75 words is sent to the Underwriters' Association, Liverpool, containing reports of the pressure, wind and weather at 14 stations on the coasts of the British Islands; and a third message of about the same length is forwarded to the Central News for despatch to the provinces. The last of these messages consists of a brief statement of the general condition of the weather in Western Europe, as shown by the reports for the morning.

"It is, however, not only at 11 a.m. that storm warnings are issued to the coasts, for a constant watch is kept during the day, and whenever on the receipt of the regular or of special telegrams the condition of the weather appears to be threatening, cautionary messages are at once issued to such parts of the coast as are thought to be menaced by a gale.

"During the year 1881 there were prepared, each morning, afternoon, and evening, forecasts of the weather, for one day in advance; these were drawn up for 11 districts in the British Islands, and issued to subscribers, to certain Clubs, and to many of the London and Provincial newspapers.

"The districts for which the forecasts were prepared were those into which the returns for the Weekly Weather Report are divided, with the addition of Scotland, N., viz.:—

0. Scotland, N.
1. " E.
2. England, N.E.
3. " E.
4. Midland Counties.
5. England, S.
6. Scotland, W.
7. England, N.W. (with N. Wales).
8. England, S.W. (with S. Wales).
9. Ireland, N.
10. " S.

"The demand for these forecasts is still considerable, and efforts are being made to increase their accuracy. At the commencement of 1881, however, some changes were made with regard to the issue of those drawn up in the afternoon and evening, to which reference is made further on.

"About an hour and a quarter is occupied in the preparation and transmission of the provincial and foreign telegrams, and in the drawing up of the 'Remarks' and 11 a.m. forecasts for the London newspapers, so that the MS. copies for the 'Times' and other papers are ready for issue soon after 11 a.m.

"The 8 a.m. charts are sent out at about 10.15 a.m. and the 6 p.m. chart at about 8.30 p.m.

"The draft of the Daily Weather Report, with two charts attached, is drawn on transfer paper, which is ready by noon, when it is at once sent to the lithographer to be printed. The copies for delivery by hand in London are issued by the lithographer at about 1.30 p.m., while the remainder are received at the Meteorological Office at about 3.30 p.m., whence they are transmitted by post to the subscribers and others.

"In addition to the charts referred to above, the Patent Type-founding Company are supplied with various diagrams showing the changes in pressure, temperature, rainfall, wind, and weather for the London district. These are engraved *daily* for the 'Daily Chronicle,' *weekly* for the 'Observer,' 'Graphic,' 'Lloyd's Weekly London Newspaper,' and the 'Agricultural Gazette,' and *monthly* for the 'Miller.' They are all accompanied by remarks on the phenomena exhibited.

"At about 3 p.m. the observations taken at 11 home stations at 2 p.m. are received, and those for two foreign stations (Skudesnaes and Rochefort) come in afterwards. Copies of these reports are issued, together with the 8 a.m. report, to certain newspapers and subscribers. Two copies of the "Remarks" (8 a.m. and 2 p.m.) are sent to the Type-founding Company for issue to provincial newspapers for publication, in order to explain the 8 a.m. charts.

"At 7 to 7.30 p.m. the nineteen evening (6 p.m.) reports arrive and are charted and discussed for the morning daily papers. The forecast and remarks are usually ready by 8.30 p.m., but in bad weather, owing to the delay of the reports and the additional care which is necessary in dealing with them, it is frequently 9 p.m. before they are issued. The 'Times' publishes the daily map showing the distribution of pressure, the winds, temperature, and rainfall at 6 p.m., the importance of which can hardly be over-estimated.

"It will be seen that the official charts for 2 p.m. and for 6 p.m. are still much less complete than that for 8 a.m. That for 2 p.m. is drawn on the information received from 11 home stations, supplemented by two foreign ones, whenever the latter arrive in time to be used. The material for the 6 p.m. charts is supplied by reports from 15 stations in the United Kingdom, supplemented by four from continental stations, but the latter frequently arrive late at the very time when they are most wanted, *i.e.*, during bad weather.

"The Sunday duty is conducted as follows:—Two of the clerks attend on Sunday morning at the Central Telegraph Station from 8.30 a.m. to about 10.15 a.m. By an arrangement with the Post Office these clerks are supplied with the telegrams immediately they arrive in London. They are examined and charted, with the view of issuing, when necessary, warnings of coming storms, to our own and neighbouring coasts. It is necessary that promptitude should be observed in this service, as the observations must be dealt with and the warnings issued so that the latter may reach the coast before the telegraph offices close for the day, which is usually at about 10 a.m. No work of any kind is transacted for the newspapers on Sunday mornings, the main object of the service being to give prompt information of storms to our coasts; but a telegram is sent to Paris and Jersey in the same way as on week days, and there is the ordinary interchange of messages with foreign countries. At 6 p.m. the same clerks attend at the Meteorological Office to receive the evening reports and to prepare the 8.30 p.m. forecasts, and another opportunity is thus offered for the correction or extension of any warnings which may have been issued in the morning."

The details of signalling storm warnings after they have been received by the local authorities are described in the following circular:—

"TELEGRAPHIC WEATHER INTELLIGENCE.

"The Meteorological Office issues (free of charge) to ports and fishing stations approved of by the Board of Trade, notices of atmospherical disturbances on or near the coasts of the British Islands.

Signals.

"The fact that such a notice has been received at any station is made known by a signal, which is hoisted on the receipt of the

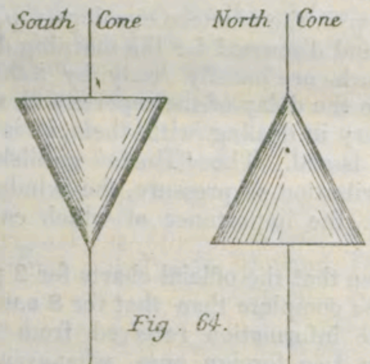


Fig. 64.

message, and remains hoisted, but only during the day-time, for the space of 48 hours and no longer, counted from the time the message is sent out.

"The signals are made by means of two canvas shapes, a cone and a drum.* *See* Fig. 64.

"The cone is 3 feet high and 3 feet wide at base, and appears as a triangle when hoisted.

"The drum (or cylinder) is 3 feet high and 3 feet wide, and appears as a square when hoisted.

Southerly Gales.

"The cone *point downwards* means that strong winds are probable, from the Southward or Westward (from S.E. round by S. to N.W.).

Northerly Gales.

"The cone *point upwards* means that strong winds are probable from the Northward or Eastward (from N.W. round by N. to S.E.).

Very heavy Gales.

"The drum will be hoisted with the cone whenever the Office has reason to think that a very heavy gale, either southerly or northerly, as the case may be, is coming on.*

Shifts of Wind.

"It must be remembered that a Southerly wind is much more likely to change its direction, veering to a point North of West, than a Northerly or Easterly wind is likely to shift.

"Accordingly, when the south cone is hoisted and the anchorage or harbour is exposed to the north-west, it is advisable to make preparations for a North-west gale in case of the wind shifting to that point from South or South-west.

On Hoisting the Signals.

"The signal is to be kept flying until dusk, and then lowered, and hoisted again the next morning; and so on until the end of 48 hours from the time the message has been issued from London (which is always marked on the telegram), unless orders are received previously to lower the signal.

"At dusk, whenever a signal ought to be flying if it were daylight, a night signal may be hoisted in place of the cone, consisting of three lanterns hung on a triangular frame (Fig. 65, p. 106), point downwards, or point upwards, as the case may be. It is not considered necessary to hoist lanterns to represent the drum. They should be kept burning until late in the evening, say 9 or 10 o'clock.

"These signals may be made with any lanterns, showing white or any colour, but *alike*. Red is best. Lamps are better than candles. The haulyards should be good rope, and protected from chafing. The lanterns should hang at least 3 feet apart.

Meaning of Signal.

"The hoisting of any of these signals is intended as a sign that there is an atmospherical disturbance in existence which will *probably* cause a gale from the quarter indicated by the signal used, in the neighbourhood (say, within a distance of 50 miles) of the place where the signal is hoisted, and the knowledge of which is likely to be of use to the sailors and fishermen on that part of the coast. Its meaning is simply, 'Look out! It is probable 'that bad weather of such and such a character is approaching 'you.'

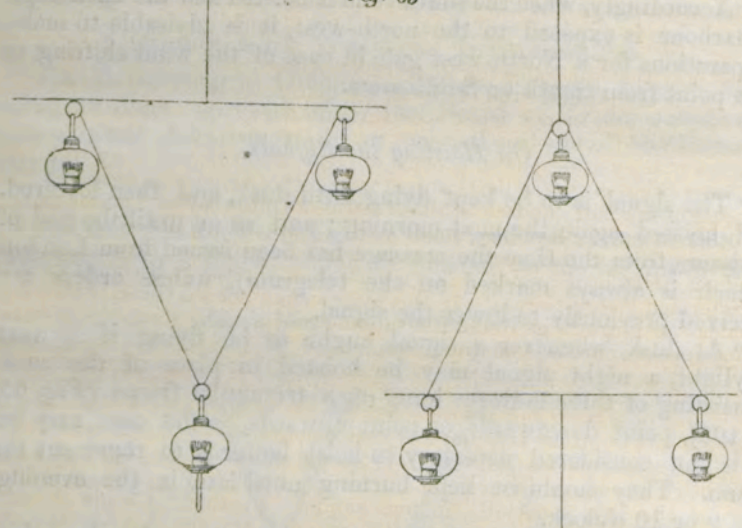
"Hitherto it has been found that at least *three* out of *five* signals of approaching storms (Force upwards of 8 Beaufort scale, a 'Fresh Gale'), and *four* out of *five* signals of approaching strong winds (Force upwards of 6 Beaufort scale, a 'Strong Breeze'), have been fully justified.

* The use of this is at present suspended.

"In every case some of the principal reasons which have led to the hoisting of the signal are explained in the telegram, *which should be always kept posted up for public inspection while the signal is flying.*

"It must be remembered that only the greater and more general disturbances of the atmosphere can be made known by this method. Local changes of less extent may be indicated to observers by their own instruments and by local signs of weather. &c.

Fig. 65



"A regular study of the Daily Weather Report will be found very useful, as showing what weather has lately been prevalent generally.

"The signal will sometimes be kept flying after the gale is over; this is the case because often one gale is followed by another before the 48 hours are out. In every case when it is thought at the Meteorological Office that immediate danger is over, orders are issued to lower the signal at once."

APPENDICES.

APPENDIX I.

Provisional Instructions in making Observations of the Upper Clouds.*

(December 1882.)

The attention of the observer is especially directed to clouds of the "cirrus" type, inclusive of what are here defined as *true cirrus, sheet-cirrus, high cirro-cumulus,* and *cirrus-haze*; and it is to these types of clouds only that the following instructions refer.

Cirrus is the highest kind of cloud. When in moderate quantities it is commonly white, though when seen through haze it is usually somewhat cream-coloured, and when the sun's rays have reached it through a long stratum of hazy atmosphere, is often of either an orange or rosy tint In all cases it has a very delicate appearance. It is sometimes arranged like bunches of fine hair; and such tufts of cirrus are often called "mares-tails." At other times it resembles small curled feathers. Quite as commonly, however, it lies in thin, light, strands, like pale gossamer threads.

When cirrus overspreads a large portion of the sky it becomes what is here termed "*sheet-cirrus.*" In this state, when not too thick, it produces "halos" or large rings round the sun and moon. The sheet-cirrus sometimes appears fibrous, sometimes reticulated.

When the veil of this cloud becomes thick it assumes some neutral or muddy tint, except in those cases when it is so disposed that the rays of the rising or setting sun are reflected to us from its under surface, which then appears of either an orange or rosy colour.

"*High cirro-cumulus*" differs from simple cirrus in consisting of small detached masses somewhat rounded in form, a great flotilla of which is often seen in the sky, especially in fine summer weather. Clouds at lower levels are frequently disposed in this manner, but the observer must be very careful to distinguish from these the high cirro-cumulus, which latter is either white, or changes its colour under the same circumstances as simple cirrus, no part of each cloudlet ever seeming to be decidedly *thrown into shadow* by another part. The *high cirro-cumulus* also possesses the same faintness and delicacy of outline which we observe in cirrus.

Sometimes, however, cirrus is only visible as either a milky or an oily-looking haze, which is here termed "*cirrus-haze.*"

I.

Amount.—Whenever on looking round the sky the observer notices clouds of the kind above described, he should in the first place endeavour to ascertain their *amount.* In doing this he should observe whether they cover, first, only a trifling portion; secondly, about a quarter; thirdly, about a half; fourthly, about three-quarters; or finally, the whole of the sky. The *extent*, not the *density*, of the cloud, should be here attended to. If there be any considerable quantity of lower cloud in the sky, the amount of upper cloud cannot be accurately ascertained, and the figure "9" should be telegraphed as the amount.

II.

Direction of Movement.—The next thing to be attended to is the direction from which the upper clouds move. Considerable difficulty will here be encountered. If some of the clouds happen to be nearly overhead, attention should at first be confined to such; and if possible the observer should so place himself as to have the projecting corner of a roof or chimney, the summit of a steeple, flagstaff, or other stationary object,

* Drawn up by the Rev. C. W. Ley.

very close to the line between his eye and the portion of cloud which he is about to watch.

A convenient plan* is to set up a pole reaching 5 feet 7½ inches above the level of the observer's eye; a mark or ring should be placed round the pole at the latter level. The summit of the pole must carry two thin rods, fixed crosswise, and set truly to the four cardinal points. Through or near the extremities of these rods should pass a thin circular iron ring of 3 feet diameter, the use of which will be mentioned presently. The observer should, when opportunity offers, so station himself that some recognisable part of a cloud appears to move vertically either upwards from the top of the pole, or vertically downwards towards it. The direction of the pole from the observer's position, which may be judged of by the cross-rods, is then, in the first case, the direction of the upper current, in the second, its opposite. In watching the movements of the clouds, the observer may conveniently use a staff, one end of which is sharpened so as to stick in the ground, while the other is fitted with a crescent-shaped top in which to rest the arm, in order to support and steady the head. If the clouds be observed from a window it is some assistance to have a few wires,—some horizontal, others vertical,—fastened across the window to the wall on the outside.

When, however, no part of the cloud is moving directly either towards or away from the observer, the effects of the perspective render it difficult to estimate the direction of movement exactly. To perfect oneself in the art, it is advisable as often as possible to endeavour to estimate the direction of movement of some portion of cloud which is inconveniently placed, and then to find the actual direction of movement of another portion of the same cloud, or same sort of cloud, which happens at the time to be conveniently placed. By patiently practising the eye in this process, the observer eventually learns to make, automatically, tolerably exact allowance for the errors arising from perspective. In no case (should he have the least doubt as to the direction of movement) must any conjecture be telegraphed, but the figure for "motion doubtful" should be inserted in the telegram.

It is always well, when observing the movements of the upper clouds, either to rest the head against a wall or tree, or to support it on a staff, or by some other means, so as to be quite motionless while taking an observation.

III.

Apparent Velocity.—The next particular to be attended to is the *apparent velocity of motion* in the clouds, *i.e.*, the force of the current which carries them. The observer is requested to notice whether the cloud be actually motionless, or whether its motion is *very slight, moderate,* or *rapid.* Clouds of the cirrus type are seldom really motionless, but owing to their great distance they commonly, though not always, appear to move more slowly than the lower clouds. To estimate, even according to the very rough scale proposed, the apparent velocity of movements we have to encounter precisely the same difficulties which have presented themselves in finding the direction, and the training of the eye requisite for deciding this is identical. A cloud which is near the horizon of course presents much less movement to the eye than one which is near the zenith, because it is at a much greater distance; and further, the *apparent* movement of clouds which are travelling either across, or more or less obliquely to, the line of sight, is different from that of clouds which are travelling directly to or from the zenith. To test the accuracy of his estimate of the apparent velocity of clouds moving crossways and obliquely, the observer should, when occasion offers, compare it with his estimation of the apparent velocity of clouds in the same stratum passing overhead at the time. To test the accuracy of his latter estimation he will do well occasionally to notice how many seconds of time a recognisable portion of upper cloud takes in travelling 15 degrees on the sky, to or from the zenith. The pole arrangement already described can be employed for this purpose. In the last case a recognisable portion of cloud must be first caught in the

* Other plans for effecting this object are under the consideration of the Council.

zenith, the observer looking up the pole, applying his eye as closely as he can to the ring or mark above mentioned. He shouuld then note the time, and again at the moment when the selected portion of cloud, as viewed from this spot, reaches the circular wire. The time taken by the clouds in passing over this distance from the zenith, which is (approximately) 15 degrees, should be then noted. When clouds of the cirrus type take a longer time than 600 seconds (or 10 minutes) in traversing 15 degrees to or from the zenith, their motion should be regarded as "very slight." When a less time than this, but a longer time than 300 seconds, or five minutes, as "moderate," and lastly, whenever they take a less time than 60 seconds, as "rapid."

It may be mentioned that in simply looking at the sky without the aid of any appliance, inexperienced observers commonly estimate the position of the zenith wrongly, because they do not throw the head far enough back.

IV.

"*R.-point.*"—Clouds of the cirrus kind very commonly lie in streaks, lines, or bands. Attention must next be given to the direction of these lines, *i.e.*, their *position* with respect to the points of the compass *altogether irrespective of the motion of the clouds.* When one of these bands happens to pass through the zenith, the point at which it reaches, or, if continued, would reach, the horizon, is to be noted. This point is called, for convenience sake, the *R.-point,** or "point of radiation," because the cirrus bands, while really parallel, appear in perspective to radiate from this point, or rather from one beyond it, and beneath the horizon. It is, however, comparatively seldom that a cirrus band happens to lie immediately over the observer's head; the bands usually appearing in perspective as arches, or portions of arches, lying in any part of the sky, and variously inclined to the horizon, according to their distance from the observer. It is easy in these cases to find the R.-point, if we imagine ourselves able to travel over the earth's surface so as to get immediately under one of these bands. The best plan, however, is to note, first, the point on the horizon which lies beneath the summit of any visible complete arch of cirrus. If there be no complete arch, but only a short thread visible, the observer should extend his arm so as to point with the forefinger towards this thread, and then pass the arm briskly two or three times backwards and forwards from one part of the horizon to another, continuing as closely as he can the curve of the cirrus thread. The point on the horizon which is immediately beneath the highest part of the curve so formed should then be noted, and in every case the R.-point will be a point at right angles to this point on the horizon.

It is obvious that there must always be two R.-points opposite to each other. Although it is in itself immaterial upon which of these the observer fixes, he is requested as a matter of convenience, when he has already found a point from which the upper clouds *move*, to report the R.-point which is nearest to that direction, if one of the two be nearer than the other. For example, if cir. travels from W.N.W. and lies in strands which are disposed lengthwise N.W. and S.E., the R.-point N.W. should be reported in preference to the R.-point S.E.

The "selvedge" or margin of a sheet of cirrus gives the R.-point in the same way as a streak of detached cirrus. And when sheet-cirrus or cirrus haze completely covers the sky, a warp may frequently be seen in it which supplies the same datum.

Small cross rays or tangled threads may very often be noticed, frequently transverse or nearly so to the cirrus bands. These are especially discernible in some varieties of sheet cirrus, when they form what we may call the "woof" of the cloud sheet, and give to the latter the reticulated appearance already mentioned. No notice of these threads is required in the telegrams. In rather common cases, however, the cross threads are so marked that it is impossible to decide whether a particular

* This is now usually called the V.-point, because it is the vanishing point of the perspective view of the cirrus stripes.

point of the compass, or one at about right angles to it, is rightly to be regarded as the R.-point. In such instances the observer should telegraph the number 99, for "Radiating point uncertain."

V.

Lastly, whenever a bank of cloud of this type appears on any horizon, or whenever being overhead, or nearly so, such a bank appears thicker in one part of the sky than in the other parts, the observer is to report the position of bank (*i.e.*, the direction in which the bank lies or in which it is thickest) and its density. The direction will not *necessarily* be at right angles to the R.-point, though it most commonly is so.

Instructions on Telegraphing to the Meteorological Office Observations of Clouds of the Cirrus Type.

In telegraphing to the Meteorological Office information as to the appearance, quantity, and motion of cirrus clouds the following rules should be observed:—

1. Not more than one telegram should be sent on any one day, unless the alterations in the motion of the cirrus (either in direction or velocity) are of a very unusual character; but if thought desirable, more minute details than can be given in the 20 words of a telegram may be sent on a post card by next post.

2. The telegram should contain, as the *address "from,"* merely the name of the observer and locality in which the observation is made; and in the address *"to"* the words "Met. Office, London."

3. In the body of the message insert—

Firstly, the time of observation.

Secondly, the precise form of cloud seen, the observer using at his discretion the terms "feathery," "thin," "thready," "hair," "very lofty," &c. as required, and distinguishing carefully (as directed further on) between *true cirrus*, "*sheet-cirrus*," the highest forms of *cirro-cumulus*, and *cirrus haze*. It is also desirable to say whether the cloud is (*a*.) in detached patches; (*b*.) in a mass (or bank); or (*c*.) spread tolerably uniformly over the sky.

Thirdly, the *amount* of cirrus, *not* its density.

Fourthly, the direction whence it is moving, and, as nearly as practicable, its rate of motion.

Fifthly, the point of the compass whence the clouds radiate (hereinafter called the "R.-point".)

Sixthly, the bearing of the centre and the density of the bank of cirrus, if there be a bank at all; and

Lastly, the direction and force of the surface wind and the weather prevailing at the time of observation.

These details are to be transmitted by a telegraphic code to be explained further on.

There is no fixed hour for taking the observations, but it will be useless to *transmit* a message before 8 a.m. or later than 7 p.m. It is, however, very desirable that the reports should be despatched so as to reach London about 10 a.m., 3 p.m., or 7 p.m.

Code.

The observations and clouds of the cirrus type should be telegraphed to London by means of a code, consisting of three groups, each containing five figures. In comparing them the following scales will be used:—

SCALE A.

Form of Cloud.

1 = True cirrus.
2 = Sheet cirrus.
3 = High cirro-cumulus.
4 = Cirrus haze.

SCALE B.

Amount of Cloud.

0 = Very slight indeed.
1 = $\frac{1}{4}$ of sky covered.
2 = $\frac{1}{2}$ do. do.
3 = $\frac{3}{4}$ do. do.
4 = All do. do.
9 = Amount doubtful.

SCALE C.

True Bearings, for Direction of Motion of the Clouds, Wind, &c.

00 = Zero (Calm).	10 = E.S.E.	18 = S.S.W.	26 = W.N.W.
02 = N.N.E.	12 = S.E.	20 = S.W.	28 = N.W.
04 = N.E.	14 = S.S.E.	22 = W.S.W.	30 = N.N.W.
06 = E.N.E.	16 = South.	24 = West.	32 = North.
08 = East.			99 = Doubtful.

SCALE D.

Velocity of Motion of Clouds of the Cirrus Type.

0 = Motionless.
1 = Very slight motion.
2 = Moderate "
3 = Rapid "
9 = Doubtful.

SCALE E.

(Beaufort's Scale.)

For Force of Wind.

Force.		
00. Calm.		
01. Light air -	Or, just sufficient to give steerage way.	
02. Light breeze -	Or, that in which a well-conditioned man-of-war, with all sail set, and clean full, would go in smooth water from - - -	1 to 2 knots.
03. Gentle breeze -		3 to 4 knots.
04. Moderate breeze		5 to 6 knots.
05. Fresh breeze -	Or, that to which she could just carry in chase, full and by -	Royals, &c.
06. Strong breeze -		Single-reefed topsails and topgallant sails.
07. Moderate gale		Double-reefed topsails, jib, &c.
08. Fresh gale -		Triple reefed topsails, &c.
09. Strong gale -		Close-reefed topsails, and courses
10. Whole gale -	Or, that with which she could scarcely bear close-reefed main-topsail and reefed foresail.	
11. Storm - -	Or, that which would reduce her to storm-stay sails.	
12. Hurricane -	Or, that which no canvas could withstand.	

SCALE F.

For Density of Cirrus Bank, when visible.

0 = Very thin and ill-defined.
1 = Thin, but definitely formed.
2 = Rather heavy.
3 = Heavy.
4 = Very heavy and angry.
9 = Doubtful.

SCALE G.

For Weather.

0 = Sky clear.
1 = $\frac{1}{4}$ covered with clouds of all kinds (*i.e.* upper and lower).
2 = $\frac{1}{2}$ " " "
3 = $\frac{3}{4}$ " " "
4 = Entirely " " "
5 = Raining.
6 = Snow falling.
7 = Hazy.
8 = Foggy.
9 = Thunder.

The following are a few examples of messages, wish explanations as to their meanings :—

EXAMPLE 1.

Two p.m. 1 1 28 2 26 22 0 20 06 7

1	Form of cloud (see Scale A. above).
1	Amount of cloud (Scale B.).
28	Direction whence moving (Scale C.).
2	Velocity of motion (Scale D.).
26	Direction of "R.-point" (Scale C.).
22	Direction of centre of bank (Scale C.).
0	Density of bank (Scale F.).
20	Direction of wind at earth's surface (Scale C.).
06	Force of wind (Scale E.).
7	Weather at time of observation (Scale G.).

Meaning of above :—At 2 p.m. True cirrus covering about a quarter of the sky, moving with moderate velocity from N.W. The cloud radiating from W.N.W., and lying in a thin bank whose centre bears W.S.W. (true) from station. Wind at surface S.W. strong, weather hazy.

EXAMPLE 2.

Noon 29241 99992 18033

Meaning of above :—Noon. Sheet cirrus, amount doubtful, movement very slight from West. R.-point doubtful. Bearing of centre of bank doubtful, but portion visible, rather dense. Wind at time of observation S.S.W., gentle breeze; sky three fourths covered with lower forms of cloud.

EXAMPLE 3.

Noon 30000 06000 04010

Meaning :—Very small quantity of high cirro-cumulus, motionless, radiating from E.N.E., no bank. Wind at surface N.E., light airs, no lower cloud.

APPENDIX II.

NAMES OF STATIONS WHICH ARE SUPPLIED WITH STORM WARNINGS.

The following stations are supplied with telegraphic information of storms free of expense, and signal "cones" have been furnished to most of them, all further expenses attendant on the maintainance and repair of the apparatus being borne locally. The stations are situated, 83 in England and Wales, 37 in Scotland, 14 in Ireland, 3 in the Isle of Man, and 3 in the Channel Islands.

NORTH.	WEST.	SOUTH.	EAST.
SCOTLAND, EAST COAST. Boddam. Lerwick. Scalloway. Kirkwall. Holborn Head. Wick. Inverness. Nairn. Burghead. Lossiemouth. Buckie. Portsoy. Banff. Fraserburgh. Peterhead. Aberdeen. Stonehaven. Montrose. Broughty Ferry. St. Andrews. Dundee. Grangemouth. Bo'ness. Anstruther. Pittenweem. Burntisland. Granton. Leith. Fisherrow. Dunbar. Eyemouth.	ENGLAND, N.W. Ramsey. Douglas. Castletown. Silloth. Maryport. Workington. Whitehaven. Barrow. Morecambe. Fleetwood. Blackpool. Lytham. Southport. Runcorn. Liverpool. *Hawarden. Mostyn.	ENGLAND, S.W. Ilfracombe. Barnstaple. Boscastle. Port Isaac. Newquay. Hayle. Scilly. St. Sennen. Penzance. Falmouth. Pendennis. Mevagissey. Plymouth. Teignmouth. Exeter. Exmouth.	ENGLAND, E. Berwick-on-Tweed. Tynemouth. S. Shields. Sunderland. Middlesborough. Redcar. Whitby. Filey. Hull. Goole. Grimsby. Boston. Sutton Bridge. Lynn. Sheringham. Cromer.
FIRTH OF CLYDE. Glasgow. Greenock. Rothesay. Campbelton. Girvan. Ballantrae.	ENGLAND, W. Port Penrhyn. Holyhead. Port Dinorwic. Carnarvon. *Aberystwith. Milford. Pembrey. Swansea. Llanelly. Briton Ferry. Porthcawl. Penarth. Cardiff. Newport. Weston-super-Mare. Burnham.	ENGLAND, S. Guernsey. St. Helier's, Jersey. Gorey, Jersey. Weymouth. Poole. Cowes. Ventnor. Portsmouth. Littlehampton. Brighton. Newhaven. Hastings. Rye. Dover. Margate.	ENGLAND, S.E. Yarmouth. Southwold. Ipswich. Harwich. Chatham. Sheerness. Faversham.
	IRELAND, E. Belfast. Howth. Kingstown.		
	IRELAND, S. and W. New Ross. Dunmore East. Dungarvan. Youghal. Queenstown. Passage. Cork. Kinsale. Tralee. Limerick. Galway.		

* Telegrams (only) exhibited.

APPENDIX III.

Opinions respecting the Value of Storm Signals.

In December 1881 a circular was issued to the local authorities in charge of storm signals requesting information as to the condition of the signals, and the general opinion as to the utility of the warnings. The following are the ~~replies~~ replies received as to the utility of the signals :—

NORTH LIST.

Boddam -	- No circular sent; signals recently supplied.
Lerwick -	- " "
Scalloway -	- " "
Kirkwall -	- "They are very serviceable, especially to fishermen, who appreciate them highly."
Holborn Head (Thurso).	"They would be of great use if the flagstaff were moved to Pennyland, or one put up there, viz., between Thurso and Scrabster."
Wick -	- "The general opinion is that they are very valuable."
Inverness (South Kessock).	"The warnings are most useful, and much appreciated."
Nairn -	- No reply.
Burghead -	- "Very serviceable."
Lossiemouth	- Same reply as Inverness.
Buckie -	- "Very generally appreciated."
Portsoy -	- "The seafaring class has learned by experience to esteem the value of the storm signal as a boon."
Banff -	- Same reply as Inverness.
Fraserburgh -	- "The warnings are much appreciated by the seafaring community and the public generally."
Peterhead -	- "The general opinion here is that the warning is of great service, inasmuch as it often prevents vessels and boats from going to sea, and the consequences which would probably result thereby."
Aberdeen -	- "The signals are hoisted at the dock entrance at Aberdeen, and the opinion is that they are certainly useful."
Stonehaven -	- "The opinion is that the signals and warnings are of great utility, and are acted upon."
Montrose -	- "The masters of this port are unanimous in saying that the warnings are of great value to them. The fishermen belonging to the village of Ferryden find them of the greatest value to them, as the signals can be seen from any door or window in their village, which saves them crossing the river Southesk to examine the telegrams."
Broughty Ferry	- "The warnings are of very great use to the fishermen and others."
St. Andrews	- "The general opinion is that the warnings are useful, but the storm occasionally comes before receipt of the telegram."
Dundee -	- "The warnings are considered of great service to the sea faring and fishing community."
Grangemouth	- No reply.
Bo'ness -	- "The general opinion as to the utility of the warnings is that they are truthful, observed, given effect to, and appreciated."
Anstruther -	- "They are regarded as of great utility, and much prized by the fishermen, who regulate themselves by them."
Pittenweem -	- "The warnings are highly approved of, and the fishermen are very grateful for the trouble taken in attending to them, and since the Eyemouth disaster a strict attention is paid to them. Only a short time ago two boats which had left the harbour under sail for the deep-sea fishing, on seeing the cone being hoisted returned to port, and as it happened, saved themselves a fruitless voyage (to say the least) of some 50 or 60 miles out and in."

NORTH LIST—*cont.*

Burntisland -	- "The general opinion, I believe to be, is that the warnings are of great utility."
Granton -	- "I think the general opinion is that the signals are useful. From my own observation the telegrams often come after the gale has arrived, but when the signal is hoisted it serves to guide shipmasters and others."
Leith -	- "The warnings are of great value."
Fisherrow -	- "I understand that comparatively little attention was in former times paid to the signal, but since the recent severe and disastrous gales the fishermen give it more heed."
Dunbar -	- "The general opinion here is that the warnings should be continued."
Eyemouth -	- "The general opinion of the fishermen is that they would not like to see it done away with."
Glasgow -	- No reply.
Greenock -	- "There is no doubt whatever as to the utility and value of the warnings. They exert a preparatory and prudential influence on all those coming within its scope, and the only drawback in connexion therewith is that the signal is oftentimes thought to be kept too long on 'sign'."
Rothesay -	- "The general opinion, so far as can be gathered, is that the warnings are *very useful.*"
Campbelton -	- "The general opinion is that the cone is useful and should not be dispensed with."
Girvan -	- "On the whole the utility of the warnings is not great."
Ballantrae -	- "Recognised as being of great practical value and are highly appreciated."

WEST LIST.

Ramsey -	- "The sailors and fishermen belonging to this port highly value the storm signals. The cone is so placed that vessels anchoring in the bay can avail themselves of the warnings."
Douglas -	- "General opinion that they are useful and reliable warnings."
Castletown -	- No reply.
Silloth -	- "The warnings are much valued both by the masters of steamers and sailing vessels; they have become indispensable. The telegrams are sometimes long in reaching us; last Friday's [23rd Dec. 1881], for instance, which I enclose, was 2 hrs. 40 min. Had it come in due course the captains of out-going vessels on that day would have seen the warnings."
Maryport -	- "I am led to believe that the seafaring people frequenting the port are influenced in their movements to a considerable extent by the exhibition of the signals."
Workington	- "The general opinion respecting the hoisting of the cone is that the warning given by the Meteorological Office is correct."
Whitehaven -	- "They are valuable and reliable on our coast."
Barrow-in-Furness -	- "The general opinion is that these signals do not give sufficient notice of storms, &c. The gale is frequently here as soon as the telegram."
Morecambe -	- "I think it is generally held that the warnings are reliable and useful, both for the mariners and the fishermen."
Fleetwood -	- "We rely most on messages noting Valencia gales. Vessels don't go to sea on notification of these gales. The general opinion is that the advices are most useful and strictly regarded by both fishermen, coasters, and foreign-going ships."
Blackpool -	- "I am glad to state that the signals are of great service during the summer season to the numerous passenger steamers and sailing boats on the coast in the arrangement of their trips as well as to the large number of visitors to the town. The hoisting of a storm signal has

WEST LIST—*cont.*

many times during the season had the effect of making five or six large steamers weigh anchor and proceed to Fleetwood Harbour; distance, 7 miles."

Lytham - - "The signal warnings are very much appreciated both by masters of vessels and fishermen and by the inhabitants of Lytham."

Southport - - No reply.

Runcorn - - "Viewed as generally reliable and of service to captains of vessels."

Liverpool - - "It is considered that the signals have some utility, though it is not thought that they are of great value."

Hawarden - - "The messages at Hawarden are duly attended to. The telegram is exposed regularly in a conspicuous place, and the warnings are much appreciated."

Mostyn - - No opinion expressed.

Port Penhryn - "The general opinion is very favourable, but the warnings often reach here after a gale is far spent."

Holyhead - - "When the signal is up a number of masters of wind-bound vessels and others call at the station to read the telegram and see what the barometer is doing. I think the signals are of great service in drawing attention to probable changes in the weather, and thus causing masters of vessels to act with caution. I believe this to be the prevalent opinion here."

Port Dinorwic - "Mariners take a great interest in the warnings, but this port being situated midway between the two entrances to the Menai Straits, viz., Carnarvon and Beaumaris, greater importance is attached to the signals at these two stations in consequence."

Carnarvon - - "They are appreciated, and the reports and charts much studied."

Aberystwith - "The telegrams are always consulted. We consider it a great boon to the town."

Milford - - "The explanatory telegrams are regularly exhibited in a box with other meteorological information, and are much valued by the masters of vessels and others frequenting the harbour, who have at all times free access thereto."

Pembrey - - "The general opinion is decidedly that the warnings are of great utility."

Swansea - - "I cannot say at the moment what is the general opinion as to the utility of the warnings."

Llanelly - - "Very good."

Briton Ferry - "The general opinion is favourable as to the utility of the warnings given."

Porthcawl - - "General opinion of the warnings, particularly from Valencia, useful."

Penarth - - "In the opinion of masters of ships visiting this dock, and of our Channel pilots, the storm signals are very useful as notes of warning; though unfortunately many masters do not regard them sufficiently."

Cardiff - - "The general opinion as to the utility of the warnings is favourable, but fault is found when the storm signals are hoisted and the gale never reaches us. When it is so, I generally haul the signal down."

Newport (Mon.) - "The warnings are of great utility, and, as a rule, very accurate."

Weston-super-Mare - No reply.

Burnham - - "Very good."

Belfast - - "Favourable."

Howth - - "Coasting vessels and fishermen take great notice of the warning."

Kingstown - - "The signals are much appreciared by masters of vessels coming to Kingstown."

New Ross - No reply.

WEST LIST—*cont.*

Dunmore East - "The warnings are a great benefit to the fishermen of the locality; generally they will not proceed to sea when the cone is hoisted. It is also an advantage to vessels proceeding to sea from the port of Waterford, as they have to pass the flagstaff when the signal is hoisted, and the chief officer of coastguard at Dunmore East states that he has often seen vessels put back to Passage when the cone is hoisted. But it frequently occurs that a telegram leaving London after 7 p.m. will not be delivered at Dunmore East until between 8 and 9 o'clock on the following morning, so that generally the depression has passed before any warning can be given."

Dungarvan - - "The public opinion of the storm warnings is that they are generally correct, but that they are sometimes late."

Youghal - - "That the general opinion as to the utility of the warnings held by seafaring men and those interested, is that it is a great boon, particularly as the pole on which the cone is hoisted occupies a prominent position, and a view of it is to be had from any part of the harbour."

Queenstown - "Appreciated."

Passage - - "I have been an old shipmaster, and my opinion, and I believe the general opinion, is that the signals are of the greatest utility."

Cork - - "They are approved of by the seafaring public."

Kinsale - - "Very useful; vessels don't go to sea when the cone is hoisted."

Tralee - - "They are considered on many occasions to be most useful."

Limerick - - "They are considered very useful, though the port is so far inland.".

Galway - - "The harbour-master finds the warnings of considerable value, and well founded in the large majority of cases."

SOUTH LIST.

Ilfracombe - - "The general opinion is that the warnings are of great service to the boatmen, Channel pilots, and coasting sailors frequenting the harbour and neighbourhood."

Barnstaple - - "General opinion is favourable; signals appreciated."

Boscastle - - "General opinion is the warnings of great value."

Port Isaac - - "They [the fishermen] do not much notice the warnings, unless from Valencia."

Newquay - "The warnings are much appreciated by the inhabitants generally, although from our situation on the shores of the Atlantic, S.W. gales often reach us as soon as the warnings. The desideratum is a floating station some 300 miles W. of Valencia."

Hayle - - "Masters of vessels at this port, as a general rule, take but little notice of the warnings."

St. Mary's (Scilly) - "Most seamen have a favourable opinion of the warnings, and the greater number of vessels remain in the roads till the cone is hauled down, especially in winter."

St. Sennen - - "Not appreciated as they ought to be, but intense ignorance must be taken into account."

Penzance - - "Of very great service, not only to mariners, but also to the large number of fishermen in the place and those who come from Plymouth, Dartmouth, Yarmouth, Lowestoft, &c."

Falmouth - - "The warnings are very much attended to, and in a crowded port like Falmouth, are of great service."

Mevagissey - - "In most cases all very satisfactory."

Devonport:—

(Commander-in-Chief.) "The warnings have been found generally accurate and of great value, especially when studied in conjunction with local indications of wind and weather and the readings of the barometer."

(Admiral Superintendent.) "They are considered very useful in giving warning to vessels on leaving the port, as to the probable weather and winds that may be expected."

SOUTH LIST—*cont.*

Plymouth -	- "Nearly all the captains are in favour of the signals."
Teignmouth	- "Most valuable."
Exmouth -	- "Most useful to the fishermen and others."
Guernsey -	- "The signals are generally appreciated."
St. Helier's (Jersey)	- "The public seem to take interest in it."
Gorey (Jersey)	- "The general opinion is amongst all seafaring men that the telegrams are very useful, and especially fishermen take much notice of them, and all are thankful for the same."
Weymouth -	- "Not much regard is paid, the code often being hoisted when the worst of the weather is past, and again often hoisted when the bad weather has not arrived here . . . The signal no doubt is good when masters of vessels in Portland Roads are undecided whether they shall weigh or not, owing to the appearance of the sky. When the cone is hoisted in such a case no doubt it decides them to hold on."
Poole -	- "The opinion is in favour of the signal, and every master-mariner and seaman thinks it a very good boon to have them."
Cowes (R.Y.S.)	- "The general opinion is that the warnings are of the greatest utility."
Ventnor -	- No reply.
Portsmouth -	- Do.
Littlehampton	- "The opinion is that the warnings are a valuable indication of the weather."
Brighton -	- "The warnings are appreciated by the public and fishermen, and appear to carry conviction as to their general utility."
Newhaven -	- "Serviceable."
Hastings -	- "Favourable."
Rye - -	- "The general opinion is that the warnings are of service, and should be continued."
Dover -	- "I think that the signals are more and more appreciated as the intelligence of the seafaring class increases."
Margate -	- "Very satisfactory both to shipping in the Margate Roads and to the boatmen of Margate."

EAST LIST.

Berwick -	- "They are of great service to the seafaring men of the port, and great reliance is put on them by the same."
Tynemouth -	- "These signals have been and will be an inestimable boon to our seafaring population."
South Shields	- No reply.
Sunderland -	- Do.
Middlesborough	- "Our experience is that these signals are of the greatest importance."
Redcar -	- "The pilots and fishermen of Redcar take great notice of the warnings."
Whitby -	- "The warnings are considered of *great utility*, to the seafaring population in particular."
Filey -	- "It is not of much service as it can't be seen by ships passing outside Filey Bay, and the fishermen as a rule do not notice it."
Hull -	- "Small craft and sailing vessels, with the exception of fishing smacks, take notice of the warnings and frequently remain in port. Steamers, however, take but little notice of the warnings, and generally proceed to sea in spite ŏ them."
Goole -	- No reply.
Grimsby -	- "That the warnings are occasionally late, but that their receipt induces many captains to act with greater caution than they otherwise would."
Boston -	- "Of much use to the fishermen and the small coasting vessels. The larger ships do not come up to Boston, but lie in the roadstead."

EAST LIST—*cont.*

Sutton Bridge (Wisbech).	- "The general opinion of the signal is satisfactory."
Lynn -	- "A good deal of interest is taken in these warnings by the mercantile and seafaring community; they are considered reliable and of public utility."
Sheringham -	- "Very little notice is taken of them."
Cromer -	- "The general opinion regarding the signal is that it is very useful at Cromer, especially to the fishing population here."
Great Yarmouth	- "That they are a great benefit to the masters of vessels."
Southwold -	- "Very much appreciated by the seamen and fishermen of this place."
Ipswich -	- "Highly appreciated."
Harwich -	- "Universally approved of."
Chatham (Dockyard)	"The general opinion as to the utility of the warning is favourable."
Sheerness (Dockyard).	No opinion given.
Faversham -	- "It is of great service, there being great traffic in and out of the East Swale, especially for vessels which use the Swale as a roadstead, of which there are a great many. It is also very useful for vessels bound to the Downs by the 'overland' (or inside) passage from London."

APPENDIX IV.

REPORT ON THE COMPARISON OF THE FORECASTS WITH THE WEATHER SUBSEQUENTLY EXPERIENCED, FOR THE TWELVE MONTHS, APRIL 1881 TO MARCH 1882.

The letters used have the following signification:—

a = complete success.
b = partial (more than half) success.
c = partial failure.
d = total failure.

The checking has been conducted on the same system as that employed during 1881, *i.e.*, each forecast has been considered under the separate headings of "Wind" and "Weather," but for this year the results of the 8 p.m. Forecasts only have been published.

The first column gives the percentage of success in "Wind," the second "Weather," and the third the average of the two.

Districts.		April 1881. Percentages. Wind.	Weather.	Average.	a + b.	May 1881. Percentages. Wind.	Weather.	Average.	a + b.	June 1881. Percentages. Wind.	Weather.	Average.	a + b.
Scotland N.	a	30	37	34	82	26	36	31	78	30	53	42	83
"	b	60	37	48		52	42	47		46	37	41	
"	c	7	13	10		13	19	16		16	7	12	
"	d	3	13	8		9	3	6		8	3	5	
Scotland, E.	a	23	50	37	77	39	62	51	80	30	30	30	85
"	b	60	20	40		29	29	29		57	53	55	
"	c	7	27	17		19	6	12		10	13	12	
"	d	10	3	6		13	3	8		3	4	3	
England, N.E.	a	23	40	32	71	45	52	49	88	40	37	39	79
"	b	54	24	39		42	36	39		40	40	40	
"	c	10	33	21		13	9	11		10	16	13	
"	d	13	3	8		—	3	1		10	7	8	
England, E.	a	30	46	38	77	42	33	38	86	27	30	29	82
"	b	53	24	39		39	58	48		60	46	53	
"	c	7	27	17		13	9	11		10	16	13	
"	d	10	3	6		6	—	3		3	8	5	
Midland Cos.	a	23	40	32	79	42	42	42	86	40	34	37	80
"	b	54	40	47		39	48	44		43	43	43	
"	c	16	13	14		13	10	11		13	16	15	
"	d	7	7	7		6	—	3		4	7	5	
England, S.	a	43	37	40	85	52	58	55		37	33	35	80
"	b	43	47	45		26	39	33		53	37	45	
"	c	11	16	14		13	3	8		7	27	17	
"	d	3	—	1		9	—	4		3	3	3	
Scotland, W.	a	27	40	34	62	36	39	38	75	34	40	37	77
"	b	30	27	28		26	48	37		43	37	40	
"	c	30	30	30		29	13	21		10	16	13	
"	d	13	3	8		9	—	4		13	7	10	
England, N.W.	a	27	37	32	76	42	58	50	81	33	30	32	74
"	b	44	43	44		36	26	31		40	44	42	
"	c	13	13	13		13	13	13		20	23	21	
"	d	16	7	11		9	3	6		7	3	5	
England, S.W.	a	37	33	35	79	36	36	36	81	20	27	24	64
"	b	50	37	44		42	48	45		50	30	40	
"	c	10	30	20		16	13	15		20	23	21	
"	d	3	—	1		6	3	4		10	20	15	
Ireland, N.	a	40	40	40	80	36	52	44	74	30	41	36	80
"	b	40	40	40		36	23	30		46	43	44	
"	c	17	13	15		19	16	17		10	—	5	
"	d	3	7	5		9	9	9		14	16	15	
Ireland, S.	a	34	43	36	75	26	45	36	74	20	37	29	77
"	b	46	27	36		42	33	38		57	40	48	
"	c	13	23	18		23	16	19		13	13	13	
"	d	7	7	7		9	6	7		10	10	10	
Summary.													
British Isles	a	31	40	36	76	38	47	43	81	31	36	34	79
"	b	48	33	40		37	38	38		49	41	45	
"	c	13	22	18		17	11	14		12	15	13	
	d	8	5	6		8	3	5		8	8	8	

Districts.		July 1881. Percentages. Wind.	Weather.	Average.	a + b.	August 1881. Percentages. Wind.	Weather.	Average.	a + b.	September 1881. Percentages. Wind.	Weather.	Average.	a + b.
Scotland, N.	a	23	49	36	80	19	42	31	66	37	37	37	84
"	b	55	32	44		45	26	35		53	40	47	
"	c	19	13	16		36	23	30		7	16	11	
"	d	3	6	4		—	9	4		3	7	5	
Scotland, E.	a	26	45	36	67	29	29	22	74	40	30	25	86
"	b	39	23	31		35	55	45		54	47	51	
"	c	25	26	25		26	10	18		3	16	9	
"	d	10	6	8		10	6	8		3	7	5	
England, N.E.	a	29	39	34	76	26	26	26	76	37	30	34	77
"	b	45	39	42		45	55	50		53	33	43	
"	c	23	16	20		16	16	16		10	30	20	
"	d	3	6	4		13	3	8		—	7	3	
England, E.	a	42	36	39	67	3	29	16	74	40	33	37	79
"	b	26	29	28		71	45	58		44	40	42	
"	c	29	16	22		23	19	21		13	20	16	
"	d	3	19	11		3	7	5		3	7	5	
Midland Cos.	a	29	29	29	75	26	23	25	60	37	37	37	82
"	b	42	49	46		26	45	35		53	36	45	
"	c	19	19	19		42	19	31		10	20	15	
"	d	10	3	6		6	13	9		—	7	3	
England, S.	a	23	45	34	81	22	29	26	81	28	37	33	74
"	b	48	45	47		68	42	55		52	30	41	
"	c	16	—	8		10	23	16		13	30	21	
"	d	13	10	11		—	6	3		7	3	5	
Scotland, W.	a	13	52	33	70	23	26	25	68	10	27	19	75
"	b	58	16	37		42	45	43		67	46	56	
"	c	19	22	20		19	13	16		20	20	20	
"	d	10	10	10		16	16	16		3	7	5	
England, N.W.	a	36	32	34	73	29	39	34	76	20	37	29	74
"	b	29	49	39		48	35	42		54	36	45	
"	c	25	16	21		13	19	16		23	20	21	
"	d	10	3	6		10	7	8		3	7	5	
England, S.W.	a	16	29	23	68	32	61	47	81	30	53	42	77
"	b	45	45	45		42	26	34		44	27	35	
"	c	26	19	22		19	10	14		23	17	20	
"	d	13	7	10		7	3	5		3	3	3	
Ireland, N.	a	32	55	44	73	23	42	33	73	23	33	28	78
"	b	32	26	29		39	42	40		47	53	50	
"	c	26	10	18		19	13	16		30	7	19	
"	d	10	9	9		19	3	11		—	7	3	
Ireland, S.	a	26	48	37	68	13	45	29	76	27	40	34	70
"	b	39	23	31		55	39	47		43	30	36	
"	c	19	23	21		19	13	16		17	23	20	
"	d	16	6	11		13	3	8		13	7	10	
Summary.													
British Isles	a	27	42	35	73	22	36	29	73	33	36	30	78
"	b	42	34	38		47	41	44		52	38	45	
"	c	22	16	19		22	16	19		15	20	18	
"	d	9	8	8		9	7	8		3	6	4	

Districts.		October 1881. Percentages. Wind.	Weather.	Average.	a + b.	November 1881. Percentages. Wind.	Weather.	Average.	a + b.	December 1881. Percentages. Wind.	Weather.	Average.	a + b.
Scotland, N.	a	27	37	32	77	33	57	45	88	29	65	47	90
,,	b	47	43	45		57	30	43		62	23	43	
,,	c	16	17	17		10	10	10		9	6	7	
,,	d	10	3	6		—	3	2		—	6	3	
Scotland, E.	a	30	40	35	70	27	37	32	81	32	32	32	86
,,	b	43	27	35		57	40	49		62	45	54	
,,	c	17	10	14		16	16	16		3	23	13	
,,	d	10	23	16		—	7	3		3	—	1	
England, N.E.	a	40	37	39	74	33	17	25	84	19	29	24	76
,,	b	37	33	35		57	60	59		58	45	52	
,,	c	16	13	14		10	20	15		19	26	22	
,,	d	7	17	12		—	3	1		4	—	2	
England, E.	a	44	40	42	81	27	27	27	77	32	23	28	76
,,	b	33	44	39		63	37	50		48	48	48	
,,	c	20	13	16		10	16	13		20	26	23	
,,	d	3	3	3		—	20	10		—	3	1	
Midland Cos.	a	27	30	29	72	16	13	15	80	23	33	28	85
,,	b	36	50	43		84	46	65		65	48	57	
,,	c	30	17	23		—	31	15		9	16	12	
,,	d	7	3	5		—	10	5		3	3	3	
England, S.	a	43	40	42	79	40	17	29	77	23	26	25	70
,,	b	37	37	37		53	43	48		45	45	45	
,,	c	13	16	14		7	13	10		32	19	25	
,,	d	7	7	7		—	27	13		—	10	5	
Scotland, W.	a	23	33	30	70	20	27	24	74	16	23	20	78
,,	b	47	37	40		60	40	50		65	52	58	
,,	c	20	17	19		20	23	21		13	19	16	
,,	d	10	13	11		—	10	.5		6	6	6	
England, N.W.	a	30	43	37	72	30	30	30	70	29	35	32	72
,,	b	47	24	35		57	23	40		52	29	40	
,,	c	16	23	20		13	27	20		19	23	21	
,,	d	7	10	8		—	20	10		—	13	7	
England, S.W.	a	30	43	37	72	30	23	27	65	19	29	24	81
,,	b	50	20	35		44	33	38		65	48	57	
,,	c	7	30	18		23	31	27		10	13	11	
,,	d	13	7	10		3	13	8		6	10	8	
Ireland, N.	a	33	27	30	77	33	30	32	82	29	39	34	80
,,	b	54	40	47		57	43	50		52	39	46	
,,	c	10	27	19		7	27	17		6	16	11	
,,	d	3	6	4		3	—	1		13	6	9	
Ireland, S.	a	33	33	33	72	30	50	40	82	26	48	37	76
,,	b	43	34	39		53	30	42		48	29	39	
,,	c	17	23	20		10	17	13		10	13	11	
,,	d	7	10	8		7	3	5		16	10	13	

Summary.

British Isles	a	33	37	35	74	29	30	30	78	25	35	30	79
,,	b	43	35	39		58	39	48		56	41	49	
,,	c	17	19	18		12	21	17		14	18	16	
,,	d	7	9	8		1	10	5		5	6	5	

Districts.		January 1882. Percentages. Wind.	Weather.	Average.	a + b.	February 1882. Percentages. Wind.	Weather.	Average.	a + b.	March 1882. Percentages. Wind.	Weather.	Average.	a + b
Scotland, N.	a	26	39	33	73	33	36	35	83	57	63	60	
,,	b	48	32	40		46	50	48		33	23	28	
,,	c	26	6	16		14	11	12		7	10	9	
,,	d	—	23	11		7	3	5		3	4	3	
Scotland, E.	a	19	29	24	70	36	32	34	74	53	30	42	80
,,	b	62	30	46		54	25	40		33	43	38	
,,	c	19	6	12		7	29	18		3	20	11	
,,	d	—	35	18		3	14	8		11	7	9	
England, N.E.	a	26	23	25	78	39	29	34	82	27	16	22	75
,,	b	61	45	53		50	46	48		50	57	53	
,,	c	13	23	18		12	25	18		16	20	18	
,,	d	—	9	4		—	—	—		7	7	7	
England, E.	a	29	23	26	59	32	39	36	82	43	37	42	82
,,	b	39	27	33		50	43	46		33	46	40	
,,	c	23	30	27		18	7	13		13	10	11	
,,	d	9	20	14		—	11	5		7	7	7	
Midland Cos.	a	23	30	27	70	32	39	36	80	40	33	37	72
,,	b	55	32	43		43	46	44		33	37	35	
,,	c	16	29	22		21	11	16		20	20	20	
,,	d	6	9	8		4	4	4		7	10	8	
England, S.	a	23	19	21	84	21	36	29	80	40	50	45	82
,,	b	69	57	63		63	39	51		43	30	37	
,,	c	8	14	11		12	18	15		17	16	16	
,,	d	—	10	5		4	7	5		—	4	2	
Scotland, W.	a	19	36	28	77	25	32	29	81	33	50	42	82
,,	b	62	36	49		54	50	52		53	27	40	
	c	19	19	14		21	14	17		14	20	17	
	d	9	9	9		—	4	2		—	3	1	
England, N.W.	a	19	26	26	83	21	32	27	82	23	33	28	78
,,	b	69	52	60		61	50	55		54	46	50	
	c	9	9	9		14	14	14		16	14	17	
	d	3	13	8		4	4	4		7	7	7	
England, S.W.	a	33	40	37	79	29	50	40	83	33	33	33	76
,,	b	52	33	42		54	32	43		46	40	43	
,,	c	9	23	16		10	18	14		14	27	21	
,,	d	6	4	5		7	—	3		7	—	3	
Ireland, N.	a	42	45	44	89	32	32	32	88	40	40	40	86
,,	b	55	35	45		50	61	56		54	37	46	
,,	c	—	17	8		14	7	10		3	16	9	
,,	d	3	3	3		4	—	2		3	7	5	
Ireland, S.	a	43	43	42	87	25	39	32	79	37	37	37	75
,,	b	53	37	45		50	43	47		33	43	38	
,,	c	7	7	7		18	14	16		23	20	22	
,,	d	—	13	6		7	4	5		7	—	3	

Summary.

British Isles	a	27	32	30	77	30	36	33	81	39	38	39	80
,,	b	57	38	47		52	44	48		42	39	41	
,,	c	13	17	15		14	15	14		15	18	15	
,,	d	3	13	8		4	5	5		6	5	5	

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