M.O. 246.

AIR MINISTRY.

METEOROLOGICAL OFFICE.

WEATHER FORECASTING

IN THE

EASTERN NORTH ATLANTIC AND HOME WATERS FOR SEAMEN.

BY

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1. INTRODUCTION.

Since 1860 the weather observations made at a number of stations in the British Isles at fixed times have been telegraphed to the Meteorological Office, where they are plotted on maps, and from these maps forecasts are made and published. This service has been considerably extended of late years, and the daily weather map issued by the Meteorological Office now takes in the whole of Western Europe and part of the Eastern North Atlantic, so that the forecaster is in a better position than ever before to make a weather forecast.

The landsman who has not had occasion to study the weather seriously, may be satisfied if he is informed that on the following day the weather is likely to be wet or dry, hot or cold, calm or windy; but to the seaman, who is of necessity by the nature of his calling a student of weather, this is not sufficient; for no one knows better than he how uncertain are the changes of weather in the neighbourhood of the British Isles; nor, perhaps, with the exception of the airman, is there anyone who stands to lose or gain more from it than he. It has recently been shown that by means of W/T the synoptic method is practicable at sea, and with a view to encouraging this method arrangements have been recently made whereby all ships fitted with suitable W/T installations within range of Poldhu W/T Station may receive data which, in conjunction with W/T reports from other ships and their own observations, provide information for constructing a weather chart and making a forecast. The Poldhu W/T reports at the outset have been simplified and restricted to a minimum, but it is hoped that if shipping avails itself of this system it may be extended later.

The greatest assistance which shipowners can give in furthering this aid to navigation is to provide their ships with good mercurial barometers. There are at present three systems of graduation of the barometer:—

(1) The millibar used by the British and other meteorological services;

(2) The millimeter used by some continental countries; and

(3) The inch, which up till recently was in very general use, and is still used in many English-speaking countries.

As the millibar is coming more and more into use it will help towards obtaining uniformity if new barometers are graduated with this scale.

Before any ship can usefully co-operate in this system it is necessary that her officers should know the index error of their barometer, and special attention is invited to the instructions for correcting the barometer. This pamphlet is intended as a preliminary guide to seamen with a knowledge of weather gained

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by experience, in order that the W/T weather reports which they exchange may be uniform. Without uniformity of method the synoptic method cannot be efficient.

A code is now being tried by a strictly limited number of steamers fitted with tested official instruments which observe for the Meteorological Office. It is hoped that if this code is successful amongst ships voluntarily observing for the Meteorological Office, it may be published for general use in the mercantile marine. Meanwhile, all merchant ships, whether they observe for the British Meteorological Office or not, will assist towards the ultimate aim of the Meteorological Office, *i.e.*, to introduce an efficient system of exchange by W/T of meteorological information at sea, by using the form of reports herein suggested, and as far as possible using observations for these reports taken at 0700 G.M.T. and 1800 G.M.T.

L. A. Brooke Smith,
Marine Superintendent.

Meteorological Office,
May, 1921.

2. FORECASTS AND DATA MESSAGES BROADCASTED (ISSUED FREE OF CHARGE) FROM **POLDHU** WIRELESS TELEGRAPHY STATION.

To come into force June 15th, 1921.

Poldhu, Lat. 50° 02′ N., Long. 5° 16′ W. Call sign MPD, wave length 2,800 m. spark.

From this station weather messages are issued twice daily at 0930 G.M.T. (civil), referring to observations taken at 0700, and 2130 G.M.T. (civil, referring to observations taken at 1800.

The message is in two parts :—

The **first part** is preceded by the word **Western** and is a **forecast,** *i.e.*, statement of the weather which may be expected in the near future for the western seaboard of the British Isles.

The **second part** is a data message which gives the actual observations taken at stations at 0700 G.M.T. (civil) or 1800 G.M.T. (civil) according to the time of despatch.

Part I.—A typical forecast.

Western deep depression, Iceland, moving east; forecast wind west to north-west, strong or gale, hail showers.

Part 2.—Is a data message in code which gives observations of the barometer, the direction and force of the wind, the visibility and the tendency of the barometer, *i.e.*, what the

barometer has done during the last three hours at the following stations :—

Stornoway	-	Lat. 58° 11′ N., Long. 6° 22′ W.
Blacksod	-	Lat. 54° 06′ N., Long. 10° 4′ W.
Holyhead	-	Lat. 53° 18′ N., Long. 4° 39′ W.
Scilly -	-	Lat. 49° 58′ N., Long. 6° 18′ W.
Dungeness	-	Lat. 50° 55′ N., Long. 0° 58′ E.

The **first five groups** of five figures each are always given in the order of the stations above, and the figures of the **sixth** group are given in the same order, so that—

The **first** group refers to **Stornoway,**
the **second** to **Blacksod,**
and so on to the fifth group.

In the **sixth** group—
the **first** figure refers to **Stornoway,**
the **second** to **Blacksod,**
and so on.

Symbolically the groups are as follows :—

(When observations are lacking dashes replace the figures or groups. **A dash** means no observations; this is necessary to preserve the order.)

$B_1\ B_1\ D_1\ F_1\ V_1$
$B_2\ B_2\ D_2\ F_2\ V_2$
$B_3\ B_3\ D_3\ F_3\ V_3$
$B_4\ B_4\ D_4\ F_4\ V_4$
$B_5\ B_5\ D_5\ F_5\ V_5$
$K_1\ K_2\ K_3\ K_4\ K_5$

BB = corrected barometer in millibars to the nearest whole millibar, the first 9 or 10 being omitted. *See* **Conversion Table I.***

D = true direction of the wind to the nearest cardinal or half cardinal point. *See* **Table II.**

F = wind force by Beaufort notation, 9 representing forces of 9 **and above.**

V = visibility by scale. *See* **Table III.**

K = barometer tendency. *See* **Table IV.**

* It will be seen that the coded figures may represent two values of barometric pressure, but this only takes place with a very low or very high barometer, so that mariners will be able to decide which value is intended.

Table I.—Conversion of Millibars to Inches.

Equivalent in Mercury Inches at 32° and Latitude 45° of Millibars.

Mb.	In.	Mb.	In.	Mb.	In.	Mb.	In.	Mb.	In.
925	27·32	955	28·20	985	29·09	1,015	29·97	1,045	30·86
926	27·35	956	28·23	986	29·12	1,016	30·00	1,046	30·89
927	27·38	957	28·26	987	29·15	1,017	30·03	1,047	30·92
928	27·41	958	28·29	988	29·18	1,018	30·06	1,048	30·95
929	27·44	959	28·32	989	29·21	1,019	30·09	1,049	30·98
930	27·46	960	28·35	990	29·24	1,020	30·12	1,050	31·01
931	27·49	961	28·38	991	29·26	1,021	30·15	1,051	31·04
932	27·52	962	28·41	992	29·29	1,022	30·18	1,052	31·07
933	27·55	963	28·44	993	29·32	1,023	30·21	1,053	31·10
934	27·58	964	28·47	994	29·35	1,024	30·24	1,054	31·13
935	27·61	965	28·50	995	29·38	1,025	30·27		
936	27·64	966	28·53	996	29·41	1,026	30·30		
937	27·67	967	28·56	997	29.44	1,027	30·33		
938	27·70	968	28·59	998	29·47	1,028	30·36		
939	27·73	969	28·62	999	29·50	1,029	30·39		
940	27·76	970	28·65	1,000	29·53	1,030	30·42		
941	27·79	971	28·67	1,001	29·56	1,031	30·45		
942	27·82	972	28·70	1,002	29·59	1,032	30·48		
943	27·85	973	28·73	1,003	29·62	1,033	30·51		
944	27·88	974	28·76	1,004	29·65	1,034	30·53		
945	27·91	975	28·79	1,005	29·68	1,035	30·56		
946	27·94	976	28·82	1,006	29·71	1,036	30·59		
947	27·97	977	28·85	1,007	29·74	1,037	30·62		
948	28·00	978	28·88	1,008	29·77	1,038	30·65		
949	28·03	979	28·91	1,009	29·80	1,039	30·68		
950	28·05	980	28·94	1,010	29·83	1,040	30·71		
951	28·08	981	28·97	1,011	29·86	1,041	30·74		
952	28·11	982	29·00	1,012	29·89	1,042	30·77		
953	28·14	983	29·03	1,013	29·92	1,043	30·80		
954	28·17	984	29·06	1,014	29·94	1,044	30·83		

Table II.—Wind Direction True.

0 = Calm.
1 = N.E.
2 = E.
3 = S.E.
4 = S.
5 = S.W.
6 = W.
7 = N.W.
8 = N.

Table III.—Visibility.

Fog and Visibility Scale.

0. Dense fog - - Objects not visible at 50 yards.
1. Thick fog - - „ „ „ „ 1 cable.
2. Fog - - - „ „ „ „ 2 cables.
3. Moderate fog „ „ „ „ ½ mile.
4. Thin fog or mist - „ „ „ „ 1 mile.
5. Hazy - - - „ „ „ „ 2 miles.
6. Horizon not visible from 40 feet (or objects not visible at 4 miles).
7. Horizon only just visible (or objects not visible at 7 miles).
8. Horizon well defined.

Table IV.—Tendency of Barometer.

0 = Bar steady.
1 = Bar rising slowly.
2 = Bar rising.
3 = Bar rising quickly.
4 = Bar rising very rapidly.
5 = Bar falling slowly.
6 = Bar falling.
7 = Bar falling quickly.
8 = Bar falling very rapidly.

Example.—Part 2.

99005 = Stornoway.—Bar., 999 mb.; calm; hazy.
..... = Blacksod.—No observations.
96447 = Holyhead.—Bar., 996 mb.; wind, S. 4; visibility, less than 7 miles.
00526 = Scilly.—Bar., 1,000 mb.; wind, S.W. 2; visibility, less than 4 miles.
05537 = Dungeness.—Bar., 1,005 mb.; wind, S.W. 3; visibility, less than 7 miles.
5-150 = Barometer.—Stornoway—Falling slowly.
Blacksod—No observations.
Holyhead—Rising slowly.
Scilly—Falling slowly.
Dungeness—Steady.

It will be seen that this data message gives the navigator much useful information in a concise form.

For example:—An Atlantic liner making a landfall at the Bishop may obtain information as to the visibility at Scilly at 7 a.m. or 6 p.m. by one figure, *i.e.*, the last figure of the fourth group.

The information as to wind and barometer, and what the barometer is doing at these five stations specially selected for their positions, gives the navigator an idea of what changes of wind and weather may be anticipated in western home waters, thus enabling him to see the reason of the official forecast.

To the navigator who obtains wireless telegraphy reports from other ships at sea for the purpose of making a weather chart, this information will greatly add to the value of his chart, especially the barometer tendency from which he may obtain an approximation of how pressure systems are moving, and so be better able to make a forecast.

3. BAROMETER CORRECTIONS.

Since an isobar is a line drawn through places which have equal barometric pressure, it is necessary that all barometer readings used for drawing isobars should be reduced to one datum. Only corrected barometer readings should be transmitted by wireless telegraphy.

If the barometer reading is not corrected, it is better not to send it by W/T at all, for an incorrect reading may be very misleading if plotted on a chart. The datum for which atmospheric pressure is required is that of sea level at a temperature of 32° F. in latitude 45°.

The barometer is therefore corrected for—

(1) height above sea level, because with height pressure is reduced;

(2) temperature, because mercury expands with heat and contracts with cold;

(3) gravity, because due to flattening of the earth at the poles, the weight is greater at the poles than at the equator, and so the height of a column of mercury required to balance the atmospheric pressure in different latitudes will vary. We use the parallel half-way between the pole and the equator, *i.e.*, latitude 45°.

Means for making these corrections are given on pages 19–21.

The correction of the barometer is of the utmost importance.

4. EXCHANGE OF WEATHER REPORTS BY W/T BETWEEN SHIPS AT SEA.

Since W/T was introduced at sea it has been customary amongst many ships to exchange weather reports, but these are often made according to the fancy of the individual, and may be brief and explicit, giving the information which other ships require, or they may not fulfil that purpose.

In order to draw the simplest synoptic chart the following is the minimum necessary:—

The position at which observations were taken.
The barometer.
Direction and force of the wind.
The weather, the time of observation, and the date.

Observations for a synoptic chart should be taken at the same time.

In order to achieve this object, if ships making weather reports to other ships, whether they wish to make weather charts themselves or not, will adopt the following method of reporting weather, their reports will be for the general good of all ships which receive or intercept them.

As far as possible the observations should be made at 0700 and 1800 G.M.T. (Civil, reckoned from midnight.)

Proposed Standard Wireless Telegraphy Weather Reports for all Ships except those specially reporting to the Meteorological Office by Provisional International Code, until that Code is published for general use.

Example:—

Latitude, 49° 20′ N.

Longitude, 27° 35′ W.

G.M.T. Civil time of observations, 1800.

Date, 2nd.

Correct barometer, 29·92 inches (or millibars may be used).

Wind force by the Beaufort scale, 3. (*See* Beaufort scale, page 22.)

Wind direction true, N. by W.

Weather by the Beaufort notation, b. (*See* Beaufort notation, page 23.)

Remarks.—Moderate northerly swell; current, S.E., half of a knot from 49° N., 33° W.

Name of ship:—"Strathearn."

Abbreviated, but still clear to all who receive it, even if they are not in possession of this pamphlet; the message would be transmitted as follows:—

4920, N. 2735, W. 1800 G.M.T. Second.
Corrected barometer, 29·92; wind, 3, N. by W.
Weather, b. Moderate northerly swell, current S.E., half-knot from 49° N., 33° W.
"Strathearn."

5. WEATHER SYSTEMS.

By charting atmospheric pressure at sea level, temperature, wind and weather conditions, continuously for many years, meteorologists have discovered that different types of pressure systems usually produce certain kinds of weather, and in 1883

the Hon. Ralph Abercromby made the following important *generalisations*, and laid down the seven fundamental shapes of isobars :—

(*a*) That in general the configuration of the isobars takes one of seven well-defined forms.

(*b*) That, independent of the shape of the isobars, the wind always takes a definite direction relative to the trend of these lines, and the position of the nearest area of low pressure. (There are occasional exceptions to this rule when the land interferes, marked examples have been found on the coasts of Australia.)

(*c*) That the velocity of the wind is always nearly proportional to the closeness of the isobars.

(*d*) That the weather—that is to say the kind of cloud, rain, fog, &c.—at any moment depends on the shape and not the closeness of the isobars, some shapes being associated with good and others with bad weather.

(*e*) That the regions thus mapped out by the isobars were constantly shifting their position, so that changes of weather were caused by the drifting past of these areas of good or bad weather, just as on a small scale rain falls as a squall drives by. The motion of these areas was found to follow certain laws, so that forecasting weather changes in advance became a possibility.

(*f*) That in the temperate zones sometimes, and habitually in the tropics, rain fell without any appreciable change in the isobars, though the wind conformed more regularly to the general law of these lines ; this class of rainfall is called "non-isobaric rain."

It is important always to remember "Buys' Ballots Law," viz. :—

In the Northern Hemisphere face the wind and the barometer will be lower on your right than on your left.

In the Southern Hemisphere face the wind and the barometer will be lower on your left than on your right.

The wind is sometimes parallel to the isobars but more often it inclines towards the nearest low pressure.

The Fundamental Shapes of Isobars.

These are illustrated by weather maps taken from the daily weather report of N.W. Europe, in which the land has been intentionally omitted ; it must therefore be remembered that some of the winds are influenced by the land and may not in all cases conform to the rules of free air over the ocean, though generally they are similar.

1. **The Cyclone.**—An area of low pressure bounded by circular or oval isobars. Fig. 1.

2. **The Secondary** cyclone, or shortly "secondary," a small circular depression, subsidiary to the foregoing. Figs. 1 and 5.

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. Fig. 2.

4. **The Anti-cyclone.**—An area of high pressure, bounded by circular or oval isobars. Fig. 3.

5. **Wedged-shaped Isobars.**—An area of high pressure bounded by isobars converging to a point like a wedge. Fig. 4.

6. **Straight Isobars.**—A barometric slope, across which the isobars lie in straight lines. Fig. 5.

7. **The Col** or neck of low pressure lying between two adjacent anti-cyclones. Fig. 6.

Cyclones, V's and secondaries usually move in an easterly direction in the temperate zones, but they sometimes travel to the westward, which makes forecasting extremely difficult.

Anti-cyclones are sometimes stationary for long periods ; they may be called the feeders of cyclones and affect their course and movement.

Cyclones.—Closed isobars, usually circular or elliptical in shape with low pressure at the centre. The wind blows round and towards the centre anti-clockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere.

The path of a cyclone is the path taken by its centre. The trough is a line drawn through the centre, usually at right angles to the path. At places before the trough the barometer is falling, and in rear of the trough it is rising. Near the trough the wind may shift suddenly and there may be much rain. The temperature is always higher in front of the trough than in the rear. In front of a cyclone the weather is usually muggy, particularly on the right front in the Northern Hemisphere and in the left in the Southern Hemisphere. In rear the weather is usually cool and exhilarating. Fig. 1 shows the wind circulation. Fig. 7 illustrates the cyclone prognostics.

In extra tropical cyclones there is seldom calm at the centre, and the barometric gradient is not necessarily steepest near the centre, so that the strongest winds may sometimes be experienced at some distance from the centre. Cyclones vary in intensity ; when deep they cause gales, but when shallow may only cause moderate winds ; they may bring much rain or none at all.

If we imagine the conditions of the cyclone in Fig. 1 with its isobars, wind arrows, and weather, and the prognostics in Fig. 7 to be embodied in one system, and that we are a stationary observer in its path, we shall get an idea of the sequence of events that will pass over us in a cyclone travelling in an east-north-easterly direction, which will be valuable when by

making a weather map from W/T reports we find that one of these systems is approaching.

In a ship under way at sea it will be necessary to consider not only the movement of the system but the course and speed of the ship with relation to it.

Secondary Depression.—A bend in the isobars usually on the equatorial side of cyclones.

Secondaries usually travel in the same direction as, and sometimes faster than, the main cyclone; they may have their own wind circulation or cause an alteration in the direction and force of the winds in their neighbourhood in the main cyclone.

They usually produce rain and sometimes much wind caused by the crowding together of the isobars on the equatorial side of the main cyclone. Secondaries are often associated with thunderstorms.

Their conditions are very variable, and so make forecasting difficult.

V-shaped Depression.—Named thus from the shape of the isobars enclosing an area of low pressure.

The V points in an equatorial direction. The wind blows along the isobars and towards the trough which passes through the points of the V's formed by the isobars. Forward of the trough there is much cloud and rain; as the trough passes there is a sudden shift of wind, often accompanied by heavy squalls. When the trough passes, the weather clears. Westward of V's the weather is usually very clear.

Anti-cyclone.—A high pressure system. The atmospheric pressure is highest near the centre enclosed by isobars, usually more or less circular or oval and widely separated. These systems often cover a large area in which the air is comparatively calm and cool near the centre, while at the outskirts the wind blows round the centre in the opposite direction to that of a cyclone and inclining out from it.

Fig. 8 shows the general prognostics for summer and winter anti-cyclones in the region of the British Isles.

The changes of weather at place in anti-cyclones are often caused more by diurnal variations than by the movement of the system as in cyclones.

Wedge.—Just as an anti-cyclone is of opposite characteristics to a cyclone, so is a wedge the converse of a V.

Wedge-shaped isobars enclosing an area of high pressure, usually extending from an anti-cyclone polewards between two depressions.

In front of the wedge there is often a region of very fine weather with northerly winds in northern latitudes and southerly winds in southern latitudes. Along the centre line of the wedge there is calm; in rear of this line the winds are from an equatorial and westerly direction and there is often rain.

THE FUNDAMENTAL SHAPES OF ISOBARS.

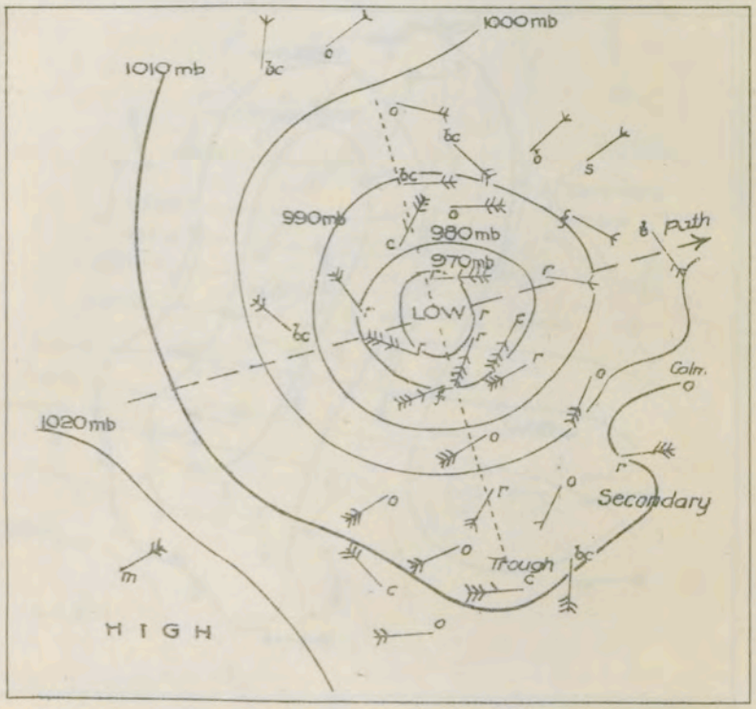

Fig. 1.—Cyclone and Secondary.

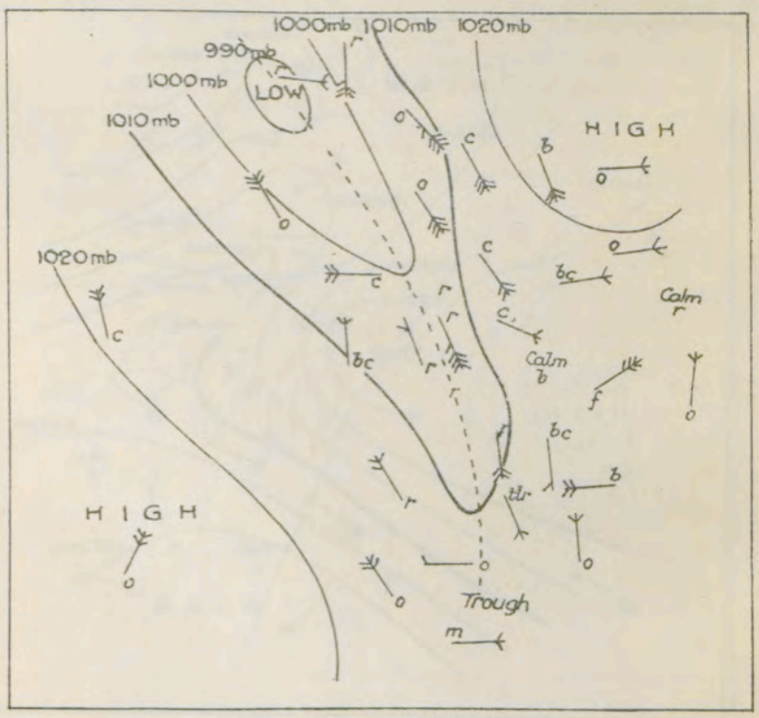

Fig. 2.—V-shaped depression.

H.M. Stationery Office Press, Kingsway W.C.2.

Pa.16982/426. wt. 9963. 6/19. 3/8. 3,250. 7/21.

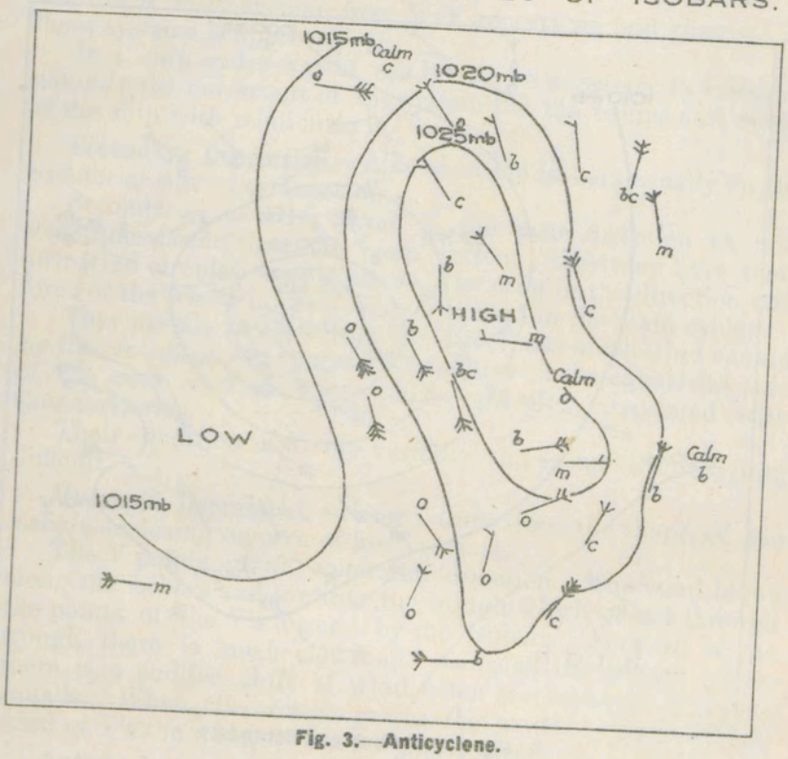

Fig. 3.—Anticyclone.

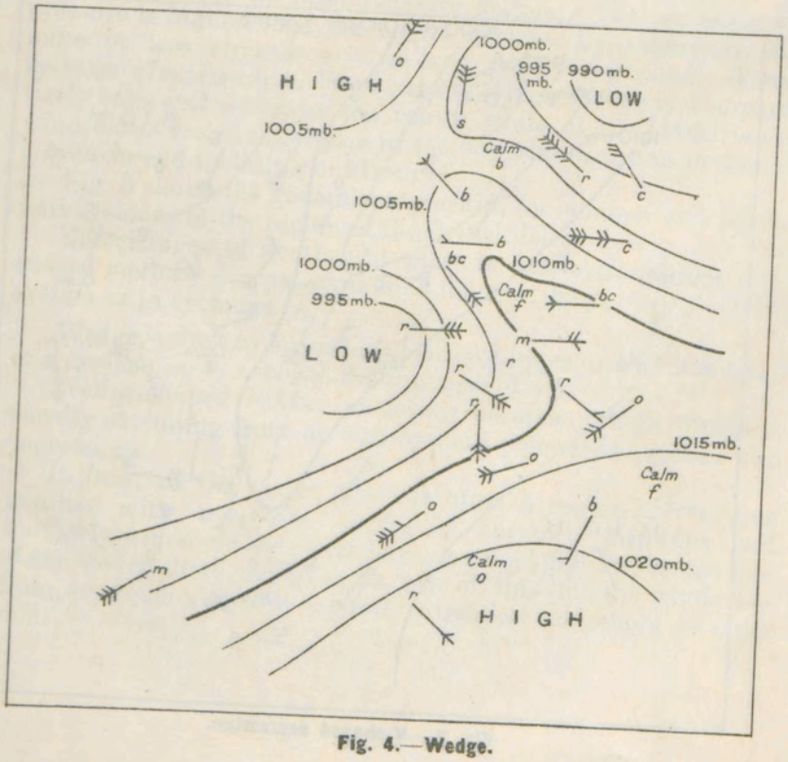

Fig. 4.—Wedge.

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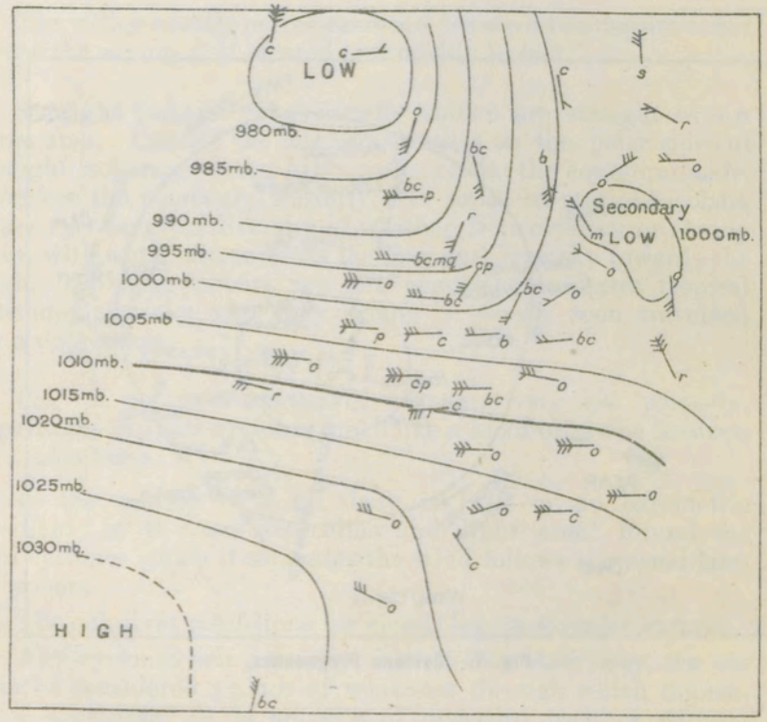

Fig. 5.—Straight isobars between Cyclone and Anticyclone.

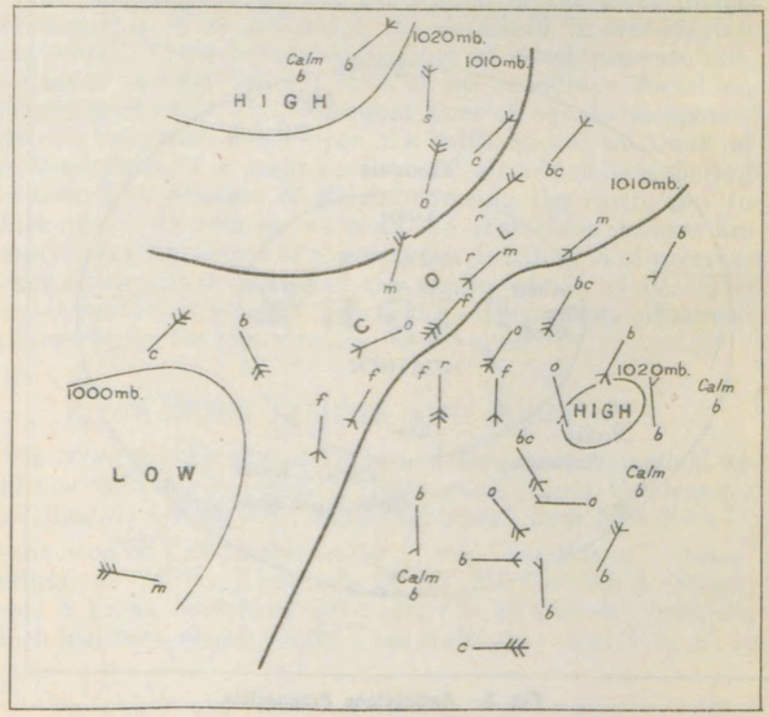

Fig. 6.—Col.

H.M.Stationery Office Press, Kingsway W.C.2.
Ps.16988/428. wt.8963. 6219/3/8. 3250.7/21.

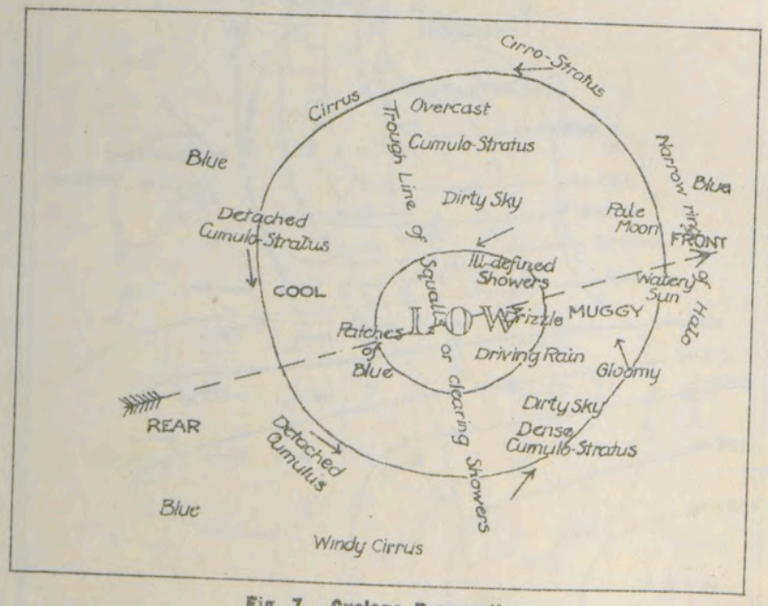

Fig. 7.—Cyclone Prognostics.

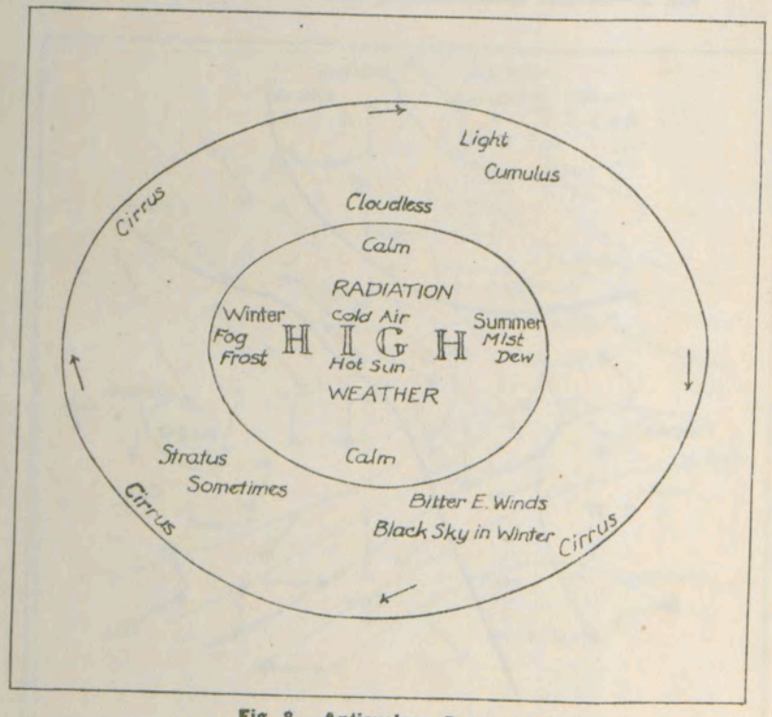

Fig. 8.—Anticyclone Prognostics.

H.M. Stationery Office Press, Kingsway W.C.2.

Pa. 19988/928. wt. 9983. 6219/318. 3,250. 1/21.

The wedge usually moves eastward between two depressions; hence the saying, "It cleared too quickly to last."

Straight Isobars.—Occasionally isobars are straight over a large area. Usually the low pressure lies on the polar sides of straight isobars, and the high pressure on the equatorial side, therefore the winds are westerly. In areas of straight isobars there may be great diversity of weather, from overcast or cloudy skies with some rain towards the low, and blue sky towards the high. Straight isobars are not persistent in extra tropical latitudes, and the area they occupy is usually soon traversed by a depression.

Col.—A col is a region of comparatively low pressure, separating two anti-cyclones much like a kloof or ravine between two mountains.

In the middle of a col there is little or no barometric gradient; in it there are calms and light airs. Round the anti-cyclones which it separates the wind follows the usual laws of isobars.

The col gives conditions for cloud, fog, or thunder storms.

Anti-cyclones being usually more or less stationary, the col may be considered a place of weakness through which depressions may pass. It is an area of unsettled weather without much wind.

The foregoing is a general description of the seven fundamental shapes of isobars which may be found in ever-varying complexity. These isobars being lines of equal pressure may be likened to the contour lines of sea soundings found on navigating charts. They represent lines of equal atmospheric pressure weighing down upon the earth, and if we think of the atmosphere as a great envelope of air which is suffering constant local changes of weight covering the earth, and in which the earth rotates, we shall see that these isobars are simply a graphic means of showing the distribution of pressure at any moment over an area of the surface of the globe. The wind is the flow of air from high towards low pressure influenced in direction by the rotary motion of the earth.

6. WEATHER CHARTS AND FORECASTS.

In order to show the advantages of the synoptic method we will first take the log of S.S. "Strathearn," Lieut.-Commander D. Jeffrey, D.S.O., R.N.R., homeward bound from New York.

At noon on 2nd December 1920, the "Strathearn" was in Latitude 49° 14′ N., Longitude 28° 45′ W., steering N. 80° E., speed 8 knots, barometer 1010 mb. (29·83 inches) corrected, which had been almost steady since midnight; wind N. by W. 4,

which had not varied more than a point in the last 12 hours; sky cloudy, clouds coming slowly from W.

The barometer rose during the afternoon and first dog watches; at 6 p.m. it was 1013 mb. (29·94 inches) corrected, the wind remaining N. by W. decreased to force 3.

With her own observations only, "Strathearn" *surmises* that a depression which passed her on the previous day is travelling at a far greater speed than her own to the east, for facing the wind she knows that pressure is lower to the right or ahead of the ship, and yet as she proceeds east the barometer rises. She expects light winds and fine weather for a time, but she cannot tell the extent of the high pressure area or its form. It may be a wedge with another depression following it quickly.

Few seamen would care to attempt more in the way of forecast than this, for they would not know how low the barometer was to the eastward or how the depression was moving, for in a ship under way we are very differently situated as regards foretelling weather to even an isolated stationary observer at the coast. With the "Poldhu" report and reports from a few other suitably disposed ships we can do better than this. As an example, suppose "Strathearn" to have received the following reports and from them let us make a weather chart.

December 2nd, 1920,
Evening,
transmitted at 2130 G.M.T.

Poldhu.

Western.—Another deep depression off S.W. Ireland, probably moving north-east; bar. falling rapidly Valencia. Forecast wind S.E. to S.W., fresh or strong, probably reaching a gale between Blacksod Point and mouth of Channel, dull, some rain, visibility fair, sea rough.

12618 = Stornoway.—Bar., 1012 mb.; wind, W. 1; visibility, horizon well defined.

13326 = Blacksod.—Bar., 1013 mb.; wind, S.E. 2; visibility, objects not visible 4 miles.

19527 = Holyhead.—Bar., 1019 mb.; wind, S.W. 2; visibility, objects not visible 7 miles.

21334 = Scilly.—Bar, 1021 mb.; wind, S.E. 3; visibility, objects not visible 1 mile.

22728 = Dungeness.—Bar., 1022 mb.; wind, N.W. 2; horizon well-defined.

26212 = Barometer tendency—Stornoway—rising slowly.
Blacksod—falling slowly.
Holyhead—rising slowly.
Scilly—steady.
Dungeness—rising.

Ship.	Position.		Bar. corr.	Wind.		Weather.	G.M.T.
	Lat.	Long.		Direction.	Force.		
Batsford - - -	51° 10′ N.	24° 8′ W.	1012	N.N.W.	4	c	1600*
Empress of Britain -	51° 9′ N.	13° 13′ W.	1002	S.S.W.	7	or	1700
Strathearn - -	49° 20′ N.	27° 35′ W.	1013	N. by W.	3	b	1600
Deseado - - -	43° 43′ N.	9° 3′ W.	1031	W.S.W.	2	o	1800
Megantic - - -	55° 17′ N.	12° 35 W.	1009	S. by E.	4	o	1700
Oristano - - -	47° 0′ N.	25° 20 W.	1022	Var.	2	bc	1600

Over a portion of a small scale chart which covers that part of the world the ship is in, pin a piece of tracing paper. Meteorologists use maps on the conical projection because these have less distortion, but a navigator being familiar with mercator charts will find that for his purpose these are most suitable. Take Fig. 9 as an example. At the position of the shore stations given in the Poldhu report, with a protractor lay off wind arrows, each feather representing one of the Beaufort scale; the arrows fly with the wind and their heads indicate position. Abreast these stations write the barometer, in millibars or inches, the tendency of the barometer and visibility. Next plot the position of each ship reporting, and at these positions draw the wind arrows and write barometer, weather by the Beaufort notation, and any other useful information contained in reported remarks.

If ship's barometer tendencies are given it must be remembered that these are compromised by course and speed. Next pick out the lowest barometer reading plotted on the chart and facing the wind to the right with soft pencil write "low"; also pick out the highest barometer reading on your chart and facing the wind to the left write "high." When this has been done, if there is a well defined weather system it will be seen that the wind arrows give a general indication of how the wind is circulating at the surface. In this case it is quite evident that the "Empress of Britain" is in a cyclonic depression and we can form an idea of how the isobars will run. The barometer of the "Empress of Britain" is 1,002 mb. (29·58 inches). For practical purposes at sea it is sufficient to draw the isobars for each 4 m.b.s. or ·12 of an inch; or steps of 4 millibars up or down from 1,000 m.b. (29·53 inches) are convenient.

Remember Buys Ballot's Law, for it helps us greatly, especially at sea, away from the land and local causes. Ashore the wind may not conform so nearly to this law, and our Poldhu

* These observations were timed ship's time in the logs, so that we are only able to give the nearest hour of G.M.T.

report only gives the wind direction to 4 points. At sea, the wind should be observed and reported to the nearest point. The force of the wind at "Empress of Britain" is 7 and its direction S.S.W.; here the space between the isobars will be fairly narrow, indicated by the force of the wind.

The isobar 1,004 mb. (29·65 inches) is lightly sketched in, passing east of "Empress of Britain," and curving so that it may pass through places which are estimated to have the same barometric pressure; these are judged by the height of the barometer of "Batsford," "Megantic," and Blacksod. Next draw the 1,008 mb. (29·77 inches) isobar from S.W. of "Megantic," curving around the low to E. of "Batsford." The 1,012 mb. (29·89 inches) isobar passes through "Batsford," curves around the low, passes W. of Blacksod, and then turns N.E. through Stornoway. In this manner the remaining isobars are roughly drawn, remembering that usually the wind blows along isobars inclining towards the low, so that the wind arrows help to guide us.

When the isobars, which it is possible to draw with the observations available, are roughed in, using pencil and india rubber we improve them, making them close together where the wind is strong and wider apart where it is light. The winds at Scilly and Dungeness, together with the barometer, help us to draw the curve in the isobars over the Channel and England, which indicate a wedge of high pressure. We now have a weather chart clearly showing a depression centred in about Latitude 52° N., Longitude 15° W., which not only governs the weather over the area it covers, but according to its movements, and increase or decrease of intensity, will change the weather at places over which it passes.

In making a forecast for eastbound ships the probable path of the cyclone is the first consideration. Now the barometer is rising slowly at Stornoway and Holyhead. It is rising at Dungeness and steady at Scilly. At Blacksod the barometer is falling slowly, and it is falling rapidly at Valencia, another station on the west coast of Ireland, so that it is probable that the centre is approaching these, and by a visual estimation we may draw an arrow from Latitude 52° N., Longitude 15° W., in an east-north-easterly direction as the probable track of the centre.

The outline of the coast may now be traced in, the tracing paper removed from the chart and our weather chart for the evening of December 2nd is complete if backed by a white sheet to make it show up clearly. From it we can now get a very good idea of how the official forecast for the western coasts of the British Isles is made; though the forecaster at the Meteorological Office had more information from shore stations,

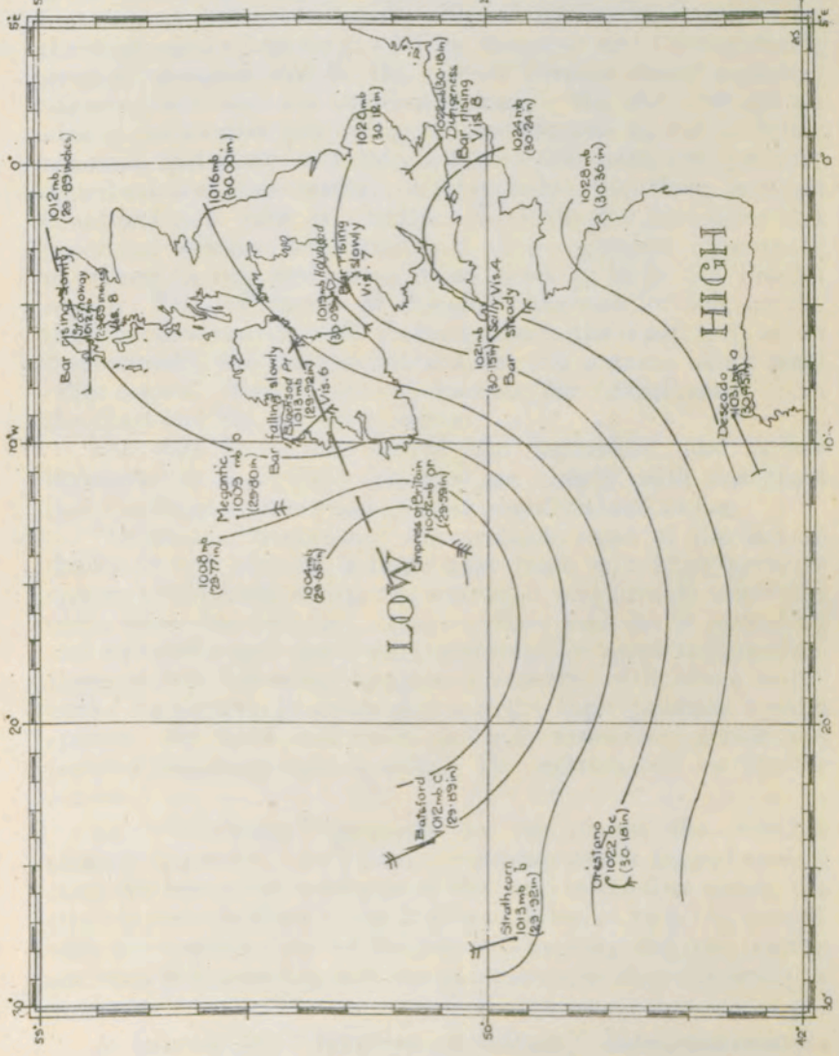

Fig. 9.

WEATHER CHART, EVENING, DECEMBER 2ND, 1920.

H.M. Stationery Office Press, Kingsway W.C.2.

including Iceland, Faröe, the Continent, and Azores. The conclusions are as follows:—

The wind is reported as S.E. at Scilly and Blacksod, which are both in the advanced semicircle of the depression. At Holyhead the wind is S.W., barometer still rising slowly, and at Stornoway the wind is W., barometer still rising slowly, so that they are not yet materially affected by the depression. As the depression advances in a N.Ely. direction and the barometer gradient steepens, that is, the isobars become closer together, the wind will veer and increase in force. We can only get an idea of the weather prevailing at these stations by the visibility reported, and where it is not good, with this nature of pressure distribution at these stations it is probable that there is much cloud and rain, mist or drizzle. No doubt the forecaster had reports of weather, but visibility is of the greatest importance to seamen, hence preference being given to it in the Poldhu report. The "Empress of Britain" has rain, which, as the depression advances, will probably reach the coast, if it is not there already, the reduced visibility at the stations being from other causes. Now to make a forecast for "Strathearn" from the chart and her own observations.

The ship is in the rear of the depression, and as her barometer is rising she can now see clearly with this chart that the depression is passing away rapidly ahead of her.

"Oristano's" report and the probable tread of the isobars drawn in her vicinity indicate that there is a high pressure system to the south and to the westward, and here is where she needs more observations. It seems likely that this is spreading and we must watch until next morning for more information. However, the following forecast is ventured with some assurance. As the ship proceeds east and the high pressure system spreads, the wind will back, probably remaining gentle and possibly becoming light or calm. The weather will be fine for a time.

As "Strathearn" proceeds on her course the weather steadily improves. At 8 p.m. the atmosphere is logged as very clear, the barometer continues to rise, and in the first watch the wind is variable force 3; at 2.10 a.m. it backs to S.W., force 3, with her weather chart of the previous evening she can almost see what is happening, and she gains some faith in the synoptic method.

A forecast for "Empress of Britain," Lieut.-Commander E. Griffiths, R.N.R., steering west at 17 knots, will serve as a better example, in this case for west-bound ships. This ship and the cyclonic depression are meeting rapidly, the centre will pass north of her and she appears to be very near the trough. The wind will shortly veer very rapidly to northward of west and the weather will then steadily improve. Visibility is likely to be very good.

December 3rd, Morning.

After breakfast the following W/T reports are received on the bridge of "Strathearn" from the W/T office :—

Poldhu.—Transmitted at 0930.

Very deep depression centred over the North Channel. Forecast, wind W. and N.W., strong or a gale, backing again later, squally, showery, fair intervals, visibility fair.

99116 = Stornoway.—Bar., 999 mb.; wind N.E. 1; visibility, objects not visible at 4 miles.

02667 = Blacksod.—Bar., 1002 mb.; wind W. 6; visibility, objects not visible at 7 miles.

97586 = Holyhead.—Bar., 997 mb., wind S.W. 8; visibility, objects not visible at 4 miles.

13777 = Scilly.—Bar., 1013 mb.; wind N.W. 7; visibility, objects not visible at 7 miles.

15565 = Dungeness.—Bar., 1015 mb.; wind S.W. 6; visibility, objects not visibility at 2 miles.

73658 = Barometer tendency :—

Stornoway falling quickly.
Blacksod rising quickly.
Holyhead falling.
Scilly falling slowly.
Dungeness falling very rapidly.

Ship.	Position.		Bar. Corr.	Wind.		Weather.	G.M.T.
	Lat.	Long.		Dir.	Force.		
Batsford - - -	51° 9′ N.	27° 33′ W.	1028	W.	5	c	0500
Empress of Britain -	51° 18′ N.	19° 7′ W.	1029	W.	7	cv	0600
Strathearn - -	49° 29′ N.	24° 49′ W.	1033	SW.	3	bv	0500
Deseado - - -	46° 3′ N.	8° 7′ W.	1025	S.W. by W.	9	orq	0700
Megantic - - -	54° 50′ N.	17° 50′ W.	1018	W. by S.	7	c	0600
Oristano - - -	46° 28′ N.	27° 59′ W.	1031	Var.	2	bc	0500

With these reports another weather chart, Figure 10, is made in exactly the same manner as that of yesterday. It will be seen that the centre of the depression has travelled some 360 miles E.N.E. in the interval, and is now, as stated in the Poldhu report, centred over the North Channel.

The Poldhu "forecast" can be verified because although we lack observations at stations nearer the centre than Holyhead, it is obvious that the barometric gradient between Holyhead and the centre must be steep, for at Holyhead the wind is at gale force.

"Strathearn" now confidently forecasts that she will have fine weather, and light to moderate winds from a south-westerly

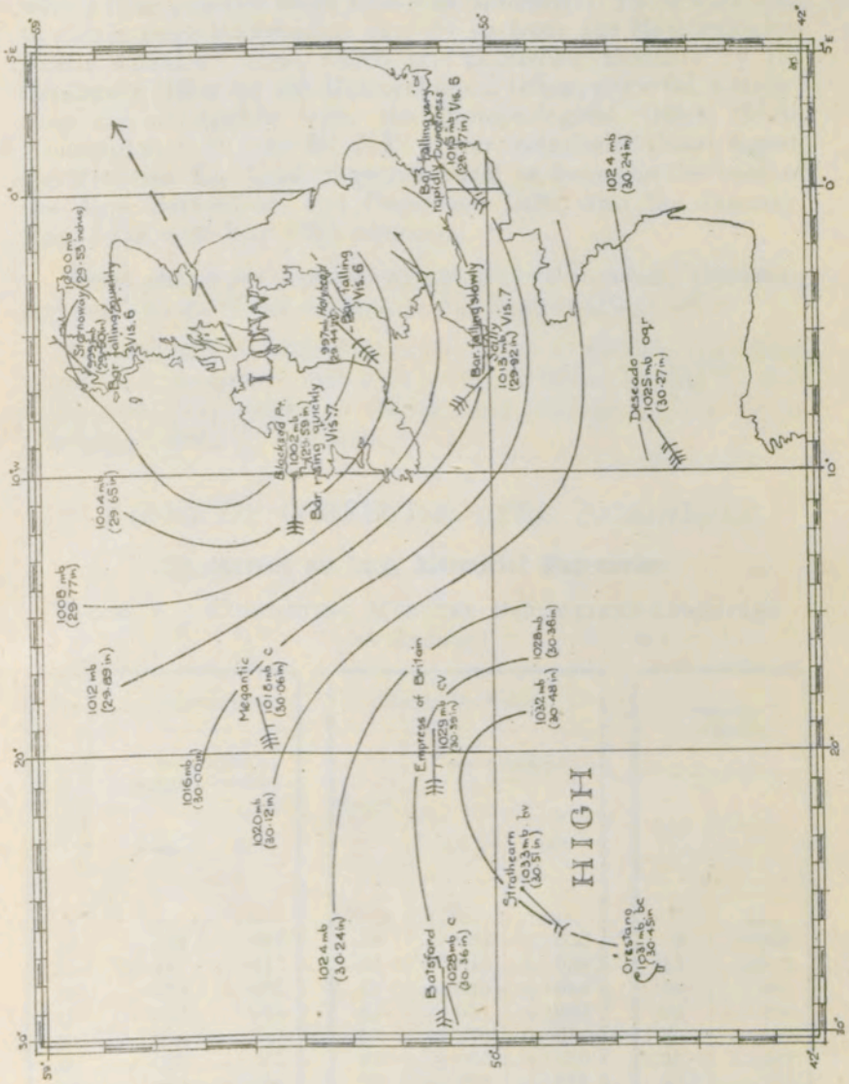

Fig. 10.

WEATHER CHART, MORNING, DECEMBER 3RD., 1920.

direction for at least one day, probably more, because the anti-cyclone centre S.E. of her is spreading to the eastward. She will, however, note that "Megantic's" wind and barometer seem to indicate a depression north of her position, and this will serve as an example for the need of accuracy in wind observation.

Navigators may find isobars difficult to draw at first, but with a little practice there is no real difficulty. Those who wish to obtain more information can do so from the Meteorological North Atlantic Charts, which are published monthly by the Stationery Office for the Meteorological Office, price 6*d*. a copy; they are obtainable from the Meteorological Office, South Kensington, S.W., and Mr. J. D. Potter, Admiralty Chart Agent, the Minories, E. Useful examples will be found on the back of the May, September, and December 1920, also the January, May, June, and July 1921 numbers.

These charts are supplied gratis to ships regularly observing and sending in official returns to the Meteorological Office.

In the North Atlantic fog is no doubt of the first consideration to the navigators, and with a view to this they will do well to include temperature of the air and the sea surface in the remarks of their W/T reports.

7. MEANS OF CORRECTING THE BAROMETER.

To correct an inch Mercurial Barometer.

TABLES FOR CORRECTING MERCURY BAROMETERS GRADUATED IN INCHES.

Temperature Correction.			Height Correction.			Gravity Correction.	
Temperature of Attached Thermometer.	Barometric Height—Inches.		Height.	Temperature of Air.		Lat.	—
	29·0.	30·0.		40°.	60°.		
° F.	Ins.	Ins.	Feet.	Ins.	Ins.	°	Ins.
30	−·004	−·004	30	+·034	+·032	0	−·078
35	−·017	−·017	35	+·040	+·038	10	−·073
40	−·030	−·031	40	+·045	+·043	20	−·060
45	−·043	−·045	45	+·051	+·049	25	−·050
50	−·056	−·058	50	+·056	+·054	30	−·039
55	−·069	−·072	55	+·062	+·060	35	−·027
60	−·082	−·085	60	+·068	+·065	40	−·013
65	−·095	−·099	65	+·074	+·071	45	−·000
70	−·109	−·112	70	+·079	+·076	50	+·013
75	−·122	−·126	75	+·085	+·082	55	+·027
80	−·135	−·139	80	+·091	+·087	60	+·039
85	−·148	−·153	85	+·097	+·093	65	+·050

Example.

In Latitude 51° N. barometer reads 30·240 at a height of 36 feet above sea level. The attached thermometer reads 58° F. and the index error is + ·005.

Uncorrected reading - - - - -	30·240	inches.
Index error - - - - - -	+ ·005	,,
	30·245	,,
*Temperature correction for 58° F. - -	− ·080	,,
	30·165	,,
*Height correction for 36 feet at air temperature of 58° F. - - - -	+ ·039	,,
	30·204	,,
*Gravity correction in Latitude 51° N. -	+ ·014	,,
	30·218	,,
	or 30· 22	,,

To correct a Millibar Mercurial Barometer.

The standard temperature of the barometer is given on the Kew Certificate pasted on the inside of its packing case; it should also be engraved on the instrument itself.

TABLE OF CORRECTION FOR GRAVITY.

(Corrections to be applied to the standard temperature.)

Latitude of Ship -	0°	10°	20°	25°	30°	35°
Correction *a* -	− 15·0	− 14·0	− 11·5	− 9·5	− 7·5	− 5·0
Latitude of Ship -	**40°**	**45°**	**50°**	**55°**	**60°**	
Correction *a* -	− 2·5	0·0	+ 2·5	+ 5·0	+ 7·5	

Example.

Standard temperature of barometer -	284·2 *a*	
Ship's latitude 52° N., correction - -	+ 3·5 *a*	
	287·7 *a*	

* When the temperature, height, or latitude is not exactly given in the table the correction is obtained by proportion. Thus we find the temperature correction for 55° is −·072 and for 60° is −·085, so the correction for 58° is −·080.

Divide height of barometer in feet above sea level by 5 and add—

Thus barometer 42 feet ÷ 5 - -	+ 8·4 *a*	
Adjusted fiducial temperature - -	296·1 *a*	
Subtract observed temperature of attached thermometer at time of observation - - - - - - -	− 289·0 *a*	
Divide by 6 - - - - - -	+ 7·1 *a*	
	+ 1·2 *a*	

Call the result millibars and add it to or subtract it from the observed reading of the barometer according to its sign—

Observed barometric reading - -	1017·1	mb.
Correction as above - - - -	+ 1·2	mb.
Corrected barometric reading - -	1018·3	mb

Broadly this method is a dodge whereby the index error, temperature, height, and gravity are applied. For full particulars *see* the Marine Observers' Handbook, obtainable through any nautical bookseller or from the Stationery Office.

Index Errors of Mercury Barometers.

To obtain the index error of a mercury barometer it is necessary to compare it with the standard barometer of which the index error is known. This may be done by hanging the two up side by side and allowing at least half an hour for them to settle. At the end of that time they are both read and corrected as explained. The difference between the two corrected readings is the index error of the ship's barometer.

Standard barometers are kept at the Marine Division Meteorological Office, Air Ministry, Kingsway, London, the Port Meteorological Office, Dock Office, Liverpool, and at all stations shown in the Daily Weather Report as taking barometric readings.

An approximate method which can be used to obtain a rough correction is to read the ship's barometer at 7 or 18 hours G.M.T. (civil time) when the ship is lying in port, and after correction for temperature, height and gravity, to compare the reading with that of a neighbouring station as given in the Daily Weather Report.

In using this method the occasion must be one on which the ship is lying within a few miles of the observatory and on a day on which the isobars of the Daily Weather Map are not too

close together. As a rough guide, when the force of the wind is less than 3 on the Beaufort Scale, this method may be used with safety.

If further information is required on the correction and care of barometers, the reader is referred to the Marine Observers' Handbook, in which full tables are given.

The most satisfactory procedure is to use a barometer with a Kew Certificate. Barometers are officially tested at the National Physical Laboratory, Teddington, for which test a fee is charged.

It must be clearly understood that before converting millibars to inches or *vice versa* the reading must be corrected.

8. BEAUFORT WIND SCALE.

Admiral Beaufort's Numbers.	Seaman's Description of Wind.	Deep Sea Criterion.	Coastal Criterion.
0	Calm	—	—
1	Light air	Just sufficient to give steerage way with the wind free.	Sufficient to give good steerage way to fishing smacks with the wind free.
2	Light breeze	Well conditioned ship with all sail set in smooth water "full and by" will make 2 knots.	Fishing smacks with topsails and light canvas "full and by" make up to 2 knots.
3	Gentle breeze	Ditto 3 to 4 knots	Smacks begin to heel over slightly; under topsails and light canvas, make up to 3 knots, "full and by."
4	Moderate breeze	Ditto 5 to 6 knots	Good working breeze. Smacks heel over considerably on a wind under all sail.
5	Fresh breeze	Ship "full and by" can just carry royals and light stay-sails.	Smacks shorten sail.
6	Strong breeze	Ship "full and by" can just carry topgallant sails.	Smacks double reef gaff mainsails.
7	Moderate gale (*half a gale*).	Ship "full and by" can just carry whole upper topsails.	Smacks remain in harbour and those at sea lie to.
8	Fresh gale	Ship "full and by" can just carry reefed upper topsails and whole foresail.	Smacks take shelter if possible.
9	Strong gale	Ship "full and by" can just carry lower topsails and reefed foresail	—

Admiral Beaufort's Numbers.	Seamen's Description of Wind.	Deep Sea Criterion.	Coastal Criterion.
10	Heavy gale (*whole gale*).	Ship "full and by" can only carry main lower topsail.	—
11	Storm	Ship can only carry storm stay-sail or trisail.	—
12	Hurricane	No canvas can stand	—

Beaufort Notation of Weather.

LETTERS TO INDICATE THE STATE OF THE WEATHER.

†b	Blue sky (not more than a quarter covered).	†o	Overcast sky.
†bc	Sky partly cloudy (one half covered).	p	Passing showers.
†c	Generally cloudy (three quarters covered).	q	Squalls.
d	Drizzle, or fine rain.	r	Rain.
e	Wet air without rain falling.	rs	Sleet, *i.e.*, rain and snow together.
f	Fog.	s	Snow.
g	Gloom.	t	Thunder.
h	Hail.	u	Ugly, threatening sky.
l	Lightning.	v	Unusual visibility.
m	Mist.	w	Dew.
		z	Dust haze; the turbid atmosphere of dry weather.

† These letters are only intended to refer to the amount of cloud. They are regarded as the equivalents of the following cloud amounts, scale 0—10; b = 0—3; bc = 4—6; c = 7 and 8; o = 9 and 10.

It is well to bear in mind that w = dew, but d = drizzling rain, and e = wet air without rain; p = passing showers of rain, and q = squalls, but s = snow.