M.O 297

WIRELESS AND WEATHER
AN AID TO NAVIGATION.

NOTICE.

In order to facilitate the practice of Wireless and Weather an Aid to Navigation, arrangements have been made for placing on sale at the Air Ministry the following outline charts, for convenience in making simple weather charts at sea.

Form 1089. Outline Chart of Eastern N. Atlantic (north of Latitude 38° N.).

„ 1973. Outline Chart of Eastern N. Atlantic and Mediterranean (Latitude 20° N. to Latitude 60° N.).

„ 1245. Outline Chart of North Eastern Pacific.

„ 1246. Outline Chart of North Western Pacific.

„ 1253. Outline Chart of South Western Pacific.

„ 1254. Outline Chart of West Indies and U.S.A. Atlantic Coast.

„ 1268. Outline Chart of Australian Waters.

„ 1269. Outline Chart of South African Waters.

„ 1290. Outline Chart of South American Waters.

„ 1297. Outline Chart of Arabian Sea and Bay of Bengal.

The price of these charts is *4s. 5d.* per 100, exclusive of postage.

Applications for these charts which should be accompanied by remittance, should be addressed to The Director, Meteorological Office, Air Ministry, London, W.C.2.

(2312) 1250

M.O. 297

FOR OFFICIAL USE

WIRELESS AND WEATHER AN AID TO NAVIGATION

BY

CAPTAIN L. A. BROOKE SMITH, R.D., R.N.R.

From "The Marine Observer."

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"Wireless and Weather an Aid to Navigation," Second Edition, is reprinted herein from Volume IV of THE MARINE OBSERVER, with three Appendices, giving particulars of Ships' Wireless Weather Signals, the British Wireless "Weather Shipping" Bulletin and Decode Tables of the International Weather Telegraphy Code. For descriptions of Wireless Weather Signals on all coasts of the World the latest Volume of THE MARINE OBSERVER and "ADMIRALTY LIST OF WIRELESS SIGNALS" should be referred to.

CONTENTS.

FOREWORD.

In 1854 the British Government established a Meteorological Department under the Board of Trade with Admiral FitzRoy at its head. The chief function of this office was to collect information regarding the prevailing winds and ocean currents in all parts of the world in order that ships might make safe and rapid passages. From that day to this the collection of meteorological data at sea has never ceased and on the observations so made our knowledge of the general circulation of the atmosphere and of the distribution of pressure and temperature in all parts of the world is mainly based.

The whole object of this laborious process was to determine the "normal conditions" so that the sailor might know the type of weather he was most likely to meet in all seas. It could never tell him what the weather would be; but only what it was most likely to be.

Land meteorology started along the same lines, the collection of climatological data being at first its only activity. The introduction of the electric telegraph, however, made a great change for now it was possible to collect information about the existing weather from a large area and with this knowledge to form some opinion as to how the weather was about to change. Thus synoptic meteorology was born and Le Verrier in Paris and FitzRoy in London were the great pioneers of the new art of weather forecasting.

For over sixty years synoptic meteorology could only be used on land, for only on land was the rapid transmission of weather information possible. During these sixty years no modification could be made in meteorological methods at sea: the collection of data and the preparation of normal values continued almost exactly as they were initiated by FitzRoy; but now Wireless telegraphy has altered all that.

It is now as easy—perhaps more easy—to communicate between ship and ship as between meteorological offices on land, and all the great resources of synoptic meteorology are now available at sea as on land. To make proper use of these resources, however, much knowledge and organization are necessary. On land it has taken many years to establish an organization for the rapid dissemination and collection of meteorological data; and it will take many years before the organization at sea is equally efficient. International co-operation is necessary and this is admittedly difficult to attain; but rapid steps are being taken by the meteorological services of most countries. The data when received cannot be used without a knowledge of meteorological laws and methods. On land it is possible for a few experts sitting in a central office to interpret the information received and to issue detailed forecasts. At sea this is not possible, at least not at present, and if the organization for the transmission of weather information is to be made full use of it will be necessary for seamen to study synoptic meteorology and to make their own forecasts.

This book, originally published chapter by chapter in "The Marine Observer", is an attempt to give seamen an insight into the organization and methods of synoptic meteorology as applied to the sea. It has been written by a seaman for seamen. While scientific accuracy has been maintained the language used is that of the sea rather than that of pure science. Scientific terms cannot of course be excluded, but every attempt has been made to use no scientific expression without translating it into language readily understood by sailors, and all the examples given are taken from actual occurrences at sea.

There can be no doubt that synoptic meteorology at sea has a great future before it; and if full and early use is to be made of this great aid to navigation and safety of life at sea there must be close co-operation between the sailor and the meteorologist. It is to facilitate this co-operation that the Marine Division of the Meteorological Office exists, and "The Marine Observer" is published. The Marine Superintendent welcomes personal visits in London and he and our Agents at ports are ready at all times to give help and advice on any aspect of marine meteorology.

G. C. Simpson,
Director of the Meteorological Office.

November, 1927.

WIRELESS AND WEATHER. AN AID TO NAVIGATION.

PREFACE TO FIRST EDITION.

The following chapters are intended to replace and extend "Weather Forecasting in the Eastern North Atlantic and Home Waters for Seamen" and the articles which have appeared upon this subject on the Monthly Charts since May, 1920.

Particulars and descriptions of Weather Reports, Signals and Codes useful to shipping will be given separately in "The Marine Observer," in as concise a form as possible, under "Weather Signals," as they become available, for all parts of the world, if possible in geographical order.

Since the establishment in June, 1921, of the coded Wireless Weather Report, broadcast for shipping through Poldhu, then Clifden and latterly Valentia and Malin Head or Land's End and Malin Head, there has been much evidence that suitably conducted wireless weather reporting can be made of great value to the Mariner.

This message gave actual observations of barometric pressure, wind direction and force, visibility and barometric tendency taken at 0700 and 1800 Civil G.M.T. at Blacksod, Stornoway, Holyhead, Scilly and Dungeness, Coast Telegraphic Weather Reporting Stations, so that the Mariner was given some idea of the conditions upon which the Meteorological Office based its forecast for the Western Coasts which was issued in plain language at the same time. It gave ships near and at a distance a means for comparing barometric pressure which has led to a better understanding of the functions of the barometer as a means of measuring the pressure of the atmosphere and formed a basis from which to extend weather charting at sea.

The period is one of transition in method. Formerly, without distant communication, the Mariner was forced to rely upon his own isolated observations to predict weather, which, in ships proceeding at speed, was extremely difficult and uncertain. Wireless telegraphy has given him a means of communication whereby he may obtain information of existing weather conditions not only along his route, but at positions within range in all directions where there happen to be other reporting ships or stations. With such information and his knowledge gained by long experience the Mariner may obtain a better idea of what conditions he may expect. If he will plot the information and construct a weather chart he will have a graphic representation of the general conditions over a considerable area with detailed information at a number of points at the time of observation. From such a chart, with a knowledge of meteorology, he will generally be able to forecast the weather to be expected along his route for a day or even longer.

It is our aim to give suitable guidance to Mariners for the making of such charts and forecasts by a simple and quick process.

It will first be necessary to give a brief description of the Fundamental Weather systems as determined from charts for Extra Tropical Latitudes; though "The Marine Observer's Handbook" will remain the standard guide to the use of instruments and observation we shall give some brief notes upon special precautions which are necessary for instrumental observation in wireless weather work; then show how charts and forecasts may be made at sea from Wireless Weather Reports, and using the observations of Marine Observers give experiences and suggestions for the application of the method in all seas from which sufficient synchronised observations are available.

September, 1923.

PREFACE TO SECOND EDITION.

Since the first edition of these serial chapters was published in the first Volume of "The Marine Observer," many officers new to the Corps of Voluntary Marine Observers have joined, a considerable number have, therefore, not had complete information upon the subject. There have been many requests for these chapters and some have asked that they might be printed in cheap separate book form so as to be readily procurable by the Officers of the Merchant Service generally.

There have been developments which have been since dealt with in separate articles in later numbers of "The Marine Observer," so that it is intended to revise and improve the arrangement of the chapters in this year's "Marine Observer."

Many weather charts made by officers at sea with coast station and single ship observations, also quite a number with several ships' reports at a distance, have been returned to the Marine Division proving that weather charting is practical and becoming popular with increasing numbers of officers at sea.

Records of routine reports sent to "All Ships" (C.Q.) in Meteorological Logs and the new edition of the Ship's Meteorological Report (Form 911) show that there is steady progress in this form of observation and communication which is the real backbone of the system.

Every ship of the 500 on the Voluntary Observing Fleet List in "The Marine Observer" which has a mercurial barometer is invited to make these standard form plain-language reports to "All Ships" daily as a matter of routine.

Amongst many valuable contributions received we have a Track chart for the round voyage out and home giving the daily positions at the correct time of observation of a ship whose Commander has been a pioneer of this system with the Wireless Weather reports sent to C.Q.; also the names of ships which were actually in wireless touch at the time.

This evidence of the number of regular observing ships suitably distributed on any day which are in a position to give essential information and the great number of ships able to receive it is convincing; with good will and the unselfish work of Marine Observers a very effective Weather intelligence service can be established at sea. Many cases have been reported where this work has been a real aid to navigation both as regards safety and economy of time and fuel. Probably, at the time, those who provide and broadcast the information have no idea how important it may be, and therefore if made a habit of routine in a suitable number of suitably equipped ships it will be the more beneficial to all at sea.

As regards observations from the coast, broadcast from a central station, these, being provided by Telegraphic Weather Reporting Stations and Observatories equipped with instruments of a high order of accuracy especially as regards barometric pressure, provide a sound foundation upon which to extend. The station reports of the British Wireless "Weather Shipping" Bulletin, which Bulletin has replaced all other routine wireless weather messages for the British coasts for shipping, provide the necessary data and no more, in the form most suitable for seamen, this bulletin having been framed and drawn up after obtaining the concensus of their opinion as far as was possible.

This system of broadcasting in one message all the most important facts as regards weather at the coast, as well as official forecasts for adjacent sea districts on a definite plan and in the International Code, is one which it is hoped all maritime countries will adopt. Sweden has already followed by adopting a Wireless "Weather Shipping" Bulletin uniform with that of Britain; so that data for the N.W. coast of Europe is made available to seamen with the least trouble to them. Recently Australia and South Africa have adopted bulletins for shipping, giving observations at coast stations, but we hope that the wish which many British seamen have expressed, that all British Dominions may some day adopt a bulletin similar to that which they advocated and which has proved a success for the British Isles may be fulfilled.

Provision of data by wireless for the coasts of most countries of the temperate zones now exists and it is hoped that progress will soon be made on the coasts of tropical countries, especially where hurricanes are common.

If wireless and weather is an *aid* to navigation, it will be an *essential* to air navigation over the sea, and there is no doubt that aircraft will be used extensively for oversea communication quite soon.

It is therefore in our interests as seamen that wireless and weather as an aid to navigation should be well established upon sound lines as a recognised branch of seamanship. My endeavour has been, and is, to obtain facilities which are practical to seamen and to inform them of these in seamanlike terms.

July, 1926.

CHAPTER I.

OBSERVATION.

The object of the Synoptic Synchronous Weather Chart, simply termed for use at sea " The Weather Chart," is to give a picture of the actual weather conditions over an area at the same moment of time—a bird's eye view. For this purpose only observed facts are required. These facts may be made known to all ships having Wireless Telegraphy receiving gear, by ships having the necessary instruments and equipment, and by coast stations, communicating meteorological observations taken at a certain time and upon a definite plan.

The plan of observation best suited for Wireless reporting at sea is simply an improvement upon that adopted in all well-ordered ships for logging the weather and full instructions will be found in " The Marine Observer's Handbook." In this chapter will be shown the precautions which are necessary for instrumental observation and in framing the messages.

Time will be dealt with in a later chapter; meanwhile it is sufficient to say that observations which are broadcast for the purpose of giving data for making Weather Charts should be taken at the same time as those of the nearest coast.

The Barometer.

Absolute Pressure.

The isobar is the fundamental feature of the weather chart, and 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 Marine Mercurial barometer is the most satisfactory instrument for measuring atmospheric pressure at sea.

Mercurial Barometer Readings should be 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 halfway between the pole and the Equator, *i.e.*, Latitude 45°.

Aneroid Barometer readings are only corrected for index error and height because difference of gravity does not affect the measurement by these instruments and they are compensated for temperature. The Aneroid is not very reliable for measuring absolute pressure but its deficiencies have been somewhat exaggerated. If constant precautions are taken it may give sufficiently accurate readings for wireless weather work in Middle and High Latitudes. It is not sufficiently constant for comparing with normals in Low Latitudes for the purpose of obtaining warning of tropical revolving storms.

Be sure to ascertain the Index Error of the Barometer before sailing.

To correct a Mercurial Barometer.

Graduated in Inches.

Tables.

I. II. III.

Temperature Correction.					Height Correction.					Gravity Correction.	
Temperature of attached Thermometer.	Inches.				Height.	Temperature of Air.					
	28·0	29·0	30·0	31·0	Ft.	20°	40°	60°	80°	Latitude.	
°F.	Ins.	Ins.	Ins.	Ins.		Ins.	Ins.	Ins.	Ins.	°	Ins.
20	+·022	+·023	+·024	+·024	10	+·012	+·011	+·011	+·010		
25	+·009	+·010	+·010	+·010	15	+·018	+·017	+·017	+·016	0	-·078
30	-·003	-·004	- 004	-·004	20	+·023	+·023	+·022	+·021	10	-·073
35	-·016	-·017	-·017	-·018	25	+·029	+·029	+·027	+·026	20	-·060
40	-·029	-·030	-·031	-·032	30	+·035	+·034	+·032	+·031	25	-·050
45	-·042	-·043	-·045	-·046	35	+·041	+·040	+·038	+·037	30	-·039
50	-·054	-·056	-·058	-·060	40	+·047	+·045	+·043	+·042	35	-·027
55	-·067	-·069	-·072	-·074	45	+·053	+·051	+·049	+·047	40	-·013
60	-·080	-·082	-·085	-·088	50	+·059	+·056	+·054	+·052	45	-·000
65	-·092	-·095	-·099	-·102	55	+·065	+·062	+·060	+·057	50	+·013
70	-·105	-·109	-·112	-·116	60	+·071	+·068	+·065	+·062	55	+·027
75	-·117	-·122	-·126	-·130	65	+·077	+·074	+·071	+·068	60	+·039
80	-·130	-·135	-·139	-·144	70	+·083	+·079	+·076	+·073	65	+·050
85	-·143	-·148	-·153	-·158	75	+·089	+·085	+·082	+·078	70	+·060
90	-·155	-·161	-·166	-·172	80	+·094	+·091	+·087	+·083		
					85	+·100	+·097	+·093	+·089		

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.

		Inches.
Uncorrected reading		30.240
Index error correction	+	.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

Graduated in Millibars.

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 ... (degrees absolute)	– 15·0	– 14·0	– 11·5	– 9·5	– 7·5	– 5·0

Latitude of Ship.	40°	45°	50°	55°	60°
Correction ... (degrees absolute)	– 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
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
	+	7°.1 a
Divide by 6	+	1.2

* When the temperature, height or latitude is not exactly given in the tables the correction is obtained by interpolation.

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 Observer's Handbook," 4th Edition.

To obtain the Index Error of a Barometer.

Mercurial Barometer graduated in Inches.

The ship's instrument must be compared with a standard barometer, the index error of which is known.

Hang the instrument, of which the index error is required, up side by side with the standard and leave for half an hour so that they may settle.

Read both barometers and correct both readings as explained; the difference between the corrected readings (no index error having been applied to the ship's instrument) will be the correction to be applied for index error of the ship's barometer + if too low, – if too high.

Mercurial Barometer graduated in Millibars.

These instruments as at present lent to ships by the Meteorological Office have the index error combined in the corrections explained above; should the index error be found by reliable comparison to have materially changed, the matter should be reported to the Meteorological Office or Agent.

Aneroid Barometers.

Hang a mercurial barometer, the index error of which is known, up side by side with the aneroid and allow to settle. Read both instruments, correct the reading of the mercurial barometer as described but apply no correction whatever to the reading of the aneroid; the difference between these readings will be the index error and correction for height above sea level combined for the aneroid. The height of the instruments must not be changed. This procedure should be frequently repeated as the index errors of some aneroids vary from time to time.

Facilities for Barometric Comparison.

Standard barometers are kept at the Marine Division, Meteorological Office, Air Ministry, Kingsway, London, W.C.2, the Port Meteorological Office, Dock Office, Liverpool, and at all important Observatories. The barometers of telegraphic weather reporting stations in all parts of the world are sufficiently accurate for the purpose of ascertaining the index error of ship's barometers.

When possible the Port Meteorological Officer or Agent boards ships on the list of regular observers to the Meteorological Office, and compares the barometer, but all wishing to derive full benefit from wireless weather reports should make their own comparisons as well as completing and sending in the blue post-card, Form 913, regularly. A further check may sometimes be made at sea by using Coast Weather Reports.

Example.

Suppose a ship is doubtful of the index error of her barometer, and she happens to be within 10 miles of Holyhead at 7 a.m. G.M.T. when the wind is light. The barometer reading is noted and corrections applied. On receipt of the morning weather bulletin, described in Appendix II of this book, the approximate correct pressure at her position at 7 a.m. will be known and the difference with that observed should be the index error.

Such a comparison is only a check. If the wind is not light it should not be used, for gradient might cause error.

Conversion of Millibars to Inches.

It must be clearly understood that if two mercurial barometers, one graduated in inches and the other in millibars, are read at the same place and time, the uncorrected readings will differ. It is only when each reading has been reduced to the same datum that they will agree; the reason being that an inch barometer corrected for index error reads true at 28°.6 F. at sea level in Latitude 45°, while a millibar barometer reads true at its standard temperature, about 285° A. (54° F.) at sea level in Latitude 45°.

Therefore, before converting the reading of a millibar barometer to inches, or vice versa, by the Table, correct it.

Table IV.—Conversion of Millibars to Inches.

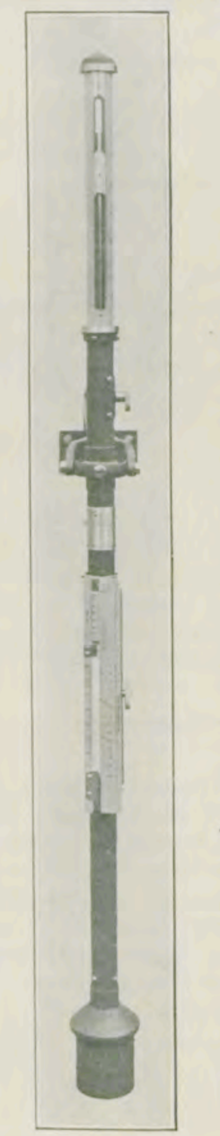
Equivalent in Mercury Inches at 32°, and Latitude 45° of Millibars.

Mb.	In.	Mb.	In.	Mb.	In.	Mb.	In.	Mb.	In.	Mb.	In.	Mb.	In.
925	27·32	940	27·76	960	28·35	980	28·94	1000	29·53	1020	30·12	1040	30·71
926	27·35	941	27.79	961	28·38	981	28·97	1001	29·56	1021	30·15	1041	30·74
927	27·38	942	27·82	962	28·41	982	29·00	1002	29·59	1022	30·18	1042	30·77
928	27·41	943	27·85	963	28·44	983	29·03	1003	29·62	1023	30·21	1043	30·80
929	27.44	944	27·88	964	28.47	984	29·06	1004	29·65	1024	30·24	1044	30·83
930	27·46	945	27·91	965	28·50	985	29·09	1005	29·68	1025	30·27	1045	30·86
931	27·49	946	27·94	966	28·53	986	29·12	1006	29·71	1026	30·30	1046	30·89
932	27·52	947	27·97	967	28·56	987	29·15	1007	29·74	1027	30·33	1047	30·92
933	27·55	948	28·00	968	28·59	988	29·18	1008	29·77	1028	30·36	1048	30·95
934	27·58	949	28·03	969	28·62	989	29·21	1009	29·80	1029	30·39	1049	30·98
935	27·61	950	28·05	970	28·65	990	29·24	1010	29·83	1030	30·42	1050	31·01
936	27·64	951	28·08	971	28·67	991	29·26	1011	29·86	1031	30·45	1051	31·04
937	27·67	952	28·11	972	28·70	992	29·29	1012	29·89	1032	30·48	1052	31·07
938	27·70	953	28·14	973	28·73	993	29·32	1013	29·92	1033	30·51	1053	31·10
939	27·73	954	28·17	974	28·76	994	29·35	1014	29·94	1034	30·53	1054	31·13
		955	28·20	975	28·79	995	29·38	1015	29·97	1035	30·56		
		956	28·23	976	28·82	996	29·41	1016	30·00	1036	30·59		
		957	28·26	977	28·85	997	29·44	1017	30·03	1037	30·62		
		958	28·29	978	28·88	998	29·47	1018	30·06	1038	30·65		
		959	28·32	979	28·91	999	29·50	1019	30·09	1039	30·68		

Simplified Method of Correcting Mercurial Barometers.

A slide which will greatly simplify the correction of the barometer has been invented: it has been tried and used with success by a few vessels on the list of regular observers, and certain modifications have been introduced. It is now intended to issue these slides more widely to ships as the slides become available.

The Gold Slide Scale Mark III.



These slides are attached by clips which embrace the cover of the barometer so that the slides can be fitted to any Kew pattern marine mercurial barometer.

The apparatus consists of a thermometer and a slide worked from a rack and pinion. On the slide are engraved scales of height and correction to pressure, while on the fixed part are engraved scales of latitude and temperature, as can be seen in the photograph reproduced here..

To use the Slide.—Revolve the large milled headed screw until height of the instrument above the water line, indicated on top right-hand scale, coincides with the latitude of the ship (top left-hand scale).

The total correction to be applied to the barometer reading is then read off at the head of the mercury column of the attached thermometer by the scale to the right. The temperature is indicated by the scale to the left.

Barometers with these scales attached should be kept free from exposure to rapid changes of temperature, for these thermometers are rather more exposed than in ordinary barometers.

To test that the thermometer is correctly adjusted when the instrument is first placed in position, set the height scale so that zero height coincides with 45° on the latitude scale. Then read the value of the temperature scale corresponding to zero on the " correction to barometer scale." If this reading of the temperature scale is identical with the standard temperature of the barometer, the slide is in correct adjustment.

Barometric Tendency, or Change in the Barometer.

In the "Laws of Storms," one of the first things experience shows us, is that the barometer falls in a ship hove to in the fore part of a travelling depression, and that when the trough passes and the ship remains stationary in the after part of a travelling depression the barometer rises. We also learn that a ship in the fore part of a travelling depression, steering in the same direction as the depression but at greater speed, will usually have a rising barometer and so on.

Now although the reason of this is well understood by experienced seamen, questions indicate that some little help is desirable for younger officers, so we will introduce Captain Henry Piddington's "Sailors' Horn Card" modernized, which we shall refer to again in a later chapter. Personally, I not only used the "Horn Card" at sea but continue to do so constantly in the Office even when there are weather charts available, for it gives one a good idea of the shifts of wind and changes of the barometer in a depression passing a ship under way without much mental effort.

The Sailor's Horn Card.

The "Horn Card" is simply a transparent diagram representing the approximate average or ideal winds and barometric pressure in a Tropical Revolving Storm upon which the "Laws of Storms" are based; and as Cyclones in higher latitudes, though more irregular in shape and often of greater dimensions have similar characteristics, the "Horn Card" may be used as a rough guide for cyclonic depressions in all Latitudes.

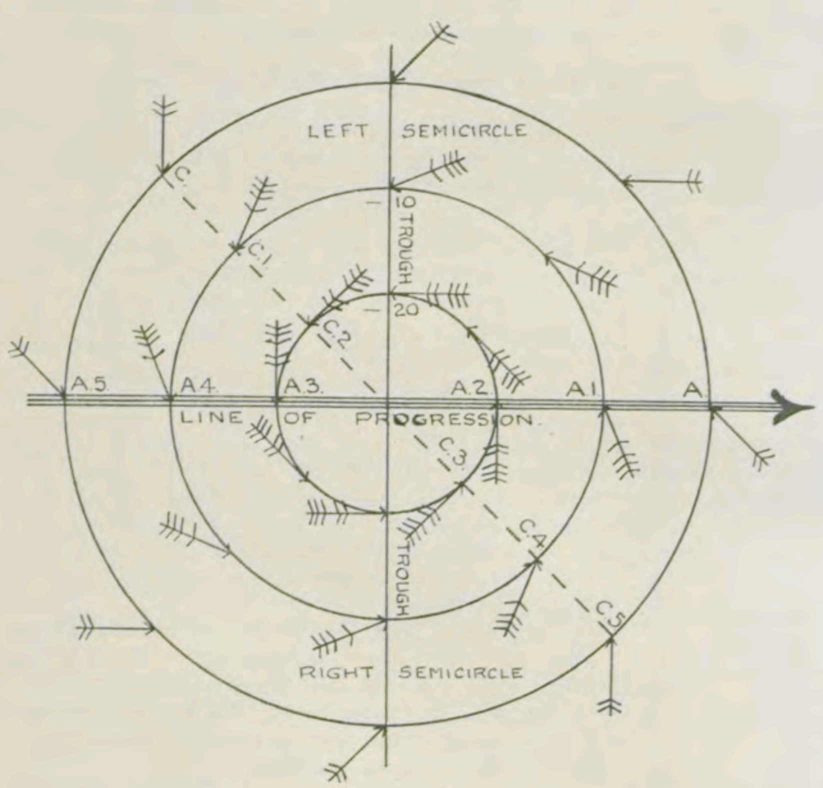


Fig. 1.—The Horn Card for Northern Hemisphere.

To construct a "Horn Card" draw concentric circles on a piece of tracing paper or transparent celluloid as in Figure 1; these represent lines of equal atmospheric pressure known as isobars. It is not usual to attach any definite value to them but it may be convenient to call the inner circle or isobar – 20 as indicating a barometer 20 millibars or 6/10 of an inch lower than at the outside isobar, and the next circle from the centre – 10 as indicating a barometer 10 millibars or 3/10 of an inch lower than the outer circle or isobar.

To represent the direction and force of the wind in a hurricane, draw wind arrows as in Figure 1, those at the inner circle being drawn at a tangent to it or flying at an angle of 8 points to the bearing of the centre, and in an anti-clockwise direction. The wind arrows at this circle where the barometer is 20 milliabars or 6/10 of an inch lower than at the outer edge of the storm may have from 12 to 10 barbs as indicating force 12 to 10.

The wind arrows at the – 10 circle should indicate a direction with an inclination or indraught of about 2 points to the isobar or 10 points from the line of bearing of the centre and may indicate force 9 to 6. The wind arrows at the outer circle should indicate an indraught of about 4 points or make an angle with the bearing of the centre of about 12 points, and should have 5 to 2 barbs. A long thick arrow should be drawn through the centre dividing the cyclone into left and right semicircles and a line at right angles to this also passing through the centre may be drawn to represent the trough and dividing the cyclone into quadrants.

We now have a "Horn Card," winds anti-clockwise for the Northern Hemisphere, and by the simple process of turning this face down, the diagram, seen through the card of tracing paper or celluloid will also give us a "Horn Card," winds clockwise, for the Southern Hemisphere, Figure 2.

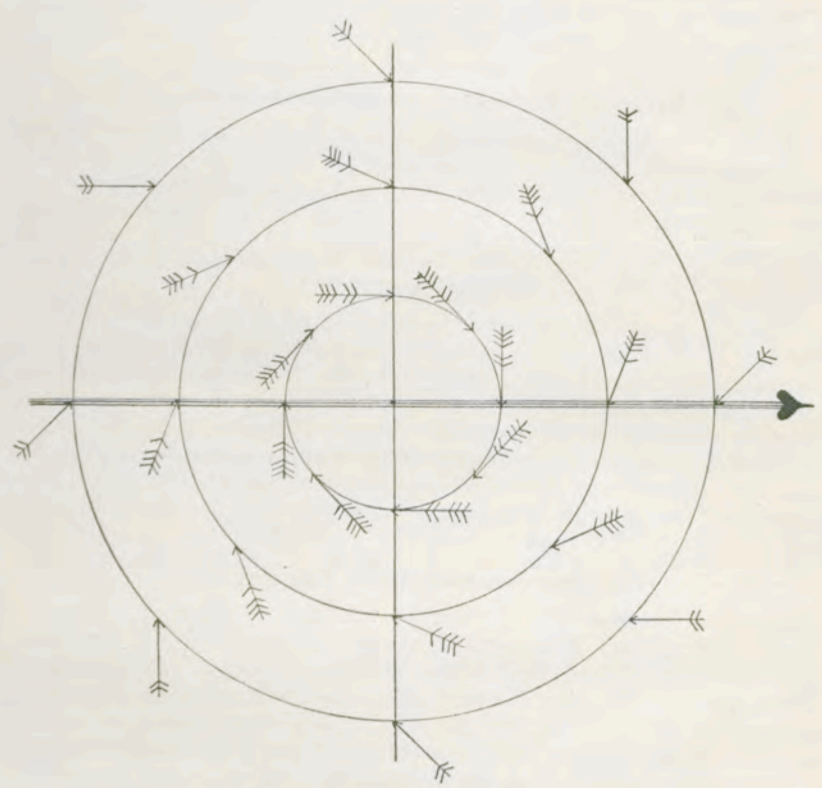


Fig. 2.—The Horn Card for Southern Hemisphere.

Let us make it quite clear that this "Horn Card" simply represents approximate average or ideal conditions of wind and barometer in a Tropical Revolving storm and is only for the purpose of explanation and easy visualizing; on no account must it be taken as representing facts in any storm for even a Tropical Revolving Storm is probably seldom quite circular and the barometer and winds may vary considerably with distance from the centre or in different sectors. The weather chart gives the facts.

Application of Barometric Tendency at Sea.

On a sheet of white paper let a black dot represent a ship hove to and place A on the "Horn Card" over her; draw the "Horn Card" slowly to the right over the dot so that A1 A2, &c., pass over the dot; this represents a cyclonic depression passing eastward over a ship hove to or a station. It will be seen that the barometer falls until the centre reaches the ship when it rises.

Now if the gradients or distances between the isobars are known and these remain constant the amount of fall or rise of the barometer in a given time should give the rate at which the depression is passing over the ship A. Should the depression stop moving when it has passed over the ship as far as say A1 (if it remains unchanged in intensity, that is the gradient remains the same) the barometer will be steady. Let a small weight at the end of a piece of twine replace the dot to represent the ship steaming or sailing at speed. Place A on the "Horn Card" over the weight; with the right hand move the "Horn Card" slowly to the right representing a depression moving East as before, and with the left hand, draw the weight slowly to the left so that it will pass under A1, A2, &c. representing a ship steaming West. It will be seen that the barometer falls quicker until the centre is reached and rises quicker after the centre has passed than in the case of a ship hove to. Next, draw both the "Horn Card" and the weight, the Horn Card with A5 over the weight to the right at the same speed, the barometer remains steady unless the depression itself is changing in depth. If the weight is next made to move faster to the right than the "Horn Card" it will be seen why a ship overhauling a depression which is unaltering in depth will have a falling barometer. Any case may be illustrated, for example, if the "Horn Card" is moved in a direction to the right and away from you (the line of progression must always be pointed correctly) to represent a depression travelling N.E. which is unaltering in depth, and the weight is drawn to the right and not inclining quite so much away from you to represent a ship steaming E.N.E. and passing through the depression on a line represented on the "Horn Card" by C, C1, C2, &c., it will be seen that the tendency of the barometer is still further complicated. Hence, if the tendency of the barometer is used, the course and speed of ship must be considered; and if the tendency of the barometer is reported to all ships by Wireless the course and speed for the period of observation should be given. In passing it will also be noted that the "Horn Card" makes it evident why the wind veers or backs at a station or in a ship under way.

Now, when the distribution of absolute pressure is given by a weather chart, the tendency of the barometer becomes much more valuable than it is in the case of a single isolated observer. Allowance must be made in low latitudes for the diurnal range, for instance the barometer will normally be rising at the morning observation.

Ashore, meteorologists not only draw isobars, lines passing through all places with the same absolute pressure, but they are able to draw what they term Isallobars, lines passing through places which have the same Barometric tendency. This is only done with observations from shore stations, fixed, and not making way like ships.

At sea if we have the barometric tendency at coast stations and the barometric tendency and course and speed of ships on our weather charts we will usually be able to get a very good idea of the movement and changes in depressions by that natural judgment which is so highly developed in those expert in the handling of ships where the eye so often solves what may be a complicated problem in the parallelogram of velocity or force with accuracy and far quicker than by mathematics.

The Observation of Barometric Tendency.

In all well ordered ships the barometer is logged at the end of each watch and in unsettled weather it is also noted every two hours, or may be hourly.

By established custom there are, therefore, frequent recorded readings of the barometer from which to ascertain its change.

It is a simple matter with these records to ascertain the change of the barometer for a definite period at any time.

The period established by International agreement for ascertaining the tendency of the barometer at telegraphic weather reporting stations is three hours before the fixed times of observation.

If the same period is used at sea uniformity can be obtained in reports by use of the International Weather Telegraphy Barometric Tendency Table in Appendix I, "Ships' Wireless Weather Signals," p. vi.

For example, at 0700 G.M.T. when the barometer is read for reporting the absolute pressure, if the difference in the uncorrected readings at 0400 G.M.T. and 0700 G.M.T. is + .03 inch the tendency will be, "Rising slowly."

For general purposes at sea the following interpretation of the Barometric Tendency Table will be convenient and is sufficiently accurate for use between ships:—

	In 2 Hours.	In 3 hours.	In 4 Hours.
Barometer steady—The Barometer has not fallen or risen more than	·3 mb. (·01 in.)	·5 mb. (·01 in.)	·7 mb. (·02 in.)
Barometer rising—The Barometer has risen	2 mb. (·06 in.)	3 mb. (·09 in.)	4 mb. (·12 in.)
Barometer rising very rapidly—The Barometer has risen over	4 mb. (·12 in.)	6 mb. (·18 in.)	8 mb. (·24 in.)
Barometer falling=The Barometer has fallen	2 mb. (·06 in)	3 mb. (·09 in.)	4 mb. (·12 in.)
Barometer falling very rapidly—The Barometer has fallen over	4 mb. (·12 in.)	6 mb. (·18 in.)	8 mb. (·24 in.)

If a barograph is carried the tendency may be obtained from the trace, for observation of barometric tendency this instrument is most convenient.

The Thermometer.

To predict visibility we want to know the temperature of the surface over which the wind blows and the temperature of the winds themselves; also their humidity.

Though to observe temperatures at first sight may seem a simple matter, precautions are essential, particularly in steamships.

Progress has been made in temperature observations since the first edition was published and as many ships record observations of the dry and wet bulb thermometers which are sufficiently accurate to give a very good indication of the humidity, we hope to show how these may be used later, even though it may be considered that the addition of humidity in wireless reports would lengthen them too much. Each individual ship may be able to use her own observation of humidity with considerable advantage.

If the thermometers used are not officially tested instruments bearing the National Physical Laboratory mark they should be compared with a standard instrument and the index error noted and applied to all readings. For descriptions of thermometers *see*, "The Marine Observer's Handbook," 4th Edition.

To observe the Sea Surface Temperature.

The water sample should be drawn from over-side, forward of all discharges. In high speed ships this operation has been rendered comparatively easy by using a canvas bucket, cylindrical in shape, with the bottom ballasted with sand, a false bottom being sewn in above the ballast to keep it in place.

To observe the Air Temperature.

The temperature of the air has been measured at sea in the past by placing the thermometer in a louvred screen fixed in one place. This had the disadvantage that the screen was as often as not to leeward of the funnel, boiler casings and other sources of artificial heat, so that the temperature observed was not the true temperature of the free air.

A portable screen has been tried at sea and also tested at Kew Observatory, particulars of which will be found in the 4th edition of "The Marine Observer's Handbook."

To observe the temperature the thermometer should be in a screen placed to windward so that as far as possible the air will come direct on to the screen from the sea before passing over any part of the ship, and where the screen will not be affected by radiation from decks and hull. Any form of local heating is fatal to accuracy.

Drafting Reports.

In wireless weather work we should think of what other ships would like to know and remember that brevity and clearness are essential, also that if all the reports received have the elements in the same order they will be more easily and quickly charted than if they are given in different forms. Therefore the columns provided at the end of the Meteorological Log and in the Ship's Meteorological Report Form 911 for recording reports sent to all ships should be used as a key, for this will ensure uniformity and the columns are arranged according to the order of importance of the elements. It will generally be an advantage to all ships if reports of ice, derelicts, and floating wreckage seen are added, with position, after the meteorological conditions, while if the observations of clouds are included with the present weather they will be of very great assistance to aircraft as well as giving ships useful information. As comparatively few ships have barometers graduated in millibars, it will assist many if the absolute pressure is given in inches.

Example. (Nearest Coast. North America East coast for Time.)

To CQ.

Weather 3045*N* 6146*W Barometer corrected* 3009 *ENE*3 *Cloudy CiStr* 8 1300 *GMT Twenty Eight May Course N*49*E* 13 *Steady Current WSW* $\frac{3}{4}$ *Knot From* 28*N* 65*W to* 30*N* 61*W Air* 73 *Sea* 74 *Cristales.*

NOTE.—The date appears in the middle of this message, the most important elements appearing before it. If abbreviation is desired omit all after date.

CHAPTER II.

THE EASTERN NORTH ATLANTIC.

Weather Systems of Temperate Northern Latitudes.

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 charts 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. Figure 3.

2. **The Secondary Cyclone,** or shortly "secondary," a small depression, subsidiary to the foregoing. Figures 3 and 7.

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. Figure 4.

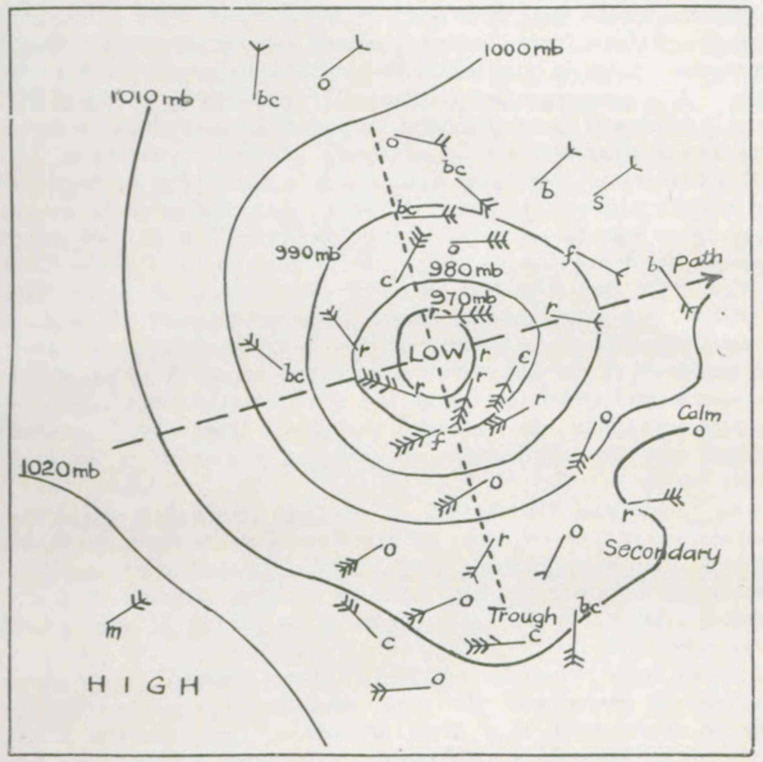


Fig. 3.—Cyclone and Secondary.

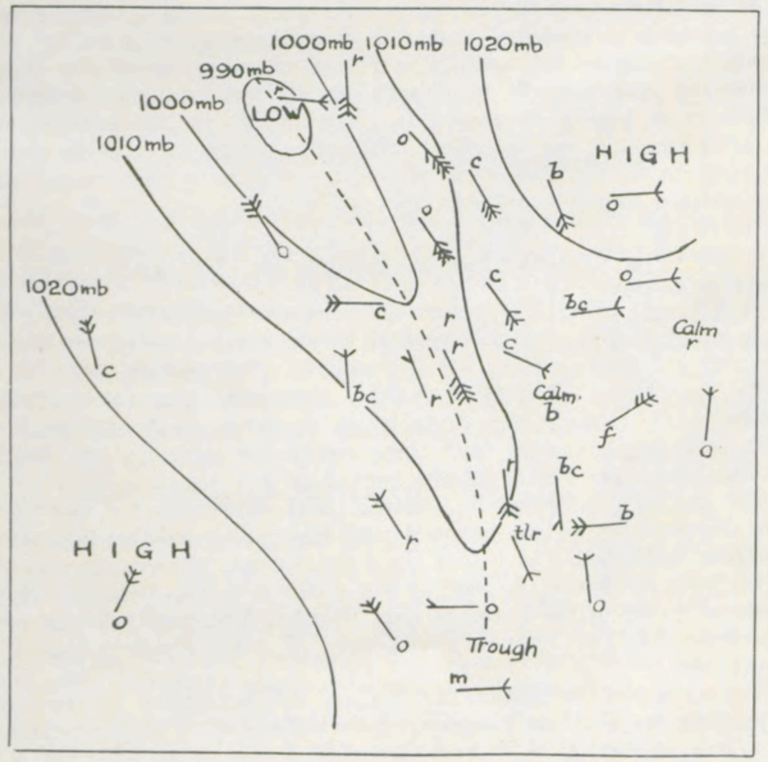


Fig. 4.—V-shaped Depression.

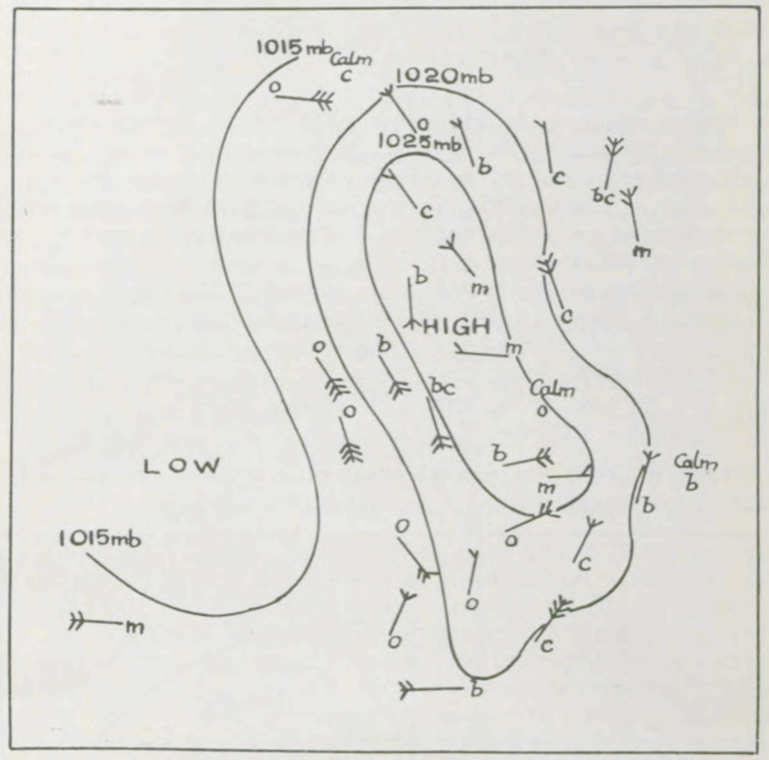


Fig. 5.—Anticyclone.

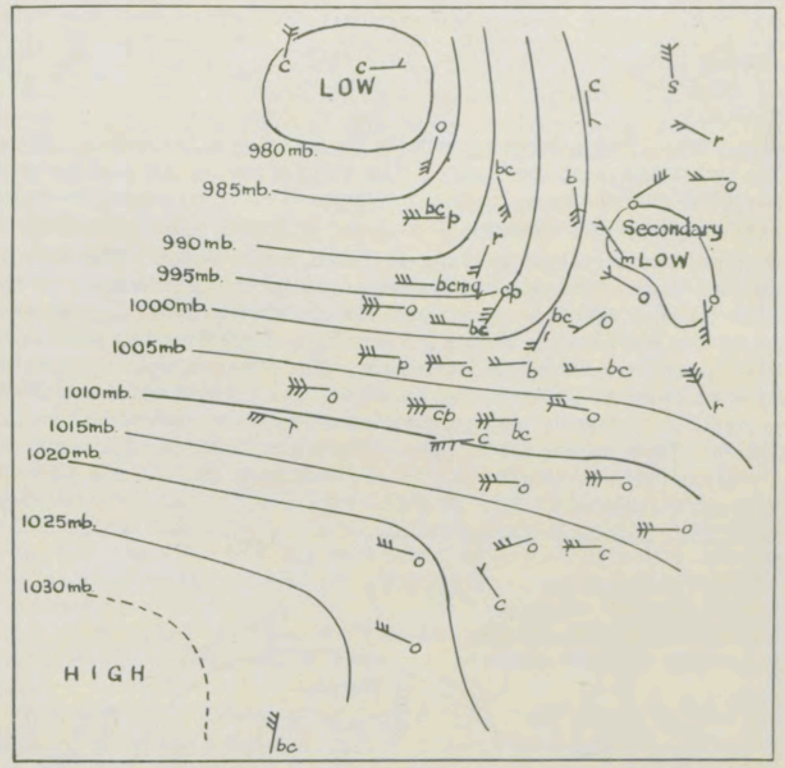


Fig. 7.—Straight Isobars between Cyclone and Anticyclone.

4. **The Anticyclone.**—An area of high pressure, bounded by circular or oval isobars. Figure 5.

5. **Wedge-shaped Isobars.**—An area of high pressure bounded by isobars converging to a point like a wedge. Figure 6.

6. **Straight Isobars.**—A barometric slope, across which the isobars lie in straight lines. Figure 7.

7. **The Col** or neck of low pressure lying between two adjacent anticyclones. Figure 8.

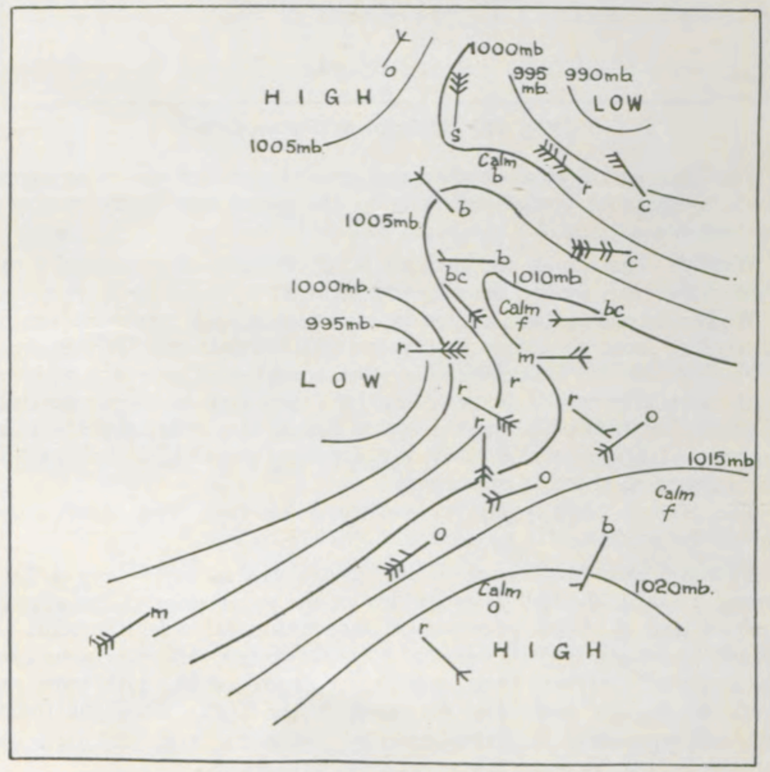


Fig. 6.—Wedge.

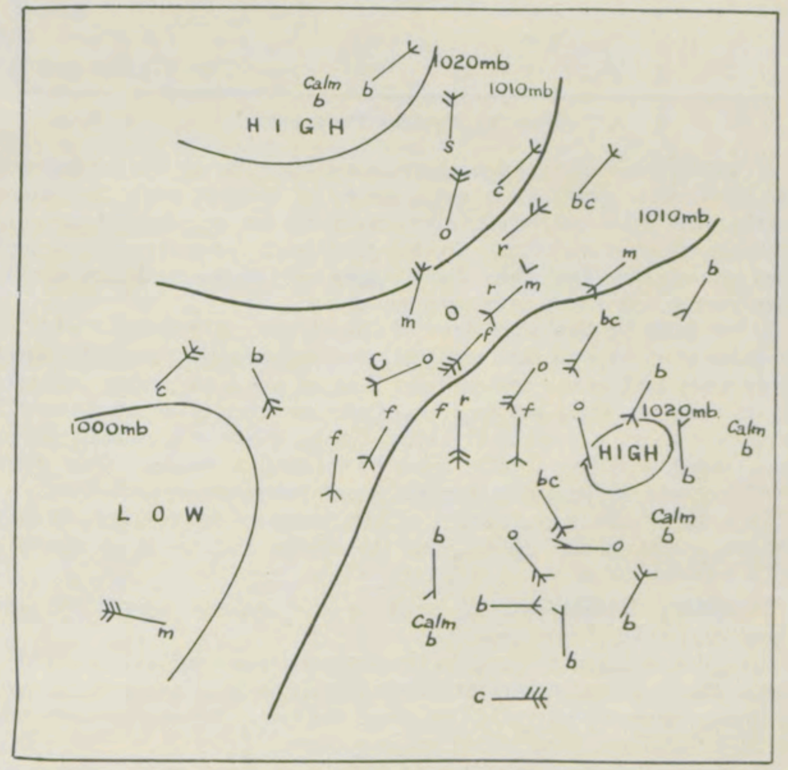


Fig. 8.—Col.

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.

Anticyclones 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 generally 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. FIGURE 3 shows the wind circulation. FIGURE 9 illustrates the cyclone prognostics.

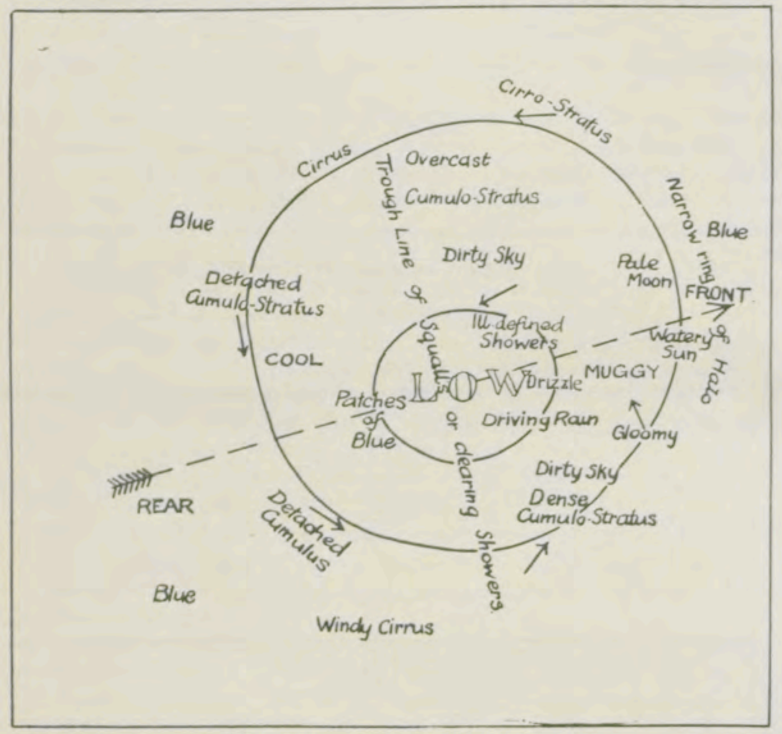


Fig. 9.—Cyclone Prognostics.

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 FIGURE 3 with its isobars, wind arrows, and weather, and the prognostics in FIGURE 9 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 chart 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.

Anticyclone.—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 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.

FIGURE 10 shows the general prognostics for summer and winter anticyclones in the region of the British Isles.

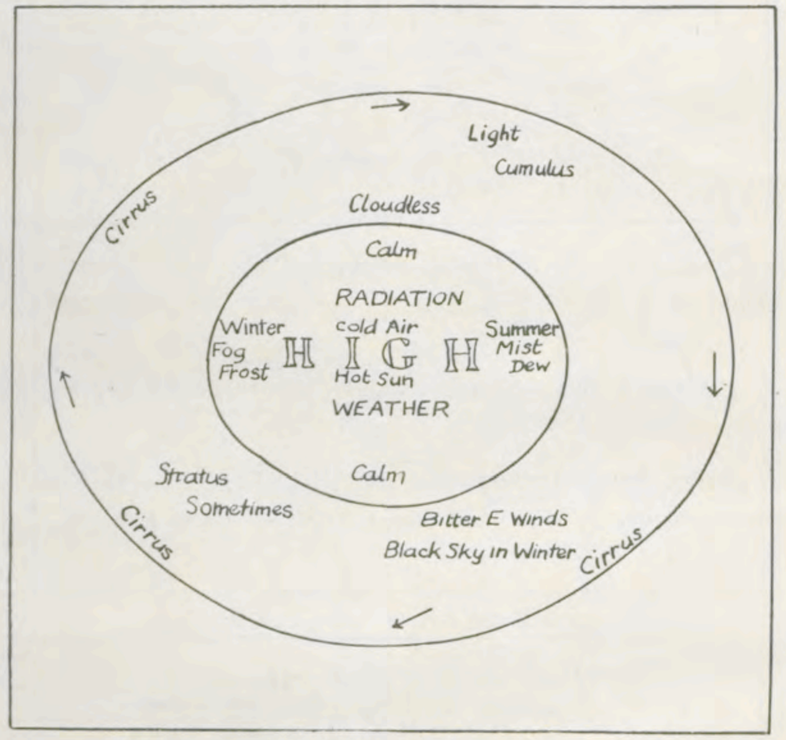


Fig. 10.—Anticyclone Prognostics.

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

Wedge.—Just as an anticyclone 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 anticyclone 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 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 the 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 anticyclones 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 anticyclones which it separates the wind follows the usual laws of isobars.

The col gives conditions for cloud, fog, or thunderstorms.

Anticyclones 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.

Weather Charting and Forecasting.

To show some advantages which may be gained by W/T communication at sea we will first consider the observations recorded in the Meteorological log of R.M.S. *Ormuz*, Commander E. P. CAMERON, R.D., R.N.R., on the morning of Sunday, February 25th, 1923, when on passage from Gibraltar to Plymouth, and see what can be gleaned from them alone. Then we will suppose that she intercepted Wireless Weather Reports which gave her observations of a number of Coast Stations and ships at a distance, show how a simple weather chart may be constructed and what it tells us.

Ormuz left Gibraltar at 6 p.m. on February 23rd, wind westerly, a moderate gale which backed to W.S.W. at midnight, when the barometer was 1012 mb. (29.89 in.), sky overcast with passing showers. During the morning watch the wind veered to the N.W. and the barometer rose slowly. At noon in Latitude 37° 38′ N., Longitude 9° 11′ W. the barometer was 1018 mb. (30.06 in.), wind force 6, blue sky. After rounding Cape St. Vincent the swell was very heavy from N.W.; later, there were two distinct swells from N.W. and West and the wind dropped to force 4. The barometer continued to rise until at midnight on February 24th it read 1023 mb. (30.21 in.), when the wind backed to west again, force 5, and the barometer fell very slowly. At 8 a.m. on February 25th in Latitude 41° 43′ N., Longitude 9° 16′ W., the wind was S.W., force 5, barometer 1021 mb. (30.15 in.), swell, confused N.W. and North decreasing, sky overcast.

Now the moderate westerly gale with slight backing of wind at midnight on February 23rd possibly indicated a depression passing far to the northward. The heavy N.W. swell experienced when clear of Cape St. Vincent some time later and the veering of the wind to N.W. supports this; so that *Ormuz* would have evidence of past bad weather over her intended route.

The backing of the wind to west at midnight on February 24th with slow fall of the barometer as the ship steamed to the northward, and further backing of the wind at 8 a.m. on February 25th, would lead Captain Cameron to expect the approach of another depression from the Atlantic; but his own observations alone could not give him an idea of the extent, intensity or probable movements of this depression.

Let us see what Wireless Weather Reports charted, tell us of these and how the weather which *Ormuz* may expect will be affected by them.

Different ships different long splices; in some ships reports may be decoded on the bridge, in others in the Wireless Office. Whatever the procedure is, it will be convenient to the navigator if weather reports are always written out in the same concise form, and that below is recommended.

Coast Weather Reports—0700 G.M.T., February 25th, 1923.

Station.	Barometric tendency.	Weather.	Visibility.	Barometer.	Wind.	
					Direction.	Force.
Wick	Steady... ...	Continuous light rain ...	Very good	1002 29·59	S.S.E.	5
Malin Head	Steady... ...	Overcast	Moderate	993 29·32	S.E.	4
Holyhead	Steady... ...	Continuous heavy rain...	Poor	997 29·44	S.S.E.	3
Scilly	Rising slowly ...	Blue sky	Very good	1001 29·56	N.W. by W.	2
Jersey	Rising	Rain	Good	1002 29·59	W.	3
Dungeness	Rising slowly ...	Blue sky	Good	999 29·50	N.E.	2
Yarmouth	Rising slowly ...	Continuous light rain ...	Thin fog or mist ...	1001 29·56	E. by N.	1
Tynemouth	Steady... ...	Continuous light rain ...	Moderate	1001 29·56	S.S.E.	3

Ships' Reports—0700 G.M.T., February 25th, 1923.

Ship.	Lat.	Long.	Bar.	Wind.		Weather.	Course.	Speed.	Bar. Tendency.	Current.	From		To		Temp.		Swell.	Past Weather.
				Direction.	Force						Lat.	Long.	Lat.	Long.	Air.	Sea.		
Ormuz ...	41° 43′ N.	9° 16′ W.	1021 30·15	S.W.	5	Overcast	N. 10° E.	14	Falling slowly.	—					56°	54°	W. Heavy	Overcast.
Michigan ...	49° 43′ N.	13° 36′ W.	1000 29·53	S.W.	8	Overcast	S. 88° W.	7½	Falling	—					51°	50°	S.W., very heavy.	Rain.
La Paz ...	40° 35′ N.	24° 31′ W.	1013 29·92	S.S.W.	6	Overcast, damp.	S. 27° W.	6½	Steady	—					61°	55°	N.W., heavy.	Cloudy, damp.
Berengaria	48° 42′ N.	19° 36′ W.	995 29·38	S.W.	7	Overcast	N. 72° E.	24	Falling slowly.	—					53°	56°	Confd.	Cloudy.
Montcalm ...	54° 46′ N.	12° 00′ W.	989 29·21	S.W.	6	Cloudy	—	—	—	—					48°	48°	S.W., Mod.	Cloudy.
Edinburgh Castle.	43° 50′ N.	9° 27′ W.	1015 29·97	W.S.W.	6	Passing showers, squally.	S. 30° W.	15½	Rising	—					54°·5	54°	W.S.W., heavy.	Rain.

Making Weather Charts of Pressure, Wind and Weather.

OVER a portion of a small scale chart for the part of the world the ship is in, pin a piece of tracing paper, or, better still, use a suitable outline chart.

Meteorologists use maps on the conical projection because these have less distortion, but for the purpose of the navigator a Mercator chart is preferable.

Take CHART I. as an example. At the position of a few suitably-disposed coast stations, with a protractor, lay off wind arrows, each feather representing one of the BEAUFORT scale; the arrows fly with the wind, their heads indicate position. Abreast these stations write the barometer in millibars or inches (both are given here for the convenience of all concerned), the tendency of the barometer, the weather indicated by the letters of the BEAUFORT Notation, and the visibility, indicated thus: Vis. V. G., Vis. Poor, and so on.

Plot the position of the reporting ships, and draw wind arrows, heads at positions. Write the name of the ship reporting, the barometer, weather, course and speed and barometric tendency. Sea and air temperatures are also written under the name of the reporting ships, but in this case we will omit temperatures, &c., in order to make the chart as simple and clear as possible. In later examples it will be shown how much more can be done if these are plotted and used also.

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 *Montcalm* is in a depression, and the wind arrows of all ships shown and stations northward from Holyhead conform to the circulation of the fore part of a cyclonic depression. The wind arrows at Scilly, Jersey and Dungeness appear to differ from the main circulation and these must be carefully examined. It will be noted that the N.E. wind at Dungeness is blowing nearly athwart that at Tynemouth and in a direction nearly opposite to that at Jersey. It will also be seen that the barometer at Dungeness is lower than at Jersey, Scilly and Tynemouth, although these stations are not so far from the main Low.

Clearly some other influence to the wind circulation is indicated and BUYS BALLOT'S Law shows us that there must be another Low somewhere S.E. of Dungeness; this we indicate by the letter L. In practice we should continue on the same chart, but in order that what has been already written may be quite clear to the reader we use CHART II. The wind circulation, as now indicated upon CHART I., will give us a very good idea of the trend of the isobars for the wind blows along isobars inclined towards the Low.

Therefore, *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.

The lowest barometer recorded at *Montcalm's* position is 989 (29.21). For practical purposes at sea isobars drawn for every four mbs. (.12 of an inch) will be convenient, stepped from 1,000 mb. (29.53 in.).

Thus the lowest proved isobar of this stepping on this chart will be 992, but it is evident with the knowledge of experience that there are actually isobars of lower value to the N.W. It will, therefore, be convenient to dot in the 988 (29.18) isobar passing close to the N.W. of *Montcalm's* position.

The 992 isobar is lightly drawn in passing west of Malin Head and N.W. of *Berengaria*, the S. Easterly wind at Malin Head will guide us in its S.S.E. trend past that station, and *Montcalm* and *Berengaria's* barometers and winds make us curve it rather abruptly over N.W. Ireland to the S.W., thus passing through places which are estimated to have the same barometric pressure. We are guided in drawing the 996 (29.41) isobar by the barometers and winds at Wick, Malin Head, Holyhead, *Michigan* and *Berengaria*, but to draw the 1,000 isobar is not quite such a simple matter.

It is evident that the 1,000 isobar passes South, to the westward of Wick and Tynemouth, but BUYS BALLOT'S Law forbids that we take it close to the eastward of Dungeness. Here the wind direction conforms to an isobar running in a S. Westerly direction, and as the 1,000 isobar cannot pass from the N.E. past Dungeness to the westward it must trend to the eastward somewhere between Tynemouth and Dungeness. We therefore dot it in round the L already marked and curve it to the northward to pass close west of Dungeness, thence Jersey, Scilly and *Michigan* will be cur guide.

Next we rough in the 1,020 (30.12) isobar with *Ormuz* as our guide. *La Paz* and *Edinburgh Castle* guide us in placing the 1,016 (30.00) isobar. The 1,012 (29.89), 1,008 (29.77) and 1,004 (29.65) isobars are roughly spaced between.

When the isobars which it is possible to draw with the observations available are roughed in, using pencil and indiarubber we improve them, making them close together where the wind is strong and wider apart where it is light, so that their spacing will roughly show the gradient. In doing this we must be careful not to smooth out too much, curves which may indicate secondaries, but remember that we only have observations at widely separated points from which we want to obtain a general idea of pressure distribution.

Our weather chart is now complete and from it we draw the following inference:—

> A large cyclonic depression centred N.W. of *Montcalm's* position is causing S. Westerly strong winds to fresh gales from Latitude 40° N. over the Eastern North Atlantic as far north as Latitude 57°, with a secondary depression extending S. Eastward centred S.E. of Dungeness, causing variable winds over the English Channel.
>
> From the chart we learn that as *Ormuz* proceeds on her course, her weather will be influenced more by the depression. She would note that the barometer was rising or rising slowly at the three stations on the coasts of the English Channel indicating an eastward movement of the secondary.
>
> The steady barometer reported at stations northward from Holyhead gives no indication of the approach to that area of the main depression. *Michigan's* falling barometer is to be expected on her course to the westward as she approached the trough whether the depression is stationary or travelling in an easterly direction.
>
> *Berengaria's* slowly falling barometer (ship on a N. 72° E. course steaming 24 knots with a moderate gale from S.W.) requires careful examination. If the depression is stationary and is neither deepening nor filling up as *Berengaria* steams eastward at high speed, the barometer would rise slowly. If the depression is deepening and stationary, *Berengaria*, in advance of the trough steaming fast to the eastward would experience a falling or steady barometer; or if the depression was maintaining the same barometric gradient and travelling eastward faster than *Berengaria* her barometer would fall.

The chart shows that secondaries have formed. Many of the severest gales in the Eastern North Atlantic and over the British coasts have been caused by secondaries forming to the southward of main depressions, westward of Ireland. Now with the indications that our chart gives, we see that this main depression is probably nearly stationary, and *Berengaria's* observations indicate that barometric pressure is reducing at a point eastward of the trough and south of the centre, which probably indicates the forming of a secondary, or, if not, the steepening of the barometric gradient in the main depression itself. Either would cause violent winds.

Ormuz therefore forecasts a heavy south-west gale in the Bay of Biscay.

According to the Meteorological Log, the wind commenced to freshen at 2.5 p.m. when Cape Villano was abeam. *Ormuz* was near the 7 a.m. latitude of *Edinburgh Castle* at about 6 p.m. when her barometer had fallen to 1,012 (29.89) approximate, showing that pressure had reduced at this position since the morning reports by about 3 mb. (.09 in.), thus adding to our expectation of a steepening gradient. With the morning chart we can almost see what is happening for there surely must be a depression deepening and stationary to the N.W., maybe it is deepening and travelling on a converging course to our own, or it may be travelling eastward without material change of gradient.

By 4 a.m. the wind increased to a heavy S.W. gale force 10, with squalls and misty rain, the ship labouring heavily to a precipitous sea.

MONDAY, FEBRUARY 26TH, 1923.

Next morning, when reports have been received, CHART III is made in the same manner. From it we see that there were good grounds for thinking that a secondary was forming in the vicinity of Latitude 50° N., Longitude 20° W., for the cyclone now centred

some 100 miles to the westward of Valentia was probably developed from a secondary.

With the barometer falling very rapidly at Valentia, Malin Head and Holyhead, representing a very rapid reduction of pressure in a line N.E. from the centre, while it is falling quickly (less rapidly) at stations on either side of the line of bearing, the cyclone may be expected to travel N. Eastward as indicated by the arrow drawn upon the chart.

Ormuz therefore expects the gale to continue from the westward for a time along her route to Plymouth; as the cyclone passes away to the N.E. the wind may be expected to moderate. By the time the evening routine reports are received, *Ormuz* will be at Plymouth or bound up Channel, and her officers being fully occupied with the navigation of the ship in crowded narrow waters may, instead of making charts and their own forecast, prefer the forecasts made at the Meteorological Office for coastal areas which are broadcast along with the station reports. The reports of visibility at the stations will also be useful.

Even if weather charts are not made as a matter of routine, it is essential that the navigator should be conversant with the method of construction, because this will enable him better to understand forecasts issued from Weather Offices and may often enable him to visualise the general conditions over an area from Wireless Weather Reports which it may not be convenient to chart.

The writer happened to be at Avonmouth on March 1st, 1923, and, hearing that S.S. *Banffshire* (5,061 tons, gross), Captain R. H. WYNNE, outward bound from Liverpool had put in through stress of weather, visited the ship. It appears that *Banffshire* had encountered the worst of the gale on February 26th, when about 30 miles S.W. of the Scillies. There being mountainous seas and squalls of hurricane force she ran up the Bristol Channel for shelter. Asked if any Wireless Weather reports had been received, copies were produced. Upon inspection these were found to be the Western Seaboard Forecast Messages. Asked if any figures had been taken in, the operator stated that their meaning not being known they had not been recorded.

It was explained that these figures would have given the actual observations of certain Coast Stations, which, together with ship's reports, would have shown the approach of bad weather. *Banffshire* is now a regular observer and Captain WYNNE has supplied some convincing proof of the value of Wireless Weather work at sea, including experiences in the Southern Ocean in which he co-operated with a sailing ship as well as a number of steamers. This is but one of many experiences that swell the ranks of converts.

Importance of Relation of Tracks of Depression and Ship in Weather Prediction.

Since the first edition was published three years ago, many have mastered the drawing of Weather Charts but others have asked for instruction in drawing isobars. Lieut.-Commander M. CRESSWELL, R.N.R., the Port Meteorological Officer at Liverpool, and Mr. W. T. GRIEVES, the Visiting Officer for the port of London, have given assistance on board ships at the docks in this, and we have been able to help some marine observers when they have visited the Marine Division. A further example in this Chapter will help to overcome difficulty. In selecting one I have taken a case which will indicate how important the correct judgment of the probable tracks of depressions is in the prediction of wind at any position or positions towards which and through which a ship will pass.

Supposing that S.S. *Nariva*, Commander H. G. SPRIDDELL, R.D., R.N.R., from Las Palmas to London, at 0700 G.M.T. in Latitude 45° 44′ N. Longitude 7° 19′ W., during the remainder of the morning watch and in the forenoon intercepted and plotted the observations on CHART IV in the same way as we indicated with *Ormuz*.

The lowest barometer reported is at Reykjavik, Iceland, where the wind is S.E. The Low is therefore placed to the westward of this station. The highest barometer reported (only two millibars or .06 in. higher than *Nariva*) is at Guernsey where the wind is W.S.W., and the High is therefore placed over France. We can now see that the trend of the wind arrows generally indicate a great cyclonic circulation and an anticyclone over the Bay of Biscay and neighbouring land to the S.E. of the depression. Using the 4 mb. stepping from 1000 mb., 984 mb. will be the lowest isobar and 1024 the highest.

Our only guides to the 984 mb. isobar are the barometer and wind at Reykjavik. We can only draw a short fragment of it from the eastward of that station southward and curved so that the wind arrow will be inclined to it towards the Low and with its end inclining so that if extended it would pass west of *Saxoleine* whose barometer is 993 and wind light and variable.

With the great area west of the British Isles (where we have the observations from the "Weather Shipping" Bulletin) and between Iceland and the parallel of 50° N. Latitude without a single observation, it will be difficult to the inexperienced to visualise how the isobars trend in this region; it will therefore be best to draw the 1024mb. isobar next. This is drawn between Yarmouth, 1023, light W.S.W. airs and Dungeness, 1025, W.S.W. gentle breeze in a westerly direction curving S.W. between Scilly and Guernsey through *Nariva's* position to the S.E. to conform to BUYS BALLOT'S LAW and so outlining the High.

If we take the middle pressure of our chart, 1004 next, it will help us. This isobar must pass close to the west of Thorshavn, well to the West of Malin Head, thence *Verentia's* westerly wind will lead us to curve it slightly more west as we take it well to the westward of that ship and then curve more to the southward to pass east of *Orduna*. We can now return to the low value isobars. First we divide the space between Reykjavik and Thorshavn roughly into five.

Only a short fragment of the 988 isobar can be drawn parallel to the 984 isobar. The 992 isobar passes from the second spacing between Reykjavik and Thorshavn to the southward, curving S.W., and passing just to the westward of *Saxoleine*. The 996 and 1000 isobars are placed by the same method at their northern end and are taken southward parallel to the 992 isobar, passing west of *Baltic* and east of *Orduna* respectively.

With the British coast station observations, *Verentia* and *Nariva*, we have little difficulty in drawing the 1008, 1012, 1016 and 1020 isobars. Now with a little alteration to adjust the barometer gradient to the wind (isobars close where the wind is strong and wide apart where it is light) with pencil and india-rubber we get CHART No. V.

In studying the chart it is well to remember that it only gives us detailed facts at the positions of the reporting ships and stations at the moment of observation 0700 G.M.T., February 24th, 1926, and that the isobars link the whole together, giving us a general idea of the wind and pressure at the time over the area charted, but that a report from a ship in, say, Latitude 55° N. and Longitude 18° W. might not be wind S.S.W. 6, barometer 1000mb. (29.53 in.), as we should expect from the isobars in that neighbourhood; it might be quite different. We can only estimate the conditions at intermediate places between those of actual observation, and the nearer these places of reported observation are to one another so will our estimations for the intermediate positions be the more correct.

This CHART (No. V) tells us that *Nariva* is in an anticyclone which lies over the Bay of Biscay, English Channel and France and that there is a large depression to the westward of the British Isles probably centred near the 30th meridian of West Longitude. Our ship's steady barometer and the steady barometers reported at all stations, except two rising slowly at Holyhead and Tynemouth, all indicate that the anticyclone is holding its ground or intensifying. The very rapidly falling barometer at Reykjavik indicates that the depression is travelling N.E. and the tendencies reported by the four ships near the 50th parallel of N. Latitude, south of the depression, steaming as they are to the southward of west, all tend to confirm this.

Therefore our chart indicates that the probabilities are considerable that anticyclonic conditions will hold along *Nariva's* route to London for the next 24 hours and that the Atlantic depressions will traverse N.E. tracks too far to the N.W. to affect the weather in the English Channel. The visibility reports ahead are Good to Very Good, but until we have considered temperature of the air and sea it will be well only to surmise that with S.W'ly winds in the month of February the chances are from 6 to .7 per cent. only, that there will be fog in the Channel according to The Wind and Fog Chart of Great Britain and Ireland, Volume III, No. 26, "Marine Observer." Captain SPRIDDELL may predict with some confidence moderate and light breezes at first easterly, later, veering S.E. through S. to S.W. with good visibility and set his speed accordingly to arrive a little before the tide on which he wishes to dock.

On the morning of February 25th, 1926, *Nariva* is in the English Channel and the official forecast for 12 hours for the Southern Area in the "Weather Shipping" Bulletin is appropriate.

It is as follows:—

Southern Area. Wind Southerly, light or moderate, freshening in district Channel. Visibility mainly moderate, but local coastal fog.

Had *Nariva* made CHART VI confidence would be increased in this forecast for it indicates that the anticyclone has intensified over the Channel. The rising barometers reported by *Saxoleine*, *Baltic* and *Orduna* all steaming to the southward of west to the southward and westward of the depression with *Verentia's* steady barometer south of it, all indicate that this part of the depression is travelling N.E. while the barometric tendencies at Blacksod and Stornoway considered with those of the other stations indicate a steepening of the gradient, progress of which steepening gradient towards "District Channel" will cause the wind to freshen there-abouts. Local coastal fog is predicted because of conditions reported at shore stations which are not included in the 12 stations of the British "Weather Shipping" Bulletin and for reasons which will be dealt with in a later chapter.

CHAPTER III.

TIME.

The importance of time, position, course and speed in navigation can only be fully appreciated by those whose business is responsibility for navigation.

When an accident has occurred, how often has it been found upon examination of the deck log and engine-room register that the times recorded have differed! Such a contingency is now averted in many ships by the use of the magneto clock; if such clocks are not carried this can only be done by co-operation between the navigating and engineering staffs. That is to say, the observation of time of the movement of the engine room telegraph on bridge and in engine-room must be sychronised if their record is to prove reliable evidence.

When it is considered that the object of a weather chart is to give a graphic representation of weather over an area at a particular moment, that the reporting ships are travelling at different speeds and upon different courses, and that weather systems are usually also moving and often at great speed, the need for the observations in all reporting ships and at all reporting stations to be synchronised will be apparent.

The meteorological log was arranged so that the times of observation were convenient to the ship; hence those times were fixed for the relief of the watch when in any case the relieved officer of the watch would be taking his observations for the ship's log.

For the purpose of detailed observations and investigation long after the observations are made, this system is admirable and has been proved to be the best which can be devised to conform to sea practice.

The immediate advantages to be gained by the navigator of weather observations reported by wireless, however, outweigh some of the objections which there are to observing and recording weather observations at other than the old established routine Ships' Times. That is to say, that so long as lookout and the duties of the officers in connection with the safety and work of their ship are not interfered with, it is possible without inconvenience to observe and record the weather conditions at uniformly fixed times.

Now before the establishment of communication by wireless at sea, fixed times of weather observation for "Land line" reports had been established and are now organized in most countries. When these times, which are given upon the chart in "Ships' Wireless Weather Signals," p. v, Appendix I of this book, happen to correspond with hours of daylight at the position of the ship, the ship's observations for wireless reports may be taken without inconvenience at the same time as those of the nearest country. There will be breaks midway between coasts which have different fixed observation times, but if the established shore observations are to be used this is inevitable.

Gradient.

In the last chapter in drawing a weather chart we saw that the isobars were close together where the wind was strong and further apart where it was light. That is to say, generally, a steep barometric gradient causes strong winds while a slight gradient brings light winds; there are exceptions, as in the case of the Mistral of the Gulf of Lyons.

The barometric gradient is referred to the inch or millibar scale of pressure and the horizontal scale of length in nautical miles measured at right angles to the isobars. For example, a ship at A, FIGURE 11, has the wind W. by N., barometer 990 mb.; at the same time another ship at B, bearing S. 70° E. from A, has barometer 990 mb., wind W. by N.; while a third ship at C, bearing due south of A, and distant 191 miles from her, has barometer 1,000 mb., wind W. by N., and a fourth ship at D, bearing S. 70° E. from C, has the same barometer as C.

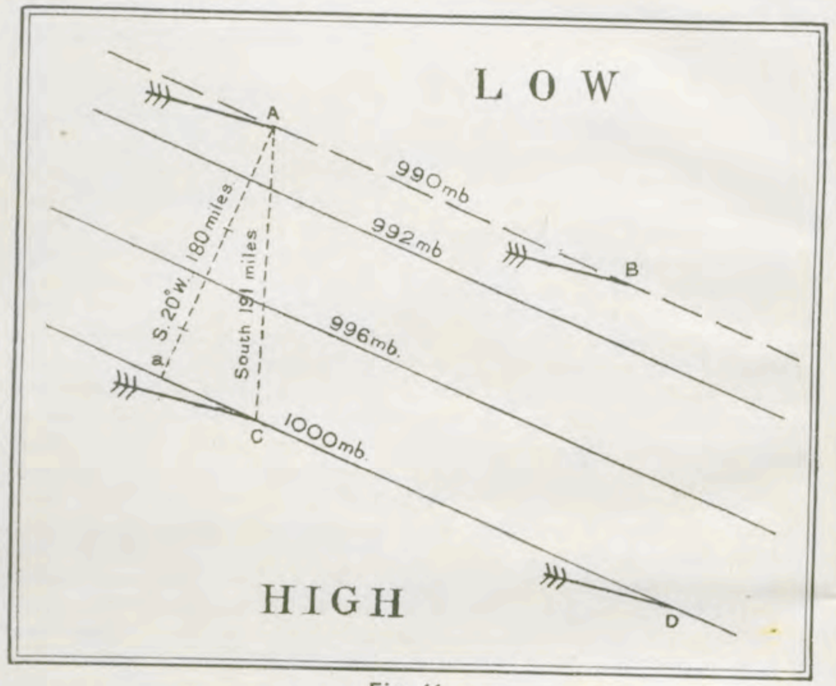


Fig. 11.

The barometric gradient does not depend upon the distance 191 miles between A and C, but upon the distance measured at right angles to the isobars, in this case, 180 miles. Therefore, in drawing a chart, Aa is the line on which to measure off the spacing of the isobars.

The most convenient lineal unit for finding the barometric gradient is 60 nautical miles.

Thus 180 miles ÷ 60 = 3;

10 mb. (the difference of pressure between A and C) ÷ 3 = 3.3 mb. gradient.

At sea, where the surface friction is less than ashore, 3.3 mb. gradient produces a wind of about force 6 in high latitudes. The wind force produced by a given gradient varies with latitude and a table will be found in Chapter X for straight isobars.

In this example, for the purpose of clearness the isobars are quite straight on a mercator chart, a condition which will scarcely ever happen in practice.

Gradient and Time.

CHART VII is made with some observations taken at 0700 G.M.T. (civil) and others at 8 a.m. Ships' Time. It will be noted that the strongest winds are not in the areas represented to have the steepest gradient.

The observations at Stornoway, Holyhead, Scilly, Dungeness, and in *Metagama*, *Celtic*, and *Aquitania*, were made at 0700 G.M.T. Those in H.M.S. *Conway*, School Ship, H.M.S. *Worcester*, Thames Nautical College, and at Pangbourne Nautical College were taken at 0800 G.M.T., and those in *Ionic Star* and *Port Darwin* at 0800 Ships' Time. Now why is it, although the wind is only force 7 at Dungeness and 5 at *Worcester*, where the gradient is very steep, that *Aquitania* and *Celtic*, clear of the land, have winds of force 7 and a less steep gradient?

It will be noted that the barometer is falling at all stations south and east of Holyhead, and it was afterwards found, as we should suppose from these observations, that the depression was moving in a south-easterly direction.

Now Pangbourne, *Worcester*, and Dungeness are roughly on a line of bearing which corresponded to the path of the depression and nearly athwart the trend of the isobars.

At 7 a.m. Dungeness had barometer 997 (29.44), while *Worcester* and Pangbourne did not read their barometers until one hour later, when they showed 989 (29.21) and 985 (29.09), respectively, by which time, with the depression approaching, the glass had fallen an appreciable amount since 7 a.m. Hence the isobars on the chart hereabouts show a false gradient, and give an entirely wrong representation of pressure distribution over S.E. England and the Straits of Dover.

It will also be observed that, though the gradient in the vicinity of *Celtic* and *Aquitania* is fairly consistent with the wind reported by those ships, force 7, the gradient in the vicinity of *Port Darwin* is much less steep than would be expected with a wind of force 6.

Aquitania's observations were made at 0700 G.M.T. (civil) and *Port Darwin's* were made at 8 a.m. Ship's Time. This ship was bound to the westward and would be keeping Apparent Time for approximately Long. 23° 30' W., equation of time 16 minutes, that is to say, her time differed by 1 hour 18 minutes from G.M.T., so that her observations were actually made 2 hours and 18 minutes later than those of *Aquitania*.

With increasing pressure in the rear of the trough the glass would read appreciably higher after such an interval.

Thus it will be seen that the gradient cannot be obtained either ashore or afloat unless the observations synchronize.

It is interesting to note that the drawing of a weather chart with these observations was a question set in the examination for the Senior Cadets of the *Conway* and *Worcester*, and though by no means easy was answered in a manner which promises well for the future.

Again, CHART VIII FOR NOVEMBER 7TH, 1925, made from observations taken at times which do not all synchronize is even more misleading than CHART VII.

Conway and *Worcester's* observations are those logged at 0800 G.M.T. Coast station observations and *Lapland*, *Majestic* and *Scythia's* are for 0700 G.M.T.; while *Zeeland*, *Orbita* and *Manchester Corporation* observations are those logged at 0800 Ship's Apparent Time.

The steep gradient indicated in the vicinity of *Orbita* and *Majestic* is entirely out of proportion with the Heavy or Whole* gale force 10 reported by those ships; it is false and indicates a gradient with which we should expect wind of hurricane force, 12. In a later Chapter a table will be given showing the wind forces corresponding to difference of barometric pressure in 60 miles. First let us deal with what is most essential and practical to those new to the work. This false gradient is due to difference in time of the observations. *Orbita's* clock being set for Apparent Time for her expected longitude at noon would be 1 hour 48 minutes slow for longitude, and the Equation of Time is 16 minutes to be subtracted from Apparent Time, so that her observation was made at 0932 G.M.T. or 2 hours 32 minutes later than *Majestic's*. The ships were on opposite courses, *Orbita* eastbound and *Majestic* westbound and the depression travelling to the south-eastward. *Majestic's* barometer represented the atmospheric pressure at 0700 G.M.T. at her position, but *Orbita's* barometer was rising and is not comparable with *Majestic's* barometer because *Orbita's* barometer was read later. Meanwhile the depression had changed its position and possibly its gradient as it advanced at greater speed than the ship to the eastward.

The effect of non-synchronization with these ships' wind observations gives an even more practical illustration. *Majestic* had wind W. by S. at 0700 G.M.T. and the wind logged by *Orbita* at 0932 G.M.T. (8 a.m. A.T.S.) as N.W. by N. was W.N.W. at 0700 G.M.T.; by using the "Horn Card" described in Chapter I., the reason of this will be made clearer than can be shown by further description here.

The gradient is also false in the locality of *Conway* and *Worcester*.

Another example in support of G.M.T.

At midnight on April 20th, 1922, S.S. *Katori Maru* having passed through the ring of winds of hurricane force was in the vortex of a tropical cyclone which was nearly stationary in the Arabian Sea. There were a number of ships in the vicinity and FIGURE 12 gives their positions with that of *Katori Maru* in the centre.

The bearing of the centre from each ship is indicated by the number of points it lay to the right when facing the wind, and the height of the barometer above that in centre, knowledge of which is of great importance.

It will be noted that in some cases the number of points does not agree with the rules (which are derived from averages) laid down in the Laws of Storms, *i.e.*, 12 points at commencement of storm, 10 points when the barometer has fallen 10 mb. (.3 inch), and 8 points when it has fallen 20 mb. (.6 in.) or more.

The time used in all cases was Ship's Time, so that no doubt there were considerable intervals between the actual moments of observation, some ships being bound west and others east; and had the cyclone also been moving fast the error in the bearings and the gradients would have been considerable, and so W/T weather reports based upon observations made at Ship's Time are misleading for our purpose.

Midnight, April 20th, 1922.

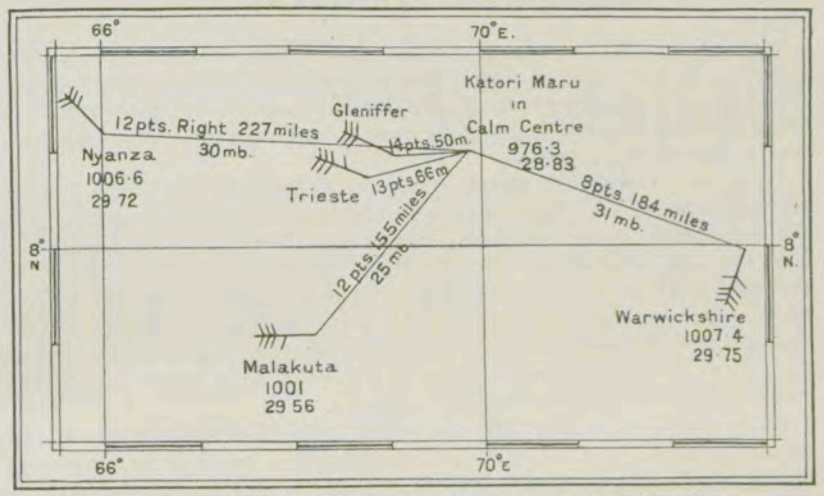


Fig. 12.—Ships' Observations in Cyclone in Arabian Sea.

A Very Heavy March Gale developed from a Secondary.

We saw in Chapter II. that a cyclone which caused severe gales on February 26th, 1923, off the S.W. coasts of the British Isles had probably developed from a secondary, but we did not give a series of charts which showed the development. As indicated in "Weather Systems of Temperate Northern Latitudes," the conditions of secondary depressions are very variable and so make forecasting difficult. There are, however, secondaries concerning which the prediction of strong winds may be made with confidence and the following example deals with such a secondary; it also serves to illustrate the need for care in drawing isobars and bears out the importance of time, position, course, speed, and barometric tendency. Having mastered the drawing of a simple weather chart and supposing that the ships shown upon CHARTS IX., X., XI. and XII. had been able to intercept each other's reports and those for the British coasts we will take it for granted that morning and evening charts were made and see how they would have assisted S.S. *Rhodesian Transport*, Captain W. FOWLER, from Teneriffe to Antwerp.

EVENING, MARCH 6TH, 1922. CHART IX.

This chart shows that there is a depression near the 20th Meridian West, far north of *Baltic's* position, and as the barometer has risen at Stornoway and Wick in the last three hours it may have filled in slightly; we must wait until morning reports are received before we can form a definite idea of its movement.

It should be noted that there is a dip in the 996 (29.41) isobar south of the St. George's Channel and that the barometer is falling at Malin Head, Tynemouth, Scilly, and Dungeness; it is falling slowly at Yarmouth and Jersey, falling quickly at Holyhead, but rising at Valentia.

Now this is caused by a secondary over St. George's Channel, the barometer falling in its front and rising in its rear as it moves eastward.

Rhodesian Transport, steaming N. 32° E., 9 knots, across the Bay, will expect her barometer to fall and strong westerly winds during the night. She will, however, note that *Baltic's* wind away to N.W.

* In the 3rd edition of "The Marine Observer's Handbook" the term "Heavy Gale" for force 10 was adopted as being that in most general use by seamen. In the 4th edition "Whole Gale" for force 10 originally laid down by Admiral BEAUFORT has been adopted in accordance with the agreement made at the last meeting of the International Meteorological Committee (1926).

is from a more southerly direction than the other winds reported to the westward, and seeing that a secondary exists further east will examine *Baltic's* barometric tendency with care. As *Baltic* is steaming S. 83° W., 11 knots and is evidently before the trough, her falling barometer tells little, for this is what would be expected.

MORNING, MARCH 7TH, 1922. CHART X.

The main depression has moved eastward since last evening. The secondary of last evening has probably moved rapidly east and there is a secondary westward of the Bristol Channel. At a glance the most important feature is the divergence of winds reported by *Scythia*, *Homeric*, and *Baltic*.

It will be noted that a secondary is indicated by the sharp curve in the 1004 (29.65) isobar in the vicinity of these ships, that *Baltic's* wind conforms to the circulation of the main depression and that steaming S. 76° W., 13 knots, she has a rising barometer.

Scythia and *Homeric* have winds from nearly opposite points of the compass and are only 120 miles apart. Here there is a wind circulation round a Low, for Buys Ballot's Law indicates that the barometer is lower to the north-westward of *Homeric*, also that it is lower to the south-eastward of *Scythia* than at the positions of those ships.

Homeric to the eastward of this small area of lower barometric pressure has a falling glass when steaming N. 75° E. at 18 knots. *Scythia* to the westward of the small area of lower barometric pressure and steaming the same course and speed as *Homeric* also has a falling barometer.

It is not a difficult matter with our knowledge of the Laws of Storms and of the effect of course and speed upon the tendency of the barometer to see what is happening. With a lower barometer between the two ships and the barometers of both the ships in the fore part of this depression as well as the ship in the after part of it falling, when both ships are steaming the same course and speed, the depression must be deepening and moving with the ships. Therefore the secondary is gaining intensity and travelling to the eastward at a speed of about 18 knots.

With observations that did not synchronize such conclusions would not be possible, and an error of one degree in latitude or longitude would also upset our calculations.

Rhodesian Transport will expect her barometer to fall and the wind to back to S.W., increasing with rain as she comes under the influence of the advancing secondary.

EVENING, MARCH 7TH, 1922. CHART XI.

The main depression is now north of Stornoway, the western secondary is indicated by the bend in the 996 (29.41) isobar and is centred east of *Homeric's* position, having overhauled and passed that ship.

Homeric still has a falling barometer. Now in a ship in rear of a depression but dropping astern of it the barometer rises when the depression is not altering its intensity and, therefore, this observation of *Homeric's* barometric tendency with course and speed is of great value, for it is an indication that the depression is travelling at great speed to the eastward and is deepening considerably.

Rhodesian Transport, now in a strong S.W. gale, expects her barometer to fall quickly as the depression approaches with increasing wind, rain and dirty weather, a shift to N.W. and terrific squalls, after which the weather will probably moderate.

MORNING, MARCH 8TH, 1922. CHART XII.

The complete wind circulation of a cyclone is now shown in this depression which is centred near Bristol. The main depression on the southern part of which this cyclone developed from a secondary is now north of the Orkneys.

During the last 24 hours this secondary depression had rapidly developed and travelled E. by N. 900 miles, causing unusually heavy gales off the coasts of the British Isles.

At Scilly the anemometer before being blown away registered 108 statute miles an hour or 93 knots, which is the second highest recorded in the British Isles.

There were many casualties, including H.M. Destroyer *Laertes* in tow from Portsmouth to Dover, stranded near Newhaven. Four-masted Barque *Garthpool*, in tow of steam tug *Homer*, adrift off Start Point, lost or damaged all sails, braces and lifts, picked up by Dutch S.S. *Themisto* and towed into Weymouth Bay.

S.S. *Orcades* dragged anchors and stranded at Southend. Steam trawler *Marie Therese* sunk with 15 hands. S.S. *Reindeer* and many other vessels suffered damage to deck work and fittings.

Possibility of Development.

This question of Time is very important not only for observation but for transmission and reception of Wireless Weather reports by ships at sea.

From time to time during the last few years pioneers in the development of Wireless and Weather as an aid to navigation have pressed for organisation suggesting that zones should be laid down for governing times of transmission and that uniform Greenwich Times for observation should be adopted for ships in all longitudes at sea.

Based on these suggestions an organisation was outlined in principle and published along with an example to illustrate how useful such a system would be to aircraft navigating over seas as well as to ships, in the December, 1925, "Marine Observer" as a separate article.

This suggested organisation received very strong support from a number of prominent seamen while a few pointed out objections in detail; but when these were replied to in subsequent conversation they were in nearly all cases withdrawn, it being recognised that the scheme was drawn up in principle only and that details could not be worked out with advantage until principles were determined.

There is no doubt that great advantages would be gained by a system of fixed times for transmission and reception of Wireless reports giving observations of weather, current and navigational dangers with uniform times for observation all over the world; but there are objections also and so at the request of some of the keenest members of the Corps of Voluntary Marine Observers this example and scheme are repeated here with reasons for adhering to (at any rate for the present) the rather loose organisation which has grown up by degrees.* Wireless Weather Reports from ships at sea to "All ships" may benefit Airships and Airmen as well as Ships and Seamen. We are told by the signal officers of the Royal Air Force that there need be no difficulty whatever in direct Wireless Telegraphy communication between airships aloft and ships at sea, so that we may assume that reports will be reciprocated direct whenever necessary and without difficulty.

Let us suppose, then, that reports are reciprocated and take an example by using observations from the Daily Weather Reports and from the Metecrological Logs and reports of ships. As no airships are as yet in regular service we shall have to exercise our imagination considerably concerning them. As ships in the Mediterranean are likely to be the first to see airships engaged in regular mercantile service let us see how Wireless Weather Telegraphy and Charts may be used with mutual advantage to ships and airships in that area.

R.M.S. *Osterley*, Commander E. P. CAMERON, R.N.R., sailed from Naples at 0.15 a.m. on December 15th, 1924, for Australian Ports, via Suez; let us suppose when in Latitude 38° 57′ N., Longitude 15° 37′ E., near the Island of Stromboli the usual weather observations are made at the standard Greenwich Time for synchronization and broadcast to all ships by Wireless Telegraphy. Reports from other ships commence to come in and by the time the ship is in the Straits of Messina data messages for Europe and North Africa have been received. With a selection from these reports CHART No. XIII. is made, from which it is seen that the Atlantic anticyclone extends eastward to Spain while another anticyclone is centred near Bucharest to the westward of the Black Sea. There is a depression to the northward of Brest and a shallow irregular depression centred near Sicily extends over the western Mediterranean which, according to the barometric tendencies reported, is neither developing nor changing its position much. With the existing pressure distribution an east-south-east movement may be expected.

It will be noted that *Knight Companion* some 130 miles to the eastward of Malta reports calm, lightning and Cumulo-Nimbus cloud, while the winds reported by ships and stations and the pressure distribution shown indicate that a wide sweep of north-easterly wind from over Asia Minor and the Ægean is faced by an area of calm and south-easterly wind in the vicinity of the Malta and Port Said track between Longitude 15° E. and Longitude 23° E. Unfortunately *City of Marseilles* does not report air temperature which would be very useful compared with that reported by

* Just before going to press (2nd Edition, December 1926). information was received that the International Meteorological Committee have adopted a suggestion to obtain uniformity of observation times for synoptic meteorology in all parts of the world. The times they recommend are G.M.T. 0100, 0700, 1300 and 1900, with suitable modifications in parts of the world where these cannot be worked.

Laomedon to show if the air coming from the south-east was warmer than the north-east wind. The significance of converging winds, how instability of the atmosphere occurs, and its association with thunderstorms and squalls will be dealt with later. Here, conditions reported are very unsettled and conducive to the development of thunderstorms and squalls. From the fact that *Knight Companion* already has lightning, thunderstorms and squalls are probable and the depression may be expected to move eastward.

Osterley will therefore expect squally weather with thunderstorms later.

According to her log, a gentle breeze continued from east-south-east until after passing Cape Spartivento, when the wind freshened from east, lightning was observed during the middle watch to the eastward.

In the morning watch off the south-west coast of Greece the wind increased to the force of a gale, Cumulo-Nimbus clouds came up and there were squalls with rain.

During the forenoon of December 16th, 1924, CHART No. XIV is made, from which it is seen that the depression which was north of Brest has spread; the large shallow Mediterranean depression has also spread considerably; there being squalls, easterly winds with much Cumulo-Nimbus cloud, rain and some lightning south of Greece in the left advance portion of the depression, which is of still more irregular shape and probably has several Lows within it. This chart tells *Osterley* that strong winds with squalls, thunderstorms and heavy rain are probable along her route for the remainder of the day.

Her actual experience was as follows:—

"December 16th, 1924, Noon, Latitude 35° 30′ N., Longitude 22° 21′ E., wind easterly 7, sky overcast, Cu-Nb, squally with rain.

"4 p.m. Wind N.E. 4. Cu-Nb 10. Orq.

"7.16 p.m. Reduced speed; low visibility; heavy rain; wind E.S.E. 7.

"8.14 p.m. Rain moderating; increased speed.

"8.40 p.m. Very heavy rain; reduced speed.

"Midnight, wind E.S.E. 6 (varying and unsteady E.S.E. to N.N.E.; very heavy rain during first watch).

"2 a.m. Vivid blinding lightning and heavy thunder. From midnight to 2 a.m. wind veered to S.W.; speed adjusted throughout to low visibility on account of heavy rain.

"4 a.m. Wind S.W. 4; barometer lowest, 1005.6.

"4.30. Rain ceased, weather cleared."

S.S. *Knight Companion*, Captain H. E. BEALE, from Newport, Mon., to Port Said recorded weather on this day as follows:—

"2.20 to 3.5 p.m. Wind E.N.E.; heavy rain, squally.

"4.00 to 8 p.m. Continuous squally weather.

"5.00. Wind veers all round compass from east through south and north to east in 10 minutes.

"8 p.m. Latitude 34° 14′ N. Longitude 24° 00′ E. Wind E.N.E. 3. o l u q r."

All the foreknowledge which wireless weather reports plotted on CHARTS Nos. XIII and XIV could have given Captain CAMERON would have been useful, particularly as to the heavy rain and reduced visibility he experienced on December 16th, 1924, but how much more useful—indeed, indispensable—wireless weather reports will be to airship commanders, may be gauged to some extent with the same charts and one more chart made with land observations only.

Now suppose that an airship is in Latitude 48° 53′ N., Longitude 1° 00′ E., indicated by **A**, on CHART No. XIIIa, at 7 a.m. on December 15th, 1924, bound for Ismalia and that for reasons including load she does not wish to fly at a great height and that she has only been able to obtain the same surface land reports as *Osterley*. CHART No. XIIIa is made from these only, from which it appears that there are light winds all over the Mediterranean basin and that there is no indication of thunder: further, by shaping a course to pass well to the westward of Sardinia and thence on a rhumb line to Ismalia she will avoid high land and expect, from the information she has, to have fair and light surface winds for nearly the whole of her passage.

Proceeding at a speed over the ground of 40 knots (which is moderate) she would be abeam of *Osterley* at about midnight, December 16th. But, on the other hand, had she been able to receive reports by long-range wireless telegraphy from ships in the Mediterranean just as we have supposed *Osterley* did, she would have all the information given on CHART XIII which shows the probability of squally weather and thunderstoms in the vicinity of Crete.

Now it seems that with the exception of a Tropical Revolving storm there are few things which may be more dreaded by airships than thunderstorms, for apart from the danger of lightning there are tremendous vertical air currents associated with them.

Possibly with this fuller information airship **A** would shape more southerly courses and prefer to increase her distance by passing over the African coast and so avoid the area of great atmospheric instability with its thunder clouds, lightning and squalls of both horizontal and vertical winds, for in December the desert is cool and so "bumpiness" in the air is less than in summer when it is a source of difficulty to the airman.

We have a great deal to learn, but one thing seems certain, that if airship navigation is developed over the oceans, ships' weather reports synchronised for time will be necessary for their safety and comfort at shorter intervals than once or twice a day both direct and through centres for collection and distribution.

It will be noted that we have only been able to chart the apparent direction of upper clouds logged by *Oxfordshire* and *Kaisar-i-Hind*, from all the logs and reports in the Mediterranean on the days used; these observations, if taken, will be especially valuable for they give some indication of the upper winds.

It must be clearly understood that what follows was published in December, 1925, for the purpose of obtaining the views of shipping and seamen and that, just as with the proposed DOUGLAS Sea and Swell scale, no alteration in the present system should be made until a decision has been arrived at.

The following is the scheme as originally published.

Some Considerations as to Time of Observations and transmission of Wireless Weather Reports, Range and Utility.

In the example we have given all the observations do not actually synchronise. Those for the land stations from Brest and Lisbon to Odessa, Athens and Ben Ghazi were taken at 0700 G.M.T., the fixed times for observation for Weather Telegraphy in Europe and North Africa being G.M.T. 0100, 0700, 1300 and 1800. Those for the land stations from Matruh to Limassol and Cairo were taken at 8 a.m. local time, equivalent to 0600 G.M.T., the time of observation for Weather Telegraphy in Egypt.

The ships' observations were logged at 8 a.m. Ship's Time (usually apparent) and therefore according to the longitude of the past or coming noon as each ship shifts her clock; also subject to equation of time.

On these days the difference of time in observation probably did not materially affect the information, but other examples given show how observations not synchronising for time produce misleading results. If this is so for ships with speed not exceeding 27 knots, error will be multiplied for aircraft with their terrific speeds and to which the weather is of the greatest significance.

As already stated the present standard times of observation were fixed ashore before communication by wireless at sea was established, and therefore while these are in vogue ships are asked to make observations for wireless weather reports at the standard time of the nearest country, so that within certain areas as many reports as possible may give synchronised data. The more wireless and weather advances and extends at sea, where observations have always to be considered in relation to position, course and speed, the more important will this question of synchronising for time become.

Then there are the questions of range, traffic, and utility.

Take the case of our imaginary airship **A** to give an illustration.

Before she proceeded from England she would require information compiled from the latest reports of observations at points along her projected route, from positions on either side of it and from the North Atlantic Ocean whence mostly weather systems approach Europe.

For this purpose, just as in the case of Forecasts and Storm Warnings for shipping, reports are required at central collective and distributive centres. Hence ships' reports will be required as the system is developed both in aid of navigation and aerial navigation at such centres as Malta, Ismalia and Aden.

These reports combined in synoptic data messages will also enable the airship to make on board, when on passage, at least a daily weather chart for a very large area of the earth's surface, just as at present the Eiffel Tower message repeating as it does ships' reports from the Atlantic and reports from America enables ships at sea to make a weather chart of a very large portion of the Northern Hemisphere. Then as ships are approached, passed, and left astern en route, while within range these same reports will be of far greater value if received direct because less time will elapse from time of actual observation.

Thus in the practical application of wireless and weather both shipping and aircraft have points of mutual interest and benefit.

Now if and when airships do work over the Oceans a definite plan is necessary if they are to reap full benefit from the co-operation of Marine Observers. From time to time Marine Observers have made suggestions and the following is outlined upon those suggestions with a view to obtaining the views of all interested and their support when an extension of the Voluntary Work of the Corps of Marine Observers is desired for the purpose of aerial navigation in combination with improved information for mariners. This outline is tendered as a suggestion presenting principles; details will have to be worked out when a plan is adopted. It is intended to obtain synchronization for observation, to reduce wireless traffic and to make information reported by selected ships at sea of the widest possible utility to shipping, aircraft, and the shore community.

Observation Times.

G.M.T. 0100 0700 1300 1900. In all Longitudes.*

By fixing observation at four equidistant times in the 24 hour day, not only may synchronization be effected, but during sun up or in waking hours ships and observing stations may observe without undue inconvenience on at least two occasions in the day.

If for special purposes four reports are insufficient additional observations could be made at

G.M.T. 0400 1000 1600 2200.†

but at least two of the four main observation times should always be used and when two are used they should be equidistant.

Transmission Times.

The times of observation being fixed for all longitudes, transmission by reporting ships will jamb unless governed by time and position. The general movement of the world's shipping is more from east to west and west to east than it is from north to south and *vice versa*. Zones may be better limited by longitude than latitude.

Zones for transmission during fixed intervals which do not overlap S.O.S. lookout time are suggested as follows:—

Zones and Times for Transmission.

Ships detailed as reporters to transmit:—

Zone.	Between	and
Long. 0° to 15°W. ...	18 minutes after observation Time (G.M.T.)	32 minutes after observation Time (G.M.T.)
15 ,, 30 ...	33 ,, ,,	45 ,, ,,
30 ,, 45 ...	48 ,, ,,	60 ,, ,,
45 ,, 60 ...	18 ,, ,,	32 ,, ,,
60 ,, 75 ...	33 ,, ,,	45 ,, ,,
75 ,, 90 ...	48 ,, ,,	60 ,, ,,
90 ,, 105 ...	18 ,, ,,	32 ,, ,,
105 ,, 120 ...	33 ,, ,,	45 ,, ,,
120 ,, 135 ...	48 ,, ,,	60 ,, ,,
135 ,, 150 ...	18 ,, ,,	32 ,, ,,
150 ,, 165 ...	33 ,, ,,	45 ,, ,,
165 ,, 180W. ...	48 ,, ,,	60 ,, ,,
180E.,, 165E. ...	18 ,, ,,	32 ,, ,,
Long. 165°E. to 150°E.	33 minutes after observation Time (G.M.T.)	45 minutes after observation Time (G.M.T.)
150 ,, 135 ...	48 ,, ,,	60 ,, ,,
135 ,, 120 ...	18 ,, ,,	32 ,, ,,
120 ,, 105 ...	33 ,, ,,	45 ,, ,,
105 ,, 90 ...	48 ,, ,,	60 ,, ,,
90 ,, 75 ...	18 ,, ,,	32 ,, ,,
75 ,, 60 ...	33 ,, ,,	45 ,, ,,
60 ,, 45 ...	48 ,, ,,	60 ,, ,,
45 ,, 30 ...	18 ,, ,,	32 ,, ,,
30 ,, 15 ...	33 ,, ,,	45 ,, ,,
15E. ,, 0 ...	48 ,, ,,	60 ,, ,,

* In view of the decision referred to in the footnote p. 14 these times have been altered since this appeared in the December 1925 Number of THE MARINE OBSERVER and those now given here are the times which the International Meteorological Committee recommend for all parts of the world. Originally we suggested 0000, 0600, 1200 and 1800 G.M.T. because they were round numbers and commenced with the day.

† Modified to fit the new International times.

For example: There are at 0700 G.M.T. on a certain day 7 fully-equipped observing ships in the Mediterranean; 4 of these ships are at different positions between Longitude 0° and 15° E. and 3 between Longitude 15° and 30° E. It is desired that weather reports should be received at the Malta Meteorological Office and by ships and airships direct.

The 3 ships between Longitude 15° and 30° E. each in turn make the call sign of Malta W/T station **GHA**. and **CQ** (all ships) followed by their weather report between 0733 G.M.T. and 0745 G.M.T. on a certain wave length. The next 3 minutes is occupied in S.O.S. lookout. The 4 ships between Longitude 0° and 15° E. follow the same procedure between 0748 and 0800 G.M.T. With such a system, when well organised, by devoting only about 24 minutes two or three times a day to ships' wireless weather report reception, it is thought that all ships would benefit by the observation and report of the Corps of Voluntary Marine Observers along all ocean routes, and not only would traffic for this purpose be reduced but there would be greater benefit from wireless installations and tested instruments, and Meteorological Offices and aircraft would receive more and better information than at present at reduced cost.

Ships reporting under this system would be restricted in number by limiting their number in the main trades to those specially equipped for meteorological observation. The best disposal would be obtained by selection according to shipping schedules, just as we have obtained such accurate, regular and well-disposed observations reported by wireless from the Trans-North Atlantic Services.

The objections to having 4 equi-distant Greenwich Mean Times for observation in all longitudes are:—

The Meteorologist requires observations taken when the sun in its passage over his particular area has nearly similar influence upon the temperature, atmospheric pressure and variations in weather. He has to cater for the shore community and therefore the times of observations must take into consideration the habits and customs of both land observers and the public for whom information is compiled.

These objections are overcome at sea by the greater need of the Navigator for more general synchronisation than that of the Meteorologist for associating Weather with the daily position of the sun at observation times.

The four times for all longitudes suggested would simplify matters and enable ships over very large areas to make reports of synchronised observations 2 or 3 times a day during sun up. The established watch-keeping system at sea disposes of the difficulty which exists ashore.*

As regards the times suggested for transmission, which are dependent upon the Greenwich Mean Times for observation in all longitudes being adopted, until the shore services will change, very little would be gained, because as was stated in the "Preface," the coast observations form the foundation of this system from which to extend, and therefore until the times of shore observation are changed, the seamen would be the loser by adopting other times for observation.

Then these times do not lend themselves to the present times laid down for Wireless Watch-keeping zones for one or two wireless operator ships, so that until all these factors can be brought into line it is best to adhere to and develop the existing system both for observation and communication.

* Attention is directed to previous footnotes, time does not permit the rewriting of this, nor should we wish to do so.

The Existing System which Marine Observers are invited to practise for the benefit of all ships fitted for Wireless Telegraphy.⁕

The Greenwich Times at which Weather observations are taken in the different countries, of which reports for coast stations may be transmitted for the information of seamen are as follows, and observing ships are advised to take their observations for sending reports to all ships at the same time within the approximate limits suggested.

G.M.T. of Shore Observations.		Suggested approximate limits for observation times by regular voluntary observers making reports to "All Ships."
British Isles and Europe	0700 and 1800	From Longitude 40° W. in the Atlantic Ocean to the west and north coasts of Europe to the Equator including the Mediterranean to Longitude 20° E.
Egypt	0600	In the Mediterranean eastward of Longitude 20° E. and in the Red Sea.
India	0230	Arabian Sea, Persian Gulf. Bay of Bengal and Indian Ocean north of the Equator.
China	2200	China Sea.
Japan	2100	From the east coast of Japan in the Pacific Ocean to Longitude 180° E., north of the Equator.
North America	0100 and 1300	From Longitude 40° W. in the Atlantic to the east coast of North America north of the Equator. From Longitude 180° W. in the Pacific to the west coast of America north of the Equator.
South Africa ...	0630	From Longitude 20° W. to the African Coast in the Atlantic Ocean south of the Equator. From Longitude 80° E. to the African Coast in the Indian Ocean south of the Equator.
Australia ...	2330	From Longitude 80° E. to the Australian Coast in the Indian Ocean south of the Equator. From Longitude 160° E. to the Australian Coast in the Pacific south of the Equator.
New Zealand ...	2130	From Longitude 160° E. to Longitude 130° W. south of Latitude 30° S.
Fiji	0330 and 2030	From Longitude 160° E. to Longitude 130° W. between the Equator and Latitude 30° S.
South America	1200	From Longitude 130° W. to the American Coast in the Pacific south of the Equator. From Longitude 20° W. to the American Coast in the Atlantic south of the Equator.

⁕As it will probably be some years before the new International times are used, this holds good notwithstanding the previous footnotes.

Communication.

If all ships were to try to make Weather Reports to "All Ships" their object would be defeated by jamming.

Of the 500 ships which are regular observers to the British Meteorological Office and whose names appear in the most recent Number of "The Marine Observer," a large number have mercurial barometers which are reliable, and these ships are best provided with information. Therefore ships indicated by the letters M.L., M., and W.T. after their names in the list are "Selected Ships" invited to make Wireless Weather Reports to "All Ships" for the purpose of providing observations which synchronise once or twice daily.

When all these selected ships carry out this practice the Corps of Marine Observers will have achieved much towards success, and as the geographical distribution of the Voluntary Observing Fleet is being steadily improved there will be suitable data in all parts of the Ocean for making a weather chart once daily.

When a weather chart is made, then, miscellaneous Wireless Reports giving weather at odd times will be the more valuable. Ships which are not selected as regular reporters to "All Ships" might be asked to refrain from communicating weather at the time that regular reporters are doing so.

The matter of wavelength and time of transmission is left to the Commanders of selected ships. They will do well to give first consideration to range and, as there are now a great many ships fitted for C.W. reception, selected ships fitted for C.W. transmission would do well to make their weather reports to "All Ships" on 2,400 m. C.W., and if they repeat them on 600 m. spark more may benefit. Selected ships fitted for spark transmission only, should usually report weather on 600 m. spark. The time of transmission should be regulated by each Commander having regard to the time zones laid down for Wireless Operator Watches. The great thing is to remember that the whole system is entirely voluntary and that the more regularly the Corps of Voluntary Marine Observers practices it the more useful will it become to the Sea Services as a whole. It is bound to benefit the shore community indirectly if not directly, and by adding the call sign of certain stations to the address "All Ships" when asked to do so, Marine Observers will receive the gratitude of Directors of Observatories who require Weather reports from ships at sea.

Apart from daily routine reports made by selected ships to "All Ships" any ship observing the formation of a Hurricane, Typhoon or Tropical Cyclone which has not been reported should make an "Urgent" report to "All Ships" and stations at any time.

Tropical revolving storms will be the subject of the next two chapters.

CHAPTER IV.

TROPICAL REVOLVING STORMS.

Of all the uses to which wireless communication may be put by the navigator as regards weather, there is probably none in which it has greater value than in these storms.

The Tropical Revolving Storm is more nearly a perfect vortex than any other cyclone, being of a more compact, intense form; and at sea experience in these storms has taught us more of the Laws of Storms than any other experience.

It will, therefore, be well to briefly summarise these laws and with them the rules which have stood us in such good stead for handling ships.

A Tropical Revolving Storm may be described as an intense whirl in the atmosphere, in which there is usually a calm centre, sometimes called by seamen the vortex; round this region of calm there is a belt of winds of hurricane force beyond which the wind blows in a direction round, but towards, the centre. In the Northern Hemisphere the air circulates in the opposite direction to the hands of a watch; in the Southern Hemisphere the air circulates in the same direction as the hands of a watch.

The area covered by a Tropical Revolving Storm may vary in diameter from 20 miles to some hundreds of miles; the wind in the same part of a storm may vary considerably, at times being hurricane force, at others lulling into little more than a strong breeze. As well as this circular motion, Tropical Revolving Storms have a forward or progressive motion. They frequently originate near the Equator, but seldom within 6° of it. At first moving westward with gradually increasing speed, they often travel round the western edge of the great ocean anti-cyclones, recurving near the Tropics when their progressive speed is reduced. Thence they travel north-east or south-east, according to hemisphere, and eastward, increasing speed, spreading, and dying out in middle or high latitudes, or they may coalesce with other weather systems of middle or high latitudes. Their tracks often vary, particularly in Monsoon regions, where they are most erratic.

FIGURE 13 shows conjectural tracks of the centre of Tropical Revolving Storms in Northern and Southern latitudes. Tracks of Tropical Revolving Storms which have occurred in all oceans have been published monthly in "The Marine Observer" in 1924 and 1925; they should be carefully studied when entering those regions in cyclone seasons.

FIGURE 14 shows the actual tracks of two hurricanes which occurred in the Western North Atlantic in September, 1921.

FIGURE 15 shows the track as far as it can be laid down with observations available of a cyclone which occurred in the Arabian Sea in November, 1920.

FIGURE 16 shows the average wind circulation in Tropical Revolving Storms in Northern and Southern latitudes, by which the rules for handling ships may be illustrated.

Nomenclature, Figure 16.

Path: the path along which the centre will probably travel.

Track: the track along which the centre has travelled.

Right Semi-circle: looking along the path, that half of the storm which lies to the right.

Left Semi-circle: looking along the path, that half of the storm which lies to the left.

Trough: the line of lowest barometer athwart the path.

Dangerous Quadrant: the advance quadrant of that semi-circle which lies on the side of the path nearest to the normal direction of recurvature, so named because a ship caught in the dangerous quadrant may be blown towards the path over which the ring or hurricane winds and the centre will pass, or the storm may recurve and pass over her. It should be noted that the strongest winds are usually found in rear of the trough, hence it often blows hardest with the first rise of the barometer.

Navigable Semi-circle: that semi-circle which lies on the side of the path furthest from the normal direction of recurvature.

Centre: at the centre of the storm the barometer is always lowest and there is comparative calm; here the sea is extremely dangerous, running in all directions, and has been described as a "boiling pot."

When the centre approaches a ship she may experience increasing wind with violent squalls, later hurricane force, with mountainous seas; as the centre passes over her the wind drops; when it has passed the wind may come from the opposite point of the compass with renewed and increased violence; as the storm recedes from the position of the ship the wind moderates; this is illustrated by A, A1, A2, etc., shown in the FIGURE. Much rain, thunder and lightning may be experienced. There is often a patch of blue sky over the centre, known as the *Bull's Eye.*

Vertex: the most westerly point reached by the centre when recurvature takes place. Also known as the *Cod* of the Track.

Angle of Indraft: the angle which the direction of the wind makes with an isobar.

Thus in North Latitude, if near the centre the wind blows along an isobar and the centre bears 8 points to the right when facing the wind, there is said to be no indraft, or if the wind blows at an angle of 2 points to an isobar, and the centre bears 10 points to the right of an observer facing the wind, the indraft is said to be 2 points. It must, however, be remembered that isobars in these storms are not always circular and therefore the angle of indraft may not conform to the angle of the bearing of the centre, minus 8 points.

Tropical Revolving Storms are known as Cyclones in the Indian Ocean, Hurricanes in the West Indies and South Pacific, and Typhoons in the China Seas.

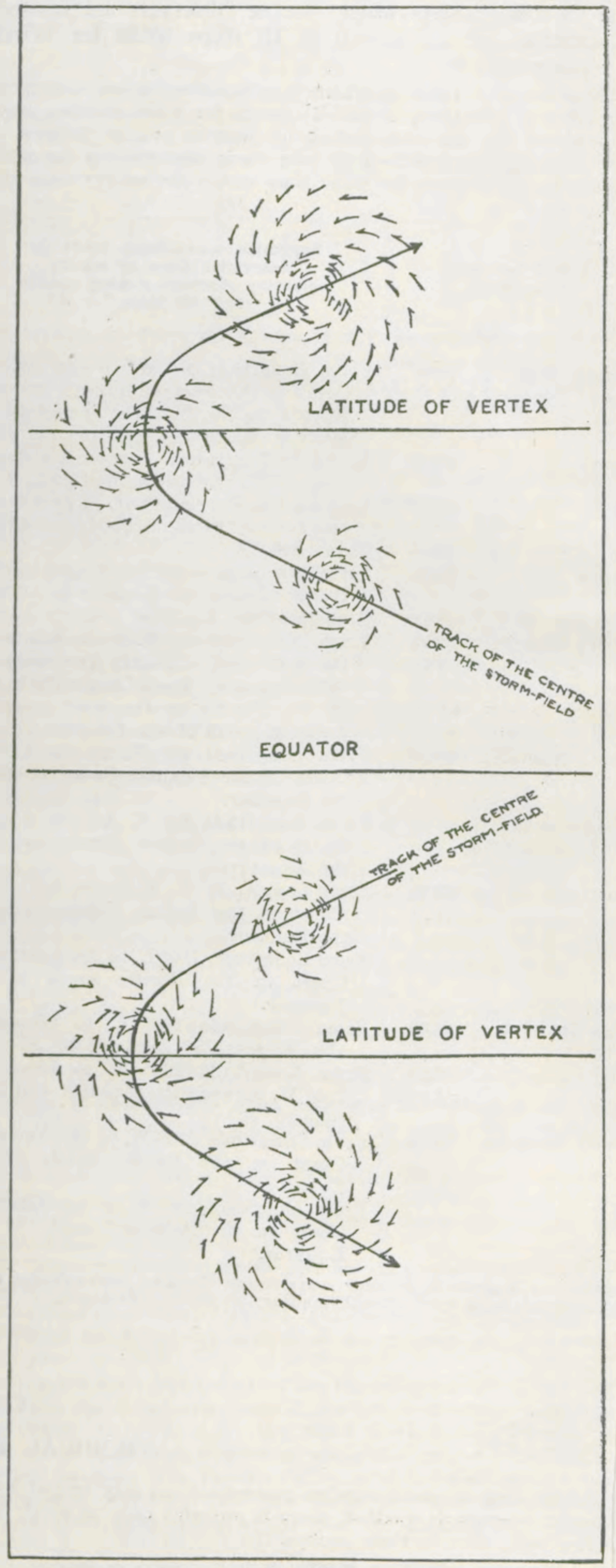


Fig. 13.

Seasons.

Hurricanes of the West Indies.—June to November, September being the month of greatest frequency.

Hurricanes of the North Pacific and Typhoons of the China Seas.—All months of the year, July to October being the months of greatest frequency.

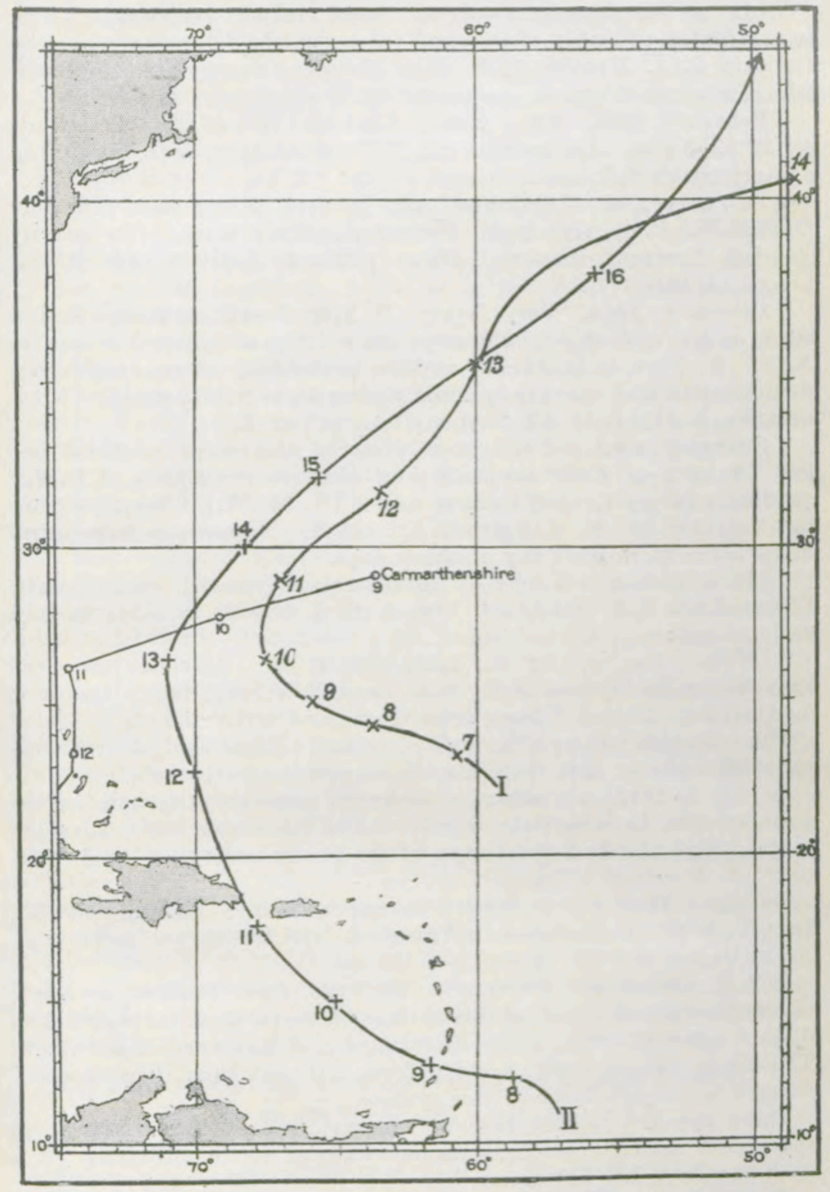


Fig. 14.—Tracks of September Hurricanes, 1921.

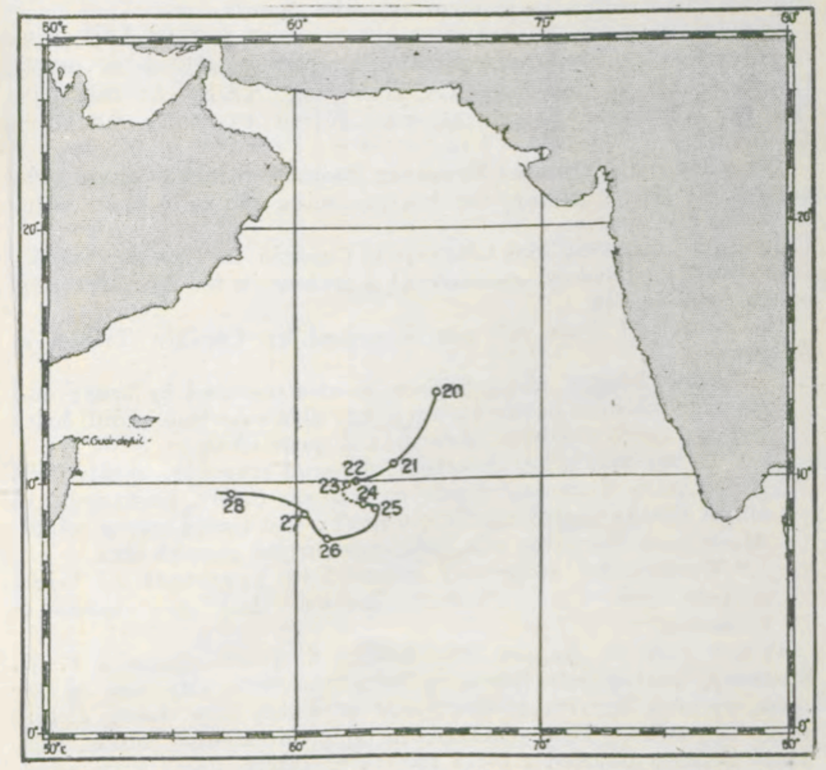


Fig. 15.—Track of Cyclone with noon positions, November 20–28, 1920.

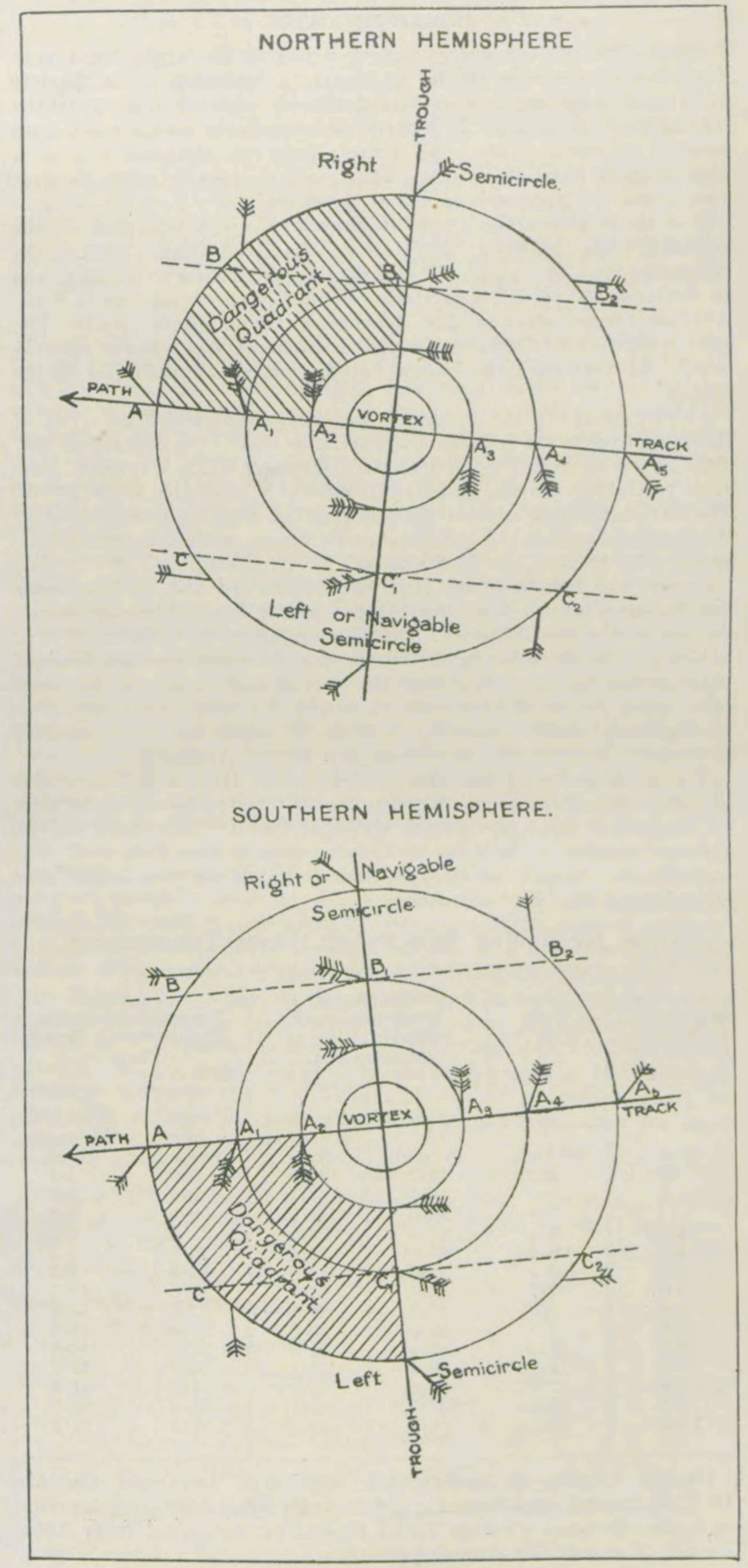


Fig. 16.

Hurricanes of the South Pacific.—November to April, months of greatest frequency January to March.

Cyclones of the Arabian Sea.—April to January, months of greatest frequency June, October and November; storms seldom occur in the month of August.

Cyclones of the Bay of Bengal.—April to December, September being the month of greatest frequency.

Cyclones of the South Indian Ocean.—October to July, months of greatest frequency December to April.

Precursory Signs.

Swell.—The action of the violent winds in the right hand rear quadrant of revolving storms in Northern latitudes, or in the left hand rear quadrant in Southern latitudes, blowing mainly in the direction of advance of the system, develops large waves which pass onward as swell. This swell travels to great distances and at a greater speed than the storm. Thus swell frequently gives the first warning of an approaching revolving storm.

FIGURE 15 shows the track of a cyclone which occurred in the Arabian Sea between November 20th and 28th, 1920. On November 20th, at 8 p.m., S.S. *Brodholme*, from Suez to Sabang, was in Latitude 13° 16′ N., Longitude 53° 10′ E.; the wind was N.N.E., a fresh breeze, weather fine, barometer 1015.6 (29.99 ins.). The only indication of the existence of a disturbance was a heavy easterly swell. At that time the centre was distant about 550 miles to the eastward.

FIGURE 14 shows the tracks of two hurricanes which occurred at the same time in the Atlantic in September, 1921. On September 9th, 1921, at 8 a.m., S.S. *Carmarthenshire*, Captain E. C. WAKEMAN, from Hull to Galveston, was in Latitude 29° 01′ N., Longitude 63° 23′ W. The barometer was normal for the time of year and conformed to the diurnal range, wind S.S.E. a gentle breeze, with a moderate S.E. swell. By 10 p.m., in Latitude 28° 14′ N., Longitude 66° 52′ W., the swell had become heavy from the Southward and the barometer had fallen slightly, with the wind a gentle South-Easterly breeze. At this time a hurricane was centred some 900 miles to the southward of *Carmarthenshire* in the Carribean Sea, of which she had received information by wireless. Had the period and length of the swell been taken it would have been shown by the table below that even if the swell could clear the Islands it could not have reached *Carmarthenshire* in the time from No. II. Hurricane.

The swell indicated the presence of No. I. Hurricane, the centre of which was distant within 100 miles to the Southward at 10 p.m. on September 9th. She passed ahead of No. I. Hurricane, experiencing its wind circulation with force 5 at most. This swell was undoubtedly caused by the Southerly winds in the right rear quadrant of No. I. Hurricane.

Table for finding Velocity of Waves Transmission.

Wavelength in Deep Sea.	Wave Period.	Velocity of Transmission of **Individual** Waves in Deep Sea.		Velocity of Transmission of the **Disturbance** or **Group** in Deep Sea.	
Feet.	Seconds.	Feet per Second.	Nautical Miles per Hour.	Feet per Second.	Nautical Miles per Hour.
25	2·2	11·3	6·7	5·7	3·4
50	3·1	16·0	9·5	8·0	4·8
75	3·8	19·6	11·6	9·8	5·8
100	4·4	22·6	13·4	11·3	6·7
150	5·4	27·7	16·4	13·9	8·2
200	6·3	32·0	19·0	16·0	9·5
300	7·7	39·2	23·2	19·6	11·6
400	8·9	45·2	26·8	22·6	13·4
500	9·9	50·6	30·0	25·3	15·0
600	10·9	55·4	32·8	27·7	16·4
700	11·8	59·8	35·4	29·9	17·7
800	12·6	63·8	37·8	31·9	18·9
900	13·3	67·7	40·1	33·9	20·1
1,000	14·1	71·4	42·3	35·7	21·2

On the evening of August 15th, 1925, S.S. *Dardanus*, Captain D. T. WILLIAMS, experienced a S.S.E. swell 8 feet high with a period of 9 seconds when clearing Isumi Strait, having sailed from Kobe, Japan, at 4 p.m. the same day.

According to the Daily Weather Chart of the North Pacific Ocean of the Imperial Marine Observatory of Kobe, Japan, at this time a typhoon, travelling northward at about 200 miles a day, was centred some 300 miles south of Isumi Strait.

This swell travelled according to our table at a speed of 13½ knots. It probably originated in the right-hand semi-circle of the typhoon, where the wind was southerly and bearing to the eastward of south.

At 13½ knots it would travel 300 miles in 22 hours, but it had come a greater distance and been in existence more than 22 hours because the typhoon was also travelling northward. The typhoon eventually passed over this place of observation and the swell gave nearly a day and a half's warning.

While in this case the swell was slight and the typhoon in which it originated probably of no great intensity, the following report by Captain C. J. HIGGINS, S.S. *Clan Malcolm*, shows the heavy swell which may reach beyond the stormfield of a cyclone.

"February 20th, 1925. Noon, Latitude 17° 48′ S., Longitude 91° 23′ E., 3 p.m. Indications of a N.W. swell observed to be running against rough S.E. sea.

"February 21st. Swell gradually increasing and now definitely from N.W. P.M., very high. Moderate easterly winds. Sky heavily clouded, frequent showers. Noon position, Latitude 15° 21′ S., Longitude 88° 04′ E.

"February 22nd. Very heavy W.N.W. swell, steamer diving bows under and shipping heavy water. 5 p.m. altered course to N. 10° W. True to avoid seas and the probability of running into a stationary or slow moving cyclonic storm: light N.E'ly winds. Noon position, Latitude 13° 23′ S., Longitude 84° 58′ E.

"February 23rd. Swell now westerly and more confused but less. Squalls of moderate force and frequent rain from N.N.W.: gradually brought vessel back to course (N. 55° W.). Noon position Latitude 10° 35′ S., Longitude 83° 21′ E. No serious barometric disturbance at ship on any of above days.

"The following is a copy of radio message received from Captain SCOTT of the S.S. *Bradford City* on 23rd showing weather he had encountered:—

"'Noon. Lat. 10° 02′ S., Long. 82° 37′ E. Past two days we have had gales between S.E., S.W., and N.W. with heavy seas now moderating. Bound Sabang from Durban.'"

The following example is useful in that it shows that observations recorded indicate that there may be exceptions to the rule.

In April, 1922, a number of steamers were in a cyclone in the Arabian Sea in which the wind reached hurricane force near the centre. For the first four days of its known existence, April 18th to 22nd, it moved little.

On April 22nd it was centred in approximately Latitude 10° N., Longitude 69° E.: whence it travelled N.N.W. at not more than 100 miles per day.

R.M.S. *Macedonia*, Captain A. F. VINE, from Bombay to Aden, steamed across the front of this cyclone on April 23rd, its centre then distant some 400 miles to the Southward and Eastward of her track. The winds logged never exceeded force 3 though their direction conformed to the ciculation of this cyclone.

There appears to have been no unusual swell at this distance, as the report stated "No indications whatever of the proximity of a cyclone except low barometer."

Cirrus clouds originating over the vortex extend to great distances. When Cirrus is observed forming a V the point of convergence may indicate the direction of a storm from the observer.

At 8 a.m. on September 9th, 1921, the Motor Ship *La Paz*, Captain C. H. CHRISTIAN, from Colon to London, when in Latitude 20° 00′ N., Longitude 64° 45′ W., logged Cirrus from S.S.E. At this time No. II. Hurricane, FIGURE 14, was centred 400 miles S.S.E. of *La Paz*.

Sky colouring.—Tropical Revolving Storms are often heralded by remarkable sky colouring, the heavens being red or copper colour at sunset and sunrise.

On June 9th, 1920, S.S. *Rotenfels*, Captain A. TAYLOR, O.B.E., from Basra to Bombay, encountered a cyclone in the Northern part of the Arabian Sea.

The sunset of June 8th was described by Captain TAYLOR as follows:—

"Sun when 10° above horizon became obscured by heavy dull coppery coloured bank—emerged just above horizon a dull brick red and much distorted, then dipped quite clear.

"To the North, low detached inky scud travelling slowly from N.E., heavy Cumulus clouds on horizon to the Eastward. In zenith streaks of rippled Cirro-Cumulus just tinted copper colour. Above bank obscuring sun, patches of bright peacock blue.

"Western sky gorgeously coloured by huge bank of bright coppery red cloud. Eastern horizon, dull grey banks of Cumulus."

At 6.30 p.m. on August 24th, 1924, S.S. *Orari*, Captain F. W. ROBINSON, having left Newport News, the same day was on the outskirts of a hurricane, the centre of which bore South distant about 300 miles. They observed an ugly threatening sunset. The whole heavens assumed a lurid red colour intermingled with orange and purple lasting for a matter of ten minutes, the sky to windward retaining a dull red glow after the sun went down.

The Barometer.—Apart from the fall of the barometer at any place over which a tropical cyclone passes there are precursory signs which are of very great importance.

According to Sir JOHN ELIOT, for many years Director-General of Observatories in India:—

"In the Bay of Bengal. If the reduced barometer reading is, at any time during the cyclone season, a tenth of an inch below the normal for the time of day, the possibilities are two to one that a cyclonic storm has formed in the Bay; if the decrease below normal is 0.15 inch the probabilities are at least three to one, and if two-tenths below it is practically certain that a cyclonic storm has formed."

It must be remembered that the barometer frequently stands above the normal on the outskirts of a storm in formation.

In order to find out how frequent variation from the normal pressure was in regions of tropical revolving storms, an examination was made in the Marine Division in 1922 of barometer readings recorded four-hourly in May, between Latitude 10° N. and 12° N., and Longitude 60° E. and 70° E. in the Arabian Sea during 1857 to 1905, a region where many cyclones have occurred.

In that region a decrease of pressure of 3 mb. ($\frac{1}{10}$ inch) below normal is infrequent, amounting to 6 per cent. of observations in 48 years. While searching the logs it was found that a number of ships had recorded barometer 3 mb. below normal and that cyclones had occurred later in the vicinity.

Since 1922 the diurnal range and departure from the normal height of the barometer has been the matter of considerable investigation for tropical regions at sea on both sides of the Equator in the Marine Division, and there can be no doubt that if there is a departure from the normal atmospheric pressure *for the time of day* of 3 mb. ($\frac{1}{10}$ inch) or more, the mariner may expect that a cyclone has formed or is forming in the vicinity and he should be on the alert for other signs.

The following tables give the correction for diurnal variation in atmospheric pressure over the ocean between Latitude 10° to 20° N. and Latitude 10° to 20° S. for all longitudes. They are constructed from a great many observations for the years 1921 to 1924, and may be used for our purpose for all tropical regions with sufficient accuracy.

Tables to correct Barometric Pressure for Diurnal Variation.

Lat. 10° to 20° N. in all Longitudes at Sea.

Ship's Time.	Northern Spring.		Northern Summer.		Northern Autumn.		Northern Winter.	
	Mbs.	Ins.	Mbs.	Ins.	Mbs.	Ins.	Mbs.	Ins.
4 a.m.	+ 0·8	+ ·02	+ 0·7	+ ·02	+ 0·8	+ ·02	+ 0·3	+ ·01
8 a.m.	− 1·1	− ·03	− 0·9	− ·03	− 0·9	− ·03	− 0·9	− ·03
Noon	− 0·9	− ·03	− 0·6	− ·02	− 0·7	− ·02	− 0·6	− ·02
4 p.m.	+ 1·3	+ ·04	+ 1·2	+ ·04	+ 1·3	+ ·04	+ 1·4	+ ·04
8 p.m.	+ 0·1	·00	+ 0·1	·00	− 0·1	·00	0·0	·00
Midnight	− 0·4	− ·01	− 0·3	− ·01	− 0·3	− ·01	− 0·2	− ·01

Lat. 10° to 20° S. in all Longitudes at Sea.

Ship's Time.	Southern Spring.		Southern Summer.		Southern Autumn.		Southern Winter.	
	Mbs.	Ins.	Mbs.	Ins.	Mbs.	Ins.	Mbs.	Ins.
4 a.m.	+ 0·6	+ ·02	+ 0·7	+ ·02	+ 0·7	+ ·02	+ 0·5	+ ·02
8 a.m.	− 1·0	− ·03	− 1·0	− ·03	− 0·8	− ·02	− 0·9	− ·03
Noon	− 0·5	− ·02	− 0·4	− ·01	− 0·4	− ·01	− 0·4	− ·01
4 p.m.	+ 1·4	+ ·04	+ 1·3	+ ·04	+ 1·1	+ ·03	+ 1·2	+ ·04
8 p.m.	0·0	·00	− 0·1	·00	− 0·2	− ·01	− 0·2	− ·01
Midnight	− 0·5	− ·02	− 0·4	− ·01	− 0·4	− ·01	− 0·5	− ·02

It should be clearly understood that the absolute pressure, *i.e.*, the barometer reading corrected for index error, temperature, height and gravity only, as explained in Chapter I should be reported by wireless or logged; this correction for the diurnal range should be applied by the receiver of a wireless report or to his own barometer observation for comparison with the normal atmospheric pressure as given on the Ocean Meteorological Chart for the month. *On no account should this correction be applied before entry in the log or for use in a report.*

We have been taught for many years that "a cessation of the diurnal range may foretell a tropical revolving storm."

Now the diurnal range of the barometer is due to atmospheric pressure waves which sweep regularly round the earth from east to west, being at a maximum in the Tropics where they are clearly indicated by the rise and fall of the barometer. That they cease when there are violent atmospheric disturbances is not proved by observation, for if hourly barometer readings are plotted and a curve drawn through them, it would be found that the diurnal range continues right into a cyclone, though when the gradient is steep or the storm is passing quickly over the place of observation this range is masked by the rapid fall of the mercury.

As there are some who still cling to the belief in this old fallacy, *i.e.*, that "a cessation of the diurnal range foretells a tropical revolving storm" it will be well to give three experiences—one of the present Principal Examiner of Masters and Mates, one of my own, and one of Captain R. H. DOMINY, C.B.E., who is still at sea (1927) and an active member of the Corps of Marine Observers.

In FIGURE 17 are plotted the observations of wind and barometer observed in S.S. *Mahratta*, Captain W. ELLERY, on June 23rd to 25th, 1907, from Calcutta to Colombo. At this time *Mahratta* was in the after part of the stormfield of a cyclone off the coast of Bengal which travelled north and passed near Calcutta at about midnight on June 24th, 1907. The observations were logged from after the pilot left at the Eastern Channel.

It will be noted that the diurnal range continued.

FIGURE 18 is constructed with the observations in a Meteorological Log in my own handwriting and in which I took many of the observations, so that I can personally guarantee its accuracy. It was kept on board R.M.S. *Orontes*, Captain J. F. RUTHVEN.

S.S. "Mahratta," Captain W. Ellery, Calcutta to Colombo.

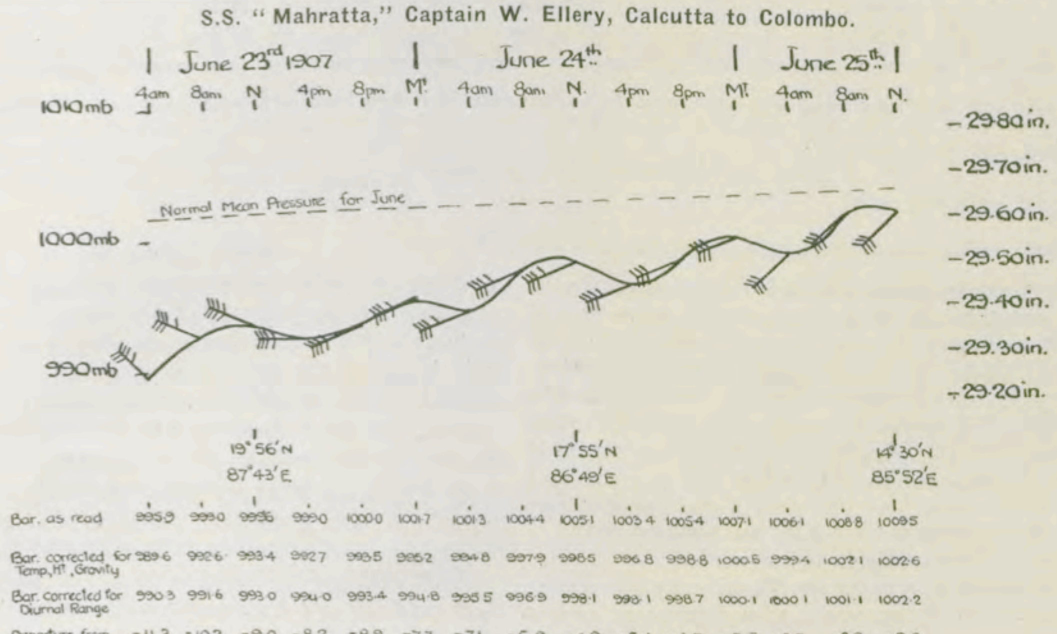
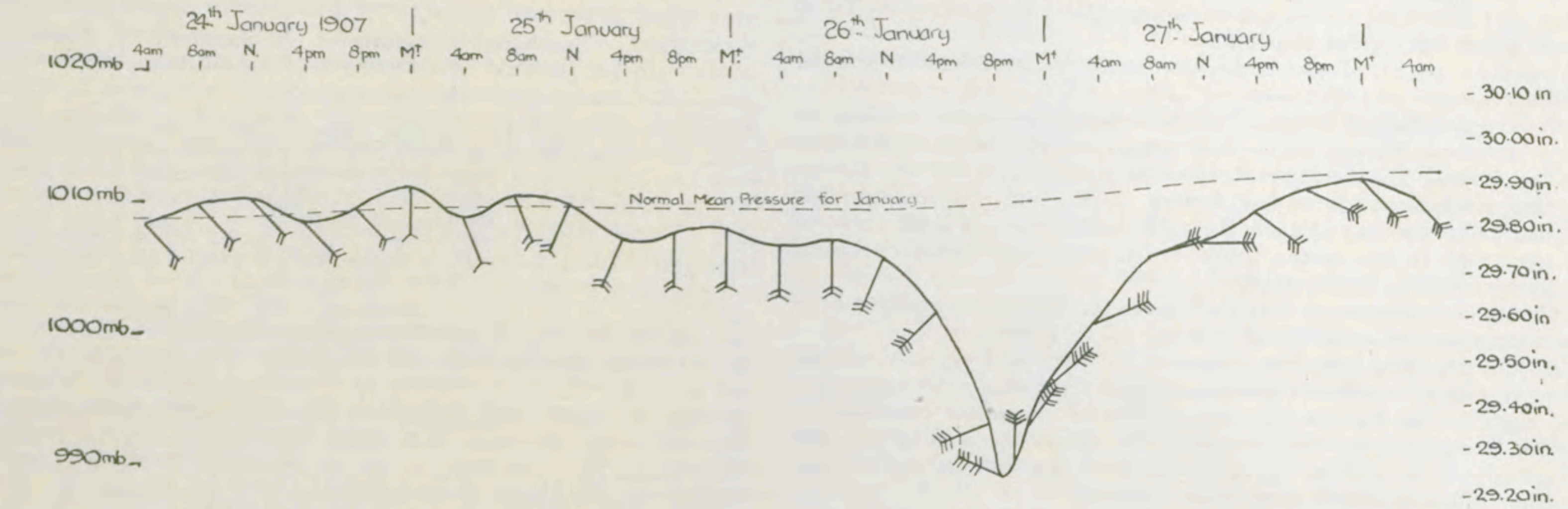


Fig. 17.

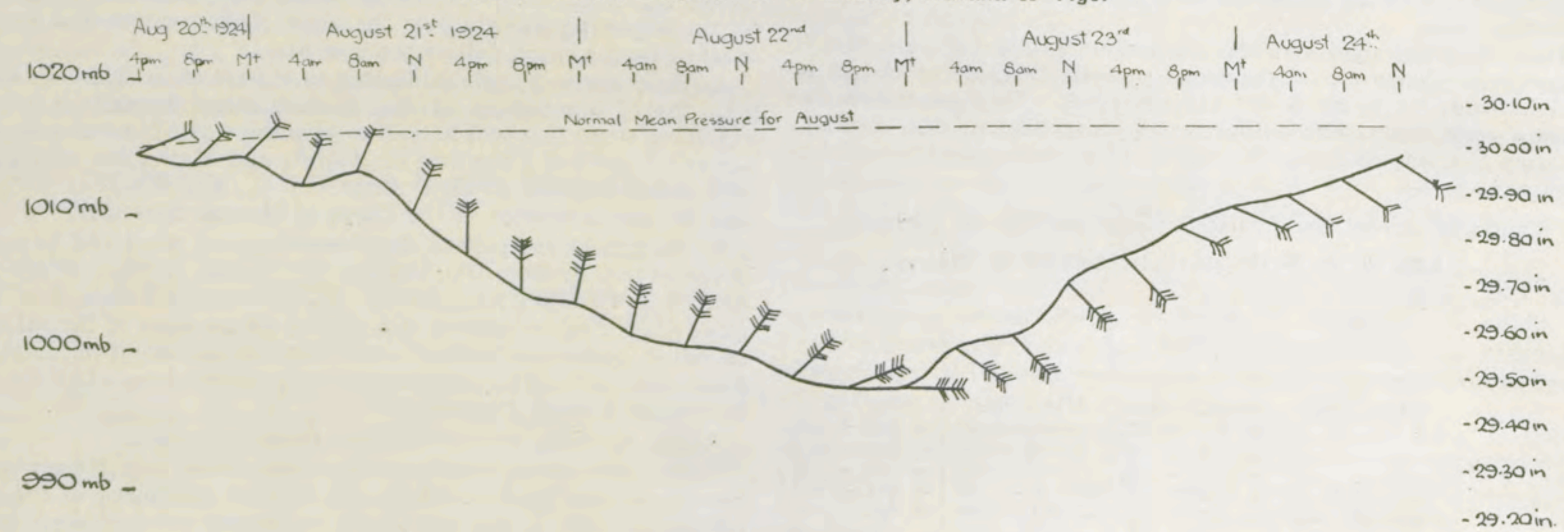
R.M.S "Orontes," Captain J. F. Ruthven, Colombo to Fremantle.



Position		8° 48'S 94° 12'E							12° 19'S 98° 22'E						15° 21'S 101° 53'E					20° 23'S 104° 49'E				
Bar. as read	1014.2	1015.9	1015.9	1014.5	1015.6	1016.9	1014.5	1016.6	1015.9	1013.5	1013.9	1014.2	1012.5	1013.2	1011.8	1007.4	999.0	1001.3	1006.8	1011.8	1013.9	1015.6	1016.9	1017.6	1015.9
Bar corrected for Temp., Ht., Gravity	1008.4	1009.9	1010.1	1008.8	1009.8	1011.2	1009.1	1010.8	1010.1	1007.7	1008.1	1008.5	1007.1	1007.6	1006.3	1002.1	993.6	999.6	1001.6	1006.6	1007.9	1010.1	1011.9	1012.8	1011.3
Bar. corrected for Diurnal range	1008.9	1009.0	1009.7	1010.0	1009.6	1010.7	1009.6	1009.9	1009.7	1008.9	1007.9	1008.0	1007.6	1006.7	1005.9	1003.3	993.4	999.1	1002.1	1005.7	1007.5	1011.3	1011.7	1012.3	1011.8
Departure from Normal	0.0	0.0	+0.7	+0.8	+0.3	+1.2	0.0	+0.1	−0.3	−1.1	−2.1	−2.0	−2.4	−3.3	−4.1	−7.1	−17.4	−12.1	−9.5	−6.3	−4.9	−1.4	−1.1	−0.7	−1.3

Fig. 18.

R.M.S. "Orita," Captain R. H. Dominy, Havana to Vigo.



Position						27°52'N 78°56'W						29°32'N 76°03'W						29°51 N 74°15'W						32°52'N 69°37'W
Bar. as read	1017.5	1016.4	1016.8	1015.0	1016.2	1013.1	1009.9	1007.2	1006.1	1003.8	1003.0	1002.4	1000.5	1000.0	1000.0	1003.2	1004.3	1008.2	1010.3	1012.2	1013.6	1014.4	1015.4	1017.0
Bar. corrected for Temp., Ht., Gravity	1014.3	1013.6	1014.1	1012.2	1013.3	1010.2	1007.4	1004.7	1003.8	1001.5	1000.7	1000.1	998.4	997.9	997.9	1000.9	1001.9	1005.9	1007.9	1010.0	1011.5	1012.3	1013.4	1015.0
Bar. corrected for Diurnal range	1015.5	1013.7	1013.8	1012.9	1012.4	1009.6	Latitude. too high for Table given for Tropics																	
Departure from Normal	0.0	−1.8	−2.0	−3.0	−3.6	−6.4																		

Fig. 19.

We were making the passage from Colombo to Fremantle in January, 1907, and experienced the S.E. trade which sprang up, as so often happens with a shower of rain, in the Indian Ocean, at 9 p.m. on January 23rd when six degrees south of the Equator. The S.E. trade was steady, gentle to moderate, until midnight on 25th when it fell light and veered to south, the diurnal range being well marked. After noon on January 25th the barometer, still continuing to show the diurnal range, fell below the normal and remained below normal to the extent of just over 2 mb. for the time of day at each recorded observation until 4 a.m. on January 26th.

At 8 a.m. on January 26th it was 3.3 mb. below normal.

Now at 8 a.m. and until about 10 a.m. in the Tropics the barometer is rising, but if the approach or development of a depression causes a reduction in the atmospheric pressure then, although the crest of the wave in the pressure of the atmosphere is also approaching, the reduction of pressure due to the depression may be greatest, and when this happens the net result is a fall of the barometer during the period when it would be normally rising. The diurnal range had not ceased, but the barometer was now steadily falling from its normal height in this locality.

At 8 a.m. on January 26th, 1907, this departure from the normal of 3.3 mb. was a distinct warning, and to wait longer to see if the barometer would rise as it should was unnecessary. The fall from normal and not the relative height of the barometer at 8 a.m. to the last reading at 4 a.m. constituted the warning.

It is quite conceivable that on some occasions to delay action when there is a departure of 3 mb. below normal to see if the barometer rises again might mean approaching the dangers of the vortex of a cyclone.

In this case by quite a small alteration of course to the eastward, Captain Ruthven passed in rear of the vortex and made a fair wind of the N.E. gales in the cyclonic circulation, thus, so to speak, "checking the fall of the barometer and the increase of wind by a timely touch of the helm."

Figure 19 is made from the observations of wind and barometer observed in R.M.S. *Orita*, Captain R. H. Dominy, Havana to Vigo, when she encountered a West Indian hurricane in August, 1924. It will be noted that the barometer was 3 mb. below normal at 4 a.m. on August 21st and that up to that time the rise and fall of the barometer with the diurnal range of pressure is clearly shown.

In all these cases the barometer as read, the absolute pressure obtained therefrom, the absolute pressure corrected for the time of day for diurnal range, and the departure from the normal are given at the foot of the figure. The positions of the ships are also given for noon each day and the normal pressure for the month at the place is shown by a pecked line in the figure.

Let us see how the normal is obtained in this instance. Referring to the Meteorological Chart of the North Atlantic for August it will be noted that the isobar 1016 (30.00) passes N.W. by W. through *Orita's* 8 a.m. position on August 21st while the 1014 (29.94) isobar passes to the westward just north of Jamaica and across the Mosquito Coast. Thus by interpolation the exact normals may be obtained at each position along *Orita's* track, and under normal conditions the barometer corrected for diurnal range would have risen slowly as she proceeded to the northward, where on the average the barometer is higher.

That there may not be a departure of 3 mb. ($\frac{1}{10}$ inch) below the normal in a vicinity where a cyclone has formed or is forming is true; proof of which was given in the cyclone reported by the steamships *Clan Macindoe*, *Clan Macfadyen*, *Titan*, *Mantua* and *Glenshane*, on November 24th, 1925, in the Bay of Bengal. On this occasion neither the coast station observations published in the Indian daily weather report nor the mercurial barometer readings in ships' meteorological logs revealed an appreciable departure below the normal, and a cyclone developed before 6.30 a.m. on November 24th, 1925, in the Southern part of the Bay of Bengal and was in existence until the morning of November 28th when it filled in near Madras.

Again on May 19th, 1926, S.S. *Risaldar*, Captain G. Park, who has made a special study of cyclones, recorded barometer readings less than 2 mb. below normal, and logged every appearance of fine weather as he proceeded from Colombo towards Calcutta. At this time a cyclone had formed in the S.E. portion of the Bay, and on May 21st S.S. *Burma* experienced winds of storm force in its rear to the westward of the Andamans.

This cyclone wrought great havoc at Akyab on May 23rd, 1926, and on Empire Day hurricane winds visited Calcutta doing damage at Kidderpore Dock.

As there may be no precursory signs sufficiently distinct to observe at sea, there is all the more reason for the invitation to regular observing ships, shown on our list to have the equipment, to report daily as a matter of routine by wireless to all ships so that a weather chart may be made upon which the collective information will be less likely to fail in giving evidence of tropical revolving storms.

Rules for Handling Ships.

Young officers will do well to reproduce the storm cards given in Chapter I on tracing paper, as it is most necessary to thoroughly understand why the wind veers, backs, or retains one direction for a time in a cyclonic storm when a ship is hove to and nearly stationary, or when she is proceeding at speed. Figure 16 will help us here.

In the Northern hemisphere let *B* be the position of a ship hove to; if this is indicated by a dark spot on a sheet of white paper, and the transparent card drawn across it from right to left representing a revolving storm moving west, the shifts of wind will conform to the arrows at *B*. 1 and *B*. 2, that is, the wind **veers.***

* *See* footnote, next column.

Replace the spot at *B*. 2 by a small piece of lead attached to the end of a piece of twine, with the left hand draw the lead to the left, at the same time moving the storm card over the lead in the same direction, but slower than the lead; it will be noted that the wind will **back.*** This represents a ship sailing or steaming in the same direction, but faster than the storm. The exercise may be carried out to represent every conceivable example and will be far more useful than learning any rules by heart.

Similarly, if values be assigned to the isobars represented by the circles on the card, the behaviour of the barometer in a cyclonic storm retaining the same gradients may be understood.

Having mastered this it will be a simple matter to grasp the following rules which were laid down for sailing ships. When there is reason to believe that a revolving storm is approaching, it is necessary to know, first, the bearing of the vortex, and second, which semicircle the ship is in.

In order to ascertain these it is necessary for a single observer to be stationary. Therefore, **heave to,** assuming that you are in the dangerous quadrant.

In North Latitude heave to on the Starboard Tack. In South Latitude heave to on the Port Tack.

Derived from average indraft and Buys Ballot's Law, the following rule for finding the bearing of the centre was laid down in the Barometer Manual.

"Face the wind and the centre will bear 12 points to the right in the Northern hemisphere at the commencement of the storm; when the barometer has fallen 10 mb. ($\frac{3}{10}$ inch), 10 points to the right; and when the barometer has fallen 20 mb. ($\frac{6}{10}$ inch) or more, 8 points to the right.

"In the Southern hemisphere, facing the wind, the centre bears 12 points to the left at the commencement of the storm; when the barometer has fallen 10 mb. ($\frac{3}{10}$ inch), 10 points to the left; and when the barometer has fallen 20 mb. ($\frac{6}{10}$ inch) or more, 8 points to the left."

There are known to be variations from this rule; for instance, Dr. Meldrum found from a great many observations in the South Indian Ocean, that north-easterly and easterly winds often blow almost directly towards the centre in the region of Mauritius.

Individual examples cannot be taken for establishing rules, but examples are useful in that, if they do not prove the amount of indraft on their occasions, they illustrate the need for caution in

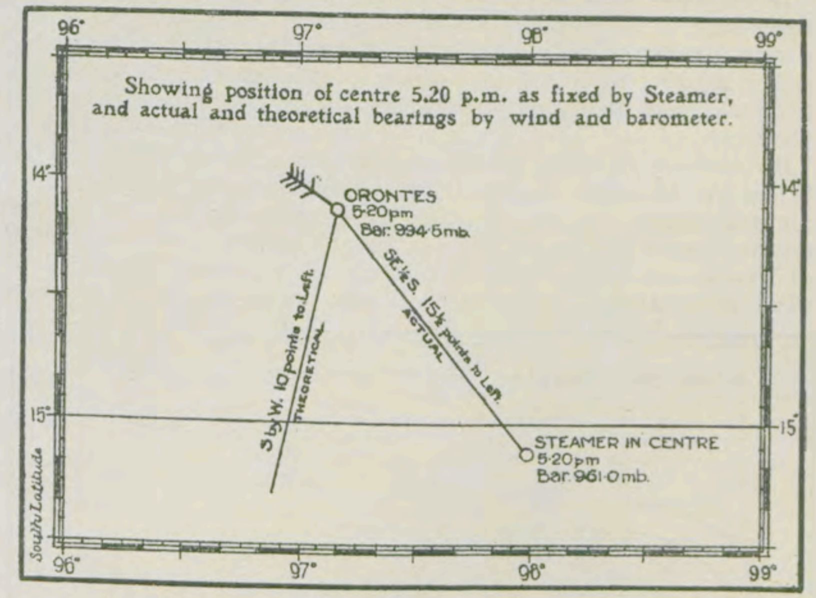


Fig. 20.—Cyclone, S. Indian Ocean, February 13th, 1904.

* The terms Veer and Back are used in accordance with the rules laid down by the International Meteorological Conference, for both Hemispheres.

i.e., *Veering*. West to North to East to South.
Backing. West to South to East to North.

Formerly at sea we used these terms in the sense that the wind *veered* when the shifts were with the sun and that it *backed* when the shifts were against the sun.

Thus shifts from East to West through South in the Northern hemisphere were termed veering, while in the Southern hemisphere they were termed backing.

The old terms should not be used for they will only cause confusion, since International Agreement has been obtained.

accepting the rule, and the need for carefully recorded observations of wind direction, position and barometer, also time, for the purpose of establising rules by averages.

At 5.20 p.m. on February 13th, 1904, a steamer was in the centre of a cyclone in the South Indian Ocean. R.M.S. *Orontes*, Captain J. F. RUTHVEN, at this time was 75 miles distant, bearing N.W.¼N. and logged wind N.W. by W., her barometr having fallen 12 mb. since she entered the outskirts of the storm. The dead reckoning positions of both ships were carefully checked, working both backward and forward from celestial fixes, and have been plotted in FIGURE 20, which shows the number of points the centre lay to the left of the direction facing the wind, also the theoretical bearing by Rule.

Another example has been given in CHAPTER III, with special reference to time.

In the Northern Hemisphere. Having hove to on the starboard tack if the wind veers, the ship is in the right semicircle; remain hove to, as the wind shifts she will come up and head the sea.

If the wind remains steady in direction and increasing in force with falling barometer, the ship is near, or on the path, run with the wind on the starboard quarter; this will take the ship into the left or navigable semicircle. If the wind backs, the ship is in the left semicircle, run with the wind on the starboard quarter until the barometer rises.

In the Southern Hemisphere. Having hove to on the port tack, if the wind backs the ship is in the left semicircle, remain hove to, as the wind shifts she will come up and head the sea.

If the wind remains steady in direction and increasing in force with falling barometer, the ship is near or on the path, run with the wind on the port quarter; this will take the ship into the right or navigable semicircle.

In the South Indian Ocean on the southern side of a cyclone there is a strong S.E. wind. It is therefore difficult to tell when the S.E. Trade forms part of a cyclone.

In the South Indian Ocean if the S.E. Trade increases to a gale it is wise to heave to and watch the barometer. If the wind shifts to the south or east the passage of the centre with respect to the ship may be inferred.

If the wind shifts from S.E. towards south, run with the wind on the port quarter in a direction northward of west.

If the wind remains steady and increases in force and the barometer falls, it is probable that the ship is in the path of the storm, a most dangerous position. In such case when the barometer has fallen 20 mb. ($\frac{6}{10}$ inch) the bearing of the centre may be nearly 8 points from the wind direction, and it is best to run to the northward of west, keeping the wind well out on the port quarter.

By running to the North-Westward with a South-Easterly wind before the barometer has fallen 20 mb. you may be heading direct for the centre, because in these cyclones South-Easterly winds, except close to the centre, have a great indraft. An examination of FIGURE 21, which gives, according to MELDRUM, flow lines of wind which are mainly conjectural, but are supported by observation, will make the reasons for the rules for the South Indian Ocean clear.

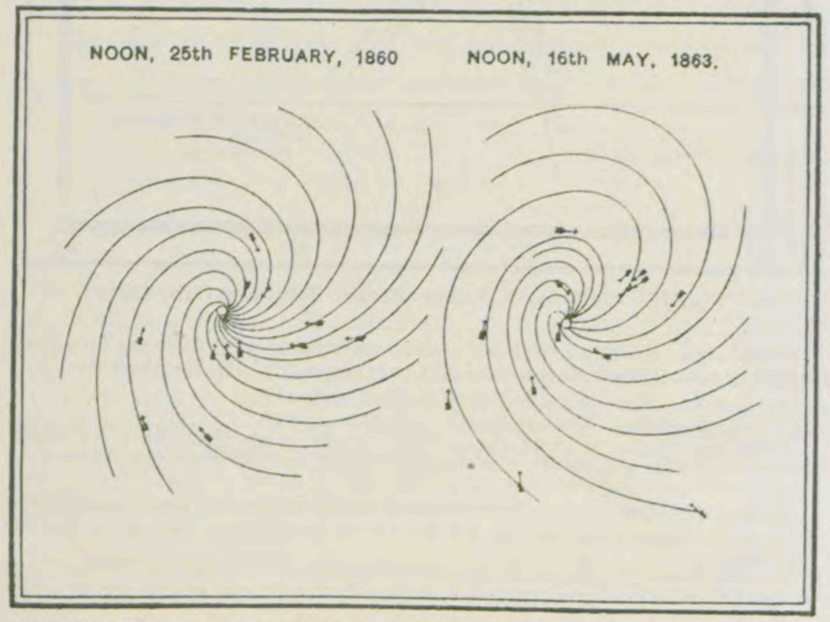


Fig. 21.—Flow lines according to Meldrum-South Indian Ocean Cyclone.

The following example in the writer's own experience may serve further as an illustration.

"The Barque *Peri*, Captain F. FISHER, from Fremantle to London, via the Cape, had a light S.E. trade at noon on May 31st, 1898, in Latitude 17° 59′ S., Longitude 77° 53′ E. At 2 p.m. the Trade, steady in direction, freshened considerably and royals and light staysails were furled, by 2.30 p.m. the wind increased to a moderate gale, force 7, all hands were called and sail was shortened to lower topsails and fore topmast staysail.

"In the first dog watch the wind steady from S.E. had increased somewhat, and the weather looked dirty, the fore topsail and fore topmast staysail were stowed and the ship hove to on the port tack.

"At about four bells in the first dog watch the wind moderated a little, but soon increased to a strong gale, veered a little, and there were frequent showers. During the second dog watch the wind was from S.E. by S., force 9, squally with rain. At about eight bells the fore lower topsail and fore topmast staysail were set, the yards squared in, and the ship kept away with the wind on the port quarter, steering W.N.W. The foresail reefed and upper topsails were next set, but when an attempt was made to sheet home the main topgallant sail, it blew to ribbons.

"During the first watch the wind veered. By midnight a whole gale was blowing with heavy squalls and high sea and the wind had veered to S.S.W. From midnight the wind moderated and the weather improved.

"On June 2nd, 1898, at noon in Latitude 19° 13′ S., Longitude 72° 39′ E., we had a moderate trade wind with passing showers. That day we spoke the Ship *Aristomene* from Chittagong to Dundee, and she reported having lost a complete suit of sails and sustained other damage on May 31st in Latitude 16° S., Longitude 80° E., and that she was putting into Mauritius for repairs."

Years afterwards, in examining the records of the Alfred Observatory, Mauritius, the following entry was found:—

"Ship *Aristomene*, May 30th to 31st, 1898, Latitude 16° 42′ S., Longitude 79° 07′ E., to Latitude 17° 08′ S., Longitude 77° 17′ E., wind force 11. Variable from S.E., sudden shift to S.S.W. and S.W., terrific squalls with high dangerous sea."

Now, at noon on May 31st, *Peri* was S.E. by S. 62 miles from *Aristomene*: later the ships were probably nearer together. From the fact that *Aristomene* had a sudden shift of wind from S.E. to S.S.W. it may inferred that she was in the right semicircle at that time.

Her course for rounding the Cape was E.S.E., and it seems likely that this cyclone had recurved and was travelling in a South-Easterly direction.

By heaving to with a strong South-Easterly wind and waiting until the barometer had fallen, Captain FISHER was able to obtain a more reliable bearing of the centre, and also to establish that he was near the path of the storm. By running to the northward of West with the wind on the port quarter he avoided the centre and the strongest winds and heaviest seas, and made a fair wind of it.

The foregoing rules were laid down for sailing ships based upon much experience and the result of many researches. This experience was probably the most valuable contribution which is ever likely to be made to Marine Meteorology, for it embodied examples whereby it was first found that the wind circulated round a calm centre. There were cases where ships scudding before the wind made several complete circles. Probably the most notorious cases being those of the Brig *Charles Heddle* in February, 1845, and the Ship *Earl Dalhousie* in May, 1863, in the South Indian Ocean.

These rules are of great value to steamers. With wireless telegraphy it may often happen that by obtaining reports from ships in the vicinity of a Tropical Revolving Storm, commanders may be in a position to avoid them altogether.

However, there may not be reporting ships in the wind circulation of a Tropical Revolving Storm, from whose observations the centre may be fixed, and direction of movement determined; while pressure of circumstances or absence of sea room may render such a course often impossible.

Warnings by wireless telegraphy giving the position and probable movement of storms are made by many Weather Offices, but it should always be remembered that these can only be reliable, if reliable information from the vicinity of the storm is available at the Weather Office. Hence the need for reports to shore stations as well as to "All Ships."

Once a ship enters the wind circulation of a storm her commander will be best guided by his own observations, and reports from other ships in the vicinity, and in the next Chapter examples will be given where commanders have in recent years proved the soundness of this system. We shall also show how to use a Weather Chart, and how advantageous these are in Cyclone Navigation.

CHAPTER V.

TROPICAL REVOLVING STORMS.

ON March 16th, 1889, a hurricane visited Samoa in the South Pacific; at this time there lay at anchor in Apia Harbour Her Britannic Majesty's Ship *Calliope*, Captain H. C. KANE, R.N., U.S.A.S. *Trenton*, the flagship of the United States Navy in the South Pacific, U.S.A.S. *Vandalia*, the German ships of War, *Adler*, *Eber*, and *Olga*, and a number of other vessels.

Calliope slipped her anchors and proceeded to sea in the teeth of the hurricane through the reefs, her fore yard passing over *Trenton's* quarter as she passed that ship sinking at her anchors. On return after the hurricane had passed on March 19th, 1889, Captain KANE "found the harbour perfectly clear, not a craft from the *Trenton* to a schooner afloat in it." Thus many vessels with 130 lives were lost.

"Captain KANE showed in Their Lordships' opinion (quoting from a letter from the Secretary of the Admiralty to the Commander-in-Chief, Australia) both nerve and decision, in determining to steam to sea in the teeth of a hurricane, which destroyed all the vessels which remained at the anchorage he left; and in conveying to him the thanks of the Admiralty, my Lords desire to express their thorough approval of his skilful seamanship, and of the measures taken by him throughout to secure the safety of his ship."

Meanwhile wireless telegraphy has been invented and come into general use at sea. In March, 1923, just 34 years later, S.S. *Clan Mackay*, Captain J. WATERHOUSE, was anchored in Apia Harbour when he observed the signs of an approaching hurricane, he put to sea and sent out by wireless the first warning, cruised on the outskirts of the disturbance broadcasting the position of the centre with weather conditions at his position, thus giving ships within range valuable information. On return to harbour he found that a very bad hurricane had swept the island.

On the morning of September 8th, 1921, S.S. *Dundrennan*, Captain R. G. SHADFORTH, observed that a hurricane had formed when about 150 miles South of Barbados; he not only took the correct seamanlike action with regard to his own ship by shaping a course to take her away from the vortex in the navigable semi-circle but broadcast a report giving his position, barometer, and wind to "All ships."

This report was intercepted by H.M.S. *Valerian*, Commander H. T. ENGLAND, R.N., as she was anchoring at Carlisle Bay, Barbados, and it enabled him to lay down rough cross bearings with his own position and observations and so to fix the position of the centre of the storm. The wind commencing to veer indicated that the centre would pass south of Barbados. This information not only enabled Captain ENGLAND to take the correct action as regards his own ship but it proved invaluable in rendering assistance to the Schooner *Lillian J. Barnes*, flying signals of distress, with 200 native immigrants from the Cuban Sugar Plantations on board, and it was probably the originator of Wireless Warnings which were issued later by shore stations of this hurricane which

Escape of H.M.S. *Calliope*

From Apia Harbour, Samoa, on the 16th March, 1889.

Reproduced from an engraving by W. L. WYLIE, A.R.A., which was presented to the Marine Division of the Meteorological Office by the late Mr. T. E. ALLEN.

was a very bad one. It is sad to think that H.M.S. *Valerian* has since been lost in a hurricane on October 22nd, 1926. The loss of this ship and S.S. *Eastway* with many fine men should increase our determination to develop at sea Wireless and Weather as an Aid to Navigation in the regions of Tropical Revolving storms; let us see how this may be done.

Modern Cyclone Navigation.

The following examples are compiled from observations returned to the Marine Division and though they do not necessarily represent what was done at the time, they indicate what may be accomplished when all those ships, indicated in the most recent number of "The Marine Observer" as selected ships, make reports to all ships as a matter of daily routine, giving observations made at the same Greenwich Time as those of the nearest coast and when coast station observations are reported by wireless; and suggesting a simple procedure. On August 19th, 1924, S.S. *Parima*, Captain P. J. McCourt, from Barbados to New York, shortly after clearing the Antilles observed signs that indicated that a tropical revolving storm had formed in her vicinity. She was not one of the ships invited to make routine reports to all ships. She immediately makes the following urgent report:—

C.Q. Urgent.

Weather 1907N 6520W Barometer corrected 29.74 Wind South force 4 overcast heavy confused ESE swell indications Revolving Storm 0900 G.M.T. August nineteenth Parima.

This message would be made on spark and in a ship fitted for C.W. transmission it would be repeated on C.W.

It is intercepted by S.S. *Manistee*, Captain J. M. Isaacson, from Santa Marta to Rotterdam, distant some 240 miles to the N.E.; by R.M.S. *Oriana*, Captain E. Kite, Havana to Vigo, a thousand miles to the N.E., and probably many other ships.

Manistee, seeing how near *Parima* is, immediately reciprocates, and makes the following report to all ships:—

C.Q.

Weather 2256N 6304W Barometer corrected 29.89 ESE 8 Overcast squally lightning rain 0900 G.M.T. August nineteenth Manistee,

which is also received in *Parima*, *Oriana* and other ships.

The positions of these two reports are plotted with wind arrow and barometer and according to the rough rule given on page 23, Chapter IV, the bearing of the centre is laid off at the prescribed angle from the direction of the wind. It is a very rough guide at best, but the interception of the two bearings gives us some idea of the position of the Vortex, Chart XV.

According to the published tracks of West Indian hurricanes, hereabouts, in August, hurricanes usually travel W. or N.W. *Parima* is in the after part of the system; she would do well to reduce speed or heave to and let it pass ahead of her or in any case wait until after the daily routine time for observation when selected ships should make reports and she will have fuller information.

Manistee is steering a safe course and she should hold on so long as the barometer remains steady or rising allowing for diurnal range. The barometer should rise slowly on her course to the N.E. hereabouts according to the trend of the normal isobars given on the North Atlantic Meteorological Chart for August. It is extremely unlikely that the hurricane will recurve in so low a latitude but we cannot say that any track is impossible.

Oriana holds on her course knowing that the routine daily reports in four hours' time will give her fuller information; these reports are of great value to her, they give timely and distant warning which is the most efficient warning.

At 1300 G.M.T., 8 a.m., seventy-fifth meridian time, regular observing ships which have mercurial barometers are invited to take observations and to report them to all ships as soon as convenient and practicable to the westward of the 40th Meridian. A ship in *Oriana's* position on the morning of August 19th, 1924, would probably be able to intercept reports from ships in the positions at which *Ormonde*, *Honorius*, *Parima*, *Manistee*, *Canadian Winner* and *Mercian* are shown to be on Chart XVI under favourable conditions with continuous wave, the range required being 1,400 miles. Assuming *Oriana* receives these reports within two hours, such reports from West Indian stations as are available, and the Arlington message at 1530 G.M.T. giving American Coast station observations for 1300 G.M.T., by 1800 G.M.T., 1 p.m., 75th meridian time, she will have complete data with which to make Chart XVI. We need not describe in detail how this chart is made, for in constructing the Weather Charts in detail in Chapter II we may learn how to make weather charts in any part of the northern hemisphere at sea.

Now Chart XVI on board any ship in the great area it covers is of great value. Firstly, it shows the ships in the stormfield how they are situated with regard to the Vortex. It will be noted that the centre is fixed approximately (but more accurately than the emergency fix at 0900 G.M.T. which is shown to have been too far to the northward) by means of the observations at Inagua and Sombrero Light Houses as well as those taken in *Parima* and *Manistee*, by judgment. The centre is shown to be somewhere about Latitude 20° N. and Longitude 68° W.; this information is of value to all ships. Secondly it gives us the general pressure distribution over the West Indies, Western North Atlantic, and Eastern States, and from this together with the tendencies of the barometers reported within the influence of the hurricane we may gain some idea of the path the hurricane will follow.

It is very important, now that it is possible by means of wireless telegraphy to construct a weather chart at sea, that it should be known more generally amongst seamen that the paths of hurricanes are greatly influenced by the general pressure distribution; their inclination is to follow a direction parallel to the outer isobars of anticyclones, that is they curve round the anticyclone and do not force through it.

Our chart indicates that the North Atlantic anticyclone holds to the eastward of Bermuda, while there is a High of equal intensity over the land to the westward of New York and pressure is comparatively high along the U.S.A. Coast. There is a depression N.W. of Sydney, N.B., which extends southward and between this depression and that of the hurricane, extending between the anticyclones is a col or wide channel of comparatively low or intermediate pressure. This indicates the path favourable to the hurricane at the moment. The steady barometer reported at Inagua Light House which is within the system, *Parima's* slowly rising barometer on a course N. 19° W. at 9 knots and the rising barometer at Sombrero Light House, all confirm a movement of the depression in a N.N.W. direction and so we will assume that the hurricane is travelling N.N.W. at the moment. The action considered correct after the emergency fix at 0900 G.M.T. for *Parima* and *Manistee* is now confirmed. *Oriana* will continue on her course at speed, but watching every sign of the weather and examining every scrap of information received by wireless with more than usual care.

After observation time on August 20th, 1924, Chart XVII is made; it shows us that our estimation was correct for the centre is now approximately in Latitude 23° N., Longitude 70° W., having travelled N.W. by N. 200 miles in the last 24 hours. The general pressure distribution is still favourable to a N.W. path and the barometric tendencies again conform to a N.W. movement. *Parima* is making good way with a fair wind, but it would now be prudent for her to make a considerable reduction of speed, for, notwithstanding that her barometer has risen, this chart shows that she is still too close up with the trough.

Oriana can continue her course and speed for the present, though great vigilance is necessary, for should the pressure distribution change and the hurricane recurve, she may find herself in the Dangerous Quadrant.

On the morning of August 21st, 1924, Chart XVIII shows the position. The centre is now in Latitude 25° N., Longitude 73° W., having travelled N.W. by W. 200 miles.

The pressure distribution is now favourable to a N.N.W. path, and the barometric tendencies reported give some support to a movement in that direction.

The hurricane is now approaching the latitude where recurvature may take place. *Parima* has continued on her course at speed and though the centre has drawn further away on her port beam, she is nearer the trough than yesterday. The storm is spreading and will probably soon begin to travel North and possibly N.E.; she should now "heave to" and wait until the wind veers to S.S.W., when she could with safety, so long as the barometer does not fall, follow in the wake of the hurricane, keeping her fair wind. However, *Parima* had not received all the reports shown on the chart and therefore she could not make a chart and have complete information. She proceeded at speed, out-distanced the hurricane and arrived at New York on August 24th ahead of it, in which she was very lucky, for on August 22nd the hurricane, at the latitude where recurvature might be expected, was checked in its northward progress by a High, which kept it nearly stationary with a very slight movement to the westward until August 24th, when it continued its path to the N.N.E.

Oriana is now on the verge of the stormfield near the trough, and with the information this chart gives her, would make a considerable alteration of course to the southward, for on her present course, even with the centre travelling N.N.W. or N., she would experience head gales and heavy seas so close as this course would take her, to the rear of the centre. With such complete information a ship in this position would possibly not only reduce the risk of damage considerably, but add to the comfort of her passengers and crew by making her landfall at Turks Island instead of Abaco, for in the circumstances though distance over the ground would be increased to Havana by about 200 miles, the coal bill might be no more or even less than if she continued on her course for Abaco. Time would also probably be saved, so that the suggestion is made for the consideration of Commanders. On this occasion, S.W'ly gales with heavy seas prevailed until August 24th to the eastward of Abaco, while further to the southward and clear of the intense part of the stormfield the winds were moderate. At Inagua, which is inside, and W. by S. of, Turks Island, from August 21st to August 24th, 1924, the greatest force of wind recorded was a "Fresh Breeze" force 5, from S.W.

On this occasion *Oriana* and other ships encountering this hurricane did not have the full assistance which the routine reports addressed to all ships by ships invited to make these reports would provide, so that the application suggested was at that time not possible.

Some years ago the Marine Superintendent of a great shipping company had a proposal put before him in which it was suggested that with proper information steamships in the North Atlantic could avoid bad weather by dodging depressions. Often quite impracticable, if not impossible. In middle and high latitudes where intense depressions sometimes have wind circulations of not less than 1,000 miles in diameter and of this diameter (athwart the line of progression) one-third the distance has been covered by winds of storm and hurricane force, the whole system advancing eastward at the rate of 800 miles or even up to 1,200 miles in a day.

Generally the rate of progression of cyclonic storms within the Tropics and until after recurving does not exceed 12 knots. The highest rate of progression recorded within the Tropics appears to be 20 knots, but that was a typhoon and very exceptional. Then within the Tropics the cyclonic storm is more compact and the winds of hurricane to gale force cover a much smaller area.

Here, with early information by wireless and a weather chart, it may often be possible and expedient to avoid the stormfield of a hurricane.

Sea room remains the first essential, for even steam or motor power cannot annul the danger of a lee shore in a hurricane. Once a ship has entered the wind circulation of an intense tropical revolving storm there can be no doubt about it, act according to the rule.

With regard to the paths of hurricanes. The path is influenced by the general pressure distribution, probably for this reason. From the general pressure distribution we can get a very good idea of the general air circulation. Now a hurricane is an eddying whirl in the general air current and is carried along in much the same way that an eddy is carried along in a stream. If the general air current or general wind moves slowly the hurricane within it is moved slowly, and when the general air current moves swiftly the hurricane moves swiftly. It is well then not to think too much in the terms of pressure, but rather of the winds relating to the general pressure distribution. In the Tropics the drift of air, the trade wind, is mainly to the westward from the surface to a great height, while in middle and high latitudes it is to the eastward, the Brave West Winds, which extend to an even greater height.

Therefore observations of the upper air are of very great importance, and certain of His Majesty's ships are undertaking this work, of which we hope Commander L. Garbett, R.N., Superintendent, Navy Meteorological Services, will continue to tell us yearly in "The Marine Observer."

Of the works of early investigators of the Laws of Storms probably Sir William Reid's "Attempt to develop the Laws of Storms" and Piddington's "Sailors' Horn Book" are the best known amongst seamen.

Reid worked mostly in the West Indies, where he had gained much experience of hurricanes, having been employed as an officer of the Royal Engineers, at Barbados, re-establishing government buildings blown down in 1831. He became Governor of Bermuda in 1839 and later Governor of Barbados, obtaining much valuable information direct from the captains of ships trading to the West Indies. Henry Piddington carried out his researches at Calcutta where, after commanding a ship, he was appointed Curator of the Museum of Economic Geology in 1830. He not only had the benefit of Reid's early work and the experience of many other seamen in the Indian seas and in all parts of the world, but he thoroughly understood his brother seamen of the time and so was able to gain their attention.

Captain Henry Piddington's "Sailors' Horn Book" was first published in 1848, and it held position as the foremost practical text book on tropical storms for more than 30 years. In it is given a chart of the Bay of Bengal and part of the Arabian Sea, showing the tracks of cyclones from 1800 to 1848, and testifying to the enormous amount of labour he put into the examination of cyclones in this part of the world.

Bay of Bengal.

Having selected our first example from the experiences of ships in West Indian Hurricanes, we cannot do better than follow it up with an example compiled from experience in the Bay of Bengal, where the geographical distribution of land and sea and the meteorological conditions lend themselves more readily to the solution of the problems of cyclone navigation by means of wireless communication than in any part of the world I have navigated, or of which the meteorological conditions have been examined in the Marine Division.

The Bay of Bengal which is in fact a sea, is probably provided with more coast stations at which meteorological observations are made daily at the time for telegraphic reports than any other area in the regions of tropical revolving storms, and so it is not difficult with ships' observations to assemble sufficient data for the purpose of this demonstration, which cannot be made for Southern tropical seas for the lack of sufficient data at the time of severe cyclones in recent years. A severe cyclone occurred in the Bay of Bengal in the first week of May, 1923.

Let us suppose that at this time the system which is now developing, had been in force and that ships in our list indicated as selected for the purpose and invited to make routine reports to all ships of observations taken at the same time as on the nearest coast, which hereabouts is 0230 G.M.T., had done so. Also, that reports of ships invited to report to shore stations for the Indian Meteorological Office at Simla were intercepted at sea, and that it were possible to receive reports of the coast station observations of barometer, wind and weather such as are made for the coast of the British Isles, but modified to suit the Tropics.

On May 2nd, 1923, S.S. *Macharda*, Captain W. O. Tyers, from Rangoon to Colombo, in Latitude 13° 56′ N., Longitude 92° 30′ E., receives the necessary information and makes Chart XIX; this indicates a cyclonic circulation of the wind with centre of its depression near the centre of the Bay. The barometer being 3 mb. below normal at Diamond Island, 5 mb. below normal at *Macharda's* position and 3 mb. below normal at *Masirah's* position, the probabilities are three to one that a cyclonic storm has formed. All ships which have received the information and made the chart can see that there is probably a cyclone centred in about Latitude 15° N., Longitude 88° E.

As *Macharda* proceeds on her course the wind veers to S.W., and by 8 p.m., ship's time, the barometer being 7 mb. below normal, *Macharda* knows that a cyclonic storm is centred somewhere to the westward of her position. She proceeds on her course at speed to the S.W. with caution, carefully watching for signs and information by wireless. At this season of the year in rear of a storm the S.W. winds in the South of the Bay increase in strength, the weather becomes more squally and unsettled and cloud increases and shows by its increasing movement indraught of a cyclonic disturbance.

On the morning of May 3rd, 1923, Chart XX is made, the centre of the cyclone can be now approximately fixed as being in about

Latitude 15½° N. and Longitude 87° E. The directions of the coast winds must not be given the same weight as those at sea, because they may be affected by the land, but the barometer observations are of great assistance. *Macharda* is now confident that she is in the rear of and drawing away from the storm. The published tracks of storms show that in May, from the vicinity the storm is now in, it may travel N.W., N., or N.N.E.

On May 4th, CHART XXI shows the conditions. The centre can now be located in about Latitude 18½° N., Longitude 88° E. *Macharda* is now well clear. Had *City of Canterbury* been able to make the previous days' chart when in the Hugli, she would now see that the centre was travelling N. by E. at about 200 miles a day, and therefore being near the trough in the navigable semicircle by continuing on her course for Madras, she would be taking the correct action, *i.e.*, running with the wind abaft the starboard beam. Generally speaking, if on the equatorial side of a cyclone before recurvature, it is safe to decrease your latitude.

CHART XXII shows the conditions as far as they can be charted with the reports from ships available. The cyclone is now, May 5th, 2.30 G.M.T., centred in about Latitude 20° N., Longitude 89½° E., having travelled about 100 miles N.E. in the last 24 hours. The tendencies of the barometers at Saugar Island, Gopalpur and Akyab stations would be most useful on this chart, for they would give a very good indication of the movement of the system. On the evening of this day S.S. *Okara*, Captain F. SMITH, foundered with all hands, "due to the fact that her hatches went and she was overwhelmed by a huge sea and this was the result of her being caught in a cyclone on the 4th and 5th May."

CHART XXIII indicates the position of *Okara* at 1224 G.M.T. (6.29 p.m. local time) May 5th, 1923, when S.S. *Angora*, Captain E. DE G. DIAMOND, proceeded towards her in response to distress signals to stand by, with the bearing and distance of each of the ships which returned observations given as a matter of general interest.

CHART XXIV gives the situation of the centre at 0230 G.M.T. on May 6th in about Latitude 20½° N., Longitude 92° E. and it will be noted that with nearness to the coast the value of the barometer observation at coast stations is increased for the barometer at Akyab is the main guide along with the other reports for fixing the centre. At *Angora's* position the indraught of the wind to the centre is far in excess of the rule.

As Captain G. PARK points out with his great experience of the Bay of Bengal, actual reports when plotted on a chart may teach us more in three days than ten years' conjecture from isolated observation. Now in no case do our charts show the weather reports of a ship ahead of the storm for no observations from ships in that position have been received.

Years ago a question somewhat after the following was put to candidates for Mate and Master's certificates. "You are in a sailing ship having just left the Sandheads and you observe that a cyclone is approaching from the southward; you find that you are in the dangerous quadrant of the stormfield. What would you do?"

This question was put, I believe, to show the candidate that in such a position he would be between the devil and the deep. The deep being the vortex of the storm, if he stood on his course to the southward with the wind which at first would be easterly and therefore on the port beam, contrary to the rule, and the devil being a lee shore, if he conformed to the rule and hove to on the starboard tack, for as the cyclone passed over the ship, though the vortex might clear her, she would later, while still in with the land, experience southerly gales with high seas running on to the coast.

Even a steamer caught in the dangerous quadrant of a cyclone near the head of the Bay of Bengal is in a very dangerous position.

It is easy to be wise after the event and let it be quite clear that no inference is intended with regard to the action of the Captain of the *Okara*, to criticise the late Captain SMITH's action would be contemptible and unseamanlike.

As the Court which investigated the circumstances attending the loss of S.S. *Okara* on May 5th, 1923, stated in their report—"To say that a man has been shown to have been wrong by after-events is a very different thing from saying that he did not act prudently before the event." After four years, reference here to the circumstances attending the loss of this ship, can only be to the good of all, for such a loss brings home to us that cyclone navigation needs improvement, and this experience can now usefully be given to stimulate the co-operation between ships at sea and ships and the shore.

It is known that the following message broadcast by Calcutta W/T Station at 7 p.m. local time, on May 2nd was received by *Okara* before the pilot left, but it cannot be proved and therefore is not known if *Okara* received later cyclone warnings broadcast by coast stations. She may have done so:—

"Area squally weather near latitude thirteen, longitude eighty-five, where storm may be forming. Special observations desired."

This message indicates much the conditions which the ships shown on CHART XIX might, with the system suggested, have known the same morning or about ten to eleven hours sooner.

At 7.03 a.m. on May 3rd, local time, Calcutta W/T station broadcast:—"Area squally weather probably developed into storm about latitude fifteen north, longitude eighty-six east, special observations desired."

At this time *Okara* was probably at sea clear of the Sandheads, and as stated it is not known if she received this message.

Now in home waters since observations at coast stations were broadcast far greater confidence has been placed in the Weather Forecasts and Gale Warnings made by wireless. Supposing that *Okara* had not only received the above message shortly after 7 a.m., on May 3rd, but that she had been able to intercept ships' reports and receive a report giving the coast station observations and make CHART XX. Surely any seaman then seeing that his own conclusions practically verified those of the meteorological experts ashore, would be in a better position to take the correct action in a position which might well develop into one of great danger.

I have on one occasion only rode out a cyclone in the Hugli in a steamer, and that was sufficient to show that attempting to return from sea to anchorage at Saugar might be as dangerous as gaining sea room and manœuvring according to the position and movement of a cyclone in the Bay of Bengal as indicated by wireless reports from other ships and weather charts, unless there were ample time to make the anchorage well in advance of the storm.

Hence the need for Cyclone Warnings from a central observatory and the great need of co-operation between ships at sea and ships and the shore in the matter of regular wireless weather reports.

If the centre of the storm is fixed correctly on CHART XXI on May 4th, the ring of hurricane winds which encircles the centre of an intense cyclone was probably small, for *City of Canterbury*, then distant only about 100 miles to the westward of the centre, had a moderate breeze, force 4, and according to CHART XXII, on the morning of May 5th, the centre was only distant about 120 miles S.E. of Saugar Island, where a light N.N.E. breeze was reported. At this time *Okara* made by wireless to *Angora*, "8 a.m., 19° 10′ N. 90° 55′ E., wind south, force 9, squalls hurricane force, barometer 29.56, wind veering to westward slowly, expect barometer to rise, sea high and confused, overcast"; so that she was, at the time of our chart, about 90 miles S.W. by W. from the centre. Probably on May 4th the diameter of the stormfield with its gales up to hurricane force was not more than 100 miles, it probably increased on May 5th.

Now the dimensions of Tropical Revolving storms are a very important matter in cyclone navigation, and the experiences of ships having the misfortune to get into the centre of a cyclone have enabled us to obtain some fairly accurate measurements.

Dimensions of Hurricane Winds.

On December 2nd, 1922, the American S.S. *Eclipse*, Captain HAWKINS, encountered a cyclone in the Arabian Sea; it travelled 200 miles that day and, estimated by the times logged when it passed over her position, the ring of winds of hurricane force was only 4 miles thick, while the calm centre was only 4 miles in diameter, thus winds of hurricane force only covered an area of about 12 miles in diameter.

S.S. *Sardinia*, only distant 80 miles from the centre, had a strong breeze, force 6, and barometer 51.4 mb. (1.52 in.) higher than that at the centre, which indicates an intensely steep barometric gradient.

On September 21st, 1922, a West Indian hurricane passed over Bermuda; it had travelled at the rate of 13 knots since the previous day.

Captain H. P. DOUGLAS, C.M.G., R.N. (now Rear-Admiral and Hydrographer of the Navy), in H.M.S. *Mutine*, at Hamilton Harbour, noted the times when the wind attained hurricane force, when it fell calm, when it came away at hurricane force again, and when it fell below hurricane force. The ring of hurricane winds was 15 miles thick in advance of the centre; the centre was about 7 miles in diameter, and the hurricane wind was 19 miles thick in rear. As so frequently happens, the greatest force of wind was in rear of the trough.

This hurricane originated in the Tropics, recurved in about Latitude 25° N., Longitude 66° W., and crossing the Atlantic reached the French coast. On September 25th, 1922, it was centred in Latitude 51½° N., Longitude 17½° W., and had spread to such an extent that its wind circulation had a diameter of about 1,000 miles. At this time observation did not show the extent of the hurricane winds; the system was no longer tropical. Several ships reported wind of that force near the centre.

The Typhoon which did great damage at Hong Kong on August 18th, 1923, from observations made on board the steamships *Yunnan*, *Steel Traveler* and *Chenan*, all of which the centre passed over before reaching Hong Kong, had the following dimensions. On August 16th the calm centre measured 28 miles across. On August 18th the calm centre measured 7 miles in diameter when the ring of hurricane winds was 27 miles thick before the centre and 12 miles thick abaft it. The total diameter of winds of gale force and above was 65 miles in the fore and aft line or along the line of progression, and the average speed at which the typhoon was travelling was 14 knots.

Now many a fine ship has been damaged or lost in the seas caused by the ring of hurricane winds round the centre. These experiences show that this ring of hurricane wind may often be as small as from 12 to 50 miles in low latitudes, and it is this ring of hurricane winds with the gales surrounding it that should be given as wide a berth as possible.

CHAPTER VI.

SOUTHERN WATERS.

THE earth's surface is divided into seven zones of comparative low and high mean barometric pressure lying roughly parallel to the Equator. These zones may be distinguished in CHARTS XXV and XXVI, "Mean Pressure and Wind in January and July." They move bodily northward and southward, following the sun's declination. The equatorial zone of low pressure is continuous round the earth; in it the Doldrums of the oceans are situated.

The great permanent high-pressure zones or anticyclones lie roughly between the parallels of 20° and 40° North and South, and it is important to note that they are not continuous round the globe. Northward of the northern anticyclones there is a zone of mean low pressure, which also is not continuous round the globe, situated in approximately mean Latitude 60° N.

Southward of the southern anticyclones there is a continuous belt of mean low pressure round the earth in about Latitude 60° S.

Over the Polar regions mean pressure is comparatively high.

The natural tendency of the air at high pressure is to make towards any adjacent area of low pressure and to continue to move until pressures are equalised. The movement of air from high to low is not direct, but nearly at right angles to the line from high to low, due to the rotation of the earth and friction, which produces a spiral circulation. This horizontal movement of air is wind.

The air circulates *with* the hands of a clock in an anticyclone in the Northern hemisphere and in a cyclone in the Southern hemisphere.

It circulates *against* the hands of a clock in a cyclone in the Northern hemisphere and in an anticyclone in the Southern hemisphere.

The Trades are anticyclonic winds; in these great drifts of air from the eastward, near the Equator, Tropical Revolving Storms originate.

We have seen in Chapters II and III that cyclones originate in the northern low-pressure zone, and in Chapter II we briefly described the seven fundamental shapes of isobars which distinguish the weather systems of Temperate Northern Latitudes.

In the southern low-pressure zone, westerly winds predominate to such an extent that the northern border of this zone between the parallels of 40° and 50° South is called the "Roaring Forties."

These westerly winds are caused by a succession of lows passing to the eastward, southward of the "Roaring Forties," and they may be traced by shifts of wind and changes of the barometer experienced in ships running their easting down.

In these latitudes sailing ships put up fine performances. The writer had the good fortune to serve in the Ship *Siren*, Captain MALCOLM MACLEAN, when she created the record passage from Cape Town to Sydney in 29 days in October, 1895. A succession of gales was experienced commencing from the north-westward, with falling barometer, hauling to west as the centre overhauled and passed the ship to the southward, and shifting to south-west with rising barometer. Occasionally easterly winds are experienced due to "lows" being further north.

On June 1st and 2nd, 1897, in the Barque *Ashmore*, Captain DOLBELL, from Brisbane to London, we were head-reaching in Latitude 56° S., Longitude 62° W., there being an easterly gale which veered to S.E.; bitterly cold, the rigging becoming ice-encased with frozen spray. At this time *Ashmore* was approximately 300 miles S.E. by S. of Cape Pembroke in the Falkland Islands, and it is interesting to note according to the Lighthouse Meteorological Register, that at midnight June 1st, 1897, the wind was W.N.W., force 3; at noon on June 2nd, N.N.W. 4, and at 4 p.m. it had veered to North, from which point it continued until 4 a.m. on June 3rd, the barometer falling, when it backed to N.W. At noon on June 3rd the barometer was at its lowest, wind S.W., force 5.

This depression passed eastward between *Ashmore's* position and Cape Pembroke.

Captain R. H. WYNNE of S.S. *Banffshire* when reciprocating reports with the steamers *Boonah* and *Gilgai* and the Belgian sailing ship *L'Avenir*, between the Cape, and Australia, in April 1923, formed the conclusion that a heavy gale which they experienced near the 60th meridian east, covered an area of small width.

During the time of Captain SCOTT's first National Antarctic Expedition, 1901 to 1904, special daily observations were taken at noon G.M.T. by ships in the Southern Ocean; and a set of daily synoptic charts covering the whole of that part of the globe South of Latitude 30° S. was drawn in the Marine Division under Captain CAMPBELL HEPWORTH. Unfortunately the observations were so wide apart or few, that these charts are not sufficiently complete for generalising weather systems.

During Captain SCOTT's second expedition to the Antarctic, 1911, 1912, Dr. G. C. SIMPSON, who was physicist of the expedition during the first year, took observations in the Antarctic, which were continued throughout the expedition's stay. With his own observations, those of previous expeditions, Captain HEPWORTH's Charts, and other work done, Dr. SIMPSON came to the conclusion that, over the Southern Ocean there are cyclones and anticyclones which travel on the whole from west to east, and in all probability are in all parts of the ocean of a similar size to those shown on the Australian Daily Weather Reports, and their centres may pass anywhere between the Coast of Australia and the Coast of the Antarctic Continent.

If we reverse FIGURES 3 to 8 in Chapter II so that north is south and south is north, the cyclone, secondaries, V shaped depression, wedge, anticyclone, and col of Northern Latitudes will resemble similar systems of Southern Latitudes, bearing in mind that BUYS BALLOT'S LAW is reversed.

In the Southern Hemisphere if an observer faces the wind, low pressure will lie to his left and high pressure to his right.

Australian Weather Types.

FIGURES 22 to 30 are reproduced from "Types of Australian Weather" compiled in 1895 by Mr. H. A. HUNT of the Australian Weather Service, in continuation of work initiated by the Hon. RALPH ABERCROMBY, who first generalised the fundamental systems in Northern Latitudes.

According to Mr. HUNT, over Australia the anticyclone is the governing type. Weather systems generally travel East.

Rapid East Moving Winter Anticyclones.

In FIGURE 22 which shows the weather chart for August 15th, 1893, there is an anticyclone over Western Australia. There is another anticyclone off the East Coast. These anticyclones are separated by a Λ-shaped depression centred south of Tasmania, a depression extending from the Tropics, and a col between them. They result in off-shore winds on the N.W. coast, southerly winds with rain from the Leeuwin to the head of the Australian Bight; westerly winds and rain on the coast of South Australia, and northerly winds on the Victorian and New South Wales Coasts, while on the coast of Queensland the wind is from east to south with rain.

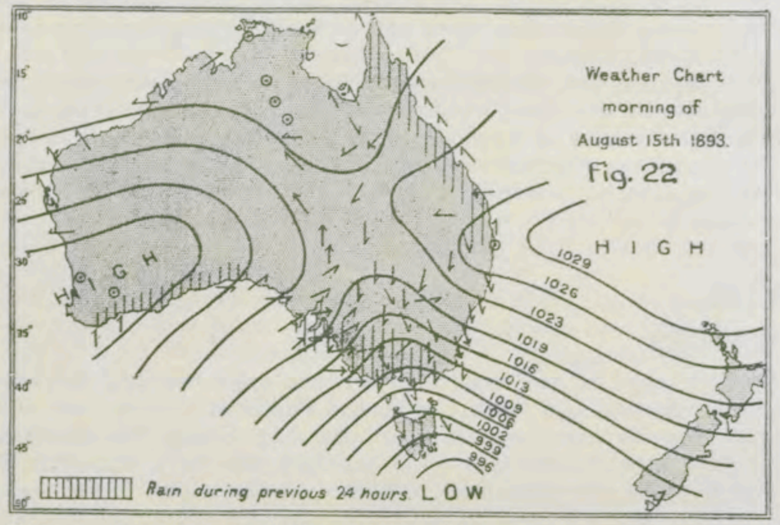
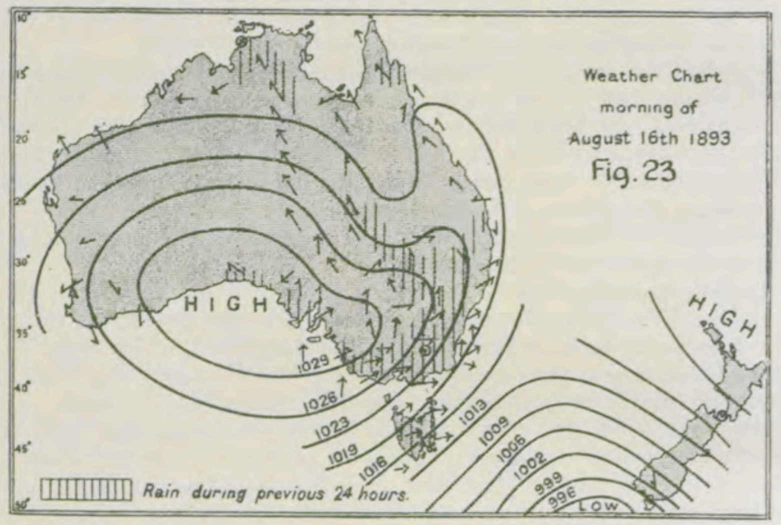


FIGURE 23, August 16th, 1893. The western anticyclone of yesterday has travelled rapidly east, and is now centred over the head of the Australian Bight. The eastern anticyclone is now N.E. of New Zealand, while the ∧ depression is now centred S.W. of those Islands and the tropical low has merged into the anticyclone, leaving a kink in the isobars following the shape of the Gulf of Carpentaria.



The anticyclone now results in off-shore winds on the Coast of West Australia. The antarctic low is causing westerly winds and rain over Tasmania, on the coasts of Victoria and New South Wales; while the shallow tropical low causes variable winds and some rain in Queensland.

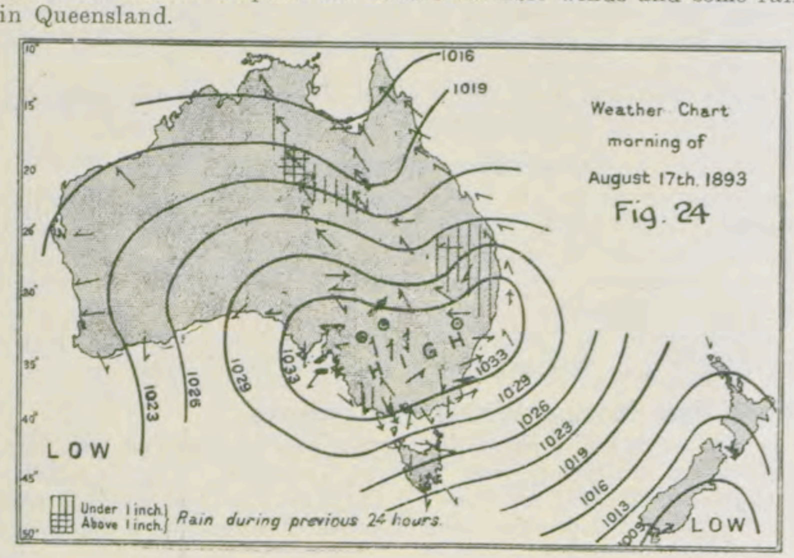


FIGURE 24, August 17th, 1893. The anticyclone has travelled further east; the tropical low has filled in somewhat, and has remained almost stationary while the ∧ depression is now centred S.E. of New Zealand. The winds of the Australian Coast follow the isobars of the anticyclones anti-clockwise as would be expected; had there been observations available, no doubt the wind between Cape Howe and New Zealand would be from a westerly and south-westerly direction due to the ∧ depression.

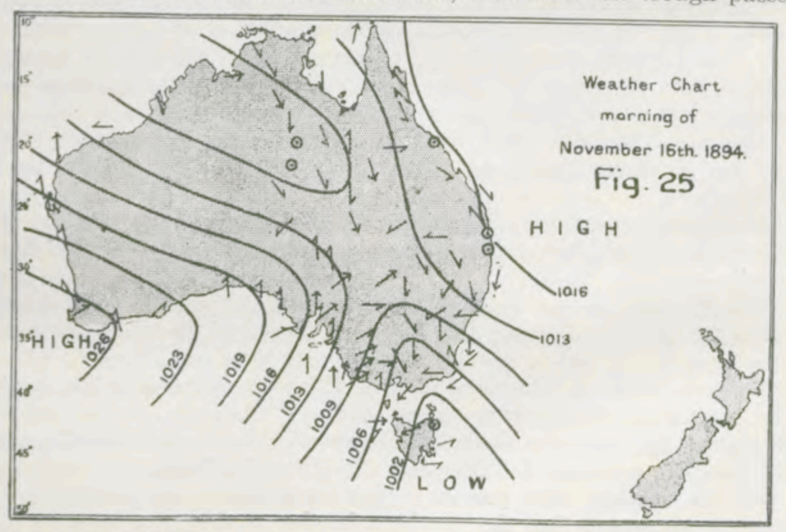
These three charts show the rapid easterly movement of winter anticyclones of settled weather: in this case the anticyclones having travelled some 1,600 miles in two days. When the sun has Northern Declination the tracks of these anticyclones usually lie over the land, but in the summer they they lie more to the southward, that is, they swing with the sun between the parallels of 30° and 42° South Latitude.

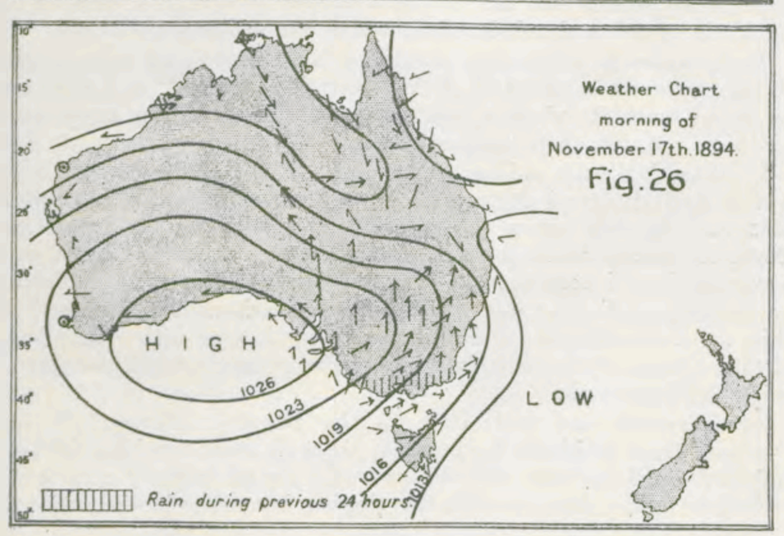
Summer Anti-cyclones and the "Southerly Buster."

In the Summer, anticyclones being further south and of smaller extent, do not exercise so complete a control of the weather over Australia, for the tropical lows extend further south. FIGURES 25 and 26 illustrate a type of weather well known to all who navigate Australian waters. On November 16th, 1894, there was an anticyclone centred S.W. of Cape Leeuwin; another anticyclone lay N.E. of Sydney. The tropical low extended well over the Northern Territory and a ∧ depression was centred S.E. of Hobart.

There are cool southerly winds in front of the advancing anticyclone along the Southern Coasts; from Albany to Cape Otway these winds are of no great strength, probably due to the surface friction of the land. There are hot northerly winds, the "Brickfielder," over Northern Australia. By the morning of November 17th, 1884, the anticyclone had travelled east, and was centred over the Bight. Now in Victoria, New South Wales and Queensland, there is a range of mountains which follows the trend of the East coast from Cape Howe to Cape Byron, rising to 6,000 feet, and therefore right athwart the general easterly atmospheric drift.

As the pressure systems travel east, the trough of the ∧ depression is tilted in a N.W. and S.E. direction, and when the trough passes





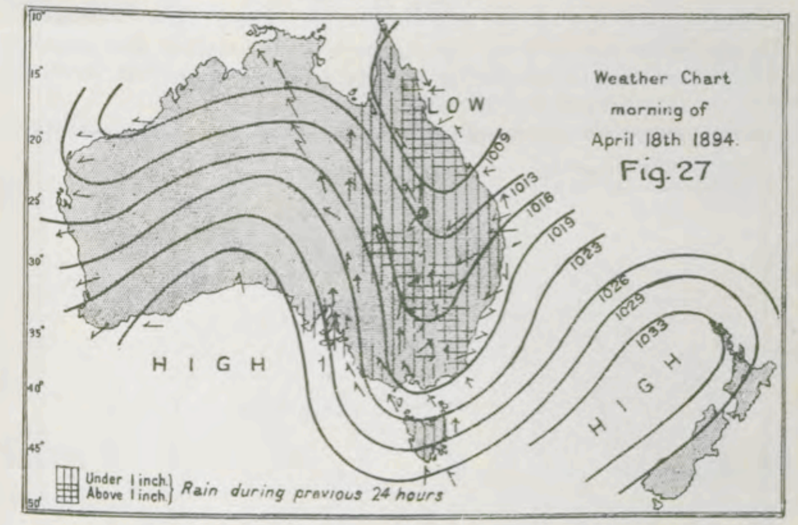
the mountains the southerly wind, which has been retarded by surface friction, bursts with great strength along the coast.

The first burst of this cold wind is known as the "Southerly Buster," but the gale which often follows may last as long as ten days. "Southerly Busters" occur on the coast between Cape Howe and Port Macquarie, Port Jackson is thus right in their path. Ball-shaped Cirro-Cumulus or heavy Cumulus thunder clouds in the south are signs that a "Buster" is coming. As the squall approaches, a light fringe rises from underneath the cloud in front, curving over the top of the cloud, and trailing behind it. The northerly wind drops suddenly, and in a few minutes it is blowing from south with gale force. No doubt the East Coast Range has much to do with the changes of weather so often experienced when passing Gabo Island.

In a later Chapter when we deal with temperature a better idea may be obtained of indications from which developments of depressions causing increases of wind may be predicted.

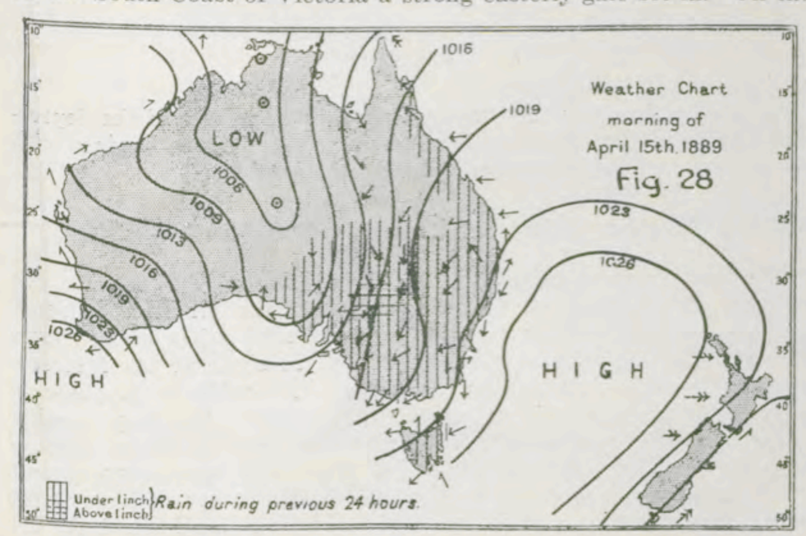
Monsoonal Rain Storm.

At all times of the year, but particularly in Summer, if the tropical low forces itself far south, much rain and thunderstorms occur over the area it crosses. Figure 27—Chart for morning of April 18th, 1894.—The tropical low extends over the whole of Queensland, New South Wales and Victoria; to the east and west there are anticyclones, resulting in monsoonal rain in all the Eastern States, in Bass Strait and on the Eastern seaboard.

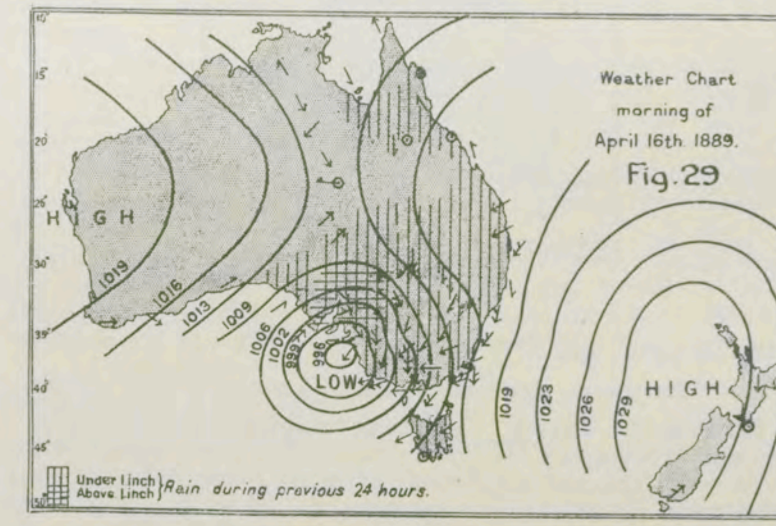


Development of Cyclonic Storms in the South of Tropical Depressions.

Sometimes, when the tropical depression extends across Australia into the Australian Bight, small cyclones develop in the South. This is illustrated by Figures 28 and 29. On the morning of April 15th, 1889, there was an anticyclone S.W. of Cape Leeuwin, and another over the Tasman Sea; these were separated by a tropical depression extending to the Bight. On the S.E. Coast of South Australia and on the South Coast of Victoria a strong easterly gale set in. On the

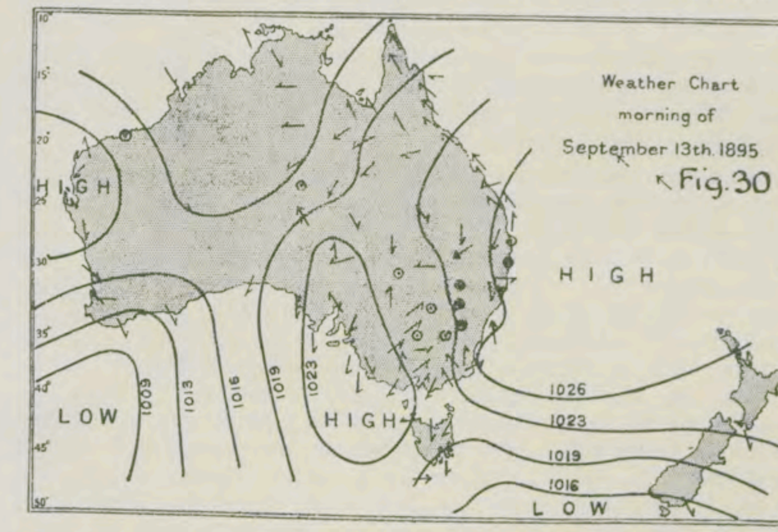


morning of April 16th, 1889, a cyclone centred S.E. of Kangaroo Island had developed with steep barometric gradient and consequent winds of gale force and cyclonic circulation.



Wind Contrary to Isobars.

Figure 30. The chart for the morning of September 13th, 1895, shows an anticyclone west of North-West Cape, a depression south of Cape Leeuwin; there is a large anticyclone east of Sydney, another High centred south of Adelaide, and a depression south-east of Tasmania. With this pressure distribution, if there were no disturbing factors, we should expect northerly winds on the coast of New South Wales, whereas it will be seen that the wind on the East Coast was actually southerly as far north as Sydney. No doubt the Mountain Range along this coast contributes to this. In a later Chapter the effect of high mountains on wind will be dealt with.



Fog in the Bass Strait.

FIGURE 31. The Weather Chart for the morning of July 26th, 1910, shows an anticyclone to the west, a depression centred S.E. of King George's Sound; there is a kink in the isobar 1016 mb. indicating a shallow tropical low S.E. of the Gulf of Carpentaria; an anticyclone is centred over S.W. New South Wales, with another High over Tasmania; and there is a depression over the Tasman Sea, resulting in light E. to S.E. winds from the Tasman Sea bringing moisture to Bass Strait and the South Victorian Coast, where there is dense fog in the col between the two Highs.

There are other types of weather systems including cyclones from the N.W. and N.E. square-headed depressions and vertical straight isobars, all of which were dealt with by Mr. H. A. HUNT in "Types of Australian Weather," and have been summarised in "Climate and Weather of Australia," by H. A. HUNT, GRIFFITH TAYLOR and E. T. QUAYLE. The type of particular interest to the navigator working the Southern Coast of Australia is that which produces westerly gales; to illustrate this we have selected a gale which the writer has good reason to remember.

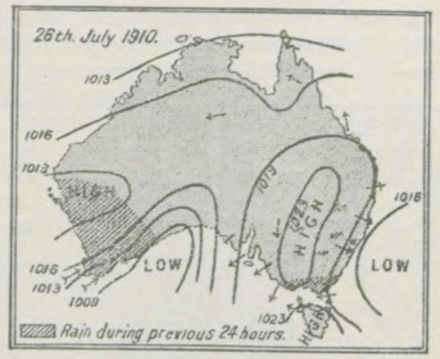


Fig. 31.

Antarctic Lows and S.W. Gales.

In his "Australian Meteorology," Mr. Griffith Taylor writes:—

"**Prediction of Storms.** These may be divided into two groups, gales and hurricanes. The former arise when the gradient of the Low is very steep, and are common along the South and South-East Coasts when 'Antarctics' are numerous, *i.e.*, in winter. They occur with similar charts in other seasons. In October, 1913, a well-developed Low occupied the Bight on the 13th, and moved normally to the east with intensifying gradients. On the 14th the gradient steepened greatly over the Bight, the isobars from 30.2 in. (1022.7 m.b.) and 29.6 in. (1002.4 m.b.) being closely packed together. The forecast was as follows:—'Squally wind and rough seas East from Bight.' This was abundantly verified; for on the 15th a severe storm swept Bass Strait and the barometer fell to 29.2 in. (988.8 mb.) at Hobart: while the wind rose to 69 miles an hour at Melbourne. It is necessary to consider the aspect of the Coast in connection with Ocean warnings. Thus a S.W. wind has much less effect on the New South Wales Coast than on the Victorian Coast."

We took advantage in the *Omrah* of a lull after a violent squall and left Port Melbourne Pier at 3.16 p.m. on October 15th, 1923, with a fresh W.S.W. gale; proceeding down Port Phillip the squalls were very heavy, and in one of these the wireless aerial was carried away. This was repaired and sent aloft, only to be carried away a second time next morning.

Passing out between the Heads, the sea broke right across the entrance, the wind then being from west a fresh gale with frequent heavy squalls. Off Apollo Bay at midnight there was a whole gale from S.W. by W. with frequent violent squalls and a very high steep sea; a considerable reduction of speed was necessary. Off Cape Otway we felt the full force of the gale, ship rolling 40°, which was unusual for *Omrah*, a particularly steady ship. At 4 a.m. the ship had made little headway, it blew a whole gale from W.S.W. and at 6.47 a.m. the wind backed to S.W., sea increasing very high and steep; by 8 a.m. the wind had decreased to a fresh gale and backed to S.S.W.; we were then able to slightly increase speed and proceed on our course N. 80° W., but we could not get steam owing to the men not being able to keep their feet in the stokehold. That afternoon the wind and sea moderated and we were able to reach Adelaide next day in time to embark His Majesty's homeward mail, and sail as appointed.

Steamers scheduled to sail from Melbourne on October 15th, remained in harbour. On the morning of October 16th, S.S. *Geelong*, bound east, informed me by W/T that she had been hove to all night about 150 miles to the westward of Cape Otway.

Figures 32 and 33. The weather chart for the morning of October 15th, 1913, shows an anticyclone centred near Cape Leeuwin; the tropical low extends in a S. Easterly direction over Northern Australia; there is an anticyclone east of Townsville and a very deep ∧ depression centred S.E. of Hobart; a col lies over central Queensland.

On the morning of October 16th, the anticyclone had travelled considerably east and was centred over the Bight and the ∧ depression had moved east also.

The barometer at Hobart had, according to the chart, risen 10 mb. since the morning of the 15th, which, if we had not a chart before us, would be an indication that the depression, whose trough lay considerably east of Hobart, had travelled east, or was filling in.

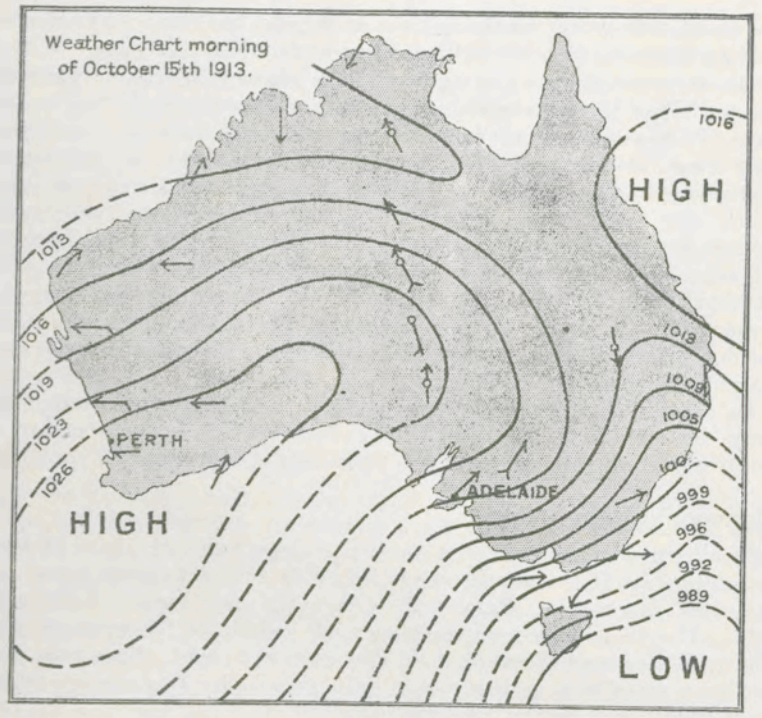


Fig. 32.

If we follow the run of the Isobars and consider the easterly movement of the depression it is easy to understand the shifts of wind we experienced in *Omrah*.

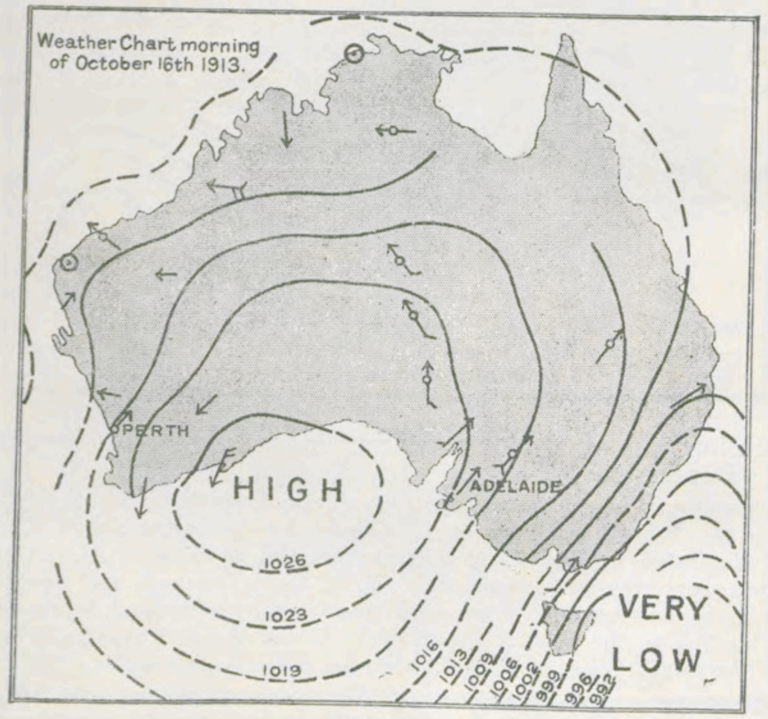


Fig. 33.

As so often happens the strongest winds were in rear of the depression, hence in the Southern hemisphere it often blows hardest with the first rise of the barometer and from the southward.

Making Weather Charts of Pressure, Wind and Weather.

Wireless weather reports have been received by ships in the Atlantic at a distance up to 2,400 miles from the Air Ministry sending station; and reports from ships up to 1,660 miles distant from Devizes, the receiving station, have been received at the Meteorological Office, on continuous wave. In the ordinary progress of advance it may be fair to expect that before very long weather reports may be reciprocated at greater distances in many parts of the world. The following examples are based upon observations whose reciprocation would require an effective range of about 3,000 miles, in order that a wide scope of utility may be illustrated.

With observations taken from the Daily Weather Chart of Australia, Meteorological Logs and Ships' Meteorological Reports, recorded as if from the ships' wireless office in the form recommended in Chapter II we will make a chart as we did in that chapter, for practice will be useful in Southern Latitudes.

R.M.S. *Orsova*, Captain C. G. Matheson, D.S.O., R.D., R.N.R., having telegraphed her expected time of arrival at Fremantle from Adelaide is anxious to keep it.

Much depends upon her maintaining schedule and to her a weather chart would be useful.

On a small scale Mercator Chart XXVII, at the position of coast stations, with a protractor lay off wind arrows, each feather representing one of the Beaufort scale; the arrows fly with the wind, their heads indicate position. Abreast these stations, write the barometer in millibars or inches (both are given here for the convenience of all concerned). Unfortunately, the tendency of the barometer is not available; if it were, it and the weather would also be written abreast the stations. Plot the position of the reporting ships, and draw wind arrows, heads at positions. Write the name of the ship reporting, the barometer, weather, course and speed, and barometric tendency.

Next, pick out the lowest barometer reading plotted on the chart and facing the wind to the *left* with a soft pencil write LOW; also pick out the highest barometer on the chart and facing the wind to the *right*, write HIGH.

When this has been done, if there are well defined weather systems, it will be seen that the wind arrows give a general idea of how the wind is circulating at the surface.

In this case, it is evident that *Berrima* is in rear of a depression and that the winds reported at the Leeuwin, logged by *Orsova* herself, and reported by the Ship *Monkbarns*, conform to the circulation in the fore part of a cyclonic depression. We rough in the

Coast Weather Reports—Morning of July 11th, 1923.

Station.	Barometric tendency.	Weather.	Visibility.	Barometer.	Wind.	
					Direction.	Force.
Carnarvon	—	—	—	1017 30·03	N.E.	2
Perth	—	—	—	1011 29·86	E.S.E.	1
Cape Leeuwin	—	—	—	1010 29·83	N.W.	4
Albany	—	—	—	1010 29·83	N.N.W.	1
Port Eucla	—	Rain	—	1016 30·00	N.N.E.	2
Cape Borda	—	—	—	1022 30·18	N.	1
Cape Otway	—	—	—	—	—	—
Hobart	—	—	—	1025 30·27	N.N.W.	2
Gabo I.	—	Rain	—	1023 30·21	S. by W.	5
Sydney	—	Rain	—	1020 30·12	W. by N.	2
Brisbane	—	—	—	1015 29·97	S.	2
The Bluff	—	—	—	1017 30·03	Calm	
Wellington	—	—	—	1023 30·21	N.E.	1
Russell	—	—	—	1018 30·06	S.E.	5
Norfolk Island	—	—	—	1014 29·94	Calm	

Ships' Reports—Morning of July 11th, 1923.

Ship.	Lat.	Long.	Bar.	Wind.		Weather.	Course.	Speed.	Bar. Tendency.	Current.	From		To		Temp.		Swell.	Past Weather.
				Direction.	Force.						Lat.	Long.	Lat.	Long.	Air.	Sea.		
Orsova -	35° 19′S.	124° 42′E.	1011 29·86	N.N.W.	4	Blue sky	N. 88° W.	15½	Falling slowly.									—
Bq. *Garthgarry.*	28° 23′S.	167° 28′E.	1012 29·89	E.N.E.	2	Overcast	S. 70° W.	2	Steady									—
Hauraki -	37° 58′S.	157° 40′E.	1017 30·03	E.S.E.	5	Some cloud.	S. 75° W.	12	Rising slowly.									—
Berrima -	42° 29′S.	94° 36′E.	989 29·21	W.S.W.	3	Cloudy.	East	8	Rising									Gale at 8 p.m.
Ship *Monkbarns.*	38° 57′S.	132° 48′E.	1013 29·92	N.	7	Overcast with rain.	East	7½	Steady									—

isobars hereabouts first, the wind giving us their trend, for it blows along the isobars, inclining towards the Low. Therefore, remember BUYS BALLOT'S Law, for it helps us greatly, especially at sea, away from the land and local causes. Ashore, or on the coast, the wind may not conform so nearly to this Law, as we have seen in FIGURE 30. The lowest barometer reported, at *Berrima's* position is 929 (29.21). For practical purposes at sea isobars drawn for every four mbs. (.12 of an inch) will be convenient, stepped from 1,000 mb. (29.53 in.).

Thus the lowest proved isobar of this stepping will be 992, but it is evident that there are actually isobars of lower value to the S.E. We therefore dot in the 988 (29.18 in.) isobar S.E. of *Berrima* on CHART XXVIII. As there are three barometers differing by not more than 1 mb. from 1012 (29.89), well spaced along what appears to be the outskirts of this probably great cyclonic depression, we next draw the 1012 (28.89) isobar, from north of Perth where the wind direction is probably due to land breeze (ignoring BUYS BALLOT'S Law here), north-east of *Orsova* and west of Ship *Monkbarns*.

The 1008 isobar is drawn with barometers and winds at C. Leeuwin, Albany, S.S. *Orsova* and Ship *Monkbarns* as our guide. The 1004 (29.65), 1000 (29.53) and 996 (29.41) isobars are spaced in as dotted lines in the absence of observations over a considerable distance.

Next, examining the region near the highest barometer at Hobart 1025 (30.27) it is seen that the wind at Cape Borda, Hobart and Gabo Island, all of which have high barometers, conforms to anticyclonic circulation. The 1024 (30.24) isobar is drawn southward passing east of Cape Borda, west of Hobart, whence it curves round to the northward and passes west of Gabo Island.

Having fixed the two main systems it will be well to examine other low and high barometers which obviously indicate the presence of other systems within the limits of our chart.

We find a LOW, north of Barque *Gathgarry's* position and a HIGH, east of New Zealand, and write these words in in pencil.

Returning to the main High, the 1020 (30.12) isobar fits in, passing south-east to the west of Cape Borda and west of Hobart, then curves east and north passing through Sydney.

The 1016 (30.00) isobar is drawn from south of Carnarvon through Port Eucla, east of Ship *Monkbarns* and probably extends over the Tasman Sea in the direction shown by its dotted line, there probably being a LOW, south-west of the Bluff. The two eastern systems may now be conveniently dealt with. A 1012 (29.89) isobar is drawn through Barque *Gathgarry's* position trending S.W. and curving to the northward between Norfolk Island and Brisbane. A 1016 (30.00) isobar passes north of Russell, curves to pass close north of *Hauraki's* position and thence west to Brisbane.

A 1020 (30.12) isobar is drawn in from the eastward passing south of Russell, curves sharply south and passes west of Wellington, then turns south-east between the last station and the Bluff.

We have now roughed in all the isobars which can be drawn with the observations available, and using pencil and india-rubber, we improve them, making them close together where the wind is strong and wider apart where it is light, so that their spacing roughly shows the gradient.

These isobaric lines give us a general idea of pressure distribution, having been drawn through places estimated to have the same barometric pressure.

The CHART XXVIII shows that there is an anticyclone over Tasmania and Victoria, probably extending to the Northern Territory. A cyclonic depression is centred far S.W. of C. Leeuwin. There is an anticyclone east of New Zealand and a depression N.W. of Norfolk Island.

Orsova left Adelaide at 1.4 p.m. on July 9th. Until midnight she had moderate winds to light airs from S.W. with barometer nearly steady at 1028 (30.36); she was then in the anticyclone now far astern.

On July 10th the wind was northerly, barometer falling slowly as she crossed the isobars on the western side of the anticyclone.

She now (morning of July 11th) sees by CHART XXVIII that, with her own barometer falling slowly, that of Ship *Monkbarns*, steering east at 7½ knots, steady, and the rising barometer of *Berrima*, steaming east at 8 knots, that the LOW to the S.W. is travelling east. She may expect an increase of wind and that it will back to the westward.

According to her log, the wind increased to a strong breeze, and backed to W.N.W. at noon; at 4 p.m. it was W. by S., fresh, after which the wind veered to the northward and fell light, probably caused by a secondary, not shown on our chart through lack of observations, between Cape Leeuwin and *Berrima*, or it was of later development. From midnight until 4 a.m. on July 12th *Orsova's* barometer fell quickly.

On July 12th, the operation is repeated, CHART XXIX, and it is seen that another depression is overhauling *Berrima;* the strong N.W. wind at *Orsova's* position is probably caused by an extension or secondary north of yesterday's south-western LOW; with a slowly falling barometer, ship steaming N. 79° W., 15 knots nearly parallel to the isobars, after the quick fall in the night, this secondary depression is probably deep. She therefore may expect an increase of wind to gale force, and that after rounding the Leeuwin as she steams north the wind will back to the westward and moderate.

According to the log, the wind increased rapidly with violent rain squalls in the forenoon; at noon it had reached force 9; at 10.55 p.m., when C. Naturaliste was abeam, the wind had moderated to force 4, and was from west. *Orsova* arrived at Fremantle at 7.53 a.m. on July 13th and sailed again that evening, the wind remaining westerly, fresh to moderate.

Special Advantages for Sailing Ships.

To the sailing ship, the foreknowledge of wind to be experienced which is made possible by the use of long range wireless telegraphy and weather charts, would be invaluable, and we are lucky in having the observations of two of the very small fleet remaining afloat in 1923 with which to illustrate the method.

Suppose the Ship *Monkbarns*, Captain W. DAVIES, from Cape Town to Sydney, 32 days out on July 11th, 1923, had been able to make CHARTS XXVIII, XXIX, XXX and XXXI. On July 12th, she would have seen that the anticyclone which, according to the chart of the previous day, was centred near Bass Strait, was giving way (*i.e.*, pressure reducing) and that the depression centred near the one hundredth meridian yesterday had probably moved east and developed the secondary now near Cape Leeuwin; also, that there was a secondary centred between her position and Cape Otway. *Monkbarn's* steady barometer when steering E. ¾ N. at 7 knots is an indication that the secondary ahead of her is also moving east; the Antarctic Low is probably moving east. She may expect the wind to veer and fall light, later coming from northward and increasing as the western secondary overhauls her.

At 8 a.m. on July 13th *Monkbarns* is distant 180 miles from Cape Otway, her point of landfall, whence she will shape a course to pass through Bass Strait. CHART XXX shows her that the depression near Norfolk Island has intensified and moved east; the anticyclone over Australia has further given way, and another anticyclone is approaching Australia from the westward and she is apparently in advance of a depression centred to the S.W.

All this points to the probability of the wind now N. by W., force 6, backing to the westward and remaining there for a time.

Monkbarns ended her observations on making Cape Otway, but the pressure distribution and coast reports in the vicinity of Bass Strait, given on CHART XXXI, indicate that the forecast made on July 13th was a good one, and she had a slant.

South Pacific.

Since the first edition was published the geographical distribution of the Observing Fleet has been much improved and we have on our list a much better proportion of ships in Pacific Trades. There are now Wireless Weather Signals made from Apia, Suva, Auckland, Sydney and Brisbane which contain a number of reported observations at coast stations and though the range of some of these stations is small, ships may be able to receive sufficient reports for coast stations when at a considerable distance to the eastward or north eastward of New Zealand as has been proved by *Rimutaka*, Captain F. A. HEMMING, whose 2nd Officer, Mr. OSWALD M. WATTS, on November 21st, 1924, constructed the first Weather Chart made at sea in the South Pacific sent in to the Marine Division, *see* Volume II of "The Marine Observer," page 158.

Though only the observations from the Australian daily weather report and Suva are available to us, ships' observations make it possible to draw quite a useful chart.

It just happens that in July, 1925, S.S. *Rimutaka* was again in a position which serves our purpose admirably for an example. She was in Latitude 33° 10′ S., Longitude 158° 34′ W., at observation time on July 11th, Eastern Time, bound from Liverpool *via* Panama

to Auckland. Now supposing that she had received the reports and made CHART XXXII; it indicates that she had just passed the trough of a depression and is now drawing away from the centre which is probably travelling East. There is another depression centred near Gabo Island (Cape Howe) while an extensive area of comparatively high pressure separates these depressions, in which to the westward of Cook Strait, *Maunganui's* report indicates the existence of a third but very small depression shown by the sharp bend in the 1020 (30.12) isobar.

Rimutaka will expect improving weather with wind steady and then backing to south, when if the depression now to the West of Cook Strait moves east and develops, her wind will increase from the Southward and veer or back again according to which side of this small depression she passes through.

Actually *Rimutaka* experienced a South to S.S.W. wind up to gale force with squalls and heavy rain during the following morning watch. This small depression which *Maunganui* passed through during the early morning of July 11th developed and travelled rapidly East causing the gale experienced by *Rimutaka*.

Unfortunately the tendency of the barometer is not given for the shore stations but the ship barometric tendencies, with course and speed, afford useful information. Take that of *Aorangi* within the Tropics on a N.E. course steaming at 16 knots away from the HIGH; the barometer was actually rising slowly but if diurnal range is allowed for we should interpret a steady barometer for the purpose of gauging whether there was a change of pressure distribution in the vicinity. *Pakeha's* barometric tendency, falling slowly, in high latitude on a course towards the LOW indicates that she is overhauling the depression centred S.E. of *Rimutaka*, or that there is a secondary developing ahead of her. Those who navigate in Southern Waters will do well to study the significance of temperature observations and the development of depressions which will be dealt with in a later chapter, but it is first necessary to master the drawing and use of Weather Charts with pressure only so that we may have a thorough ground work on which to extend in all parts of the World.

South African Waters.

Since we commenced our endeavour to demonstrate the use of Weather Telegraphy and the construction of Weather Charts at sea, attempts have been made to find suitable examples for illustrating the utility of the method in the region of the Cape, but sufficient observations from ships at sea and stations on the coast, or ships in harbour at the same time have not been available.

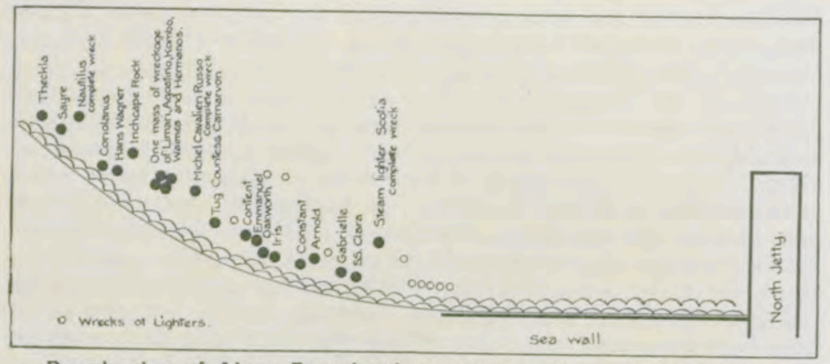
In 1925 information was received from Commanders of observing ships of the UNION CASTLE LINE that a system of routine Wireless Weather reports had been introduced for the Coasts of South Africa and a description of these was given in "Weather Signals" in the December 1925 Number of "The Marine Observer."

Copies of the actual reports received in observing ships forwarded by Commanders with observations recorded in Meteorological Logs and Reports (Form 911) now provide sufficient data for making simple charts, one of which is reproduced, which may be of some assistance as a guide to those who wish to put into practice Wireless and Weather as an aid to Navigation in South African Waters. Though weather on the South African coast has been a subject of study for many years and many have written upon it, including Captains CAMPBELL HEPWORTH and TOYNBEE, it does not appear to have been dealt with fully in synoptic meteorology. No daily weather maps or charts of types of weather such as Mr. HUNT'S for Australia, are available, though we are told in a chapter on "Climate and Weather" by Mr. C. STEWART, in "Africa" of the Oxford Survey of the British Empire, that "the weather of South Africa, more particularly in the south, is largely due to a series of moving anticyclones passing from west to east with their associated Λ-shaped depressions and to secondaries."

In the absence of South African Weather Types those given for Australia may serve as a rough guide to Marine Observers, who are advised to refer to them for the same Latitudes in other parts of the Southern Hemisphere. Before Wireless Telegraphy made the synoptic method possible at sea and before Meteorological Services had been developed, when seamen were entirely dependent upon their own isolated observations for prediction of weather, it is probable that there was no coast in the World where weather changes were more significant and sudden and where we were better able to anticipate them. Notwithstanding this and the precautions of springs on cables, upper yards sent down and so forth, there were few places in the world where more ships were lost in consequence of weather.

Algoa Bay was a veritable graveyard for sailing ships; as late as September 1st, 1902, no less than 17 sailing vessels, 2 steam tugs, and several lighters were driven ashore in a terrific S.E. gale, many of them literally piled up on top of each other, while others were broken to pieces or driven so high on the beach by the enormous seas that it was found impossible to repair and refloat them. In all, 63 lives were lost and an aggregate tonnage of about 12,500.

The ship in which the writer was serving at the time for the purpose of R.N.R. training, H.M.S. *Barracouta*, Commander SELBY ASH, R.N., arrived with the Cape Squadron a fortnight later, and the photograph and rough plan following will give some idea of the scene of destruction.



Rough plan of Algoa Bay showing positions of vessels stranded on the night of August 31st-September 1st, 1902.

During the same month we rode out another very heavy gale in Simon's Bay. On September 22nd, 1902, the barometer fell and the wind increased from N.N.E ; by 10 a.m. there was a whole gale from N. by E., (directions all magnetic). At noon the wind was storm force N. by E., with terrific gusts off the mountains, occasional rain; 4 p.m. north, force 10; at 6.30 p.m. the wind veered to N.N.W. and dropped to force 3. At 10 p.m. it veered (or to use the terms which have since been laid down for both north and south Latitudes *backed*, but I simply quote from my journal) to N.W. a moderate gale, after which the wind dropped and there was a perfect deluge of rain. H.M.S. *Gibraltar*, flagship of Rear-Admiral MOORE rode out this gale with both bowers and the sheet anchor.

The four-masted barque *Principality* dragged her anchors and, by a fine piece of seamanship on the part of the Mate who was in charge, did not go ashore. It happened this way; Simon's Bay lies in the N.W. corner of False Bay, which is surrounded by mountains except for a stretch of beach extending from the Cape Flats from Muizenberg to Gordon's Bay. It therefore affords a weather anchorage with winds from S.W. through west and north, and the mountains break the steady drive of the wind from those directions.

This mountain break-wind is, however, the cause of terrific gusts, which are a great danger in the Bay, these gusts being more sudden and terrific than the squalls accompanying the gale out at sea to windward of these mountains.

Now, at 10 a.m. the wind shifted from N.N.E. to N. by E. and increased with terrific gusts; *Principality* started her anchors, and at 10.45 a.m. there was a tremendous squall with gusts which came down the Valley past Elsey Peak, a hill 990 feet high to the north of the anchorage. She commenced driving to leeward so fast that we thought she had parted her cables and that nothing could save her from going on to the rocks.

The mate promptly hoisted the fore topmast staysail with sheet to port, her head paid off to starboard, and soon afterwards her starboard anchor fouled the heavy moorings of H.M.S. *Penelope*, the depôt ship, cable was veered and *Principality* placed alongside of *Penelope* as neatly as if she were a twin-screw steamer assisted by tugs.

Captain CAMPBELL HEPWORTH, who served for a number of years in the steamers of the old UNION STEAMSHIP COMPANY, gave an account of the variations of Meteorological phenomena of the south and south-east Coasts of Africa, with the oscillations of the barometer associated therewith, in his "Notes on Maritime Meteorology" which describe admirably the seaman's method of anticipating weather changes before distant observations were available by Wireless Telegraphy; and Captain H. STRONG, of the UNION CASTLE LINE, who has had very long experience in South African Waters, remarked upon the infallibility of the barometer as a guide to forecasting wind on these coasts in his contribution to the first number of "The Marine Observer."

With this weight of testimony of the value of the barometer it would seem that, now weather reports from coast stations are available by Wireless Telegraphy, much more may be done by the seaman himself in the matter of weather prediction.

The following is to illustrate what may be done with a little trouble and the co-operation of other ships.

On May 17th, 1925, R.M.S. *Edinburgh Castle*, Commander H. STRONG, R.N.R., was in Latitude 31° 06′ S., Longitude 15° 27′ E. at 0630 G.M.T. She made a weather report by wireless and received the Cape Town Radio weather message at 0835, but appears not to have received reports from any other ships. At this time there may have been other ships within W/T. range, but the only other steamer on our fleet list in the vicinity was S.S. *Clan Lamont*, Captain A. B. MCCOMISH, distant some 450 miles to the northward and westward.

Let us, however, take the appropriate observations available and with them make WEATHER CHART No. XXXIII, carrying out exactly the same procedure and method as that advocated for Australian Waters.

This chart shows us that the South Atlantic High extends eastward nearly to the coast, and comparison with the South Atlantic chart for the month of May shows that *Edinburgh Castle's* barometer is normal. There is a depression south of East London, while the barometers at Walvis Bay and Port Nolloth indicate a shallow depression along that coast, while a small High separates this area of intermediate pressure from the main depression. Fine weather is general.

Now, *Edinburgh Castle* is within a day's steaming of Table Bay and she wishes to know most if she may expect the S.E. head wind to increase or decrease and if the visibility will remain very good, or if depressions will come from the S.W. and cause bad weather.

Now, with CHART No. XXXIII we can see the distribution of pressure with the wind circulation from the vicinity of East London to Walvis Bay, but we have very little to go upon to gauge how the systems are moving or altering; for this purpose we should be glad to know what the barometer had done at each of the coast stations during the last three hours, and the higher the latitude these are in, the more valuable will they be; as it is, we must depend very largely upon what *Edinburgh Castle's* barometer is doing. We should also like a report from a ship to the S.W. or from Tristan da Cunha; perhaps when *Discovery* is on her station she will supply that need.

Now with the isobars as they run and with the ship steaming S. 37° E. 14 knots, and the barometer rising slowly (part of which rise is no doubt due to the diurnal range), the anticyclone is probably stationary or spreading towards the coast, so that it is probable that there will be very little change in the force of the wind and there is nothing to indicate the likelihood of decreased visibility.

With the barometric tendencies at Port Nolloth and Cape Town we might get a very good idea of what change of gradient to expect along the coast, which gradient is, of course, directly associated with the "South-Easter." The tendency of the barometer at East London would give us some indication of how the depression was moving or altering.

CHAPTER VII.

TEMPERATURE AND FOG OR CLEAR WEATHER.

In middle and high latitudes it is frequently found that the slow passage of air from a region of warmer sea surface to one of cool sea surface is associated with fog at the latter. Also that air passing from colder sea surface to warmer sea surface is frequently associated with good visibility.

With reports from distant ships, if they include the elements suggested in Chapter I, not only may charts be made which give the pressure distribution and therefore wind circulation, but the changes of temperature which the air is suffering in its passage to a region may be ascertained, which knowledge may give an idea of the conditions of visibility which may be expected.

It is not the purpose of this chapter to explain in detail the process of fog formation, but to continue as tersely as possible to show how application of Wireless and charting may give the fore-knowledge desired.

There is probably no region on the trade routes of the world where fog is more prevalent than on the Grand Banks, and where the conditions causing fog are more pronounced. We therefore cannot do better than use experience gained in that region as a preliminary.

General Conditions in the Vicinity of the Grand Banks.

The Labrador Current brings cold water from the Arctic by way of Smith Sound, Baffin Bay, and Davis Straits, which expands over

the northern part of the Grand Banks, spreading eastward and dividing. One branch setting S.W. flows past Cape Race; the other flows south along the eastern edge of the Grand Banks until it meets the northern edge of the Gulf Stream forming the Cold Wall.

The Gulf Stream brings warm water from the tropical Atlantic and the Gulf of Mexico north of the Antilles and by way of the Strait of Florida, following the coast of the United States to Cape Hatteras, expanding and inclining eastward.

Thus, over the Grand Banks, the sea surface temperature is cold, while to the southward it is warm, there being a steep thermal gradient running from west to east to the southward of the Grand Banks. The Charts of Mean Sea Temperatures of the North Atlantic illustrate this.

Now, if the barometer is high at the Azores and low at Halifax with an even and shallow gradient, it follows by Buys Ballot's Law that the wind will be light from the southward over the region of the Banks and the drift of air will be coming across the warm waters of the Gulf Stream where it will pick up moisture. On reaching the Cold Wall, the air at the surface will be rapidly chilled, if it contains sufficient moisture this will condense as fog. The lower layers of the air, having been chilled, rapidly become colder than those above them, so that convective currents fail to take the moisture aloft, and it remains as fog at the surface.

It is interesting to note that the frequency of gales in Winter in this region is very high, the mean path of depressions passing hereabouts.

A Typical Case of Fog on the Grand Banks.

CHART XXXIV. On the morning of May 19th, 1920, the central part of the North Atlantic was dominated by an extensive anticyclone, causing light to moderate winds and fine weather. There was a shallow depression centred south of Nova Scotia in which *Adriatic* experienced light and variable winds, and rain in Latitude 40° 29′ N. Longitude 56° 30′ W.

No fog was reported though it is probable that it was present on the eastern side of the depression between the Newfoundland coast and Latitude 42° N., caused by the warm moist southerly and south-easterly winds which would be expected with the pressure distribution shown in this area, coming in contact with the cold water of the Labrador current.

CHART XXXV. On the evening of May 19th, 1920, the depression had become a little deeper and moved a little eastward, and the anticyclone had spread to the south-east, the general pressure distribution remaining the same.

The development of fog between the Meridians of 40° and 50° West is now clearly shown, and the influence of air and sea temperature can be traced.

At 8 a.m., CHART XXXIV., *Finland* and *Mississippi*, both homeward bound, were in the Gulf Stream, both having sea temperature 67°—*Finland* 66° air, and *Mississippi* 68° air.

At 8 p.m. *Finland* got into cold water, sea temperature 46° and had fog. *Mississippi*, 160 miles ahead, was still within the boundary of the Gulf Stream, with sea temperature 66° and air 65°, recorded exceptional visibility.

The warm southerly wind, chilled considerably in its passage, had extended its influence northward to *Minnedosa* and produced fog; *Melita*, in Latitude 49° 53′ N., Longitude 44° 34′ W., experienced fog from similar cause.

From a study of the general conditions of currents with mean sea temperature, together with the pressure distribution existing on the evening of May 19th, 1920, it may be inferred that fog probably existed over the stippled area on CHART XXXV. Of course, it will be realised that the limits of the currents and cold and warm water vary considerably at short intervals.

In all probability fog was prevalent on the Grand Banks in the south-east quadrant of this depression until it moved east or filled in.

Prediction of Fog or Clear Weather in the Eastern North Atlantic.

For this purpose a number of standardised reports over a considerable area are necessary for success. On several occasions within the last few years, when a large number of ships forwarded copies of Wireless Weather Reports, made and sent during exceptional weather conditions, it was apparent that better results had not been obtained owing to insufficient range, traffic interference, observations not synchronising, and uncorrected barometers. On the other hand since the 1st edition was published there have been many occasions when ships have been so fortunate as to receive a number of reports direct, made by selected ships to "All Ships" and they have made charts and successful forecasts not only of wind but of fog or visibility. In short, experience shows that popular organisation is required if Wireless and Weather is to prove the aid to navigation hoped for. The following examples give an idea of what is aimed at, and are based on the supposition that a limited number of ships broadcast standard reports of observations taken at the standard times laid down, by long range Wireless Telegraphy, at arranged times for transmission, thus tending to reduce the traffic difficulty but increasing the value of information, and providing synchronised data over a great area to all ships who can intercept it.

Visibility.

On the morning of August 5th, 1922, S.S. *Catalina*, Captain R. COLLINS, from St. Domingo to Havre, distant some 480 miles from Scilly, her point of landfall, would like to know if she may expect clear weather along her route, and particularly when approaching the land.

CHART XXXVI shows that there are anticyclones to the north-westward of Ireland and south-westward of the Azores, and between them lies a very large area of low and intermediate pressure in which are two depressions, one centred in about Latitude 53° N., Longitude 30° W., the other in about Latitude 47° N., Longitude 13° W.

Catalina steering east-north-east at 10 knots throughout August 4th, had light easterly winds which backed through N.E. to N.N.W. thus indicating that the depression now east-south-east some 200 miles from her position, had overhauled and passed to the southward of her.

As her barometer is rising slowly, this depression is probably continuing in an easterly direction at greater speed than her own, but the slow-rising barometers at Corunna and St. Mathieu, Brest, do not as yet confirm an easterly movement, though further east at Bordeaux the mercury is falling.

Losada, steaming S. 48° W., 11 knots, across the front of this depression, has had a falling barometer, and *Aba* on a nearly opposite course, N. 27° E., 13 knots, also across the front of the depression, has had a falling barometer, while *Matheran*, steaming S. 19° W., 11 knots, not far to the north-west of Corunna, has a steady barometer.

We must remember that though the expressions rising or falling are used, the reports really give us what the barometer has done in an interval, and during that interval the ship was changing her position.

The tendencies observed by *Catalina*, and reported by *Losada*, *Aba* and *Matheran*, allowing for courses and speeds, give a very good indication that the depression is moving to the eastward.

Catalina is, however, more concerned with the depression to the north-west which, with the distribution of pressure existing, is most likely to follow in the wake of the last, though it should be noted that the barometer is falling slowly at Malin Head and Wick, while it is steady, or rising slowly, at Valentia, Holyhead, Dungeness and Spurn Head.

Now *Vellavia* in rear of this depression steering N. 88° E., 11 knots, has barometer steady, an indication that the depression may be moving eastward at about her own speed.

Alpine Range to the southward of the depression, steering N. 67° E., 10 knots, has barometer falling slowly, and *Menominee* to the south-east of depression, has barometer falling slowly when steering N. 78° E., 16 knots; and *Melita* steering N. 78° W., 18 knots, still under influence of eastern depression and approaching the position of the westerly Low, has barometer steady.

From all these tendencies, allowing for the effect of course and speed upon each, it is indicated that the western depression is moving in a direction to the southward of east.

Catalina may therefore expect, steering N. 70° E., 10 knots, to maintain a position between the two depressions where she may expect light winds from the northward or southward according to which depression the wind circulation is due, and the weather is likely to remain clear in the rear of the eastern Low.

If the western depression overhauls her, it is probable from the wind circulation and temperatures reported by *Vellavia* and *Alpine Range*, that the visibility will remain good because the air will have come from over cold water to warmer water, and so have been gradually warmed in its passage. The sky is likely to be cloudy or overcast.

It must be clearly understood that the passage of air from cold to warmer water under all circumstances will not produce good visibility, indeed there are conditions when this process may actually produce fog, but generally speaking, when associated with the rear of a depression, such a circulation and temperatures may often bring clear weather, while the passage of air from warm to colder water is often associated with fog.

According to the log, *Catalina* was in Latitude 48° 10′ N., Longitude 18° 15′ W., at noon on August 5th, and there were light and variable airs with sky $\frac{7}{10}$ths covered with Strato-Cumulus; the barometer fell very slowly.

At 4 p.m. light N.E. airs, clouds practically stationary. In the first watch Cumulus and Strato-Cumulus moved slowly from west. Light airs and calms, with overcast sky, continue until 4 a.m., when the wind is south, force 2, and the barometer has fallen to 1010 mb. (29.83 in.); the ship is now under the influence of the westerly depression.

Morning of August 6th, CHART XXXVII. This chart when compared with that of the previous day, will be of more value. It will be seen that the eastern depression travelled E. by N. ½ N. some 400 miles, and is now centred between Brest and Jersey. The western depression has moved about 250 miles east-south-east.

Catalina is shown by the Chart to be in front of the western depression, which is advancing at greater speed than her own. With exceptional visibility reported by *Kroonland*, 140 miles N.W. by W., and temperatures with wind favourable to good visibility reported by *Melita*, *Alpine Range* and *Aquitania*, the prospects of the weather remaining clear, though there will probably be showers, as the right semi-circle of the depression passes over her, are excellent, and clear weather is forecasted for the following morning in the vicinity of the Bishops.

According to the log the weather remained fine until 8 a.m. on August 7th, when for an hour there were passing showers of light rain. The visibility was 8 or 9 by scale throughout.

CHART XXXVIII is made in the forenoon of August 7th; the western depression has travelled east-south-east, 350 miles, and spread, and is dominating the weather from the western coasts of the British Isles to 30° W. and as far south as Latitude 40° N. The barometric tendencies of stations from Brest, northward, indicate that the depression is still moving eastward.

The report of visibility at St. Mary's, Scilly, at 7 a.m. G.M.T., indicated 7 by scale, *i.e.*, good, or about 10 miles; at this time there was rain at the station.

At 10.30 a.m. the Bishop Lighthouse was sighted bearing N. 53° E., distant 20 miles.

Fog, when will it lift?

On the morning of August 6th, 1922, R.M.S. *Ormonde*, Commander H. G. STAUNTON, C.B.E., R.N.R., from Gibraltar to Plymouth, was in fog off the Portuguese Coast. They would like to know when it will lift, and it, when it has cleared, it will remain so, along her route?

All who have navigated the West Coast of Portugal are familiar with fog in patches during the summer months, when the ship may be enveloped in a dense fog bank at one moment, and in the next there may be extreme visibility, conditions which are most dangerous for collision.

A glance at the Charts of the N. Atlantic of mean sea surface temperature for every two degrees of Latitude and Longitude will give an indication of a frequent cause.

Close in to the coast the water is colder than to seaward under average conditions and on occasions this is even more marked.

Now, if the drift of the air is from the west over warm water gradually becoming cooler, it will become saturated, so that on reaching the coastal region, where the fall in sea temperature is steep, not only will condensation take place, but the air near the surface will be so quickly cooled, that convective currents will fail to take the moisture aloft, and it will remain in fog banks at the surface.

Ormonde arrived at Gibraltar at 6.12 a.m. and left again at 9.48 a.m. August 5th. Supposing that she had been able to intercept the reports, and had made CHART XXXVI, although there are no observations off the West Coast of Portugal, she would have known from the general pressure distribution shown that light airs and calms might be expected, with conditions favourable for the formation of fog.

In the middle watch there was extreme visibility, and Cape Roca Light was sighted, distant 47 miles. At 6.22 a.m., when Cape Roca was abeam, dense fog set in.

From the reports on the morning of August 6th, CHART XXXVII it will be noted that S.W. of St. Vincent, *Deseado* reports exceptional visibility, light S.W. airs, air temperature 72°, and sea 65°. *Matheran*, some 60 miles north of *Ormonde*, has fog, light S.W. airs, air temperature 66°, and sea 65°. All over the region off this Coast very similar conditions are probable, while the wind reported by *Losada*, and the Azores indicates that the air supply is coming from the westward.

It has been shown that the westerly depression is moving east-south-east, and as it advances the wind will freshen from the westward off the North-West Coast of Spain, and there any fog which may exist will be dispersed. *Ormonde* may therefore expect fog as far north as Cape Finisterre, thence to the Channel the visibility is likely to be good.

According to the log, *Ormonde* had fog patches throughout the forenoon of August 6th, and clear weather from Latitude 40° N., when there was a light N.N.W. breeze which backed to W.S.W. after passing Cape Finisterre, when the shore lights were visible outside their range. Ushant Light was sighted at 11.30 p.m. on August 7th, visibility very good, there being a gentle S.W. breeze with blue sky and cloudy.

Fog, associated with Mixing of Cold and Warm Winds, or Light Airs.

Fog may frequently occur near the boundary between contrary winds, and this is sometimes seen in the North Sea when a depression over England causing southerly winds in its front is accompanied by a secondary, bringing light and relatively cold northerly airs in rear; the mixing of these winds often taking place at the coast, where they produce a fog of short duration.

A col frequently produces conditions which cause fog. The fog which prevailed from May 18th to 20th, 1922, when R.M.S. *Egypt* was sunk in collision with the S.S. *Seine*, off Ushant, originated in the air circulations meeting in a col off the coast of Portugal, lying between two anticyclones.

CHART XXXIX, MORNING OF MAY 19TH, 1922, shows the conditions. From this it will be seen that air drawn from the eastward of the Azores was blowing from warm to cooler water round a High, and meeting air coming over from Spain, and Southern France, to the southeast of another High in the col where *Hororata* and *Desna* were in fog. The mist and fog further northward are probably more due to the usual cause of sea fog.

Local Fogs.

CHART XL, MORNING OF AUGUST 8TH, 1923, shows that there was a large shallow depression centred to the northward of Latitude 57° N. near the 28th meridian of West Longitude. A wedge of High pressure extended northward of Madeira to latitude 45° N. and there was an anticyclone over France, with a col over the Bay.

The tendencies of the barometer at British stations, and those of ships to the westward, allowing for their courses and speeds indicate that the depression is probably moving to the N.E. or filling up, while those reported at Portuguese stations, and by ships in the vicinity of the wedge, indicate that it (the wedge) is probably spreading north and intensifying.

Fog is reported at Corunna, in the col, probably due to radiation during the night.

Clan Sinclair, off Lisbon, with a light westerly air, has mist, and *Bosworth*, to the westward of Scilly, with a fresh S. by E. breeze, haze; there is fog at Holyhead; no other reports indicate the presence of obscurity other than that caused by rain.

The conditions are such from Madeira to the Channel, that fog may occur if the wind comes light from the southward, and morning fog may spread in the vicinity of Corunna should light airs off the land continue. Let us continue our deductions from the point of view of an individual ship. S.S. *Woodarra*, Captain J. V. REILLY, from Las Palmas to Dublin, provides an example. She had a light N.N.E. air in the col, with sea temperature one degree higher than air. *Bosworth*, some 260 miles ahead, and to the westward of Scilly, in haze, with a fresh S. by E. breeze, reports air temperature 62° and sea 61°. Here, if the wind falls light, it is highly probable that fog will form. Now with the depression moving to the N.E., or filling in, and the wedge spreading northward, pressure is generally rising over the Eastern North Atlantic; a less steep barometric gradient may be expected near Scilly, and the isobars may be expected to trend more east and west which will result in the wind falling light and coming more from the westward; thus, the air at Scilly tomorrow morning will probably have come a considerable distance over a sea surface in which the thermal gradient may be expected to lie more or less athwart its course. The air will become saturated with moisture followed by condensation. According to *Woodarra's* log, the wind became southerly at noon, a light air, at 4 p.m. it was S.S.W. force 3, at midnight S.W. by S. force 3, and at 1.20 a.m. they ran into thick fog; at 2.30 a.m. a light drizzle commenced which ceased at 3 a.m., when the visibility slightly improved, and at 4.5 the fog thickened again.

CHART XLI, for morning of August 9th, 1923, indicates that there is low pressure to the northward of the Trans-North Atlantic tracks; the wedge has spread to the northward and depressions appear to the N.W. and S.E. of it. The fog experienced by *Woodarra*, with the conditions shown, we should expect not to cover an extensive area, and it will be noted that good visibility is reported at St. Mathieu, Brest, and at Jersey.

For the prediction of wind and general weather conditions, southern trading vessels look for reports from ships to the westward along the Trans-North Atlantic routes. By this example it will be seen that reports of these vessels will be of considerable value to Western Ocean ships.

When we were collecting views for framing the "Weather Shipping" Bulletin so that it might fulfil as many purposes as possible, the Commodores of two great Atlantic services pointed to the need for visibility reports at the Scillies and Channel Islands. *For*, said they, *when bound for Cherbourg, we could shape a course to make a landfall at the Bishops or Casquets, according to what visibility there was on either side of the Channel.*

Oriana, off Vigo, has fog with a light N.E. breeze, but ships further off the land, and to the southward, are reporting clear weather, there being fresh north-easterly winds along this part of the Madeira route.

The observations of *Manchester Corporation*, *Metagama*, and *Montrose*, all on the Tory Island route, afford a good example for tracing the passage of air, and in this case it is passing from cold to warmer water; there is cloud but no fog. Further south, the passage of air cannot be so well traced, and it will be evident how this is complicated by the movement of weather systems.

At 9.30 a.m. *Woodarra* was N.W. of Scilly, the wind veered more to the westward, and the fog lifted; it appears to have been quite local.

S.S. *Traveller*, Captain E. W. JONES, from Liverpool to Kingston, Jamaica, reported heavy rains, calms and variable airs, accompanied by waterspouts and violent whirlwinds in the morning watch, on August 9th, 1923. At this time *Traveller* was in the centre of the depression, indicated close to the eastward of her on CHART XLI. Here, convective currents would be strong, and the conditions would be unfavourable for fog formation.

It will often be found that though conditions which might be expected to produce fog at a place or over an area are present, fog is not present. Enough has been said in this Chapter to show how desirable observations of humidity are for fog prediction.

The humidity of the air is found by calculation from the difference between the temperature observed by the dry bulb and wet bulb thermometers, for which purpose tables are given below. A small error in reading, or a false temperature, even though slight, may result in an entirely erroneous humidity.

Fog and the Utility of Humidity Observation.

Since the 1st Edition was published Portable screens have been finding their place in an increasing number of ships and better observations of air temperature are now made. To include the depression of the Wet Bulb thermometer in Wireless Weather reports to "All ships" is not advocated, at any rate for the present, because the elements recommended make the messages quite long enough and brevity is so essential for regulating wireless traffic. But each individual ship making a chart may be able to gain something from her own humidity observations. Here are the tables necessary to find the relative humidity and the dew point, and the following example will give some indication of the utility of them.

Suppose that R.M.S. *Kenilworth Castle*, Captain STANLEY OWEN, from Cape Town to Southampton on July 10th, 1926, at 0700 G.M.T. made CHART XLII with the observations given in the British Wireless "Weather Shipping" Bulletin and observations reported by selected ships invited to report to "All ships." They note their own observation of the depression of the wet bulb on their chart.

This chart indicates a depression centred far to the N.N.W. and probably moving northward and a small anticyclone centred not very far to the westward of the ship apparently nearly stationary.

Table for Finding the Relative Humidity (per cent.).

Dry Bulb. °F.	Depression of Wet Bulb. 0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°
90	100	96	92	88	84	81	77	74	70	67	63	60	57
88	100	96	92	88	84	80	77	73	69	66	63	59	56
86	100	96	92	88	84	80	76	72	69	65	62	58	55
84	100	96	92	87	83	79	76	72	68	64	61	57	54
82	100	96	91	87	83	79	75	71	67	64	60	57	53
80	100	96	91	87	83	79	74	70	66	63	59	55	52
78	100	95	91	86	82	78	74	70	66	62	58	54	50
76	100	95	91	86	82	78	73	69	65	61	57	53	49
74	100	95	90	86	81	77	72	68	64	60	56	52	48
72	100	95	90	85	80	76	71	67	63	58	54	50	46
70	100	95	90	85	80	75	71	66	62	57	53	49	44
68	100	95	90	84	79	75	70	65	60	56	51	47	43
66	100	95	89	84	79	74	69	64	59	54	50	45	41
64	100	94	89	83	78	73	68	63	58	53	48	43	39
62	100	94	88	83	77	72	67	61	56	51	46	41	37
60	100	94	88	82	77	71	65	60	55	50	44	39	34
58	100	94	88	82	76	70	64	59	53	48	42	37	31
56	100	94	87	81	75	69	63	57	51	46	40	35	29
54	100	93	87	80	74	68	61	55	49	43	38	32	26
52	100	93	86	79	73	66	60	54	47	41	35	29	23
50	100	93	86	79	72	65	59	52	45	38	32	26	20
48	100	92	85	77	70	63	56	49	42	36	29	22	16
46	100	92	84	77	69	62	54	47	40	33	26	19	—
44	100	92	84	75	68	60	52	45	37	29	22	—	—
42	100	91	83	74	66	58	50	42	34	26	18	16	—
40	100	91	82	73	65	56	47	39	30	27	—	—	—
38	100	91	81	72	63	54	44	39	31	22	—	—	—
36	100	90	80	70	60	54	44	35	26	18	—	—	—
34	100	90	79	70	60	50	41	31	21	—	—	—	—
32	100	89	79	68	57	47	36	27	17	—	—	—	—
30	100	88	76	65	53	43	33	22	—	—	—	—	—

Table for Finding the Dew Point (°F.).

Dry Bulb. °F.	Depression of Wet Bulb. 0°	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°
90	90	89	87	86	85	83	82	80	79	77	76	74	73
88	88	87	85	84	83	81	80	78	77	75	74	72	70
86	86	85	83	82	80	79	78	76	75	73	71	70	68
84	84	83	81	80	78	77	75	74	72	71	69	67	66
82	82	81	79	78	76	75	73	72	70	68	67	65	63
80	80	79	77	76	74	73	71	69	68	66	64	62	61
78	78	77	75	74	72	71	69	67	66	64	62	60	58
76	76	75	73	72	70	68	67	65	63	61	60	58	55
74	74	72	71	69	68	66	64	63	61	59	57	55	53
72	72	71	69	67	66	64	62	61	59	57	55	52	50
70	70	69	67	65	63	62	60	58	56	54	52	50	47
68	68	66	65	63	61	60	58	56	54	52	49	47	45
66	66	64	63	61	59	57	56	53	51	49	47	44	42
64	64	62	61	59	57	55	53	51	49	47	44	41	38
62	62	60	59	57	55	53	51	49	46	44	41	38	35
60	60	58	56	55	53	51	48	46	44	41	38	35	32
58	58	56	54	52	50	48	46	43	41	38	35	32	28
56	56	54	52	50	48	46	43	41	38	35	32	29	25
54	54	52	50	48	46	43	41	38	35	32	29	25	20
52	52	50	48	46	43	41	38	36	32	29	25	20	16
50	50	48	46	43	41	39	36	33	29	25	21	16	10
48	48	46	44	41	39	36	33	30	26	22	17	12	4
46	46	44	42	39	36	34	30	27	23	19	13	6	—
44	44	42	39	37	34	31	28	23	19	15	8	—	—
42	42	40	37	34	32	28	25	20	16	9	—	—	—
40	40	38	35	32	29	26	22	17	11	8	—	—	—
38	38	35	33	30	26	22	18	15	10	3	—	—	—
36	36	33	30	27	23	21	16	11	5	—	—	—	—
34	34	31	28	25	22	17	13	7	—	—	—	—	—
32	32	29	26	22	19	14	8	—	—	—	—	—	—
30	30	27	23	20	15	10	4	—	—	—	—	—	—

The wind circulation is such that the air which *Kenilworth Castle* will come across on her course at a speed of 15 knots next morning, in a position now distant some 360 miles to the N.N.E., will have come from a position about a third of the way between the present positions of *Hobson's Bay* and *Intaba* during the interval and probably from nearer *Intaba* earlier; force 3 gives a velocity of 9 knots.

The temperatures of air and sea reported by those ships indicate that air following this course will be passing from warm to cooler sea and will therefore be humid. At present *Kenilworth Castle* has a fresh breeze from north, air 64°, wet bulb 3° below that temperature, and sea same temperature as the air.

By inspection, the table for relative humidity shows this to be here, 83 per cent. and the air is not very humid, while the dew point table indicates that with this amount of invisible water vapour in the air the temperature would have to fall to 59° for fog to form.

Now disregarding the daily range of temperature, with the wind circulation shown by the chart we should expect that the change of temperature due to change of latitude would be about compensated by the source from which the air came as the ship proceeded northward. That is to say as the ship steams across the N.E. end of the anticyclone the wind will back by way of West to S.W. so that the wind will be coming from a warmer region with consequent greater evaporation.

Supposing that the temperature now reported by *Hobson's Bay* will be about the same with the wind from the same direction on the morning of July 11th, if the humidity increased to 100 per cent. the air still being 64°, fog will form.

Chart XLIII shows that on the morning of July 11th, 1926, *Kenilworth Castle* had a light S.W. breeze but was still with good visibility, *Sylvafield*, 100 miles to the N.W. and *Intaba*, 340 miles to the westward both have fog. Now at 8 a.m. on July 11th, 1926, *Kenilworth Castle* logged air 64° but the wet bulb was 63° giving relative humidity 94 per cent. and dew point 62° so that though we were right in our expectation of temperature we over-estimated the amount of moisture which would be brought from the S.W. Thick fog set in with *Kenilworth Castle* at 10.55 a.m., no temperature observations were recorded at that moment but at noon the air was 66°, wet bulb 64°, with visibility 3 by scale, *i.e.*, half a mile, the fog was evidently reducing, for these observations give relative humidity 89 per cent., and dew point 63°, the sea temperature at 8 a.m. was 63° and remained the same at noon so that the air in contact with the sea had evidently been brought to that temperature when the fog commenced at 10.55 a.m.

Occurrence of Low Visibility when Current sets towards the Land.

On several coasts it has been observed that when the prevailing wind drops the current changes; for example, in Vol. I, No. 7 of The Marine Observer, in his article accompanying the "Current Charts for the Direct Cape Route," Mr. Durst proved by worked up observations, that off the West Coast of Cape Colony the current normally sets N.W., while the prevailing wind in summer is S.E. Observations throughout all months of the year showed that when the wind fell light or was from the westward, the current frequently set more towards the land

Now hereabouts the sea surface temperature is cold, while it is warmer to seaward, so that a surface set towards the land may possibly often be concurrent with fog; thus, just as the navigator is deprived of means of fixing his position by terrestrial bearings, his ship may be being set into danger.

It will be noted that current arrows are plotted in Charts XXXVI, XXXVII and XXXVIII; in a future chapter we hope to be able to show some advantage in charting current reports with weather.

CHAPTER VIII.

WIND, AND SET AND DRIFT OF CURRENT.

In the chapter on this subject in the First Edition the following quotation was made from Lord Kelvin's lecture on Navigation given on page 184 of the Ninth Edition of "Lecky's Wrinkles."

"There are in fact certain currents of ten miles and upwards per day, due to wind (it may be wind in a distant part of the ocean) which the navigator cannot possibly know at the time he is affected by them."

And we went on to say, when Lord Kelvin said this there was no means of long distance communication at sea. It is the purpose of this Chapter to suggest how wireless may be applied to fill that breach more fully than at present, having regard to the smallness of our knowledge. As an aid to the prediction of current a table of frequency of components of current per 10 observations with the wind from the different octants of the compass for the route from the Channel to Latitude 40° N., off the West Coast of Portugal, with wind and current roses was given as an experiment. This latter has not proved a success, probably, because there were insufficient observations upon which to base the table and wind and current roses, and also because it is necessary to associate the set and drift of current not only with the wind at the place of observation, but with the wind over a very large area and with all other causes. Since then the Quarterly Charts of current along the main trade routes in the North and South Atlantic have been nearly completed, and some progress has been made in current investigation. Also, as might be expected, more questions have been asked with regard to current and more interest has been shown in this branch of Marine Meteorology by the Corps of Marine Observers as a whole than in any other.

In an endeavour to give information of what was being done, what was essential in the way of observation, and what might be done at sea, at the invitation of Captain C. Brown, of the Royal Technical College, Glasgow, last October, I addressed a large meeting of Captains and Officers upon the subject, and as this address was specially compiled for the information of navigators it is repeated here.

Ocean Currents and Navigation.

Of recent years the findings of Courts of Enquiry into the strandings of ships alone—if it is necessary—prove the importance of the study of currents to the navigator.

The Court which investigated at Vancouver, the stranding and loss of S.S. *Tuscan Prince* on February 15th, 1923, on Village Island, Barkley Sound, British Columbia, found this stranding and loss due to an abnormal current setting to the northward during weather conditions so bad as to be almost unprecedented in those waters.

They accepted as corroborating other evidence of abnormal velocity of current, the drift of the waterlogged and burning *Niko* which had caught fire and had been abandoned. The *Niko* drifted in a waterlogged state 56 miles in 22 hours, or at an average speed of 2½ knots. She was seen to pass Village Island by the shipwrecked crew of the *Tuscan Prince*.

Tuscan Prince's D.R. differed 50 miles with her position of stranding.

On this occasion no less than four steamers stranded within a few miles of each other on the same date, there being a southerly gale with heavy snow.

More recently, on June 15th, 1926, the stranding and loss of S.S. *City of Naples* on the coast of Japan was found by a Naval Court of Inquiry at Yokohama to be due to an abnormal set and drift of current caused by the weather conditions at the time, a strong gale with high confused sea and heavy rain equalls, while the Board of Trade Inquiry held in London, in July 1926, found the cause of S.S. *Otranto* striking the rocks at or near Cape Grosso on May 11th, 1926, was a current which set the vessel to the northward of her course; and there are many others. Current observations at the time of accidents are not always the best for establishing information of currents, in fact they must often be unreliable since had there been reliable observations with which to fix the vessel's position, no accident would have happened.

The more one knows of currents both from experience at sea in navigation and from studying them from the great number of observations we are collecting, the more difficult it is to explain their causes or indeed to associate correctly with them conditions which may affect them. In fact I might say that with increased knowledge begot by experience we are the more cautious, for so often theories which with limited data appear correct, are exploded when more observations are applied to them and so do not let me mislead you in anything that I may say in which I may suggest causes.

We can only deal with surface currents, that is currents to the depth of the draught of a ship.

There are a number of forces at work which produce currents in the ocean, some internal, others external.

Of internal forces there are differences in temperature, specific gravity, defect due to evaporation or excess due to rain, rivers and melting ice at different parts of the ocean. These all contribute their quota while pressure has effect.

Of external forces the rotation of the earth influences and controls currents from whatsoever cause they occur. Difference of atmospheric pressure has a twofold effect, one direct upon the surface waters transmtited to the depths but probably small in its contribution, the other indirect causing wind which by friction induces motion in the surface layers of the water.

The Charts of Mean Pressure and Wind accompanying Chapter VI.

Charts XXV and XXVI show the pressure of the atmosphere or height of the barometer all over the world on the average in the months of January and July. It will be noted that the wind blows from regions of high to regions of low barometer but not directly; it takes a spiral course.

For example, in July there is a region of high barometer centred S.E. of Mauritius in the Indian Ocean while the barometer is low over N.W. India.

In the Indian Ocean the S.E. trade is composed of air out of the anticyclone which upon crossing the Equator in its race to the area of low barometer, is turned to the N.E. and so becomes the S.W. monsoon. This is due to the rotation of the earth and friction. At sea we are all familiar with the general wind systems of the globe, let us compare them with the general surface current circulation.

Charts XLIV and XLV show the general current circulation in January and July.

By these charts it will be seen that generally the current runs clockwise round the anticyclones in the northern hemisphere and anti-clockwise in the southern hemisphere. That is, it flows before the prevailing wind. As I have said, there are many other causes of current than wind. The experience of the navigator is sufficient to prove that the set and drift of current is often influenced by wind prevailing at the place of observation and at distant places.

Sometimes we experience current which sets right against the wind and in many other directions but by taking a great many observations of set and drift of current in regions away from the great stream currents, and comparing them with the wind at the time of observation, it is proved that on the average the surface current runs before the wind at an angle of about 45° to the right in north latitude and to the left in south latitude.

This is also due to the rotation of the earth.

RELATION OF CURRENT TO WIND.
North Atlantic, Lat. 47° to 53° N., Long. 10° to 30° W.
Summer Months, 1908–1920.

If the wind arrow is slewed to fly with the wind, the frequency of current in any direction is given by the length of the arrow of the rose in that direction.

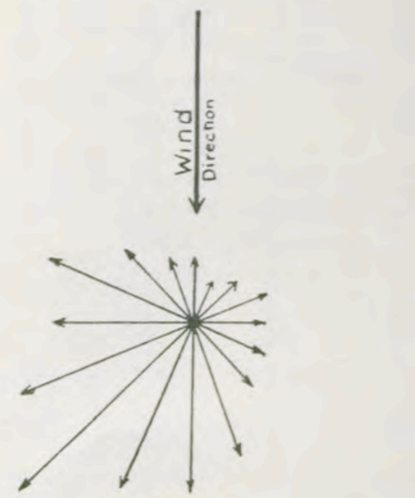


Fig. 34.

509 observations.

Frequency of set in relation to wind when the sea amount by scale is approximately the same as the wind force on the Beaufort scale.

The currents of the sea perform offices in the terrestrial economy which are stupendous in their effect, but when all is said and done the working of the Divine Creator in the laws which He has bestowed upon Nature in the Ocean are so little understood that we know positively of no **definite** laws yet, by which the variation of the set and drift of currents may be foretold. Current is extraordinarily fickle and the navigator requires information of its vagaries as well as its general flow.

I propose to deal first with information and last with its application.

To provide information of currents, observation is of the first importance.

Observation.

There are four methods of observation of the set and drift of current which we must consider.

(1) Set and drift obtained by drift bottles, derelicts, or floating wreckage have disadvantages as well as advantages.

If a bottle or floating object is released at a certain position at sea and is picked up at some place on a distant coast in a few months, we only know that it has travelled a not less distance than that between the place of release and the place of finding; and even if the bottle is seen to come ashore, we can only say that it has travelled at a rate of not less than so many miles a day. It may have made a devious track and so have travelled a greater distance in the time, of which we have no proof.

Then, there may be a skim of surface current quite different to that at, say, half the draught of a ship, which latter is really what the navigator wants to know. For example, I have seen, and no doubt many of you have too, a boat at sea near the ship in a calm in the vicinity of ice, set in an entirely different way to the ship, indicating that there was a surface current setting the boat with her draught of about 2 feet in quite a different direction to the general set at half the ship's draught of, say, 20 to 30 feet.

Even the drift of derelicts may be quite misleading as an indication of set and drift of current, unless they are waterlogged with decks awash, and the drift of a ship not making way through the water may also give a misleading impression of current.

There are two cases to my knowledge which I think, go to prove this.

In September, 1922, before the German S.S. *Hammonia* foundered off the coast of Portugal, when the *Kinfauns Castle* and other British ships made such gallant rescues, she drifted with engines stopped, according to observation, S. 29° W., 38 miles in 8.2 hours, or 4½ knots, on September 9th, 1922, when there was a fresh N.E. gale. P. & O. S.S. *Nore* found a current of only ½ a knot setting to S. by W. when steaming in the vicinity the next day when the N.E'ly wind was still prevailing.

In June, 1924, S.S. *Archimedes*, whilst broken down with propeller gone, drifted 78 miles in the North Atlantic, by observation, between June 24th and 26th, the wind being S.W., a fresh breeze for the most part, but light N.N.E. during the part of the time when other ships steaming through the same water indicated that the current did not amount to more than 30 miles.

Archimedes had a mean draught of 16½ feet and displaced 8,297 tons, her broadside showed an area of 14,750 square feet above the water line upon which a wind of force 5 would exert a pressure of about 9 tons when abeam; she had probably sailed 48 miles to leeward.

(2) The current meter is probably the most accurate means of obtaining the direction and velocity of current both at the surface and in the depths, for it measures the rate at which the water passes it in much the same way as the patent log measures the rate at which it is being towed through the water by a ship. The direction is indicated by means of a compass attached to the meter, and thus positive measurements are obtained, but as the use of this instrument is only practicable in surveying vessels it is no good advocating its adoption in the Merchant Service. A ship should be anchored when she uses it, and it is too costly even if there are occasions when merchant ships anchor in places where current observation is desirable.

(3) When at anchor, too, the Dutchman's log may be used to advantage. A drogue with a float will ensure that the current is indicated by a drift of the float. Cable vessels at their mark buoys have obtained very good observations by this method.

(4) The method by which the largest amount of suitable data can be obtained is the old time one of difference between observed and D.R. positions at the end of a run.

The set and drift obtained between noon and noon by this method is valuable, but over the distance traversed by a fast ship in 24 hours there may be entirely different sets of current.

Stellar navigation is most valuable for current observation, and probably the best observations of current can be obtained on the run between twilight stellar fixes. Some young navigators obtain the set and drift between star sights taken before sunrise and the noon position, but there is an objection to this.

If the ship's position is fixed by position lines from, say, 4 star altitudes on opposite bearings with a good horizon at daylight in the morning, a good navigator can usually be confident that his fix is a dead fix, and after a run of, say, 12 hours, if the dead reckoning is accurately kept, by fixing his ship by the same method with evening twilight stars, he can say with confidence that the difference between the last observed position and the D.R. position *is the set and drift of current* in the interval.

But supposing that having got an exact stellar fix at daylight in the morning he takes the difference of the D.R. from this position, at noon, and the position obtained with the sun's meridian altitude and sun's position line obtained by altitude in the forenoon transferred by D.R. to noon, his second position is really only a running fix and may be in error to the extent of as much as 3 miles. The interval may only be 6 or 7 hours and the error in the last position alone would be accounted as half a knot of current or 12 miles in a day.

What is wanted on every possible opportunity, when the D.R. is considered reliable and sights accurate, is the set and drift over the noon to noon run, and the set and drift between morning and evening stars and evening and morning stars; the two latter provide the information required and the first provides a check.

When coasting, the set and drift obtained at suitable intervals between cross-bearings are most desirable, and upon all occasions when the current can be determined with fair reliance, it should be entered in the log. In large deep draught ships of high speed the revolution of the propellers, if careful allowance for slip is made, will probably give the best indication of distance run through the water; but where possible, and particularly in small slow ships, the patent log should be used also, if only as a check.

Leeway is a matter for judgment, and if judgment is sound, with well adjusted compasses, careful allowance for deviation and variation, with good steering, it will be safe to assume that the course steered is made through the water. Experienced commanders and officers will forgive my dwelling at length upon matters which are simple to them, but the fact is, returns made, show that there are some young officers who do require advice upon this very simple but important matter. It is good that more attention is now being paid by the navigation schools to sound teaching as regards the position line, a clear understanding of which is so essential in modern navigation.

The encouragement of current observation is in the interest of every commander and of the shipowner even if only as an incentive to accurate navigation and good steering.

Not only should the set and drift be entered in the Meteorological Log and Ship's Meteorological Report so that data may be provided for research work and the making of charts, but I would ask Marine Superintendents and Commanders to require these entries to be made in the ship's log; for the careful recordings of them is an inestimably good habit, it reflects well upon the navigation of a ship, and no navigator ever knows when he may require such documentary proof in preserving the cleanness of his certificate.

Information.

Information of two kinds is desirable.

First.—Information of the general set and drift of current in each locality and its variations compiled from past experience.

Second.—Information at the time when a vessel is approaching a locality, and if possible what changes may be expected during the time she is passing through that locality.

For the first, charts are required. The second may in part be provided by "Selected ships" in the locality reporting the set and drift they have experienced to "All ships" by wireless, and by doing this possibly by-and-by prediction may follow.

The Admiralty current charts were drawn from information prepared under the superintendence of my predecessors long ago. They plotted all the observations of set and drift upon large working sheets and then arrows to represent the general flow of the current were drawn by eye at the Admiralty. This gave a general idea of the circulation of the surface water for each month all over the Oceans, but it did not give the variations of the current in each locality, and I think that with modern observations and by calculation we can give more reliable resultants from these observations as well as showing the variations. We have learnt through the work of these old time Oceanographers, and this is what we are doing in "The Marine Observer," and when the tracks are charted for each quarter over each ocean in this manner I hope that they may be combined and so provide improved atlases.

Referring to the Current Chart, North Atlantic Tracks, February to April, given in Volume III No. 27 of "The Marine Observer."

On these charts are grouped observations of the set and drift of current experienced in February, March and April, from 1910 to 1924, by British and Dutch ships.

To the right are arrows giving the resultant current worked out from all the observations in the squares shown. These show the general movements of the water at half the draught of ships.

To the left are current roses constructed from the same observations.

Current is extraordinarily fickle, and these roses show the frequency of direction and the frequency of the different velocities, in fact its vagaries.

For example, in the Gulf Stream between Longitude 62° and 66° W. the resultant current is E.N.E. 21 miles per day, but the current is nil or less than 6 miles per day on 12 out of 100 occasions. It sets E.N.E. on 35 occasions out of 100, and on these 35 occasions it ran at the rate of 6 to 12 miles, 4 times; 13 to 24, 7 times; 25 to 48, 15 times and from 49 miles to 72 miles per day, 9 times.

Then on 3 occasions in 100 it set due west once at the rate of 25 to 48 miles in the day and twice at 13 to 24 miles, and so on; which is a very different thing to the old charts, which only indicated the current as running in one way.

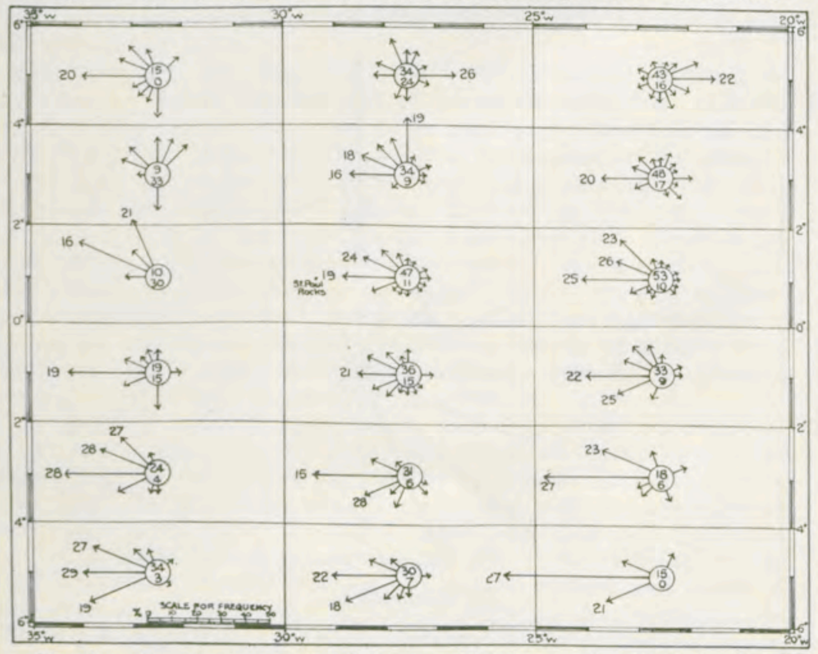
With the observations worked up and charted in this way not only can these charts be used by the navigator, but they should be of assistance in revising the sailing directions, and so we are anxious for your support in furthering this work, which we believe will contribute to safer navigation.

Application.

A case which impressed us very much was reported by Captain J. B. Hall of S.S. *Tudor Star* in June, 1921, and this has had considerable influence upon the progress of the work.

On May 24th, 1921, when on a voyage from Liverpool to the Plate, *Tudor Star* found a set drift N. 81° E., 32 miles, in 24 hours near the Equator where the Equatorial Current usually sets to the westward. He reported this set and drift by wireless to S.S. *Balzac*, Captain T. James, who was in the vicinity bound south, who replied that he had experienced a current of N. 87° E., 39 miles, still continuing, Latitude 2° 38′ S., Longitude 31° 17′ W. S.S. *Narenta* and other steamers reported much the same. We sent a circular letter to ships on the same run and received a number of observations in return.

Fig. 35. Current Frequency, May, in the vicinity of St. Paul Rocks.



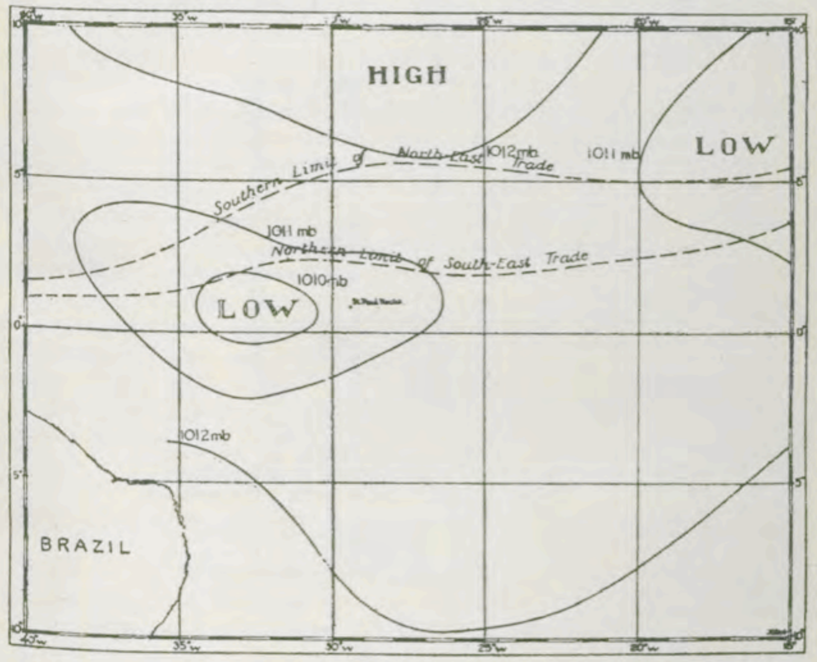
Based on figures given in the "Charts of Meteorological Data for Nine Ten-degree Squares, Lat. 20° N. to 10° S., Long. 10° to 40° W."

Explanation:—

Current Roses.—The arrows show by their length the frequency of current experienced in any direction. The figures at the ends of the arrows show the mean velocity of the current in miles per day in the direction of maximum frequency. The figures in the upper portion of the circle give the total number of observations, those in the lower part, the percentage of observations of no current (less than 5 miles per day).

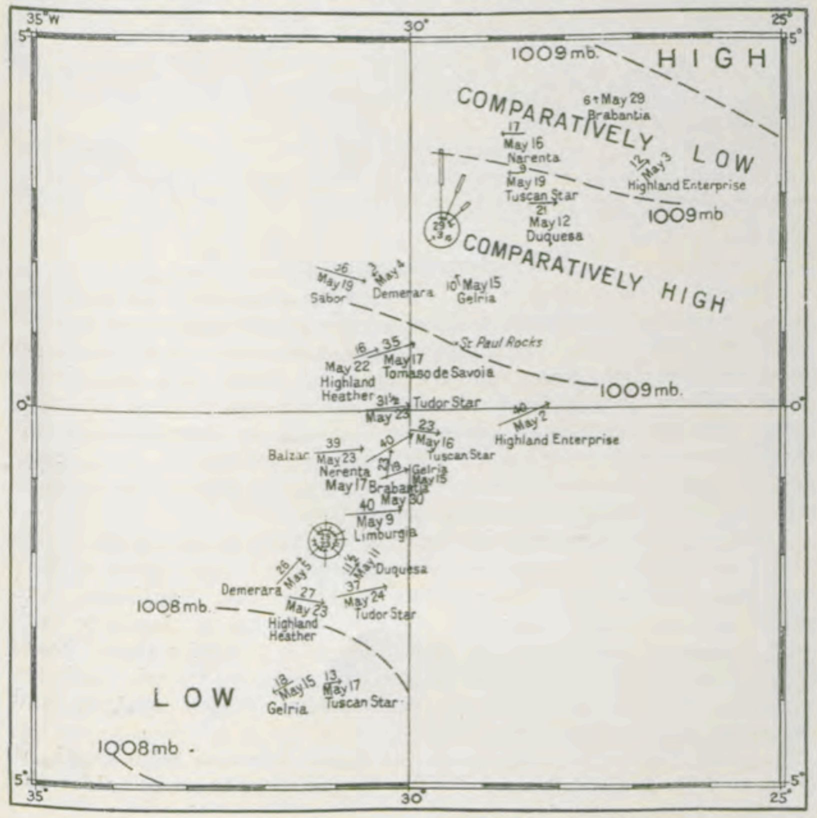
The chart (Fig. 35) shows the variations of current between Latitude 6° N. and 6° S. from Longitude 20° W. to 35° W., and is based on Captain Toynbee's work many years ago. You will see that the current sets most frequently to the westward near St. Paul Rocks, but occasionally it has set to the eastward. The greatest frequency of easterly set is in about Latitude 4° N.

Fig. 36. Normal pressure in May, in the region near St. Paul Rocks.



Based on figures given in the "Charts of Meteorological Data for Nine Ten-degrees Squares, Lat. 20° N. to 10° S., Long. 10° to 40° W."

Fig. 37. Current in May, 1921, in the region of St. Paul Rocks.



Explanation:—

Currents are shown by arrows, drawn from the mid-position of the ship's run, and proportional to the strength of the current. The velocity in miles per day is shown above the arrow, the date below, together with the name of the observing ship.

The wind roses refer to the track from the equator to 5° N., and from the equator to 5° S. The arrows which fly with the wind show by their length the frequency of the winds and by their thickness the various forces, light winds, forces 1-3, ——— ; moderate winds 4-7, ═══ ; and gales 8-12, ▬▬▬ ( ). The circle supplies a scale for estimating the frequency of winds in any direction. From the heads of the arrows to the circumference represents 5 per cent of the whole number of observed winds. The upper figures in the centre of the wind rose are the total number of observations, the percentage of calms being given underneath.

The isobars are not reliable for absolute pressure, but give a conception of the relative distribution along the track.

The chart (Fig. 36) shows the normal distribution of barometric pressure in the Equatorial Atlantic in the month of May, also the limits of the N.E. and S.E. Trades in that month; you will note that the Low approximately occupies the position of the Doldrums.

On the chart (Fig. 37) all the observations of set and drift reported in May, 1921, are plotted with the day of the month and the name of the ship, also isobars. Compared with the observations compiled by Captain Toynbee, these sets and drifts are abnormal, for they all set to the eastward, where the current is most frequently —I might almost say nearly always—setting to the westward.

You will also note that the Low is some 5° south of its normal position in May. The N.E. trade extended to a mean latitude of 3° 10′ N. during the month and the Doldrums were approximately 4° further south than usual in May, in the longitude of St. Paul Rocks.

We searched the logs and data books to see if there had been a similar case in previous years and found that in May, 1862, easterly sets had been logged near the Equator, also in 1859, when the Doldrums were south of their normal position.

The chart (Fig. 38) shows the conditions in May, 1862, when H.M.S. *Euryalus*, ships *Lalla Rookh*, *Tipoo Saib*, *Chili* and *Daylight*, all well-known ships of their day (the day of the sailing ship) reported easterly sets and the Doldrums were centred some 6° south of the normal position.

From these experiences we conclude that the N.E. Trade sets the surface water to the westward north of the Doldrum belt and the S.E. Trade sets the surface water to the westward south of the Doldrums. Usually in May the Doldrums are centred in about Latitude 4° N. and here between the two westerly currents there is a current setting to the eastward which joins the Guinea current.

When the Doldrums are moved abnormally south this easterly current moves with them.

Now if we attempt to try and explain the cause of this without sub-surface observations we are almost sure in time, when observations from the depths are obtained in this region, to find that we have overlooked some explainable thing and, therefore, I think it best not to try to advance a theory. There is too much at stake in navigation, the facts, as we know them, are our best guide.

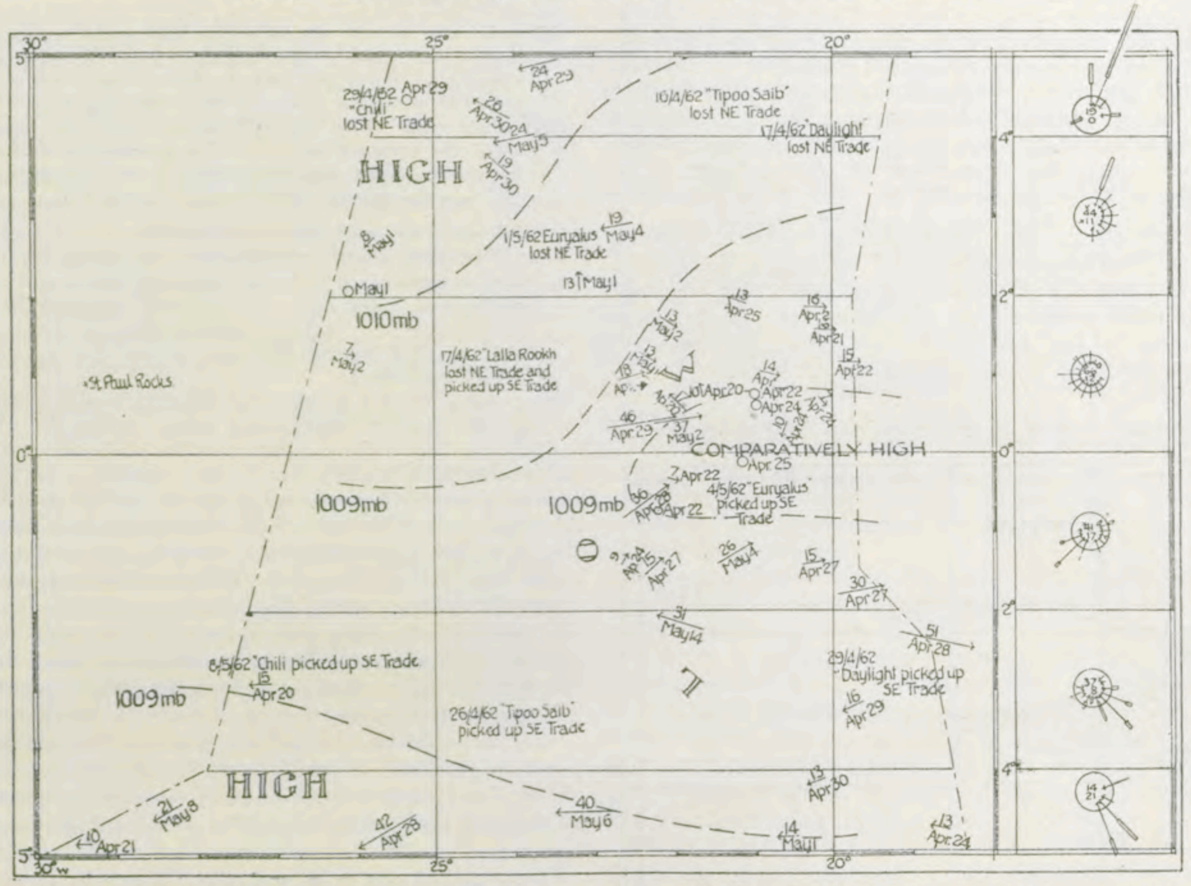
There are probably practical advantages to be obtained even with our present knowledge, and I suggest that "Selected ships" making weather reports to "All ships," and giving their set and drift may contribute to safe navigation. There is no light on St. Paul Rocks and therefore it is wise to give it a wide berth at night and in heavy rain with reduced visibility. Ships receiving reports a day or so before passing St. Paul Rocks indicating the position of the Doldrums would have a better idea of where to expect the easterly current and the lines of demarkation bordering the westerly currents.

I doubt very much if many, if any, know the extraordinary variations of current, it is more fickle, I think, than we realise. Cable ships note by the pranks played by the cable when they are laying it, how current varies not only at and near the surface but in the depths.

If we could lay down the course of a ship with absolute exactitude even for a good day's run we should probably find that current had varied so much that the course would represent a very complicated traverse.

How often, when coasting where there is supposed to be little tidal current, we find by cross bearings that the ship has not made her course; this may be attributed to many causes, leeway, heave of the

Fig. 38. Current in May, 1862, in the vicinity of St. Paul Rocks.



Currents are shown by arrows drawn from the mid-position of the ship's run, and proportional to the strength of the current. The velocity in miles per day is shown above the arrows, the date beneath.

The wind roses are made from observations between the parallels of latitude shown, and extend over areas contained between the diagonal lines marked thus —.—.—. The arrows which fly with the wind show by their length the frequency of the winds, and by their thickness the various forces, light winds, forces 1 to 3, ——— ; moderate winds 4 to 7, ═══ ; and gales 8 to 12, ▬▬▬ : (LIGHT MODERATE GALE). The circle supplies a scale for estimating the frequency of winds in any direction. From the heads of the arrows to the circumference represents 5 per cent. of the whole number of observed winds

The upper figures in the centre of the wind rose are the total number of observations, the percentage of calms being given underneath.

The isobars cannot be considered as giving more than a rough representation of the relative pressure distribution during the period.

sea (theory has it that the particles in waves oscillate, but when the heads of the waves curve over and break the particles of water probably advance in a horizontal direction near the surface and so tend to force the ship with them), and then there is deviation of the compass. But I think that current is a very frequent cause, and when the weather becomes thick with rain, or there is fog, it may often happen that just as the navigator is deprived of the means of fixing his position by terrestrial bearings through the land being obscured, his ship may be being set into danger by a current which is associated with the very same causes as those contributing to fog. Along the west coast of South Africa the Benguela current sets northward and its velocity increases with the "South-Easter" in the summer months. Sets towards the land are most frequent in the winter when westerly winds occur. Along this coast there is a strip of cold water upwelling from the bottom. The steady pull of the "South-Easter" tends to draw up the water from depths owing to the rotation of the earth and this is said to cause a pressure gradient in the water which accentuates the northerly current. When the wind drops there is a tendency for the water at the surface to flow towards the coast and with air coming off warmer water out to seaward, charged with moisture, fog forms as its lower layers are chilled by the cold water near the coast.

I can remember having a five knot current in the Agulhas Stream and south of Sokotra in the Indian Ocean; but so far as I can remember the biggest set and drift that I have ever experienced throughout a day's run was 86 miles or 3½ knots setting to the eastward near the Equator, in the Indian Ocean, to the westward of the Maldive Islands and until I came to the Meteorological Office I used to think that other than in tidal waters there were not currents of more than five knots.

In 1921, when compiling a current chart for the S.W. Monsoon season in the region near Cape Guardafui and laying down recommended steamship routes for Colombo to Perim we found a set and drift of 7.6 knots equal to 183 miles a day, recorded by S.S. *Ramsay*, Captain F. C. MULLAN, on July 2nd, 1906. At first I would have rejected this as impossible but I found that Captain HARRIS of the Bibby Line, *Worcestershire*, who has been long known as a very careful current observer, had recorded by good stellar sights on the very next day, July 3rd, 1906, a current of 7.4 knots equal to 177 miles a day, 120 miles away, so that *Worcestershire* had passed through the same water as *Ramsay* and many ships have since reported sets of over five knots in this vicinity. A study of the currents in this region and the tracks recommended in the June, 1924, "Marine Observer" will repay navigators running home from the East.

We constantly find by comparing the set and drift logged that navigation is more accurate than is often supposed and that this method though not perfect is the best that is practicable generally at sea.

Wireless Telegraphy.

There is no doubt that wind is one of the greatest of the contributory causes of current and with wireless communication now general at sea, the unravelling of the mysteries of ocean currents is no longer only possible for those who are able to collect and assemble a great volume of data long after the event from the logs of many ships, but the navigator himself at sea can do something in this direction with observations of other ships as well as his own, immediately after they are taken. He can obtain direct information which will be most valuable in navigation.

In our recent researches in charting the currents along the North and South Atlantic tracks we have examined a great deal of data including sub-surface observations made by the *Challenger* and other research ships, and Mr. DURST, who up to January 2nd, 1927, assisted in this work, has put forward a tentative theory based upon assembled surface observations of current, wind, and sea temperature, and sub-surface observations of temperature and density. It is briefly this.

Generally, the temperature of the ocean decreases with depth, it is very cold at the bottom. As the temperature becomes colder the density of the water increases.

If cold water rises from the depths to the surface, where it is surrounded by warmer water, the cold heavier water will be depressed lower than the warm light surrounding water, thus producing a slope towards the cold water in the centre. This will produce a pressure gradient in the water which will tend to make a current flow counter-clockwise in North Latitude around the cold water. When deep cyclonic depressions pass over the ocean they have left the surface water colder in their wake than can be accounted for by a surface current coming from a place where the surface water is cold, or by the cooling of the surface waters by the cold winds in the rear of depressions, or by radiation, or cold rain. It seems, that the vortex of a cyclone has the effect of drawing up cold water to the surface and that the currents, which are induced by surface friction by the wind revolving counter-clockwise (in North Latitude) are increased by the pressure gradient in the water caused by the difference of density and slope towards the centre. The column of cold water would be raised quicker than it sinks back to its former level, so that the passage of a cyclone should, by this theory, leave behind it possibly for a day or so, two currents running parallel to the track of the cyclone, the one to the right of the track (in North Latitude) setting in the same way as the cyclone had travelled and the one to the left in the opposite direction. You will find an interesting article in the June and December, 1926, "Marine Observer" upon this giving charts and diagrams with observations.

It is another incentive to the practice of Wireless and Weather as an aid to Navigation. All the 500 regular observing ships on our list which have mercurial barometers are asked to make a daily report by Wireless, of weather observations made at the same Greenwich Mean Time as those of the nearest coast and to give the last determination of set and drift of current with position "From" and "To", addressed to "All ships."

All ships may benefit and participate in the work by intercepting these reports and making weather charts from which, with the Current Charts we are now publishing in "The Marine Observer" and their own study, they may be able to glean much useful information and thereby to improve navigation. Here is an example:—

The Cable Ship *Colonia*, Captain V. CAMPOS, on passage from London to New York, at observation time on the morning of August 25th, 1924, is in Latitude 40° 24′ N., Longitude 45° 05′ W., and according to the difference between her D.R. and observed positions she experienced a current setting N. 57° E. at the rate of ¾ knot with middle position in Latitude 40° 58′ N., Longitude 43° 33′ W.

The charts of currents on the trans North Atlantic tracks for this quarter are given in Volume III, No. 33, of "The Marine Observer." They indicate by arrow that in the region *Colonia* has just steamed through the resultant set and drift of a total of 54 observations was E.N.E. 5.2 miles per day.

The current rose shows that in the region she has steamed through and will be still steaming in next day, that though the current most frequently sets E.N.E. and N.E. up to 2 knots, yet it may set in any direction and may be less than a quarter of a knot on 24 out of 100 occasions.

Further west the current has set east over 49 miles per day very occasionally. Now this information is useful but it does not give us the foreknowledge we wish. Wireless weather reports charted may help us towards this end.

Supposing that *Colonia* intercepted the reports of all the regular observing ships within a range of, say 1,500 miles which had been able to ascertain the current they had experienced by reliable stellar sights at dawn and the D.R., also the coast station reports from the "Arlington" message. With these reports she could make WEATHER CHART XLVI, the set and drift found and reported by each ship being indicated on the chart by an arrow, midway between the positions "From" and "To", with the initial letter of the ship's name and the velocity to the nearest quarter-knot abreast it

This chart indicates a West Indian Hurricane centred S.E. of Charleston, a V depression, east of Newfoundland, while the permanent North Atlantic anticyclone reaches northward of Latitude 40° N., to the S.W. of *Colonia's* position, and there is an extensive wedge of high pressure extending northward to Nova Scotia. We can now see the wind circulation. Not only over the water we are to steam through during the next 24 hours, but over a great strip of the ocean, the currents reported now form a comprehensive picture, and the sea surface temperature is also conveniently given.

We now see that the currents reported in the region of south-westerly winds in advance of the V, and within the average limits of the Gulf Stream set before the wind and to the right, while *Scholar* has had a W.S.W. set of ¾ knot just south of the Gulf Stream. *Culebra*, away to the eastward has had current setting N.W. where the wind is now W.S.W. and the currents reported to the westward are southerly and S.E. Unfortunately just where *Colonia* wants to know how the current is setting, no report is available. As *Colonia* proceeds to the westward and passes the trough of the depression the wind will veer and so the water she will be passing through will be subject to a tendency of induced frictional movement to the eastward. Comparing the sea surface temperatures reported with the average given on the chart of mean sea surface temperature in Volume III, No. 32, "Marine Observer", we see that it is 4° above normal in Latitude 41° N. Longitude 44° W., and 3° above normal in Latitude 41° N., and 56° W., while in Latitude 37° N., Longitude 48° W., as reported by *Scholar*, it is 78° and normal. By comparison then, the water is colder to the S.E., and according to deductions which have been made recently in conjunction with the charts of currents on the routes to the West Indies, a slight S.W. set would be expected hereabouts, while the Gulf Stream to the northward and right in *Colonia's* course being warmer, may be expected to set to the eastward with more than usual strength.

CHART XLVII, FOR THE MORNING OF AUGUST 26TH, 1924, shows there are N.W'ly winds between the 40th and 50th meridians west in the latitudes of the Trans-North Atlantic tracks. The hurricane is now centred S.E. of New York. *Colonia* has experienced a set of East 2¾ knots in the Gulf Stream and *Scholar* has had a current setting W. by S. 1 knot to the southward of the Gulf Stream and with the wind acting nearly against it. The sea surface temperatures now are such that *Colonia* will not expect a continuance of the strong Gulf Stream set to the eastward.

CHART XLVIII, FOR THE MORNING OF AUGUST 27TH, 1924, indicates that the hurricane is now centred North of Sydney, C.B., and *Colonia* is within its wind circulation with a strong S.S.W. breeze; she has experienced a slight current from N.N.E. but has now entered warmer water. These charts serve to show how useful reports of current may be if assembled suitably by the navigator, but until more experience has been gained of the method and more research work has been done in the Marine Division it must not be expected that predictions of current will be fulfilled, for, as stated previously, really very little is known of the laws which govern Ocean Currents. The man on the spot, and that is the man on the bridge of a ship at sea, with the data which other ships can give him, together with the information now being supplied in "The Marine Observer", can do much to promote a true knowledge of Ocean Currents and prediction of their vagaries.

As this system is developed by Commanders of ships at sea, more may be learnt of the changes and variations of currents which may be expected with changes of wind and other observable conditions; but even when we reach that happy state of affairs there can be no doubt that navigational precautions must not be relaxed; increased knowledge only tends to make us the more careful and that means the *four L's*, Lookout, Lead, Latitude and Longitude; in the two latter the Wireless Direction Finder is giving more and more assistance.

CHAPTER IX.

THE THERMOMETER AS AN AUXILIARY TO THE BAROMETER.

THE examples in previous chapters give conclusive proof of a definite law of relation of wind to pressure away from the land and disturbing causes.

The persistent alternation of sea and land breezes in the Tropics, caused by the inrush of cooler air over the sea to take the place of the warmed rising air over the land during the day, and the outrush of air cooled over the land at night to replace a warmer layer over the sea, is sufficient to prove that there is a relationship of temperature to wind and indirectly to pressure, but no rule for temperature and wind or temperature and weather such as Buys Ballot's law for wind and pressure has been found.

As heat is a fundamental source of energy in the atmosphere it follows that it must have great effect upon weather and therefore consideration of temperature is important for general prediction.

In the middle of the last century the German professor, H. W. Dove, propounded a theory by which he accounted for the formation of cyclones as the result of the conflict of cold polar and warm equatorial winds meeting. Dove dedicated the second edition of his book "The Law of Storms considered in connection with the ordinary movements of the atmosphere" to Admiral FitzRoy.

Of recent years Professor Bjerknes of Norway has developed a theory which seems to revert to Dove's line of thought. Instead of dividing the cyclone with reference to the centre into four quadrants lying to left and right of the line of progression and in front and in rear of the trough according to Abercromby as in Figure 3, Chapter II, Bjerknes divides it into two very unequal parts by two lines which meet at the centre. See Figure 39.

These two lines indicate the boundary between the warm and colder air of the cyclone and are dotted in the figure, thus dividing it into warm and cold sectors.

The dividing line from the centre, eastward and south-eastward or in advance, is called the warm "front," while that from the centre, south-westward or in rear, the cold "front." In this Figure the cyclone is supposed to be moving eastward.

The dark flow lines represent cold wind and the light flow lines warm winds.

Usually there is a marked rise of temperature at the warm front preceded by considerable rainfall, the area of which is shaded in

Typical Flow Lines of Air in a Cyclone of Northern Latitudes, after Bjerknes.

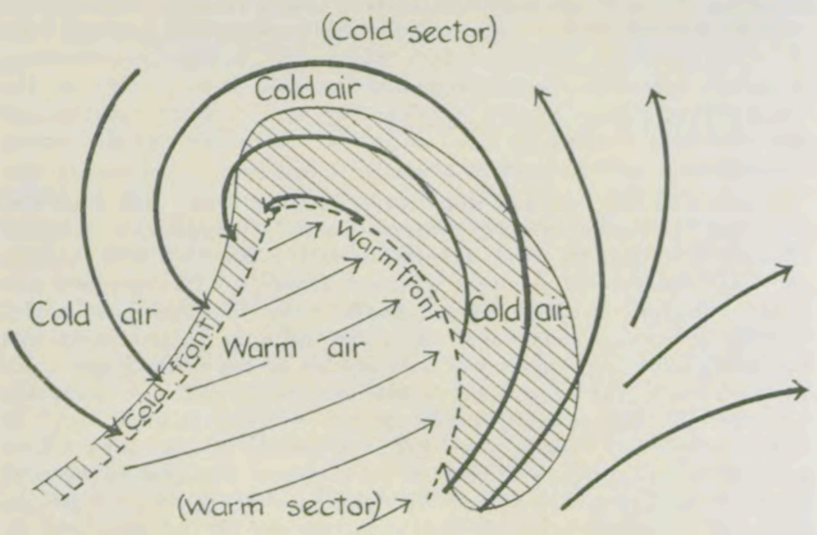


Fig. 39.

the figure. At the cold front there is a sudden fall of temperature accompanied by a shower of rain; this corresponds with the "trough."

The rain in advance of the warm front is attributed to the ascent of warm moist air over cold air, and the rain in rear of the cold front to undercutting of the warm air by the cold winds from the rear.

Rainfall in regions outside the shaded areas in advance of the warm front and in rear of the cold front is attributed to local instability of air passing over warmer sea or land.

Working on this hypothesis the Norwegian Weather Service predicts local rainfall in all parts of its mountainous sea-girt country. What is of more interest to seamen is that it is contended that when the warm sector is of marked higher temperature than the cold sector, cyclones develop, while if the warm sector is cut off by cold air, surrounding it, the supply of warm air to the centre being cut off, the cyclones fill up.

The former case may frequently happen in the western North Atlantic when the wind from the southward circulating round the western side of the Atlantic anticyclone blows into a cyclone.

The latter case may occur when cyclones have crossed the Atlantic and the chilled air drawn from the Arctic circulates round them.

Since the first edition of these chapters was published Dr. Bjerknes has paid a long visit to the British Meteorological Office and the forecasters have had the benefit of his experience. Though the improvement in the forecasts given in the "Weather Shipping" Bulletin is undoubtedly due to the steady progress being made generally in forecasting in this country, which is in no small measure owing to reliable reports from the Atlantic, received ashore, there is no doubt that a closer study of the use of the thermometer as an auxiliary to the barometer and consideration of Bjerknes' method have contributed to progress. Dr. Bjerknes tells us that the generalised plan of the cyclone depicted in Figure 39 represents a stage of its existence. In earlier stages the cyclone has the structure represented in Figures 40 and 41.

Figure 40 represents two winds from opposite directions separated by a nearly straight dividing line between the cold easterly wind and the warm westerly wind. The first step towards the formation and growth of the cyclone is shown in Figure 41. A bulge in the dividing line towards the colder wind occurs. At the polar ex-

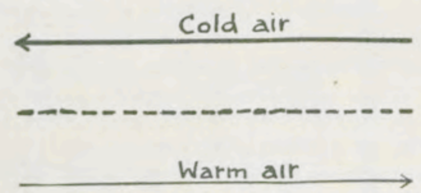


Fig. 40.

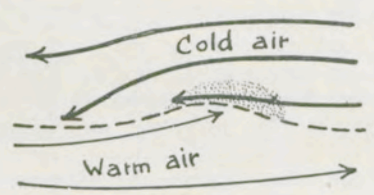


Fig. 41.

tremity of this bulge of warm air is the centre of the growing cyclone and the cyclone draws eastward with the warm wind.

The bulge of warm air increases in length in a north and south direction as shown in Figure 42. The cold wind curves round the northern end of the warm bulge or tongue and arrives in rear of centre as a north-westerly wind. The next stage is as represented in Figure 43. The warm tongue has now narrowed, particularly on the southern outskirts of the depression. Cyclones of the structures shown in Figures 40 to 43 and 39 are deepening and when observations of temperature, barometer and wind plotted on a weather chart show this horizontal wind circulation and temperature distribution, generally an increase of wind in the cyclone may be predicted with fair certainty.

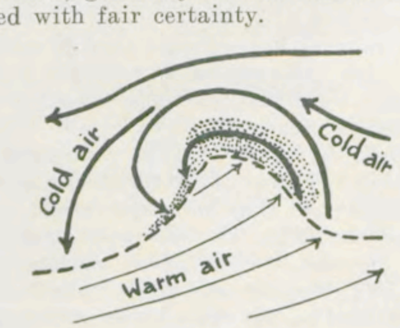


Fig. 42.

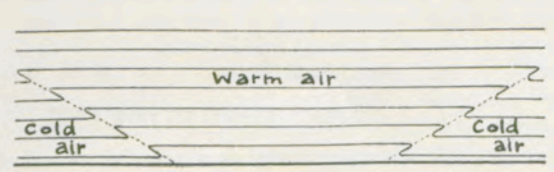


Fig. 42a.

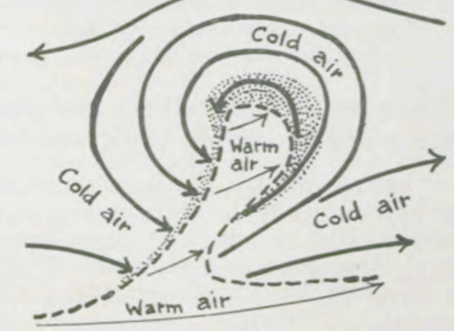


Fig. 43.

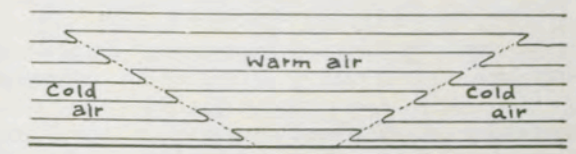


Fig. 43a.

Fig. 44.

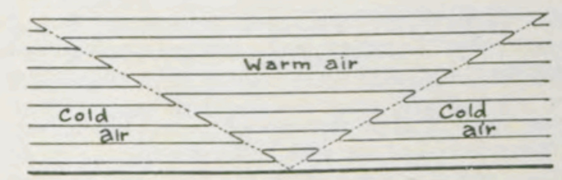


Fig. 44a.

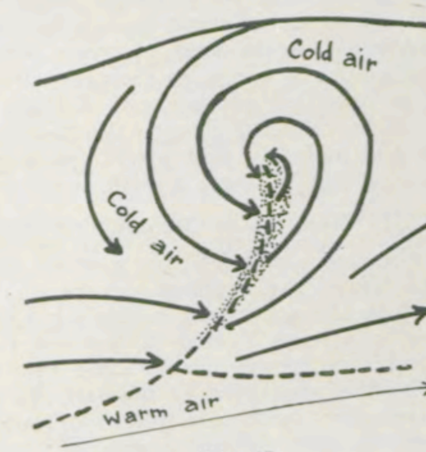


Fig. 45.

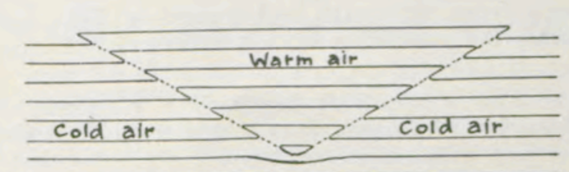


Fig. 45a.

In the next stage shown in Figure 44 the cold air of the N.W. winds in the rear of the cyclone extends where the warm sector was at the surface in Figure 43 and cuts off the supply of warm air. The warm sector then soon disappears at the surface, Figure 45; where the warm sector disappeared a dividing line still can be traced if observations are taken with sufficient accuracy. Finally this dividing line vanishes and the cyclone becomes a nearly symmetrical circulation of cold air, Figure 46. In this condition the depression is filling in and the wind dies away.

The different stages in the development and filling in of a cyclone are illustrated by Dr. Bjerknes also by vertical sections.

Looking at Figure 42a as if from the southward (in North Latitude) the dotted line indicates the boundary in the vertical plane between the cold and warm air at the stage shown by horizontal plan in Figure 42.

Figure 43a represents the vertical conditions of temperature corresponding with those given in Figure 43. Figure 44a shows the vertical temperature conditions when the cold N.W. wind has shut off the warm air entering the centre at the surface as in Figure 44.

Figures 45a and 46a show the warm air lifted clear of the surface after the warm sector at the surface has disappeared as in Figures 45 and 46 when the cyclone is dying.

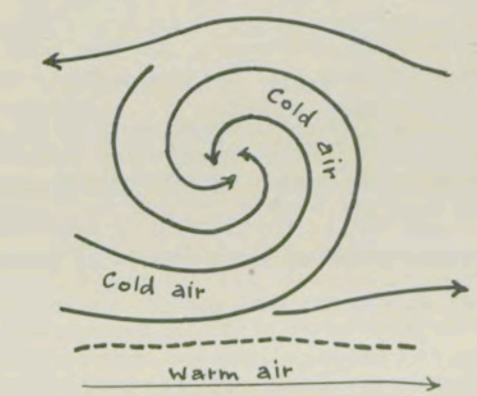


Fig. 46.

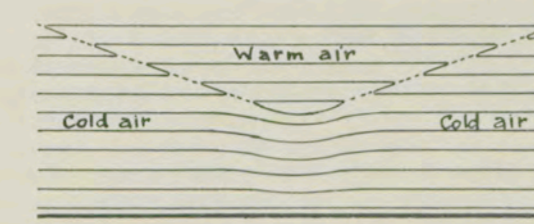


Fig. 46a.

An example which gives support to Bjerknes' contention.

A severe storm which was encountered by R.M.S. *Olympic*, Commodore Sir Bertram Hayes, K.C.M.G., D.S.O., R.N.R., and other ships in December, 1921, affords an excellent example of a cyclone intensifying with a marked warm sector.

Chart XLIX, for morning of December 11th, 1921, shows a depression centred just south of *Olympic's* position to the southward of Cape Sable and a wedge extending N.W. from the anticyclone to the S.E. The wind at Bermuda, south of the depression is S.W. force 7, with air temperature 62°; this is the only report to indicate the warm sector; the ships in the depression are west, north and E.N.E. of the centre and all report much lower temperatures.

The depression travelled E.N.E. at 23 knots and *Olympic* steamed E. by N. 21 knots, so that the ship and depression were on slightly converging courses, the storm travelling rather faster than the ship. *Olympic* experienced a steady E.N.E. wind increasing in strength. At about 7.30 p.m. the storm's path had curved north-eastward and *Olympic* ran into the centre. Chart L shows the pressure distribution, wind, weather and temperatures existing in the cyclone at 8 p.m., on December 11th, 1921. *Olympic* had a moderate gale from S.E. with rain and air temperature of 61°. *Missouri, Winifredian, Orduna* and *Valacia* have northerly winds and air temperatures as much as 19° lower than *Olympic* in the warm sector.

The storm continued to travel N.E. by N. at about 15 knots, *Olympic* continuing on her course E. by N. at 17 knots, the wind remaining nearly steady in direction from E.S.E. but increasing in force with falling barometer.

At 4 a.m. (ship hove to) the wind was S. by E. force 10 and the trough passed.

In the morning watch with barometer rising the depression drawing away from the ship to the northward, the wind veered to N. by E. but increased in strength. At 6 a.m. the wind was S.S.W. force 11, very high sea, with frequent fierce rain squalls.

CHART LI, MORNING OF DECEMBER 12, 1921. *Olympic* and *Nile* have wind S.W. force 11, air temperature 52° and wind S.S.E. force 11, air temperature 53° respectively, indicating that the air in the warm sector has cooled some 8° since the previous evening. All other ships in the cyclone including *Vellavia* with wind south, temperature 40°, still report considerably lower temperatures. Thus a shallow depression on December 11th, 1921, with a warm sector developed into an intense cyclone in less than 24 hours.

CHART LI affords another example regarding the wind in moving cyclones of middle and high latitudes. It will be noted that ships nearly equidistant from the centre but on different bearings from it have widely different wind forces and that *Megantic*, nearest the centre and north of it, had only a fresh breeze from east.

Now the wind at any position or place over which a cyclone is passing is made up of two constituents, that due to the progressive movement of the system and that due to the spin within the whirl itself.

With an east moving cyclone at places south of the centre these two constituents are in the same direction and here the winds are strong, while north of the centre the constituents are in opposite directions resulting in less wind.

Practical consideration of some effects of Temperature.

The atmosphere derives its heat directly or indirectly entirely from the sun. The temperature of the air depends more upon heating by conduction and radiation from the earth's surface heated by the sun's rays, than by the direct rays of the sun. That is, the sun's rays pass through the air without imparting much heat to it, but the surface of the earth is heated by the sunshine and the air is warmed by contact with the earth by radiation and convection. Land absorbs heat and radiates it more quickly than water.

When the sun's rays fall upon water the heat produced, instead of being arrested at the surface, penetrates and by vertical and horizontal currents is diffused to a considerable depth over a large expanse.

The capacity of air to carry heat is small *compared* with water. Water absorbs heat, stores it, and conveys it whither it flows.

Over the ocean there is small diurnal variation of the temperature of the air but over the land this is considerable.

CHARTS showing the mean sea surface temperatures over the North Atlantic may be found in Vol. III of "The Marine Observer", in which the influence of currents particularly the Gulf Stream and Labrador current may be seen by the trend of the isotherms.

Variable currents produce frequent variations from these normals so that large or even small areas of sea surface may have widely differing temperatures, which impart different degrees of heat to the air above them. These variations tend to produce unstable conditions which may contribute to the development of atmospheric disturbances.

Rain or any form of precipitation is generally attributed to cooling of ascending air, which is often produced by converging or crossing winds of different temperatures, the warm wind of moist light air riding over the cold wind of heavy air; where this happens there are also frequently, squalls.

Instability of the atmosphere, that is when a layer of light air under a layer of heavier air breaks through the layer above it causing a violent upward air current until stability is restored, produces heavy showers, thunderstorms, hail and squalls.

The processes involved are extremely complex and beyond the scope of these Chapters, but the following examples will illustrate that prediction of weather at sea may be improved if reports of air and sea temperature are used as an auxiliary to barometric pressure.

Barometer reports enable us to obtain the pressure distribution and its probable changes with which, and wind reports, we may be able to obtain the approximate flow lines of the air at the surface from day to day. Temperature reports will also assist us in tracing the air and ascertaining the changes it is undergoing.

Weather Charts of Pressure, Wind and Air and Sea Temperature and predicting Wind and Weather.

For exercise let us suppose that the reports have been broadcast, intercepted and charted by all the ships shown on CHARTS LII to LVII each morning, and let us join the Commanders and Observing Officers of three of these ships in their Chart House in turn, i.e., *Miami*, Captain MAXWELL BROWN, Liverpool to Jamaica; *Empress of France*, Captain E. GRIFFITHS, Quebec to Cherbourg; and *Nascopie*, Captain T. F. SMELLIE, Newfoundland to Liverpool.

CHART LII. MORNING OF OCTOBER 17TH, 1923.

There is a depression to the north-westward of *Empress of France*, a small anticyclone centred east of *Miami* and a depression east of the Azores.

Barometric tendencies allowing for course and speed, reported by *Adriatic*, *Empress of France*, *Colonian* and *Zeeland*, indicate that the northern depression is travelling eastward or S.E., or spreading south or may be it is deepening, while those reported by Horta and *El Paraguayo* make it appear that the southern depression is nearly stationary and changing little.

Miami proceeding S. 59° W. 12 knots in the small anticyclone sees that *Empress of France* with a fresh breeze from S.W. has air 50° sea 51°, overcast and drizzle, while *Adriatic* to the S.S.W. of *Empress of France* has a gentle breeze from west, air 59°, sea 65°, overcast and that *Colonian*, E.N.E. from *Empress of France* with a strong S.W. by S. wind has sea and air 54°, overcast. The air at *Empress of France's* position is too cold to have come far from S.W., it has probably taken a curved cyclonic course from a region to the N.W. The sea surface is normal. According to the Chart of Mean Sea Temperatures for October, the air at *Adriatic's* position has possibly taken a curved anticyclonic course from a region to the southward of west where there is the cold water of the Labrador current. The sea surface is 4° above normal, probably due to the Gulf Stream or an off-shoot from it being further north than usual in October.

The air at *Colonian's* position being 4° warmer than *Empress of France* has probably travelled on a curved cyclonic course from a position southward of that ship. The sea is only about 1° above normal.

These three reports give indications from which we may conjecture winds composed of air with different regions of departure of widely differing temperatures. With the northern depression travelling S.E. or spreading south and the southern depression stationary it is very difficult to predict what the pressure distribution is likely to become, though it will probably result in a large depression over the eastern North Atlantic in the next 24 hours and *Miami* may expect variable then southerly winds, as she proceeds on her course and that there will be unsettled weather with showers of rain.

According to her Meteorological Report (Form 911) *Miami* had the wind east, force 4 at midnight with air 57°, sky overcast, misty, rain showers, later wind S.S.W. force 3, with passing showers.

CHART LIII. MORNING OF OCTOBER 18TH, 1923.

Since yesterday when we discussed the weather and attempted prediction on board *Miami* the northern depression has travelled eastward and spread to the southward coalescing with the Azores depression, resulting in a large V-shaped, but not very deep, depression extending with its trough nearly along the 20th meridian of West Longitude to the southward of the latitude of Horta.

Generally the barometric tendencies reported indicate that the depression is deepening and moving eastward. The barometric tendency reported by *Verbania* on a S. 87° W. course at 7 knots steaming away from the trough and towards a High to the westward, indicates the possibility of a "secondary" forming in her vicinity.

Empress of France sees that her wind N.W. force 5 (air 49°, sea 54° sky overcast) has come from a cold region and that the air will move onward with cyclonic curvature, she notes that eastward of the trough *Miami* and *Majestic* have southerly winds with much higher temperatures than her own and that they have passing showers and rain respectively, while *Colonian*, also east of the trough but much further to the northward, has a moderate gale from S.S.E. with air 3° higher than her own and sea the same, sky overcast.

Near the trough the cold, comparatively dry, heavy air of the N.W. wind curving more from the westward, will be undercutting the warm comparatively moist light air of the southerly wind which will probably ride over the cold air coming from the N.W. causing rain and possibly squalls. *Empress of France* will expect that if the trough travels east at a greater speed than her own she may have north-westerly winds and clear cold weather, but if she overhauls the trough she may expect the wind to back considerably and that there will be rain. If a secondary is forming in *Verbania's* vicinity this prediction may be compromised. As *Empress of France's* barometer is rising slowly the depression is probably moving east at greater speed than her own.

According to her log, the wind remained N.W. until midnight; after 8 a.m. on October 18th the barometer fell, indicating that she had probably begun to overhaul the trough, or that the depression was deepening.

There were occasional rain squalls of short duration in the afternoon watch. From midnight the barometer rose slowly. At 2 a.m. on October 19th, 1923, the wind commenced to back and was logged as west, force 6 at 4 a.m., when there were passing showers. It is interesting to note that *Miami*, some 300 miles to the southward of *Empress of France's* track, experienced a heavy squall with rain at 11.40 a.m. when the wind shifted to N.N.W. This was on the line of the trough.

CHART LIV. MORNING OF OCTOBER 19TH, 1923.

This chart shows us that the trough of the depression travelled some 550 miles eastward in the 24 hours and that it drew further ahead of *Empress of France* and now stretches on a curved line from Cape Wrath to Brest.

Secondary depressions have developed to the N.W. of Corunna and near Latitude 48° N. Longitude 30° W. Barometric tendencies at stations in the British Isles indicate that the depression will probably continue to travel eastward. The barometric tendencies of ships between the meridians of 25° and 35° W. indicate that there may be a not very dissimilar repetition of the pressure distribution which formed over the eastern north Atlantic between a.m. October 17th and a.m. October 18th, 1923.

Discussing the situation in *Nascopie's* chart house we see that it is not easy to forecast. However we bank on the expectation that the secondary to the southward will coalesce with the main depression. If this happens there will be a considerable strip of cold north-westerly winds in rear of the trough and ahead of *Nascopie*.

We therefore expect a fresh breeze to a gale from N.W. for the next 24 hours with cloudy weather and possibly passing showers. According to *Nascopie's* log the wind continued from W.N.W. with slowly falling barometer until 8 p.m., the sea and air temperature only falling 1° since 8 a.m.

At 8 p.m. the wind veered to N.N.W. and at midnight it was from N. by W. the barometer continuing to fall slowly up to that hour. The sky was cloudy or overcast throughout. During the first and middle watches the ship passed through a strip or tongue of cold water, the sea surface temperature being 50° at 8 p.m., 43° at midnight and 48° at 4 a.m., during this time the air temperature fell another degree and squalls and rain were experienced. The passage of the cold N. by W. wind over warmer water, then over colder water and finally over warmer water, cannot be attributed to causing these squalls and rain; they were more likely due to processes connected with the coalescing of pressure systems.

Nascopie has been in the Arctic and they have much of interest to tell, let us stay on board a few days, for we may hear much that is not in the log, or available for "The Marine Observer" to publish, and the sequence of weather discussed on 4 days in one ship, will be more helpful.

CHART LV. MORNING OF OCTOBER 20TH, 1923.

There is now the extension of a depression with its trough along the meridian of 17° W. Longitude, which appears to be centred at some distance north of the limit of our chart and judging by the wind and barometer reported at Wick the centre has moved to the northward or north-west instead of to the eastward as we expected, showing the difficulty of prediction of movement or change in weather systems when observations are not available to the northward of the centre as well as to east, south, and west. Here is where the Iceland observations now given in the "Weather Shipping" Bulletin come in.

In view of the conditions reported by *Baltic* near the trough, this extension cannot be regarded as a true V, for her observations indicate that there is not a sharp dividing line between the north-westerly and south-westerly winds.

Generally considered, the barometric tendencies indicate that the depression is moving eastward with steepening of the gradients in parts of the system.

Nascopie on her course for Inishtrahull will expect a continuance of north-westerly winds with cloudy weather and squalls with passing showers of rain or hail; the wind may be expected to increase to gale force at times.

According to the log the wind remained from N.N.W. a strong breeze until 8 p.m. and there were frequent heavy squalls with rain; at 8 p.m. it backed to N.W. and increased to force 8; at midnight it was W.N.W. force 8 after which it moderated.

CHART LVI. MORNING OF OCTOBER 21ST, 1923.

This chart shows *Nascopie* that north-westerly winds and good visibility may be expected for another day, after which the possibility of the depression to the westward of *Vardulia* approaching will have to be considered in predicting the weather at the time of her landfall.

According to the log the wind was N.W. by W. force 7 and 6 throughout the 24 hours for which we predicted, there were squalls and sky clouded with Cumulus and Cumulo-Nimbus.

CHART LVII. MORNING OF OCTOBER 22ND, 1923.

Nascopie now sees that the trough of the depression ahead has moved very little, but that the centre has moved eastward so that the trough now lies over the west coast of Scotland and the Irish sea. The barometric tendencies at coast stations indicate that this depression is nearly stationary.

The depression to the westward has travelled east, not less than 200 miles in the last 24 hours, probably more; the barometric tendencies of ships under its influence reported, indicate that it is probably deepening. *Nascopie's* own slowly falling barometer appears to be due to her approach to the trough of the depression on her port bow, but it may also be due to a general reduction of pressure spreading from the Low astern.

To predict visibility and weather in this case for the time of landfall next morning is not easy.

We anticipate that the wind will back as the depression astern comes up and probably coalesces with the depression ahead. With a S.W. or southerly wind some rain and reduced visibility may be expected. The reports are not sufficient to enable us to trace convergence of winds; indeed under such conditions even with a number of reports this would be an extremely difficult matter.

According to the log the wind backed to west at 8 p.m. and S.W. at 11.15 p.m. moderating to force 4. At 4 a.m. October 23rd, 1923, the wind was still S.W. force 4; there was rain with visibility reduced to less than 5 miles.

At 8 a.m. the wind had backed to S.E. by S. and the visibility improved; course was altered at 8.55 a.m. and Inishtrahull was abeam, distant 1.4 miles, at 9.30 a.m.

These examples are sufficient to show that until fairly extensive observations have been made in the upper air by ships at sea, we have to conjecture much of what may be happening aloft.

As Commander L. G. GARBETT, R.N., Superintendent of Naval Meteorological Services, has shown in his articles in "The Marine Observer" the officers of the Royal Navy are making air soundings in certain of His Majesty's ships in different parts of the oceans.

North Pacific.

The Kurosiwo (Japan Stream) a warm current, which has been often called the Gulf Stream of the Pacific and the Oyasiwo, a cold but weaker stream than the Labrador current, flowing down the east coasts of Kamchatka, the Kuril Islands and Japan, together with the continent of Asia produce changes of temperature and conditions in the atmosphere not unlike those found in the western North Atlantic where we have shown that cyclones frequently have a marked warm sector and develop. These same cyclones travelling across the N. Atlantic Ocean become a more symmetrical circulation of cold air. This will probably be found to be the case in the North Pacific also.

With the strides which are now being made in British ships for the advancement of Wireless and Weather as an Aid to Navigation in the Pacific Ocean this chapter would not be complete without an example.

On the morning of January 19th, 1926, R.M.S. *Empress of Asia*, Captain L. D. DOUGLAS, from Kobe, approaching Yokohama, was in Latitude 30° 34′ N., Longitude 139° 04′ E., at observation time.

A selection of coast station observations from the Weather Message issued by the Tokio Observatory and reports from regular observing ships would provide the necessary data for drawing CHART No. LVIII which indicates a depression centred west of Minatsuki in the Japan Sea, an anticyclone S.E. of Bonin Island in the Pacific and a large depression to the N.E.

Empress of Asia in the S.E. sector of the Japan Sea depression has a fresh S.W. breeze with air temperature 60° the same as that of the sea surface; the only other observation of temperature available that is likely to give an indication of the nature and distribution of warm and cold winds in the region of Japan is that reported by *Belgenland* to the eastward of Shanghai where there is a moderate N.N.W. breeze, air temperature 49° over a sea surface 10° warmer. These observations coincide with a cyclone having a warm-sector and we may expect the depression to deepen with more wind in the system as it moves eastward. The Japan reports do not give us the barometric tendency so that the path of the depression is difficult to predict by means of barometer observations, but according to the BJERKNES theory cyclones travel on a path parallel to the isobars in the warm sector, hence this depression may be expected to travel N.E.

Empress of Asia arrived at Yokohama at 11.20 a.m. on January 19th, 1926, and sailed again for Vancouver, B.C., at 11.45 p.m. At 4 a.m. on January 20th she logged wind N.E. force 4, when the air temperature had fallen to 44° the barometer falling rapidly. CHART LIX indicates the weather conditions in the Western North Pacific at observation time on the morning of January 20th, 1926. The N.E. depression is now passing away to the eastward of the 180th meridian as indicated by *Benalder's* report; the depression which was yesterday centred over the Japan Sea has travelled N.E., centred S.E. of Shana in the Kuril Islands and has deepened considerably. *Empress of Asia* in rear of a secondary extending S.W. from the main depression has a strong N. by E. breeze. Unfortunately no observation is now available in the S.E. sector of this system so that we have no specific information of a marked warm sector. The pecked line indicates where we should expect the trough to be and probably before this the southerly and S.W. winds coming off the Kurosiwo and from lower latitudes are warm. With such conditions we should expect the depression to continue to deepen and *Empress of Asia* may expect a Northerly gale which will back as the trough draws to the Eastward.

At noon *Empress of Asia* had a fresh gale from N. by W. the air temperature continuing to fall, later the wind backed to the West and in the second dog watch there was a great display of " St. Elmo's Lights " with snow squalls during the night.

CHART LX indicates the weather conditions on the morning of January 21st, 1926, *Empress of Asia* now has a W.N.W. gale in the rear of the depression which has deepened considerably; as she proceeded on her course the wind increased to a whole gale with very hard snow squalls accompanied by a very high sea. Snow is probably the most difficult form of precipitation to predict but of all forms of precipitation there is none of which foreknowledge is more desirable to seamen, for not only does snow seriously reduce visibility but a snow covered coast usually means obliterated land marks.

CHAPTER X.

THE TRADE WINDS.

OF all the climates of the Oceans, the Trade Wind regions have the most stable weather conditions; so that averages or normals are more likely to represent the weather a ship will experience in any season than in any other part of the Oceans.

There are, however, considerable variations of wind in the same season, and, if these can be predicted, the navigator is likely to be the gainer, particularly if his is a steamer working to an exacting time-table to fulfil a mail contract.

In this Chapter, much of our information is derived directly from charts of normals and frequencies, and for the methods advocated it is desirable that these charts should be referred to regularly.

Looking back to Chapter VI. and in reference to Charts XXV. and XXVI., it will be found that we laid stress upon the fact that the high pressure zones lying roughly between the parallels of 20° and 40° North and South Latitudes are not continuous round the globe.

Generally speaking, the Trade Winds exist between the belts of high pressure and the equatorial zone of low pressure; they also occupy the gaps of less pressure occurring in these High Pressure belts.

The Trade Winds proper, being to the eastward and northward, according to hemisphere, of the centres of the anticyclones, continue round the south-west and north-west sides of the anticyclones, always inclining out from the centre. Hence we often get the S.E. Trade in the vicinity of Martin Vaz as a N.E. wind or the N.E. Trade as a S.E. wind, near the West Indies. Readers who served in sailing ships will remember the old joke when squaring in the main yard, outward bound in the South-East Trade.

The Trade Winds form a great part of the general circulation of the atmosphere governed by distribution of pressure. They are due to the difference of pressure in the great anticyclones and in the equatorial Low, caused by the distribution of the sun's heat over the earth's surface. In the Atlantic and Pacific Oceans, the Trade Winds continue throughout the year, but in the North Indian Ocean they are replaced by the Monsoons.

The late Captain CAMPBELL HEPWORTH investigated the Trade Winds of the Atlantic in the following areas:—

North-East Trade, area between Latitude 10° and 30° N. and Longitude 30° W. and the African Coast.

South-East Trade, area contained between the meridian of Greenwich and Longitude 10° E. from Latitude 10° to 30° S., and between the first meridian and Longitude 10° W. from the Equator to Latitude 20° S.

In these areas, which represent the hearts of the Trades of the Atlantic, he found that the N.E. Trades were strongest from January to May, while the S.E. Trade increased in the months of April, June, August and November, decreasing in the intervening months.

The Meteorological Charts of the Indian Ocean show that generally the S.E. trades do not vary much in strength from month to month, but are rather stronger during the prevalence of the S.W. monsoon in the Arabian Sea (June to September) than during the N.E. monsoon. This is due to low pressure being developed over Asia in the northern Summer and the South Indian Ocean anticyclone being intensified.

The South-East Trade continuing across the Equator and turned by the rotation of the earth gradually becomes a S.W. wind. In the Atlantic during July, August and September, the S.E. Trade is turned gradually to the right, becoming a S.W. wind north of the Equator known as the S.W. monsoon; at this time low pressure has developed over Northern Africa.

The limits of the Trade Winds, as is well known, move north and south after the sun; they are given on the Meteorological Ocean Charts each month.

During the southern Summer the South-East Trade extends considerably to the southward; at the Cape it is known as the " South-Easter "; at this time low pressure is developed over the Kalahari Desert, causing a steepening of the barometric gradient near the coast and to seaward. In the Indian Ocean when the southern limit of the S.E. trade passes south of Cape Leeuwin in the southern Summer, low pressure has developed over the great sandy desert of Western Australia; at this time south-westerly winds prevail in the Timor Sea, due to the cyclonic circulation of air northward of this depression.

Referring again to Chapter VI. and " Australian Weather Types," it will be seen that travelling anticyclones pass over Australia and that the Antarctic Lows to the southward extended as Λ's to the northward between the anticyclones; also tropical Lows extend southward.

Mr. C. STEWART, of the South African Union Weather Service, considers that weather is largely due to anticyclones passing eastward with their associated Λ depressions and secondaries at the Cape, and the behaviour of ships' barometers, and wind and weather experienced along the South Pacific trade route seem to indicate that anticyclones are constantly passing eastward in these Latitudes.

According to Mr. HUNT, the Mean Latitude along which the centres of anticyclones pass is about 40° S. in Summer and 30° S. in Winter.

The variations of force and direction of the " South-Easter " at the Cape in Summer and the South-East Trade in all oceans and in all seasons near its southern limit may be accounted for by the passage of these moving pressure systems. Further north their effect is diminished and the pressure distribution remains more settled. The prediction of the strength of the S.E. Trade in its heart would be useful to the outward Cape or Australian bound steamer, but if the force and direction of the wind at the southern extension could be predicted it would possibly be still more valuable, for here it is that we are more uncertain, the variations from the normal being more frequent and usually greater.

It is at the southern extension that it is proved that what Captain S. T. LECKY termed " steamanship " has been used with good judgment for the passage.

South-East Trade in the Indian Ocean and Economy of Coal.

The following are notes taken from my journal when in *Omrah*. This was a lucky voyage and we had a remarkably small coal bill. Unfortunately we did not keep a Meteorological Log, the only voyage during the whole of my time in the Australian Mail Service that we did not do so:—

Colombo to Fremantle.

September 6th, 1913.—10.46 passed Breakwater, set speed 66 revolutions. Light to moderate S.W. breeze and fine clear weather.

September 7th.—Noon, Latitude 4° 10′ N., Longitude 81° 30′ E. Fresh W.S.W. wind, rather rough sea. Current since 3.8 a.m. Pt. de Galle, S. 34° E., 4 miles.

September 8th.—Noon, Latitude 0° 29′ S., Longitude 85° 47′ E. Rain in middle and morning watches. Current S. 74° E., 32 miles. P. & O. *Macedonia*, Captain BENNETT, homeward, reported by W/T strong S.E. Trades from Latitude 26° S. to Latitude 6° S.

September 9th.—Noon. Latitude 5° 02′ S., Longitude 89° 39′ E. Gentle to moderate S.E. Trade throughout. Distance to Rottnest 2,181 miles, reduced to 65 revs.

September 10th.—Noon, Latitude 9° 19′ S., Longitude 93° 31′ E., current S. 68° W., 5 miles. Strong to fresh S.E. Trade.

September 11th.—Noon, Latitude 13° 26′ S., Longitude 96° 57′ E., current S. 40° W., 10 miles. Fresh to moderate S.E. Trade.

Distance to Rottnest 1,513 miles, reduced to 61 revs.

September 12th.—Noon, Latitude 17° 32′ S., Longitude 100° 56′ E., current S. 46° E., 15 miles. Gentle S.E. Trade until 4 p.m., then gentle S.W. breeze and fine. *Orsova*, Captain HEALY, homeward, reports by W/T, moderate to light variable winds from Fremantle. Reduced to 60 revs.

September 13th.—Noon, Latitude 21° 28′ S., Longitude 104° 59′ E., current N. 80° E., 16 miles. Strong S.W. and southerly wind, rough sea; fine and clear.

September 14th.—Noon, Latitude 25° 30′ S., Longitude 108° 50′ E., current N. 73° E., 14 miles. Fresh to gentle southerly wind.

September 15th.—Noon, Latitude 29° 26′ S., Longitude 112° 45′ E., Light and variable airs to moderate W. by S. wind. Distance to Rottnest, 211 miles.

September 16th.—4.17 a.m. came to an anchor in Gage Roads. 6.17, received signal to proceed into harbour and Health Officer would board inside Breakwater.

Averages for passage.—Actual steaming time, 9 days, 3 hours, 9 minutes. Distance 3,128 miles. Speed, 14.27 knots. Revs. per minute, 62.34. Apparent slip per cent., 6.2.

Notes from proposed programme worked out in the Mediterranean in consultation with Chief Engineer: Leave Colombo, September 6th midnight. Distance to Fremantle, 3,131 miles; arrive Gage Roads (September 16th) for 6 a.m. medical inspection. Speed required, 14.3 knots, allowing for 9 per cent. slip. Revolutions required, 64.5 (go 15 knots until S.E. Trade).

NOTE.—*Omrah's* normal slip under conditions of loading for 15 knots was 7 per cent.

From this it will be seen that we commenced at nearly four revolutions more than was required for the passage in view of former averages in September, and that for the time of year we had less head wind than usual, with currents as a whole a little favourable.

The weather information received from *Macedonia* near the Equator indicated that from just within the month's average Southern limit, for some days before, the S.E. Trade had been strong. With this information of *past weather* I judged it expedient next day when we had got the S.E. Trade not to make a material reduction of speed, hence the revolutions were only reduced by one.

On September 11th it was found, in the heart of the Trades, that they were not strong and revolutions were reduced to only one above speed required.

Next day on receipt of information of *past weather* from *Orsova* which indicated that the S.E. Trade had been considerably north of the month's average southern limit, the weather by our own observation at the time appearing to be settled, we reduced another revolution and maintained that speed, arriving with nearly two hours in hand. Had it been possible to forecast only a fresh Trade and the absence of head winds at the end of the passage, rather less coal might have been burned.

In those days our wireless only had a range of up to about 200 miles, whereas now, in numbers of ships of the same class, the range is measured by as many thousands of miles; the utility of the barometer for exact comparison of atmospheric pressure at different places was almost unknown to many of us, the scientific use of charted climatic normals was only popular with few, and making a weather chart at sea was almost unheard of.

Let us see with recent synchronous observations of *present weather*, what it may be possible to do in the future with tested instruments and long range wireless telegraphy, and, though we have not got details of engine speed, nor notes of what was at the back of the Commander's mind, in the following examples we will suppose, in accord with our practice in these chapters, that all ships shown on the weather charts numbered LXI to LXVI broadcast and received the reports.

In drawing these charts with so few and widely spaced observations, the normal charts give us an idea of the probable shape of the isobars, and in order that these may be more readily compared with the normals, they are drawn for every two millibars. *Ormonde* wishes to know if the Trade Wind will be strong or moderate, and later if she may expect a head wind approaching Fremantle.

Chart No. LXI, Morning, November 7th, 1923.

Ormonde picked up the S.E. Trade at midnight, 5th November, in Latitude 2° S., Longitude 88° E., or about 5° north of the average limit for the month, after which it remained fairly steady.

Pricking off *Ormonde's* position on the monthly chart we find that the normal pressure is 1010 (29.83) there. Her barometer, corrected for index error, temperature, height and gravity is 1013 (29.92); according to the table for correcting for diurnal range in the Tropics, given in Chapter IV, at this time of the year we must subtract 1 mb. = 1012; thus, at *Ormonde's* position, pressure is about 2 mb. above the normal.

Further, comparing this chart with the normal chart we find that over the S.E. portion of the South Indian Ocean pressure is generally about 2 mb. above the average for the month. *Ormonde*, north of the heart of the Trade, has the wind S.E. 4 and *Ormuz*, well within the average southern limit for the month, has the Trade Wind S.E., force 5. *Ormuz* bears S. 43° 56′ E., 1,565 miles from *Ormonde*, and their barometers differ 5 mb. This tells us little directly, and we must depend upon the isobars as drawn to obtain an idea of the gradient. The distance between the 1014 and 1018 isobars measured approximately at right angles to them, and mid-way between these ships, is about 540 miles or 9 degrees on the latitude scale.

5 mb. ÷ 9 = .55 mb. gradient, which according to the following table should produce a wind force of rather less than 4 on the Beaufort scale.

Table of Calculated Gradient and Wind Force.
For Straight Isobars over the Ocean.
Pressure 1,000 mb. Temperature 45° F.

Beaufort Wind Force.	Velocity.	Difference in Pressure in 60 nautical miles.				
		Lat. 52°.	Lat. 45°.	Lat. 30°.	Lat. 20°.	Lat. 15°.
	knots.	mb.	mb.	mb.	mb.	mb.
2	4–6	0·5–0·8	0·3–0·7	0·3–0·5	0·2–0·4	0·2–0·3
3	7–10	0·8–1·3	0·7–1·2	0·5–0·8	0·4–0·6	0·3–0·4
4	11–16	1·3–1·9	1·2–1·7	0·8–1·2	0·6–0·8	0·4–0·6
5	17–21	1·9–2·6	1·7–2·3	1·2–1·7	0·8–1·1	0·6–0·8
6	22–27	2·6–3·4	2·3–2·9	1·7–2·1	1·1–1·4	0·8–1·0
7	28–33	3·4–4·2	2·9–3·6	2·1–2·6	1·4–1·8	1·0–1·3
8	34–40	4·2–5·0	3·6–4·4	2·6–3·1	1·8–2·1	1·3–1·6
9	41–47	5·0–5·8	4·4–5·2	3·1–3·7	2·1–2·5	1·6–1·9
10	48–55	5·8–6·8	5·2–6·1	3·7–4·3	2·5–2·9	1·9–2·2
11	56–65	6·8–8·0	6·1–7·2	4·3–5·0	2·9–3·5	2·2–2·6
12	Over 65	Over 8·0	Over 7·2	Over 5·0	Over 3·5	Over 2·6

Later, when these ships passed each other, it was proved how well their barometers compared, but we have only been able to place the isobars by the values reported at the positions indicated, approximately, and though on this occasion the gradient agreed with the general force of the wind at the two ships, with so few reports, it cannot be relied upon, as an examination of the daily charts which follow will prove. However, the gradient so obtained gives an indication of the force of the Trade between observation points and so it is useful.

It must be clearly understood that the Table of Calculated Gradients is for straight isobars; in a cyclone the velocity of the wind is affected considerably by the curvature of the isobars.

During the next 24 hours *Ormonde* may expect the Trade to remain steady in direction and force.

We should like to know what the barometer is doing at Carnarvon, for if a tropical Low is moving south or developing over Western Australia, the wind is likely to veer to the S.W. and freshen with the steepening gradient which would result off the West Coast of Australia.

Ormonde had wind S.E., force 4, throughout the 24 hours, according to her log.

Chart LXII. Morning, November 8th, 1923.

Pressure is still about 2 mb. above normal and the gradient has steepened a little in the heart of the S.E. Trade. A depression has developed over Western Australia, where the winds are cyclonic. Comparison of the temperatures reported with those of yesterday are interesting in that they show how the air is becoming heated in its passage to the Doldrums, where much of the moisture taken up will be precipitated.

According to an investigation made in the Marine Division in 1924, an abridged account of which was published in Vol. II, No. 14 of "The Marine Observer," if the air temperature in the Doldrums is above normal the Trade Wind will probably be light, but if the temperature is below normal in the Doldrums the trade wind will probably be strong. Confirmation of this is required, and careful observation of temperature by use of the portable screen when making routine wireless weather reports is therefore the more necessary.

In using the barometric tendencies it must be remembered that in the Tropics the barometer is rising at this time of day.

Ormonde may expect the Trade to increase to about force 5.

If the tropical Low over Western Australia continues to develop, strong South-West winds will occur off the N.West Coast of Australia. The barometric tendency at Carnarvon and Perth, if reported, would now be especially valuable.

According to the log the S.E. Trade increased to force 5 on this day and remained at that force and from the same direction.

Chart LXIII. Morning, November 9th, 1923.

The tropical Low has moved South and is now centred east of the Leeuwin. Pressure is still over one millibar above normal in the South-East Trade. As the depression moves south the anticyclone may be expected to move east or spread east, in which case *Ormpnde* may expect the South-East Trade wind to back a point or two, but with ships so close together within the Trade Wind, we have little to go upon as to force which may be expected; there seems, however, nothing to indicate a material change in force. The wind off the North-West Coast of Australia will probably become more southerly. *Ormonde* will experience a westerly set. According to the log, the wind was S.E., force 5, throughout.

Chart LXIV. Morning, November 10th, 1923.

The positions of the ships again enable us to obtain an idea of the gradient in the S.E. Trade, but astern of them both, and from it we should expect about force 5. The chart indicates that *Ormonde* will experience the continuance of the South-East Trade nearly as far south as its average southern limit for the month, which her route cuts near the 30th parallel of south Latitude.

Chart LXV. Morning, November 11th, 1923, Sunday.

The absence of observations at Australian stations is now felt, for the eastward passage of Antarctic Lows may soon commence to affect the weather considerably. The pressure distribution has probably changed little since yesterday, and probably gentle southerly winds will be experienced as *Ormonde* proceeds through the eastern side of the anti-cyclone.

Chart LXVI. Morning, November 12th, 1923.

The Λ of an Antarctic Low has now appeared, centred S.W. of Cape Leeuwin; as it passes eastward, the wind in the vicinity of the Leeuwin and Rottnest Island will back through west to the south-west and moderate, and the gradient at the S.E. side of the anti-cyclone will become less steep. *Ormonde*, therefore, predicts with confidence moderate to light south-westerly winds to Fremantle. According to the log, this forecast was correct.

Though not conclusive, these examples are sufficient to show the possibilities of the method, and if steamers fitted with long range wireless sets regularly using the three routes, Cape Guardafui to Cape Leeuwin, Colombo to Fremantle and Fremantle to Durban, would broadcast reports of observations once daily, made at the times suggested in Chapter III, probably material results would be obtained after the practice and experience of the method, which is so essential. The procedure outlined is equally applicable to the Trade Wind regions of the Atlantic and Pacific, though the weather conditions differ owing to distribution of land and sea. It is a far easier matter to work out what should have happened long after the event, but the following example of another experience the writer had in the *Orontes*, with Captain J. F. Ruthven, in January, 1907, will illustrate the use of normals; and then we will give experiences in which the value of wireless weather reports in the South-East Trade region of the Indian Ocean cannot be questioned.

"Orontes" dodges Hurricane Winds of a Cyclone in South-East Trade Region.

On this voyage we left Colombo at 11 p.m. on January 21st, 1907, and had the N.E. monsoon until 8 p.m. on January 22nd, in Latitude 1° 13′ S., Longitude 86° 34′ E.; thence Doldrums until 9 p.m. on January 23rd, in Latitude 6° 06′ S., Longitude 91° 23′ E., when we picked up the S.E. Trade, commencing with a light shower of rain. The Trade wind was gentle to moderate and light at times, first from S.E. and later from south and S.S.W., with barometer conforming to diurnal range and normal pressure until noon on January 25th, in Latitude 12° 19′ S., Longitude 98° 22′ E. At 4 p.m. that day the barometer, corrected, was 29.758 inches or 1007.7 millibars. Correction for diurnal range + 1.3 = 1009, or 1 millibar below the normal isobar on the month's chart. The wind continued from S.S.W. and south, force 3 and 4, until 8 a.m. on January 26th, when the barometer was 3.3 millibars below the normal, allowing for diurnal range; it was now evident that a cyclone might be encountered.

At noon, in Latitude 15° 21′ S., Longitude 101° 53′ E., the wind freshened to force 5 from S.S.W., and from then onwards it increased and veered gradually, being W.S.W., force 8, at 8 p.m., when Captain Ruthven altered course to the eastward and we passed in rear of the ring of hurricane winds and centre, making a fair wind of the N.E. and northerly gale, which did not exceed force 10. The wind rapidly moderated and veered to the S.E. again as the storm passed away to the S.W. and the ship receded from it on a south-easterly course. We had very heavy rain in the first watch, when the ship was nearest to the centre.

When the South-East Trade blows into a Cyclone.

In the South Indian Ocean it is not difficult to avoid the intense part of the storm field of a cyclone approached from the north-west, for there is not the same temptation as there is to a ship bound to the northward or westward, because by passing in rear a ship bound to the south-eastward will benefit by a fair wind.

In this ocean, cyclones often form near the northern limit of the South-East Trade, which, during the months December to April, is also the southern limit of the N.W. or Middle Monsoon. Now, it is proved by observation that, before cyclones form, there is a reduction of barometric pressure and it is also proved by observation that cyclones in this ocean are not detached whirls of air beyond which light airs prevail, but the winds extend north and south from the centre for hundreds of miles. For this knowledge we are indebted to the great work of Dr. Meldrum at Mauritius, where, in consultation with Captain Wales, Captain of the Port, he also drew up the rules which were outlined in Chapter IV. A cyclone having formed, it draws its supply of air from the N.W. monsoon to the northward and the S.E. Trade to the southward, and it is difficult to tell when the increasing S.E. Trade forms part of a cyclone. Dr. Meldrum also found that in the South Indian Ocean cyclones, north-easterly and easterly winds often, if not always, blow towards the centre.

Upon Chart LXVII the track of R.M.S. *Orontes*, Captain J. F. Ruthven, is plotted with wind and barometer from the Meteorological Log kept by Mr. J. Avern, 3rd Officer, who later became Marine Superintendent of the Commonwealth of Australia Line, also the track of a homeward bound steamer, who did not realise that the South-East Trade was blowing into a cyclone and passed through the centre, in which were seen great flocks of birds.

This chart also serves to show the great distance covered by the winds to the N.W. and S.E. of the centre, though it should be remembered that the observations covered several days. The advantages of routine reports reciprocated by these two vessels are obvious, but it was not until six years later that wireless was fitted in steamers in the Australian Mail Service, R.M.S. *Otranto* being the first to be so fitted, and it is interesting to note that her first operator is now the General Manager of a great Wireless Service in Australia.

Looking through the logs of vessels which have encountered cyclones in the South Indian Ocean in recent years we have not found a single case of a ship bound to the south-eastward; but we find records in March, 1923, where, of three steamers homeward bound in the South-East Trade, two, *Surrey* and *Port Albany*, ran into the hurricane winds of a cyclone, and from the following it would appear that the third, *Tenessee*, did not avoid them; we have no other report regarding *Tenessee*. As reported in "The Marine Observer's Log," March, 1924, number, of The Marine Observer, page 37, S.S. *Port Lincoln*, Captain C. N. Jones, Port Pirie to Port Said, reported:—

"After having the barometer somewhat high for a considerable period, about March 9th it began to fall—from 29.87 to 29.62 (uncorrected) between 8 p.m., March 8th, and 8 p.m., March 10th—and sky changed from blue and Cirrus clouds to overcast, with passing rain, which we assumed to be a great change in weather, or that we were in the vicinity of some disturbance; but it came to be the outskirts of a cyclone. We were in communication by wireless, daily with S.S. *Port Albany*, *Surrey* and *Tenessee*, who by their reports appeared to be making heavy weather of it, judging from their positions and day's run, which were all we received."

Port Lincoln's barometer was an aneroid, and comparison made on arrival in London showed that it read .35 inches too low (i.e., index error and correction for height combined + .35 inches).

On 8th March, at 8 a.m., *Port Lincoln* was in the position indicated on Chart LXVIII and her barometer, corrected and allowing for diurnal range, was .29 in., 9.8 mb. above normal. Examination of the readings of this aneroid barometer, logged, show that they cannot be relied upon for obtaining the departure from the normal, as its error is probably not constant.

On the outskirts of a tropical revolving storm in formation the barometer is frequently unusually high and steady.

In this vicinity two days later, on 10th March at 8 a.m., *Surrey* and *Port Albany*, both with tested mercurial barometers, recorded pressure 5 millibars, .15 in. below normal by the month's chart.

The tracks of S.S. *Port Albany*, Captain C. A. Robinson, Fremantle to Suez, and S.S. *Surrey*, Captain C. R. Kettlewell, Adelaide to Suez, are plotted on Chart LXVIII with barometer and wind observed every four hours.

Both ships had the South-East Trade from 6th March off the S.W. Coast of Australia, which backed to the northward of East at 4 a.m. on 10th March. Up to midnight on 9th March, blue sky and Cumulus cloud was logged in both ships; at that time *Surrey* recorded Cirrus radiating from N.N.W., the sky became overcast later. Both ships encountered a confused swell at 4 p.m. on 9th March, which increased from E., E.N.E., and N.E. as the path of the centre and the ships' courses converged.

The Cirrus, barometer below normal, and confused swell with wind backing to the eastward, all gave warning.

At 8 a.m. on 11th March, had routine reports been broadcast, not only would these ships have been confirmed in their anticipation that they were approaching the path of a cyclone, but all others within range would have had early and distant information.

If the bearings of the centre are laid off from the ships' positions at midnight on 11th March in accordance with the average rule given in Chapter IV it will be seen that they do not fit, the indraft of the easterly winds being much greater at quite a small distance from the centre.

Port Albany's wireless aerials were carried away, which accounts for the absence of weather reports between these ships.

There can be no doubt that in the absence of several reports of synchronous observations on different sides of a cyclone in the South Indian Ocean when the S.E. Trade increases materially or backs, or the barometer is 3 or more millibars below normal within the Tropics, that it is best to heave to, until, by the veering or backing of the wind the passage of the centre with respect to the ship can be inferred. Even if such reports are received, once the wind circulation of a cyclone has been entered from the S.E. with an easterly or S.E. wind it is best to heave to, unless very near the line of progression.

Distant reports and careful observation and comparison with normals are the best means of obtaining information for shaping course or regulating speed to avoid the storm field of a cyclone in the Trade Wind regions within which heavy seas may cause damage or straining to decks and hull, or worse.

CHAPTER XI.

CONCLUSION.

In preparing charts of the percentage frequency of observations of gales in all oceans for the Board of Trade Committee upon Weather Zones and Seasons for the Load Line, we were struck with the high percentage of gales occurring in the western parts of the North Atlantic and North Pacific Oceans as compared with the gale frequency in the eastern parts of these Oceans. In both these Oceans to the west there are cold currents coming from the Arctic regions and warm currents coming from the Tropics.

Thus, the average of a large number of observations shows the association of bad weather with steep sea thermal gradients. The Gulf Stream has long been known by seamen as a "weather breeder." Maury wrote of it: "The most furious gales of wind sweep along with it; and the fogs of Newfoundland, which so much endanger navigation in Spring and Summer, doubtless owe their existence to the presence, in that cold sea, of immense volumes of warm water brought by the Gulf Stream."

In a report upon an "Investigation of the Meteorology of the North Atlantic," published in 1869, Captain Toynbee wrote: "The effect of the temperature of the surface water on the wind and weather seems to be a phenomenon of universal occurrence."

It was under Captain Toynbee that daily synoptic charts of the North Atlantic were first drawn, and daily synoptic charts drawn for areas over the sea have since proved that in middle and high latitude, where the changes of the surface temperature from place to place are more sudden, depressions more often occur or develop.

Different degrees of heat imparted by the surface to the air above it and the rotation of the earth contribute to pressure gradient, and in preceding Chapters we have seen that pressure gradient is proportional to wind.

There are, however, exceptions to this rule, for air cooled by mountain tops moves down the mountain slope by gravitation and attains a velocity, as wind, out of all proportion to the pressure gradient.

In his "Physical Geography of the Sea and its Meteorology," Maury wrote:—

"When we travel out upon the ocean, and get beyond the influence of the land upon the winds, we find ourselves in a field particularly favourable for studying the general laws of atmospheric circulation. Here, beyond the reach of the great equatorial and polar currents of the sea, there are no unduly heated surfaces, no mountain ranges, or other obstructions to the circulation of the atmosphere—nothing to disturb it in its normal courses.

"The sea, therefore, is the field for observing the operations of the general laws which govern the movements of the great aerial ocean.

"*Observations on the land will enable us to discover the exceptions, but from the sea we shall get the rule.*

"Each valley, every mountain range and local district, may be said to have its own peculiar system of calms, winds, rains and droughts. But not so the surface of the broad ocean; over it, the agents which are at work are of a more uniform character."

The Mediterranean Sea is land-locked, having lofty mountains along its northern coast, while to the southward lie the deserts of Africa. In this sea there often occur exceptions to the rule of the barometer and peculiarities of weather. There are the "Mistral" of the Gulf of Lyons, the "Bora" of the Adriatic, and the "White squall" of the Ægean Sea; "Tramontana" or winds off the mountains.

In the Mediterranean we also get, particularly in the Malta Channel, the "Sirocco," a hot southerly wind sometimes charged with the sands off the African desert occurring with suddenness, chiefly in the Autumn.

The "Gregale" or N.E. wind frequently blows with great violence in the winter at Malta.

In the Western Mediterranean, "Vendavales" or S.W. winds occur frequently in Winter, accompanied by much rain. Land and sea breezes are common on the coast of Spain in Summer.

"Contrastes," or opposing winds, are frequent off the southern coast of Spain. It is by no means a very uncommon sight to see sailing vessels in with the land and in the offing, steering nearly opposite courses, both with the wind aft or quartering. The name Capo Spartivento given to the southern point of Italy, "Cape split the wind," is significant (*spartire*, to divide: *vento*, wind). The "Mistral" and "Bora" are usually preceded by cloud-caps over the mountains which often continue while the wind lasts, and there are other signs known locally, all of which, when observed, should be noted in the Meteorological Log, in order that by publication in "The Marine Observer" they may become more generally known. Indeed, Marine Observers can do much in every part of the World, by remarking in their logs upon peculiarities of weather phenomena, but such remarks recorded in the Mediterranean may be of special value, for the Meteorological Office has a branch at Malta, where, for successful forecasting, this information may be valuable.

Though the barometer in the open ocean may be an unfailing guide to wind, there are exceptions in the vicinity of high land, of which the following is an example:—

Excessive Wind for Barometric Gradient.

Chart LXIX for the Morning of 31st December, 1921.

It will be noted that pressure is Low over the Gulf of Genoa and High over the Atlantic west of Portugal, the wind being N.W. at Pic du Midi, where the air temperature is 21° F., altitude 9,380 feet, and at Perpignan the wind is W.N.W. with air temperature 57°, altitude 104 feet. At sea, off Marseilles, the air temperature is also 57°, and off Barcelona it is 56°, as observed by *Tottori Maru* and *Antilochus.*

The P. & O. S.S. *Nyanza*, Captain C. D. Forbes, left Marseilles at 8.39 a.m. on 31st December, wind W.N.W., a fresh breeze, though it should be noted that at 8 a.m. *Tottori Maru*, not far off Marseilles, logged the wind as force 7.

Noon, wind W.N.W. 6 increasing, barometer 1016.8 (30.02), air temperature 58°, wet bulb 54°, which gives humidity 76 per cent., weather b. Cirrus and Cumulus are logged as covering 1/10th of sky. (We should like to know if these clouds were over the mountains or nearer the zenith?)

4 p.m., wind N.W. 9, barometer 1017.3 (30.04), air temperature 55°, wet bulb 50°, humidity 70 per cent., weather b.

At 6.30 p.m. the wind from N.W. increased to storm force 11, with very high steep sea. Ship labouring heavily. Hove to with ship's head N.N.E.

8 p.m., wind N.W. force 11, barometer 1020.8 (30.14), air temperature 49° (the wet bulb reading was by this time probably affected by salt-water spray, so that humidity cannot be found), weather b.

Chart LXX is made from ships' observations only, taken at 8 p.m. on 31st December. Comparing it with Chart LXIX it will be seen that during the day the Low which was over the Gulf of Genoa has moved south and is now over the Straits of Bonifacio, also that the barometric gradient over the Gulf of Lyons is much less steep than would be expected for so much wind.

Herefordshire bears N. 72° E. 116 miles from *Nyanza*, the line of bearing is nearly at right angles to the isobars, and there is only a difference of 4 mb. (.12 inches) in their corrected barometer readings; while *Antilochus* bears S. 34° W. 236 miles from *Nyanza*, this line of bearing is at an angle of about 4 points to the isobars, so that the distance for gradient would be about 167 miles, with barometers only differing 2 mb. (.06 inch).

It should also be noted that between noon and 8 p.m., *Nyanza's* barometer had risen 4 mb (.12 inch), the ship having made S. 48° W. 60 miles during this time, the depression also moving south.

With a wind of storm force out in the open ocean the difference in barometers, 60 miles apart, and on a line of bearing at right angles to the isobars, would be about 6.8 mb. (.20 inch). *See* Table, Chapter X.

The Mistral.

At noon, with wind W.N.W. 6, the temperature of the air was 58° and humidity 76 per cent. By 4 p.m. the wind had veered to N.W. and increased to a strong gale, while the temperature fell 3° and the humidity 6 per cent. By 8 p.m. the air temperature had fallen 9° altogether since noon, and the wind was then N.W., force 11.

Now in the morning the Low was over the Gulf of Genoa and the general direction of the wind from W.N.W. over the Franco-Spanish boundary, where the Pyrenees Mountains, rising to a height of 11,000 feet, lie in an E.S.E. and W.N.W. direction. North of the Pyrenees, the Cevennes Mountains, rising to 5,000 feet, extend in a N.N.E. direction.

The Low travelled south during the day, which would tend to a veer of the wind from a more northerly point of the compass with slight increase in force in the Gulf of Lyons, due to slight steepening of the barometric gradient. The cold, dry, heavy air over the tops of the mountains accelerates the N.W. wind by gravitation and rushes down to the sea as the "Mistral."

The cold, dry, heavy air striking downward on the surface of the sea no doubt accounts for the well-known fact that the sea rises with extraordinary rapidity in the Mediterranean with Northerly winds, of which we had many unpleasant experiences in the light, fast, little ships of the Fleet messenger service during the late War.

Chart LXXI shows the conditions on the morning of 1st January, 1922. It will be noted that the Low is now over the Tyrrhenian Sea, and that the gradient has steepened over the Gulf of Lyons, conforming more to the force of the wind. During the day, the wind moderated until at 4.20 p.m. *Nyanza* was able to proceed on her course with a fresh N.N.W. gale on the starboard quarter, the air temperature having risen again to 53° F. and barometer to 1026.3 mb. (30.31).

During several winters in the Mediterranean, and on many passages through it, I have noticed, when bound in or out of Marseilles and Toulon, that with the wind from northward of west, if it increases round about noon it almost invariably blows with gale force before midnight, and doubtless others will have noticed the same.

With a clear sky the air at the mountain tops, already cool due to altitude, is further cooled by terrestrial radiation at night, hence the "Mistral" usually blows hardest with a clear sky.

The "Mistral" may be concurrent with the southerly passage of the right semi-circle of a deep depression; when this happens the pressure gradient will be more nearly proportional to the wind.

The following example will not only serve to illustrate this, but it will also demonstrate the utility of wireless reports in these waters:—

"Mistral" with steep Barometric Gradient in rear of a Depression.

The Bibby Line S.S. *Oxfordshire*, Captain B. W. Adamson, was approaching Marseilles, outward bound, on December 28th, 1923.

They sent out a weather report addressed to "All Ships" as usual, but received none.

The Bibby Line steamers call at Marseilles, and it is important to these ships and to all mail and passenger steamers with a schedule to maintain, to know in Winter time if a "Mistral" may be expected during the time of their call, for often it may be desirable, if the "Mistral" is likely to be violent, to anchor in l'Estaque Roads, not going inside the breakwater for fear of delay.

It has often been found advantageous to embark passengers in this roadstead by tender in a strong "Mistral," for with that wind it is often not safe to attempt to go to sea from the harbour within the breakwater.

Had *Oxfordshire* received reports from other ships and intercepted the Eiffel Tower message, by making a weather chart, she could probably have seen that a heavy "Mistral" was to be expected, and that it would probably last until some time after noon on December 29th, when she was due to sail.

In the Western Mediterranean the station reports and ships' reports contained in the Eiffel Tower message are particularly useful, for the latter cannot always be received direct from the Eastern North Atlantic because of the interference of the land. A selection of these reports will give the general pressure distribution over the Eastern North Atlantic and Western Europe, and, with ships' reports received direct, a sufficiently complete chart for the purpose may be made.

In Chart LXXII we have such a Chart for the Morning of December 28th, 1923.

By it, *Oxfordshire*, and ships in the Gulf of Lyons, could have seen that there was a large and fairly deep depression centred north of Paris, and that with the barometer rising quickly at Holyhead in its rear, falling at Paris and Lyons, and falling rapidly at Zurich, that this depression would probably travel in a direction to the south-eastward. Such a movement of the depression would cause the wind over the mountains to the westward and north-west, which by the trend of isobars and observation at Perpignan was from the westward, to veer to the N.W. and so cause the air to flow down the mountain slopes with increasing velocity. Further, with this depression moving to the S.E., the wind would be from a north-westerly direction at Marseilles, due to the pressure distribution until the depression had passed away a considerable distance to the S.E. With this combination of the effects of gravitation and barometric gradient a heavy and fairly long spell of "Mistral" would be expected.

Oxfordshire arrived at Marseilles in the forenoon, and was in harbour throughout the strength of this "Mistral"; her meteorological log was not continued until she proceeded to sea.

The meteorological logs of S.S. *Clan Malcolm*, Captain C. J. Higgins, and S.S. *Orsova*, Captain C. G. Matheson, indicate that the "Mistral" blew with very great severity over the Gulf of Lyons from the evening of December 28th until the morning of December 30th, 1923.

Chart LXXIII shows the conditions on the morning of December 29th, 1923, when the depression was centred west of Rome. There is a steep gradient over the Gulf of Lyons, where the wind from off the mountains is reported by *Orsova* and *Clan Malcolm* to be of storm force, and it will be noted that in this vicinity the air temperature has dropped 8 degrees since yesterday morning.

Chart LXXIV Morning of December 30th, 1923.

Oxfordshire is at sea again, and has a light N.N.W. breeze in rear of the depression. *Clan Malcolm*, though no longer under the influence of the depression, is still experiencing the "Mistral," or mountain wind, from the northward, the gradient in her vicinity being less steep than would cause a wind of force 10, due to pressure.

High Seas.

This "Mistral" set up a very high, steep sea in the Gulf of Lyons on December 29th, 1923, *Clan Malcolm* and *Orsova* both being obliged to heave to. Captain Higgins, who is one of our most experienced "excellent" observers, estimated the sea to have been 45 feet high at 4 p.m. when *Clan Malcolm* was distant only some 180 miles from the "weather" shore. The fact that the sea compelled *Orsova* to heave to is sufficient to indicate the severity of the weather. The question has been asked, "Why is it that heavier seas occur with northerly winds in northern latitudes, and southerly winds in southern latitudes?" The following is possibly an explanation.

The barometric gradient is usually steeper and wind stronger in the rear of depressions than in front of them, and, therefore, in middle and high latitudes where depressions are usually moving eastward stronger winds occur from polar directions.

Further, polar winds being composed of comparatively cold, heavy air appear to set up more sea disturbance than equatorial winds composed of warmer, moist, light air. The matter requires investigation and observations and remarks upon sea and wind will be very welcome.

The length of waves is influenced by the "fetch." The highest sea reported of recent years was that encountered by *Majestic* on the night of December 29th, 1922, in the North Atlantic, in approximate Latitude 49° N., Longitude 20° W., when Sir Bertram Hayes and his officers estimated that the sea reached a height of 80 feet. Upon investigation of the weather conditions, Captain Hennessy found that this month in the North Atlantic had been remarkable for the frequency and strength of its gales. The phenomenal seas were caused not only by storm winds in the vicinity, but also by reinforced waves due to westerly winds which had been blowing continuously for at least 36 hours over an area extending 800 miles west, aided further by heavy westerly swell entering this area from the westward.

The inclusion of sea in weather reports has not been suggested in Ships' Wireless Weather Reports, because winds reported usually give a very good idea of what sea may exist or be expected. Swell is an essential element to report. There are, of course, localities where the sea is far more dangerous than in others with the same amount of wind, as, for example, off the South African coast on the edge of the Agulhas Bank. Captain Toynbee remarks in his "Report on the Gales of the Ocean District adjacent to the Cape of Good Hope": "In some cases the sea was tremendous, the eastern edge of the Agulhas Bank (where there is a strong current setting to the south-westward) is remarkable for its extremely high and confused seas, more especially in south-westerly gales, which blow counter to the current."

Squalls.

Apart from increase of wind force due to gravitation of cold air from mountain tops, the cold "front" or line of demarcation in a depression where the cold and warm winds converge is a place of conflict where squalls occur. Sometimes this line is marked by a sudden squall with a shift of wind, heavy rain, thunder and lightning, a sudden fall of temperature and a very rapid short rise of the barometer extending for hundreds of miles. This is a Line-Squall. More often squall lines are shorter and less well defined following in quick succession. The conditions which prevailed in the Mediterranean on December 20th to 22nd, 1923, were typical of squally weather.

Chart No. LXXV for the morning of December 20th, 1923 indicates that a depression was centred over the Adriatic with northerly winds in the Gulf of Lyons taking cold air to the southward of the Balearic Islands, while to the southward of a line indicated approximately by the pecked line on the chart the wind is westerly and S.W. and comparatively warm. The depression is moving S.E. and the cold "front" will probably travel in the same direction so that s.s. *Maimyo*, Captain G. Hamilton, from Port Said to London might predict wind veering with squalls and rain.

Chart No. LXXVI shows the conditions on the morning of December 21st, 1923 *Maimyo* is now near the line of the cold "front," the air temperature has dropped 10°, the wind veered 5 points and increased to a gale with squalls; great atmospheric instability may be expected. According to her report on this day, between 4 and 5 p.m., there were frequent shifts of wind between south, west and north, and at 5 p.m., in Latitude 36° 40′ N., Longitude 12° 50′ E., there were frequent violent squalls from N.W., with thunder and lightning.

Chart No. LXXVII shows the conditions on the morning of December 22nd, 1923.

The French airship *Dixmude* was lost at about this time. It seems likely that the violent vertical winds, as well as the horizontal wind, and thunder and lightning which were observed in the squalls experienced by *Maimyo* at 5 p.m. on the 21st, may have caused the loss of *Dixmude* not far from Malta.

The advantage to aircraft of information of actual squalls or observations which may indicate the growth or prevalence of squally weather broadcast by "Selected ships" to C.Q. will be evident.

System applicable to all Parts of the Oceans.

Throughout these Chapters we have kept before us the aim set in the "Foreword"—"to give suitable guidance to Mariners for the making of charts and forecasts by a simple and quick process by using the observations of marine observers, and giving experiences and suggestions for the application of the method in all seas from which sufficient synchronised observations are available."

Examples and suggestions have been given for all the permanent atmospheric pressure zones shown upon the Charts of the World XXV and XXVI, except those of the Polar regions. That is, we have dealt with weather at sea in all Latitudes covered by the trade routes; broadly, the same procedure is applicable in the same Latitude in other Longitudes over the Oceans.

Examples of all seven fundamental shapes of isobars which were generalised in Chapter II have been given. Marine observers, having read these Chapters as they were received month by month, are now asked to peruse them as a whole. Weather at any place is connected with the general circulation of the atmosphere and, therefore, a world-wide conception of the conditions of the atmosphere must be kept in view. The forecaster on shore is dealing with weather systems passing or developing over his area; he has been given a very large range of reports of recent years by means of wireless telegraphy. The mariner is continually passing over the oceans, not only through weather systems which are passing or developing, but through the great zones of different atmospheric pressure in which are attendant all types of weather. His should indeed be a wide outlook and wireless telegraphy has enabled him to "see," with the assistance of other observers ashore and afloat, up to several thousand miles distant; whereas, not more than 30 years ago, his range of communication was that of vision bounded by the horizon, and his predictions were more conjectural.

Prediction of the Movement or Change of Weather Systems.

The examples given in previous chapters show how important it is to consider the relative position and movement of the ship to the weather system she is in or those which may approach her position or course.

In using the barometric tendency observed in ships at sea, the influence of course and speed should ever be borne in mind.

When that has been considered, with ships' reports and reports from coast stations of barometric tendency plotted on a chart, it will often be possible to tell in which direction pressure is reducing, in which it is increasing, and in which there is little or no change, and so to gauge approximately the path of the depression; also as to whether it is becoming deeper, remaining the same depth, or filling in.

In the Norwegian method, see Chapter IX, the line of advance of a cyclone is said to be at a tangent to the warm "front" at the centre of the depression or parallel to the isobars in the warm sector.

With tropical revolving storms, so much may depend upon the direction that one of these storms will move in, to the navigator, that there is no more important matter for prediction. Since the 2nd Edition some progress has been made, and it is important to note what is said in Chapter V. With each year's investigations of tropical revolving storms in those regions where there have been sufficient observations to make synoptic charts during hurricanes, we have found that usually the pressure distribution has indicated the path.

The tendency of the barometer in ships or at coast stations coming under the influence of a tropical revolving storm will often give more definite indications of movement than in the case of depressions of higher latitudes, because the isobars are more uniform in shape and are closely packed near the centre. Wind direction and its changes are a further guide. With upper air observations and an intricate and extensive organisation of reports over areas traversed by tropical storms, weather offices are making progress in the prediction of movement, and issue warnings containing forecasts of probable direction of advance, particulars of which, with much other information broadcast by wireless or made by visual, are given in "Weather Signals" month by month in "The Marine Observer" for all parts of the world.

Weather Signals.

We have confined our suggestions and experiences entirely to the application of weather reports received and charted on board ship by the navigator himself, and there is little doubt that as this method gains popularity at sea it will have far-reaching results, its success must mainly depend upon marine observers.

In areas adjacent to coasts of countries with weather services and in ocean areas from which numerous reports can be constantly and regularly received at routine times without fear of interruption, very effective forecasts may be made ashore and broadcast for the information of shipping and no doubt, in time, this practice will be considerably extended.

The "Weather Shipping" Bulletin was adopted by the British Meteorological Office with a view to assisting the mariner by both methods; it provides weather reports from coast stations, with which and ships' reports he may construct his chart and form his own conclusions; as well as forecasts for defined areas and districts for a definite period also giving the "further outlook" when possible. Reports for two far northern stations in this message

are of particular value for ascertaining the movement of depressions passing between Scotland and Iceland.

Having regard to the movement of weather systems when forecasts are broadcast—the receiver cannot see the weather map—it should be remembered that the message refers to a definite place or area and is for a definite period. In fairness to this system, all who receive and use the signals—wireless or visual—should give due consideration to the explanations published for their information. There is a mutual moral responsibility.

Coast station reports provide a basis for the mariner to work on; the broadcasting of these reports has already had a profound influence upon barometer observation at sea, and has enabled seamen to make weather charts at sea in many parts of the world; thus permitting those at sea to form their own conclusions and to judge as to how much weight they may attach to the Forecasts made ashore and broadcast to them.

The British "Weather Shipping" Bulletin is the outcome of a very large expression of nautical opinion, and as such is recommended as a pattern upon which to base Weather Shipping Bulletins in other parts of the world but especially within the British Empire. Many British seamen have advocated uniformity of code and method in these bulletins so that time and trouble may be saved in their use at sea.

Ships' Weather Signals.

All who have practised wireless and weather as an aid to navigation agree that Ships' Reports should be made in a form which enables the receiver to plot the observation quickly and without trouble and that the observations must synchronize. That the barometer observation should represent the correct atmospheric pressure at sea level and give a fairly accurate indication of the tendency or change in pressure with course and speed of ship and that wireless traffic should not be jambed.

Therefore the form of report given in Chapter I, and in Appendix I, page vi, should be used and until some method of regulating times of communication to prevent jambing and to facilitate reception as suggested in Chapter III under the heading "Some Considerations as to Time of Observation and Transmission of Wireless Weather Reports, Range and Utility," with uniform Greenwich times of observation for all longitudes has been adopted, Marine Observers should be guided by that part of Chapter III, following the heading "The Existing System which Marine Observers are invited to practise for the benefit of all ships fitted with Wireless Telegraphy."

The provisions of the Meteorological Office authorise the loan of sets of tested instruments to the Captains of British merchant ships

Weather Charts made at Sea indicating Mastery of Subject by Seamen.

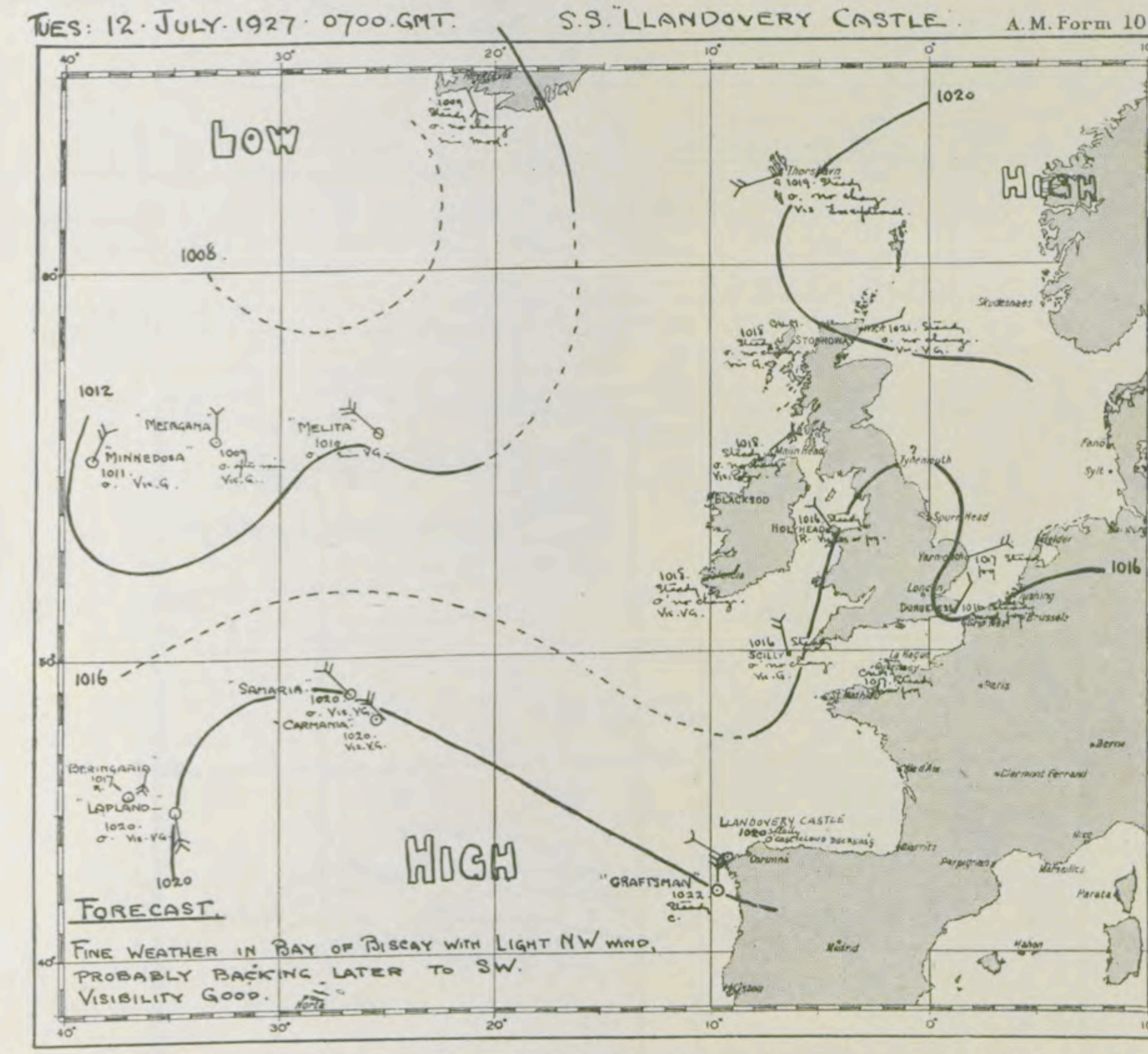


Fig. 47.—Weather Chart of Eastern North Atlantic and Forecast made on board S.S. *Llandovery Castle*, Captain G. Owens, from Marseilles to London, by Lieutenant C. H. Williams, R.N.R., Extra Second Officer. It will be remembered that Mr. C. H. Williams made the first weather charts on board a ship at sea with British Coast Station observations broadcast by Wireless Telegraphy in September, 1921.

According to the Meteorological Log of *Llandovery Castle* she actually experienced light airs from N.W. and W.N.W. during the forenoon and afternoon of July 12th, and in the dog watch there was a light breeze from W. by S., the wind being variable approaching Ushant. The visibility, 8 by scale, and it was fine, *i.e.*, no rain.

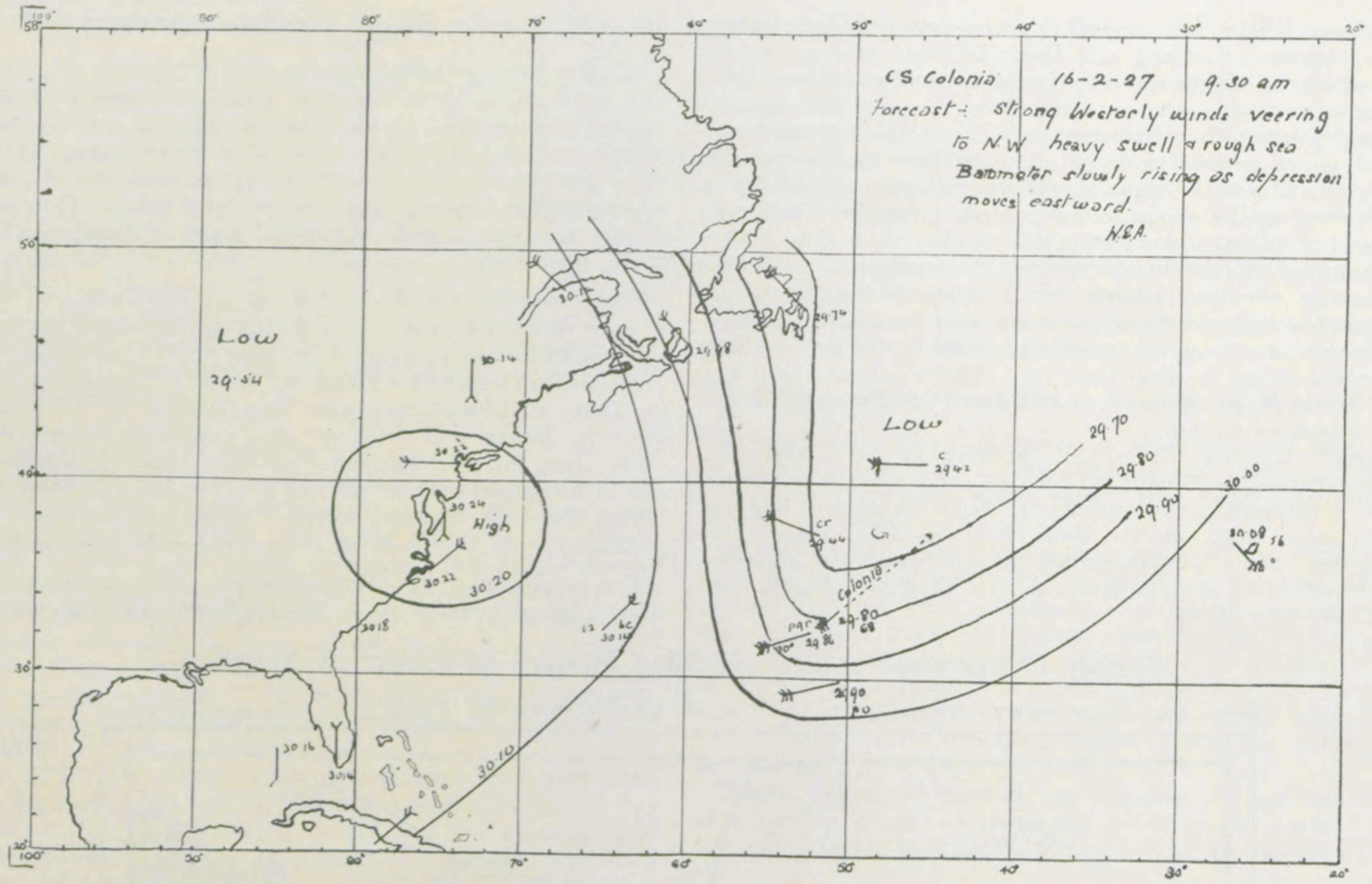


Fig. 48.—Weather Chart of Western North Atlantic and Forecast made on board Cable Ship *Colonia*, Commander G. F. Carlton, O.B.E., R.N.R., from Colon to London, by Lieutenant W. E. Allen, R.N.R., Second Officer.

According to *Colonia's* Meteorological Log she experienced a strong breeze to moderate gale from W.S.W., which veered to N.W., the sea being 6 to 7 by scale, and later she had a heavy N.W. swell, the barometer steadily rose after 4 p.m.

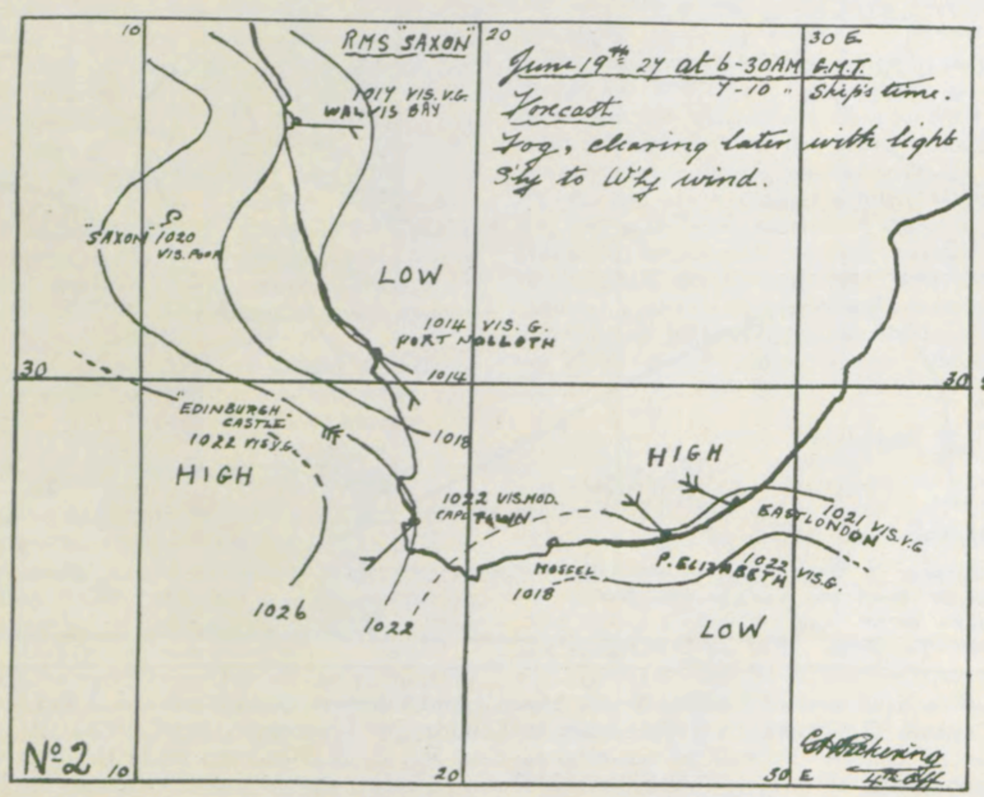


Fig. 49.—Weather Chart of South African Waters and Forecast made on board R.M.S. *Saxon*, Captain T. M. Lang, from Cape Town to Southampton, by Mr. G. H. Pickering, Fourth Officer. The weather actually experienced was thick fog, which cleared with light E.S.E. airs during the forenoon. At noon there was a light W.N.W. breeze which gradually backed to S.E.

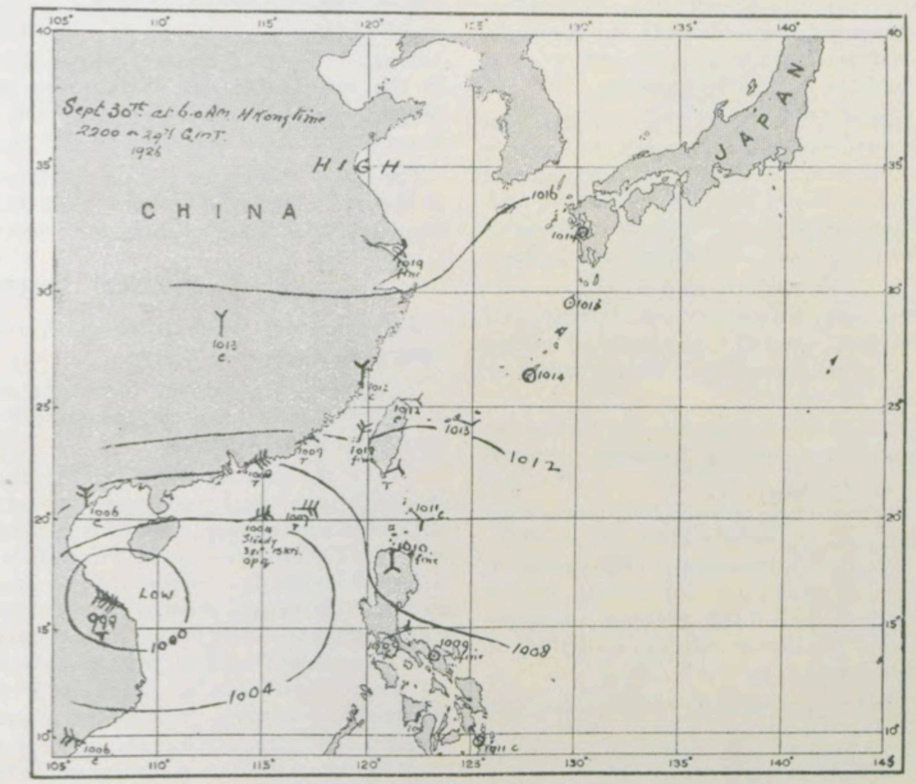


Fig. 50. — Weather Chart of the China Sea made on board S.S. *Khyber*, Commander C. Hester, R.N.R., from Singapore to Hong Kong, by Mr. C. B. Roche, Chief Officer. The chart for the day before was published in "The Marine Observer's Log," Vol. IV, No. 45 of "The Marine Observer", which indicated that the ship could maintain her course with safety. This chart shows the typhoon at some distance on the port quarter of *Khyber*, with wind now a whole gale in the S.W. quadrant of the system near the centre where the day before the wind was light.

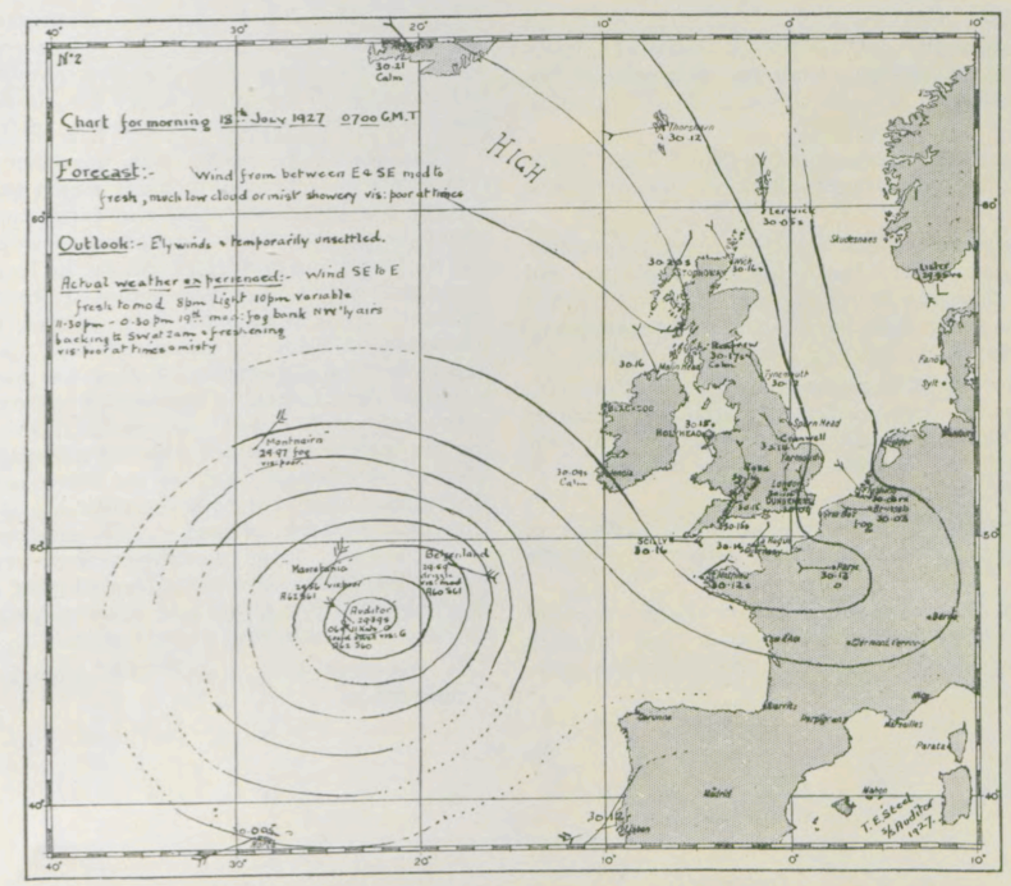


Fig. 51.—Weather Chart of the Eastern North Atlantic made on board S.S. *Auditor*, Captain W. T. Owen, Tampico to Rotterdam, by Mr. T. E. Steel, Third Officer.

for the purpose of the collection of reliable observations of weather at sea. These observations are required to provide data for research, for compiling information required for navigation, for the general purposes of meteorology ashore, and for central forecasting.

The provisions of the Meteorological Office do not permit the loan of instruments to ships for their own exclusive purposes, but where instruments are lent for the first, it is understood that they should be used also for the second, and so there are about 150 British merchant ships with highly efficient official instruments on board, which may be used for the general advantage of shipping on the high seas in all parts of the world.

In 1921, in "Weather Forecasting in the Eastern North Atlantic and Home Waters for Seamen," published when the principle of giving actual observations at British coast stations by W/T to shipping was first adopted, it was stated:—

"The greatest assistance which shipowners can give in furthering this aid to navigation is to provide their ships with good mercurial barometers."

It would seem that many shipowners are now realising more truly the value, to those navigating their ships, of a reliable barometer; and there are now on our list over one hundred ships with mercurial barometers in their outfits, which with the 150 ships with official instruments make about 260 in our total of 500 regular observing ships which have a good mercurial barometer and are invited as "Selected ships" to make routine reports to "All Ships."

Not only is the number of selected ships regularly performing this most useful voluntary service steadily increasing, but the distribution of these reporting ships on any day along the trade routes of the world is steadily improving.

Since January, 1926, when we commenced to keep a record of the number of "Selected ships" regularly making routine reports to all ships when at sea the number of ships so doing has multiplied by six and the rate of multiplication steadily increases.

Reciprocation of these reports at sea provides an aid to navigation both on the sea and in the air; reception of ships' reports at Weather Offices not only is the means of aiding navigation by the issue of forecasts and warnings to shipping from the shore, but they have a profound effect upon weather intelligence generally.

In the great stock and grain districts of the Dominions overseas, foreknowledge of rain or drought may contribute considerably to production. For example, it is thought that the strength of the North-East Trade in the Atlantic may be associated with rainfall in the cornfields of Canada.

Supposing it is, ships reporting weather in the North-East Trade would possibly contribute indirectly to the production of grain cargoes to be shipped to England.

It is certain that the navigator with a Weather chart before him is far better able to form an idea of what wind, sea, visibility and current he will experience, than the navigator who has nothing but his own isolated observations to go upon, or, indeed, a forecast made for him by people on shore, much though this latter will help him.

The making of a weather chart becomes a simple matter with practice; the difficulty at sea is to get sufficient of the right kind of reports, and here is where the Wireless Operator can give valuable assistance. It is well worth the trouble to Marine Observers to interest him.

In the middle of last century MAURY wrote in capital letters in that book beloved by sailormen, "The Physical Geography of the Sea":—

"The greatest move that can now be made for the advance of Meteorology is to extend this system of co-operation and research from the sea to the land, and to bring the Magnetic Telegraph regularly into the service of Meteorology."

Very shortly afterwards Admiral FITZROY set an example to the world in the use of the Electric Telegraph for weather reporting ashore. **"Selected ships" on our list are invited to set an example in the use of Wireless Telegraphy for weather reporting to "All Ships."** A space has been provided in the Meteorological Log and in Form 911 in which they may record exactly what they have broadcast.

The ways of commerce over the Oceans and the hereditary chivalry of the sea are beyond doubt more adaptable to voluntary Meteorological Service than to obligatory Service.

Economical Passage Making.

We repeat what we said on the North Atlantic Chart for November, 1922:—

"Concerning passages, there are many ways in which prediction of weather may have an economic bearing as well as contributing very largely to safety.

"Take the passage from the Straits of Gibraltar to Channel ports as concerning mail and passenger steamers with ample speed and a time-table to keep, the weather which may be expected in the Bay, off Ushant and in the Channel is frequently a source of anxiety to the Commander, who wishes to arrive at his disembarkation port on time. Without information of the conditions ahead and what those conditions are likely to be in the near future, it is often considered wise to assume that they may be unfavourable—i.e., fog, dirty weather or strong head winds. With W/T some idea may be obtained by intercepting reports from ships ahead and to the westward, from whence most weather comes, together with reports from land stations, and on occasions it may be possible to forecast with some accuracy that fine clear weather is most probable.

"In the first case it is usual to steam at a speed in excess of the average required to arrive on time, and when sufficient is considered to be in hand to ease down; thus, if the weather remains favourable, more coal than necessary is consumed.

"In the second case, if reports indicate that clear favourable weather is reasonably probable, provided confidence is sufficient, a speed very little in excess of the required average will be steamed from the commencement of the passage."

When I wrote this I referred to steamers with reciprocating engines such as those I had commanded before coming to the Meteorological Office. It is now desirable that Commanders of steamers with turbine engines and oil fuel, and motor vessels should give us the benefit of their experience regarding economies of fuel and weather.

"The term 'Forecast' was introduced by Admiral FITZROY as meaning a statement of weather which may be expected in the near future, but of recent years the term appears to have conveyed to many the meaning that a prophecy of weather was intended. This is not so, for all the forecaster can do, be he meteorologist, with a highly organised system of quickly reported observations from a great many stations over a large area, or a seaman, with a number of ships co-operating with him by means of W/T, is to chart his observations, and then from experience of what has happened before with similar pressure distribution, winds and weather over the area under consideration, state what the probabilities are. If reports received contain false observations, the forecast may miscarry, pending changes may be overlooked, and, as we know only too well at sea, Divine Providence often ordereth the elements at sea to act in ways beyond the comprehension of man. Still, experience shows that it is worth trying at sea," and the charts here reproduced by photography, FIGURES 47 to 51, show something of what seamen are doing to master this subject which I was told when making early attempts to simplify its practice at sea, was beyond them.

It has ever been for British seamen to achieve what seemed "impossible."

The End.

PLOTTED OBSERVATIONS FOR WEATHER CHART, MORNING OF FEBRUARY 25TH, 1923.

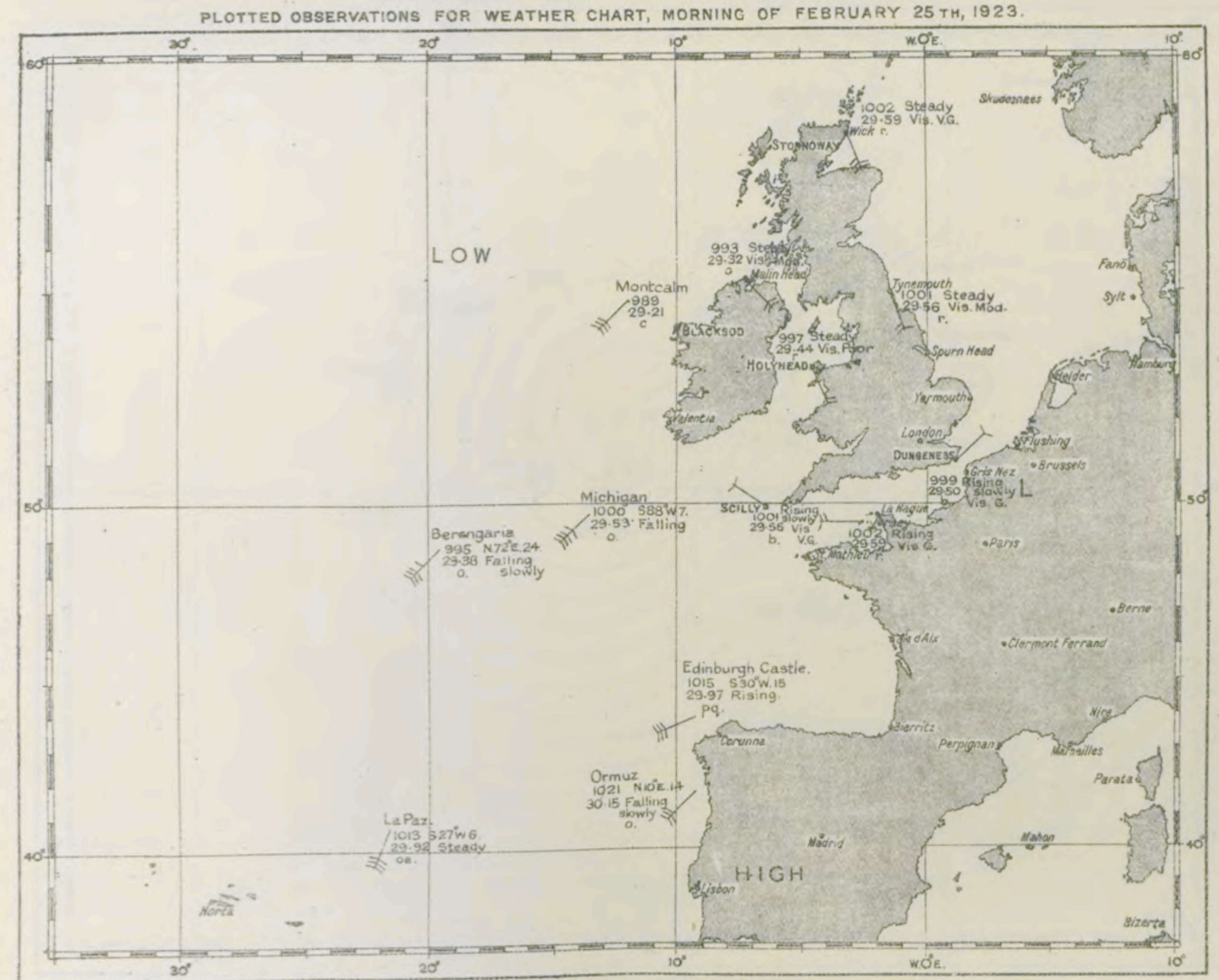


Chart I.—"WIRELESS AND WEATHER."

WEATHER CHART, MORNING OF FEBRUARY 25TH, 1923.

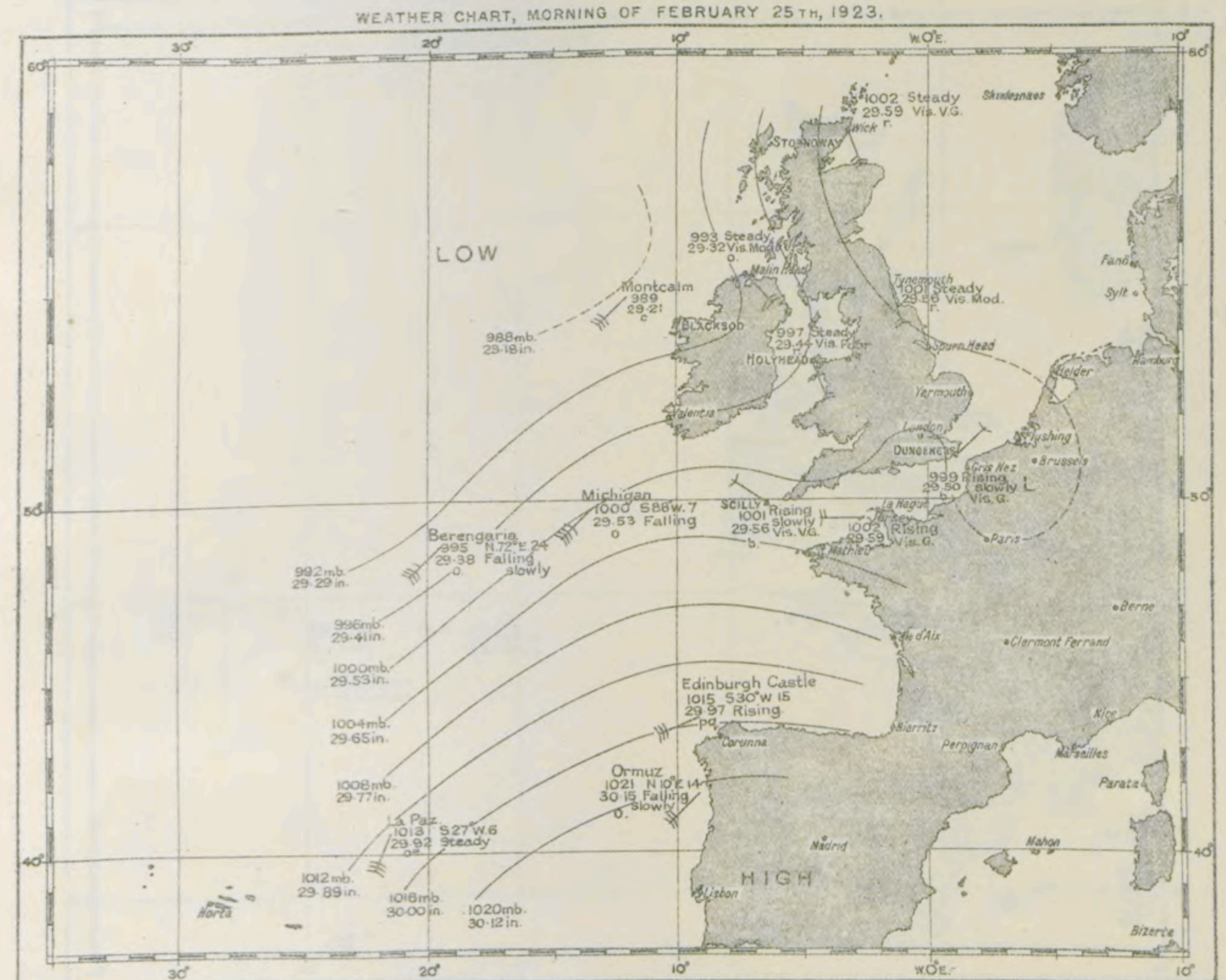


Chart II.—"WIRELESS AND WEATHER."

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

Ps.4063/1685. ... 1250. 6/28.

WEATHER CHART, MORNING OF FEBRUARY 26TH, 1923.

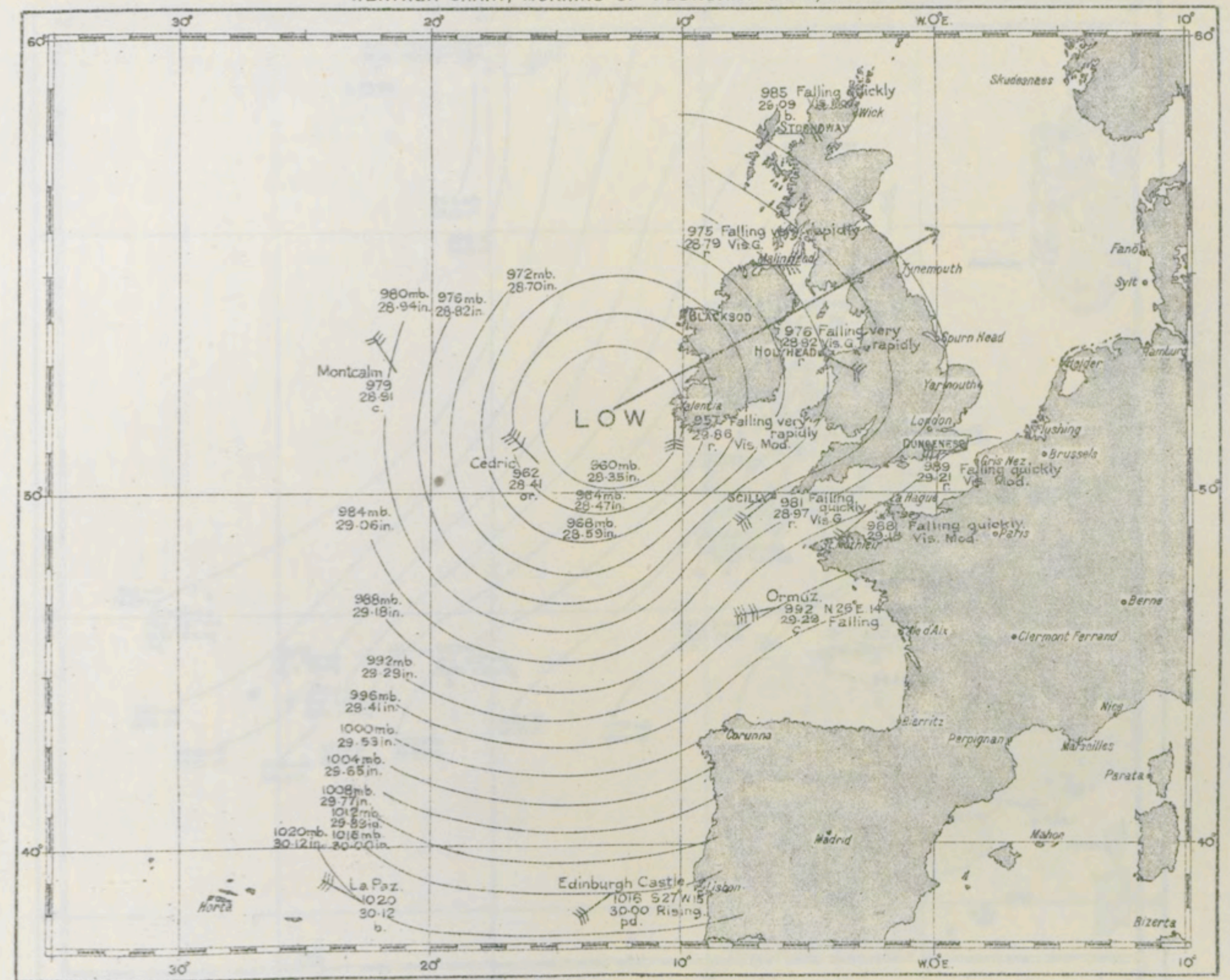


Chart III,—"WIRELESS AND WEATHER."

PLOTTED OBSERVATIONS FOR WEATHER CHART MORNING OF FEBRUARY 24TH, 1926.

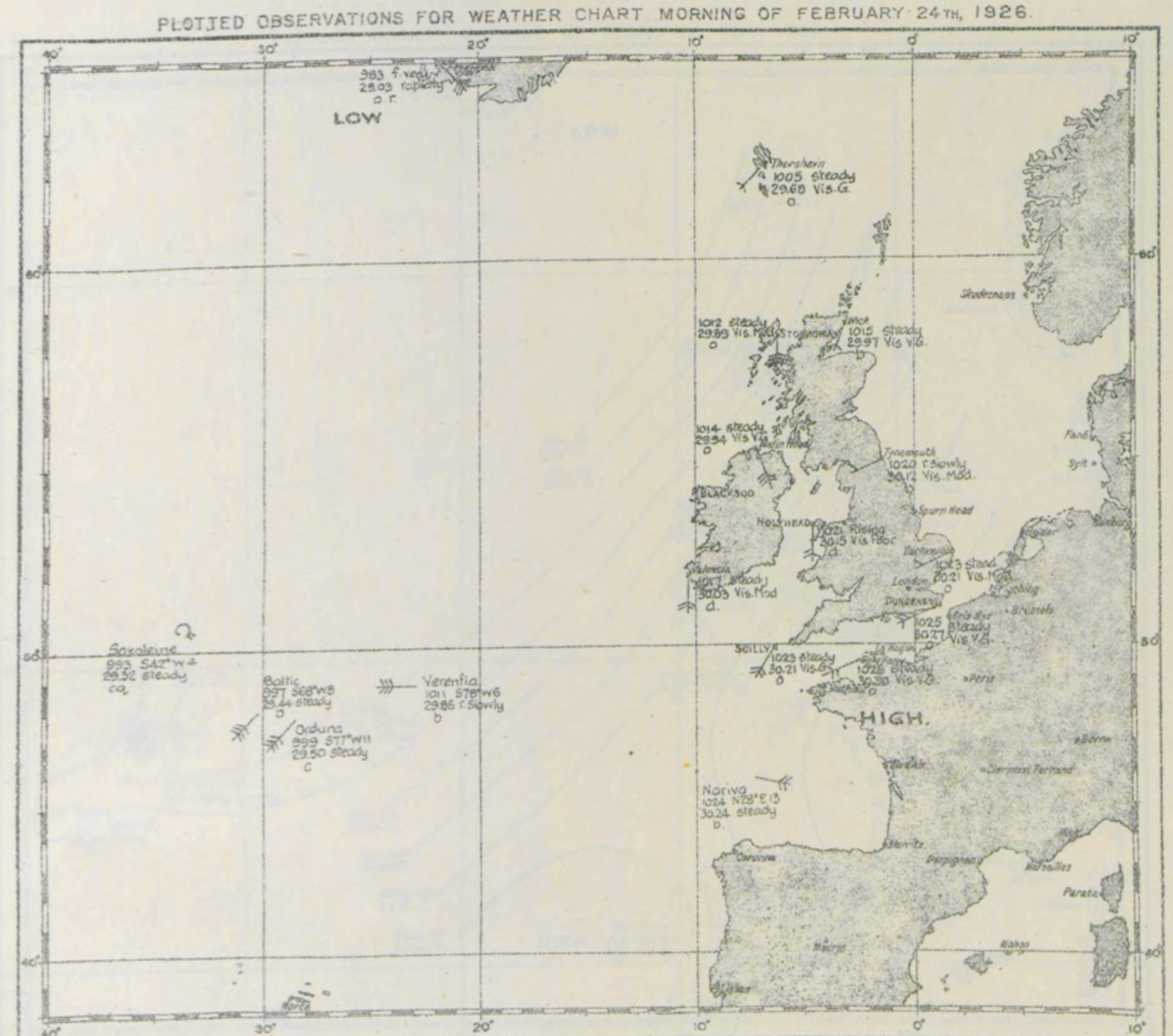


Chart IV,—"WIRELESS AND WEATHER."

WEATHER CHART, MORNING OF FEBRUARY 24TH, 1926.

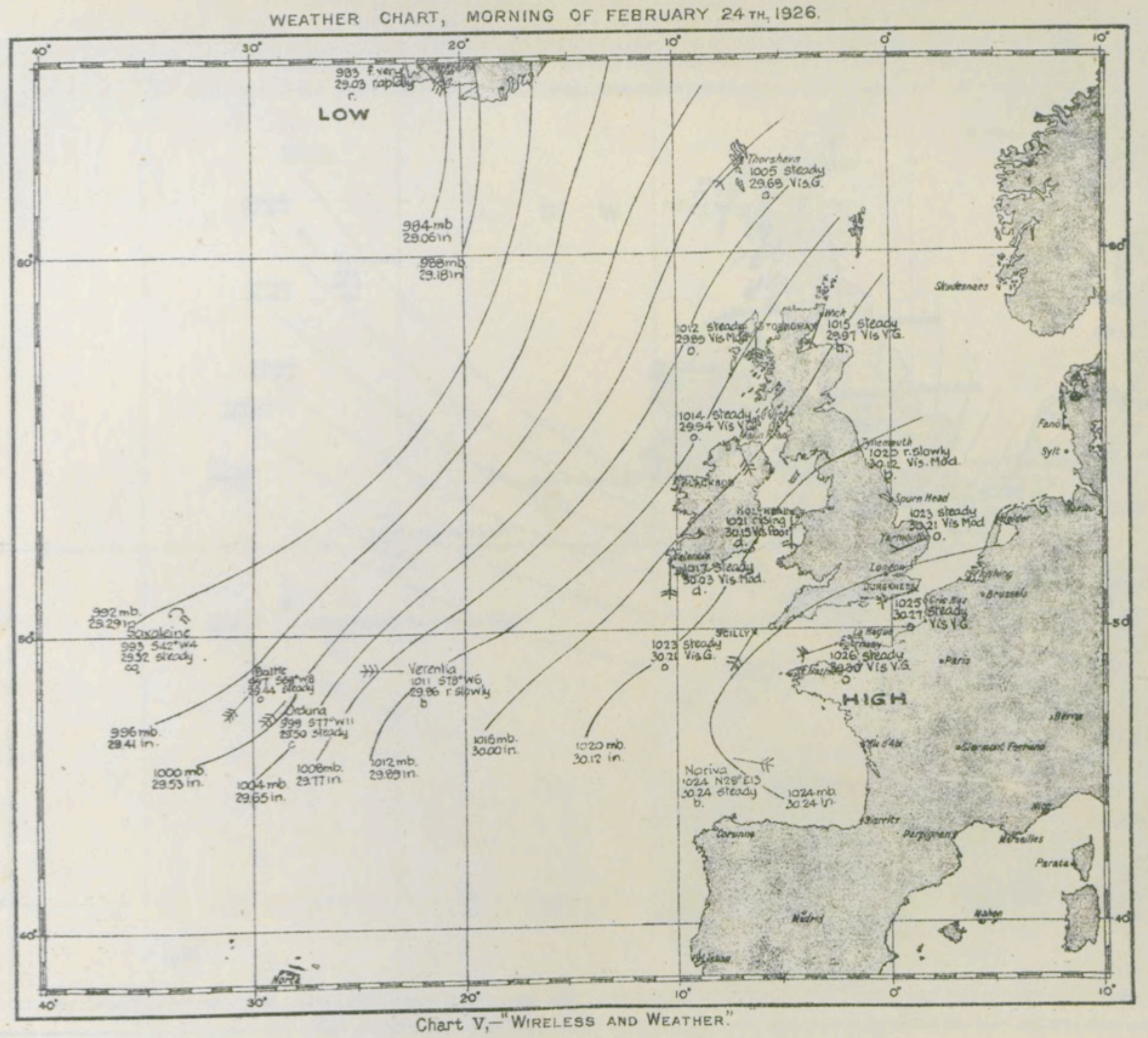


Chart V.—"WIRELESS AND WEATHER."

WEATHER CHART MORNING OF FEBRUARY 25TH, 1926.

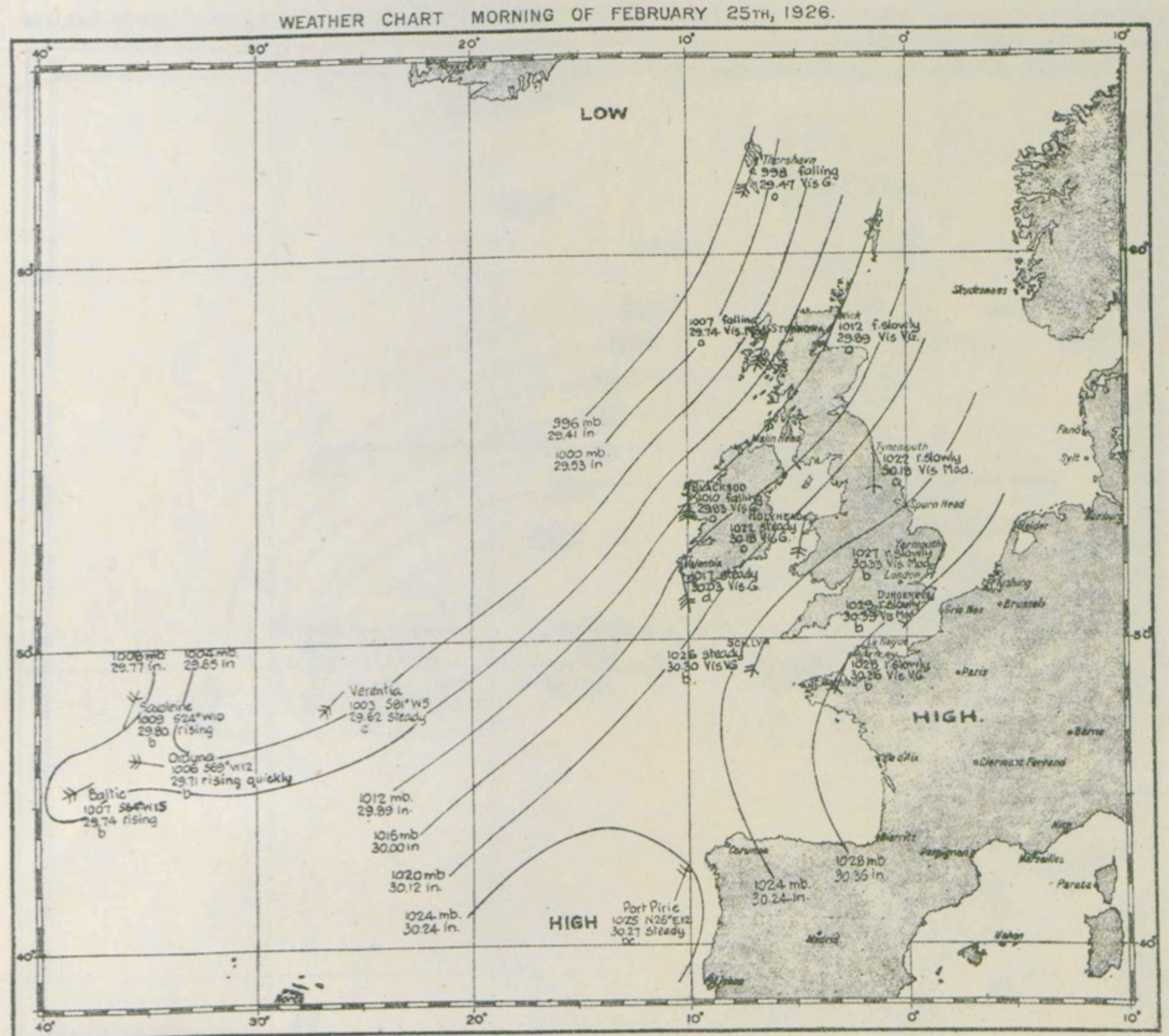


Chart VI.—"WIRELESS AND WEATHER."

MISLEADING WEATHER CHART, MORNING OF NOVEMBER 6TH 1922. FALSE GRADIENT AND TIMES WHICH DO NOT SYNCHRONIZE.

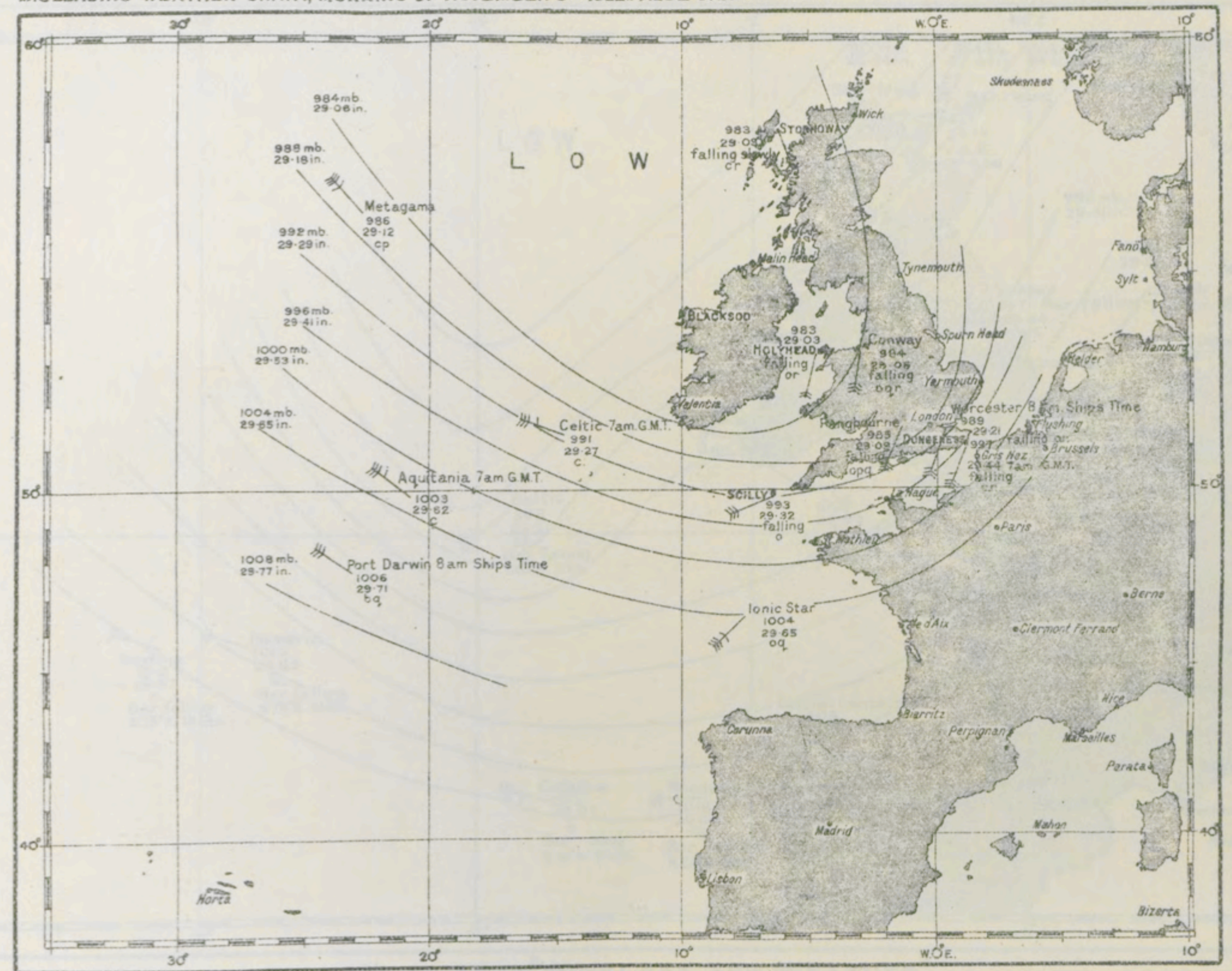


Chart VII – "WIRELESS AND WEATHER"

MISLEADING WEATHER CHART, MORNING OF NOVEMBER 7TH 1925. FALSE GRADIENT AND TIMES WHICH DO NOT SYNCHRONIZE.

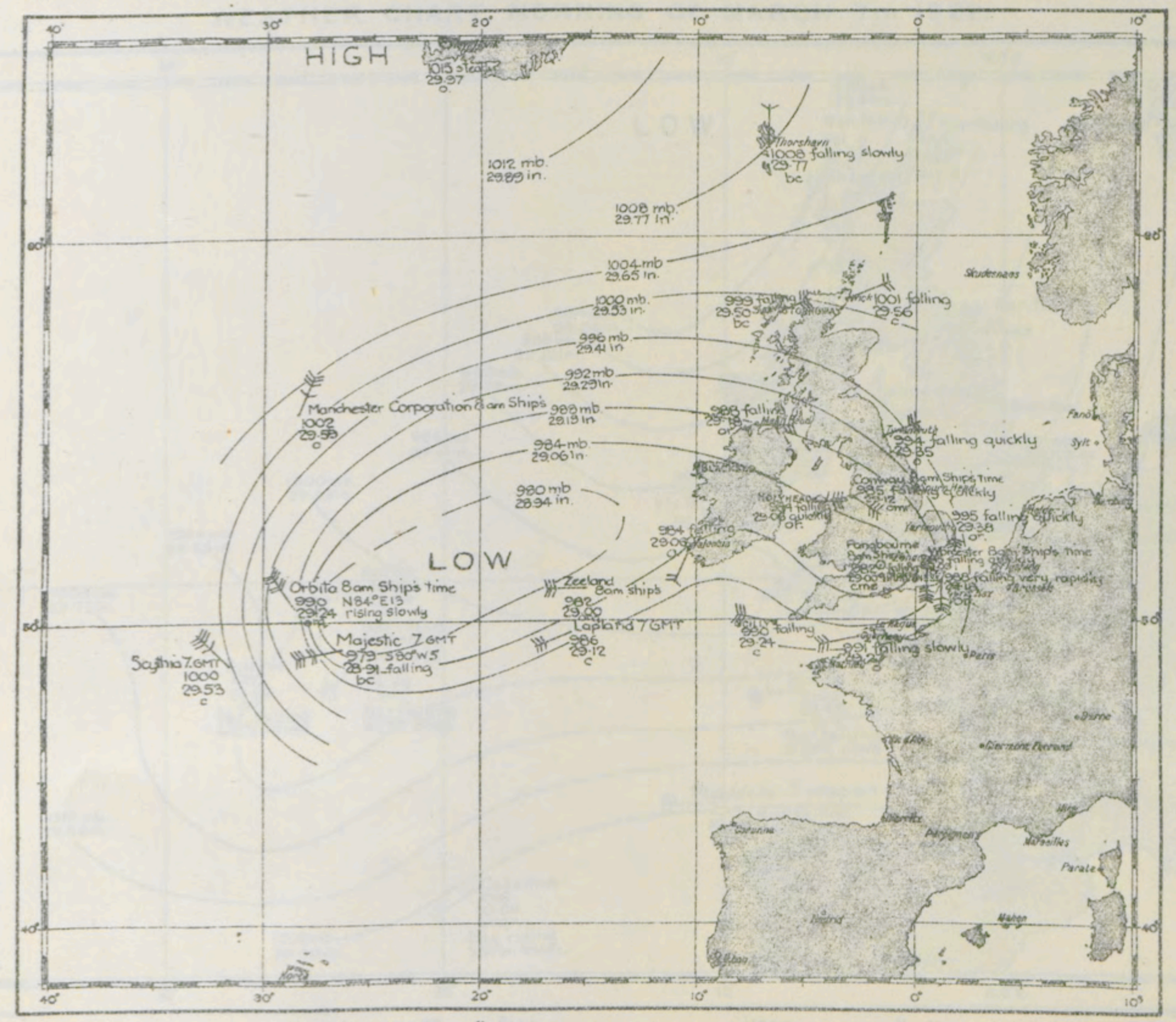


Chart VIII – "WIRELESS AND WEATHER."

WEATHER CHART, EVENING OF MARCH 6TH. 1922.

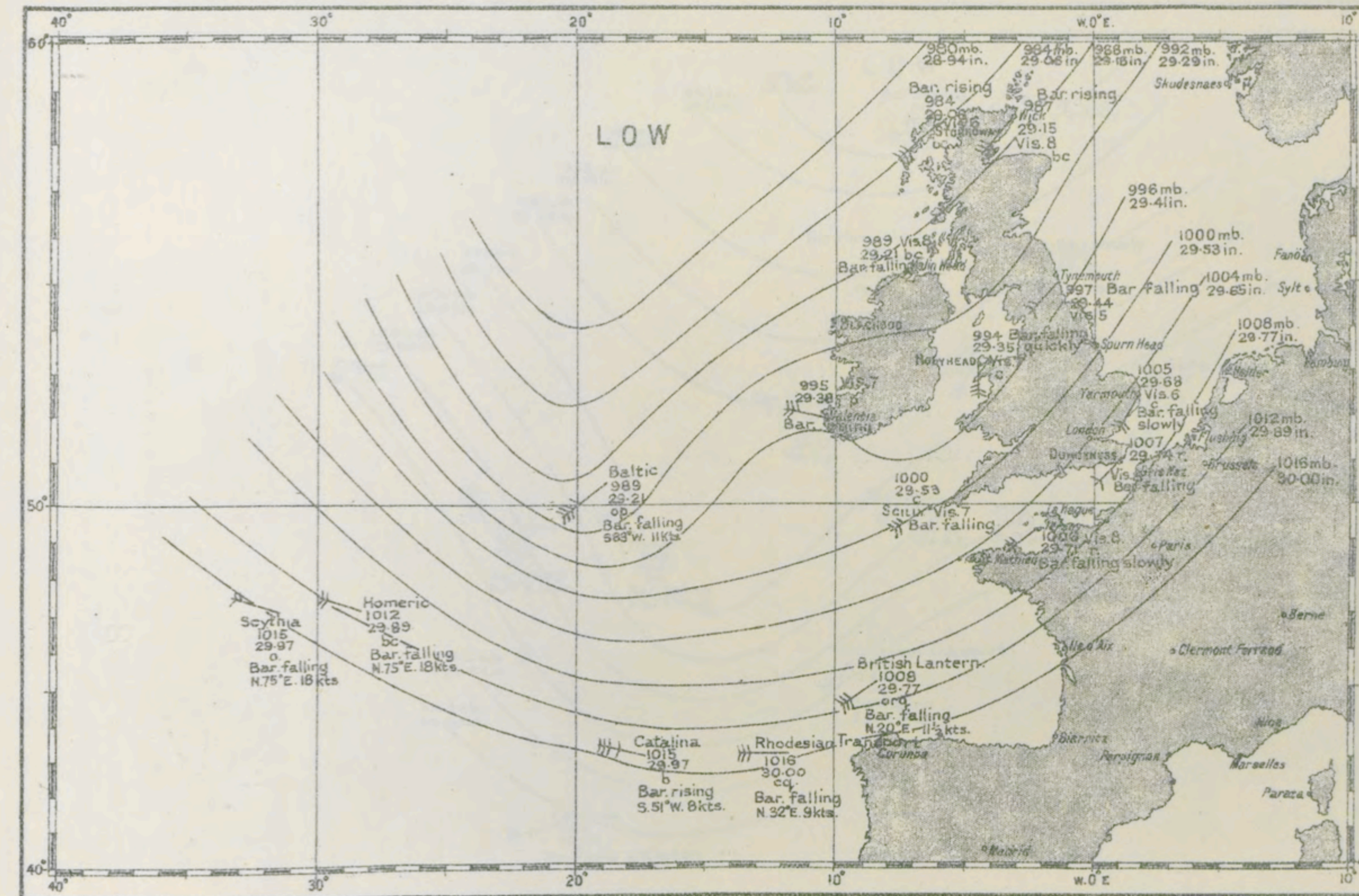


Chart IX, —"WIRELESS AND WEATHER."

WEATHER CHART, MORNING OF MARCH 7TH. 1922.

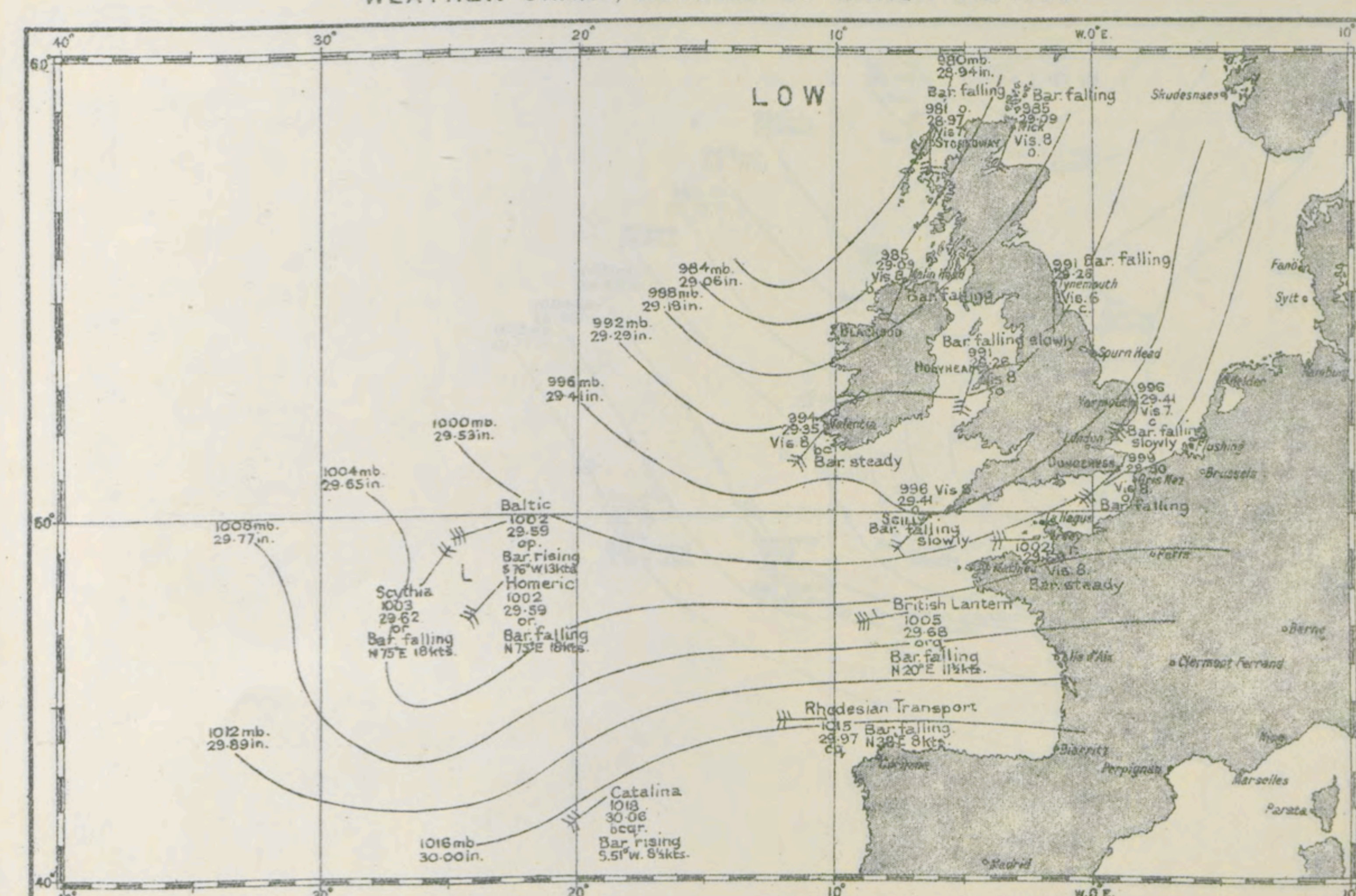


Chart X, —"WIRELESS AND WEATHER."

WEATHER CHART, EVENING OF MARCH 7TH. 1922.

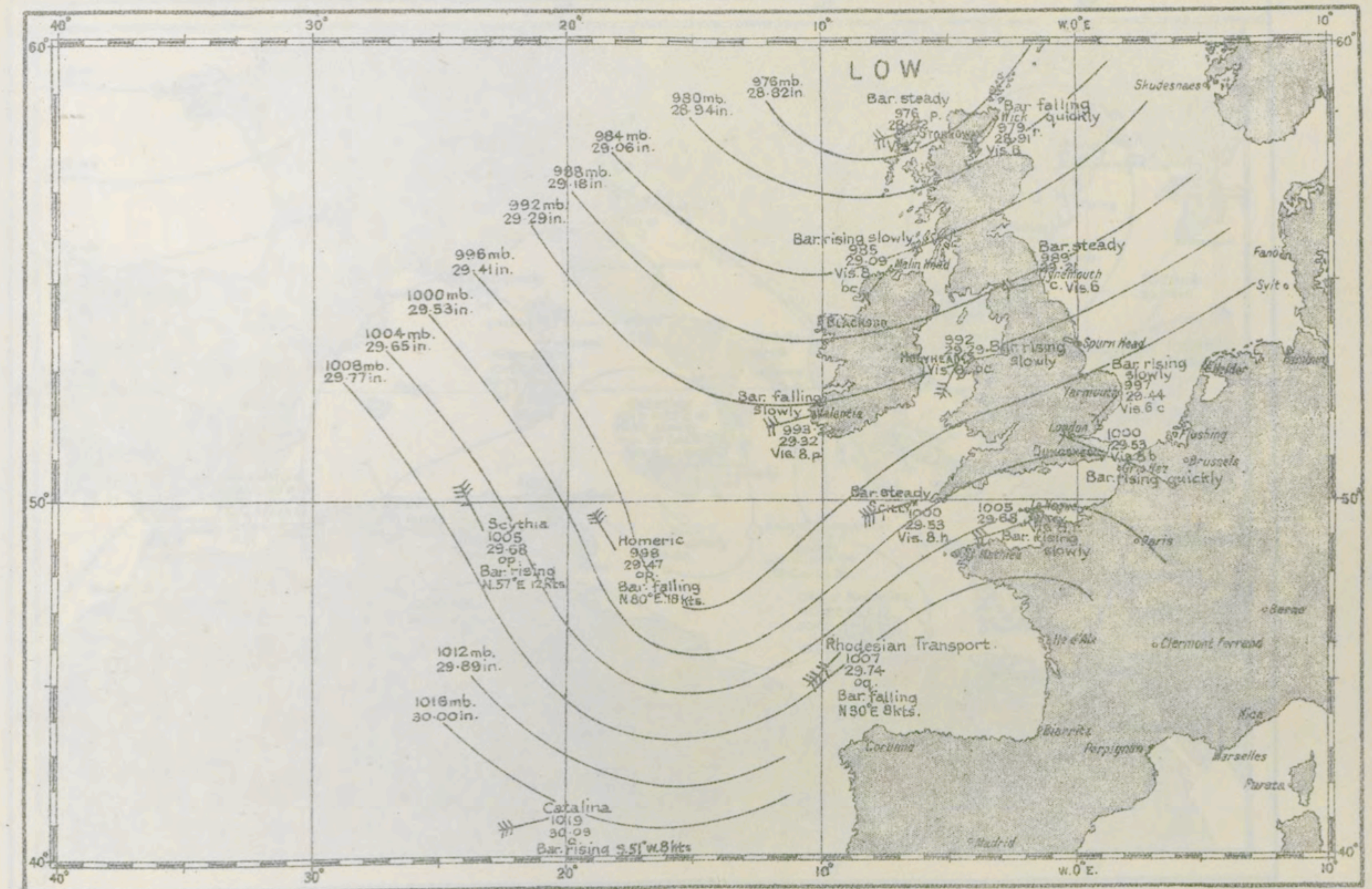


Chart XI. —"WIRELESS AND WEATHER."

WEATHER CHART, MORNING OF MARCH 8TH. 1922.

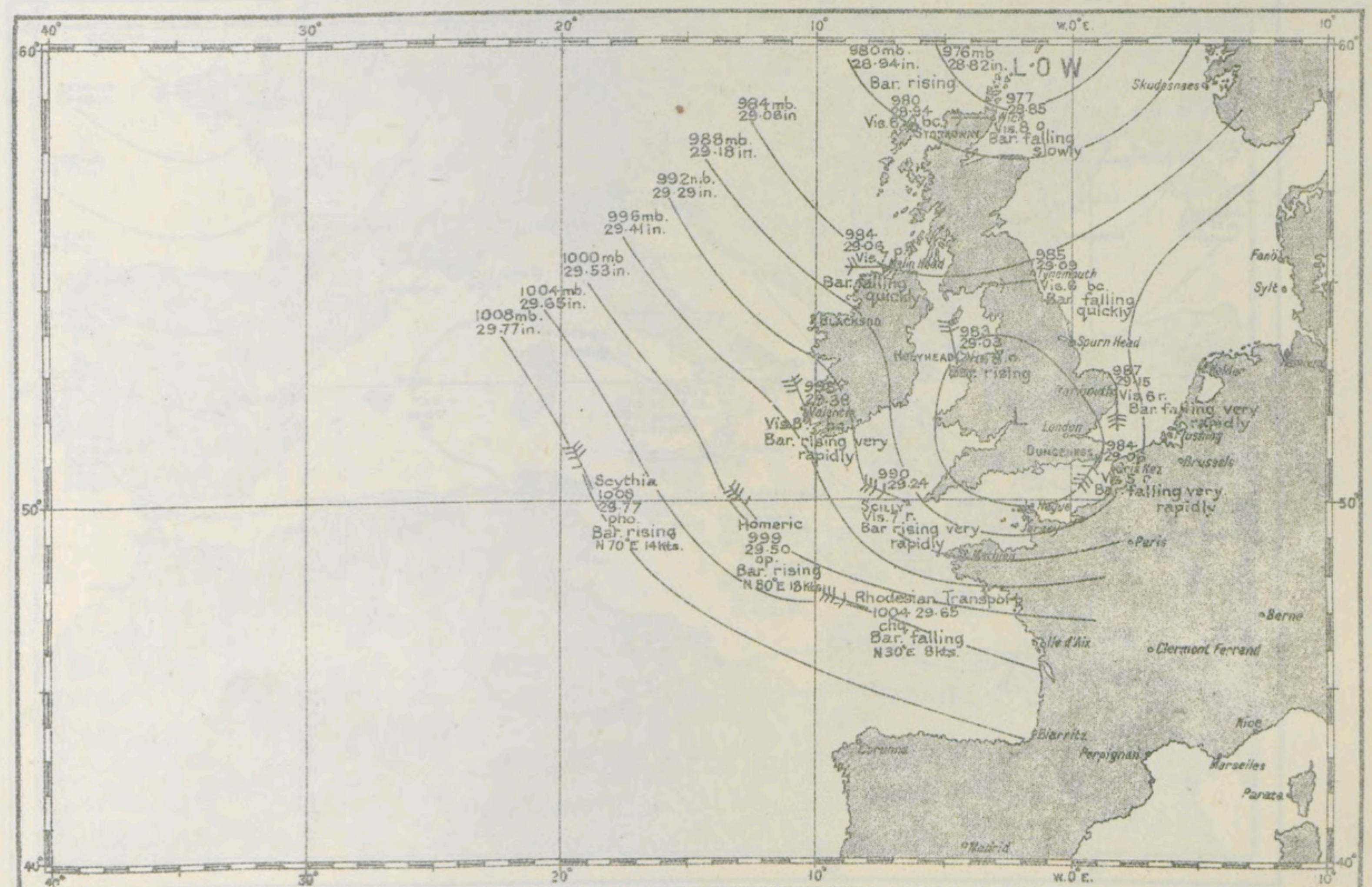


Chart XII. —"WIRELESS AND WEATHER."

WEATHER CHART, MORNING OF DECEMBER 15TH 1924.

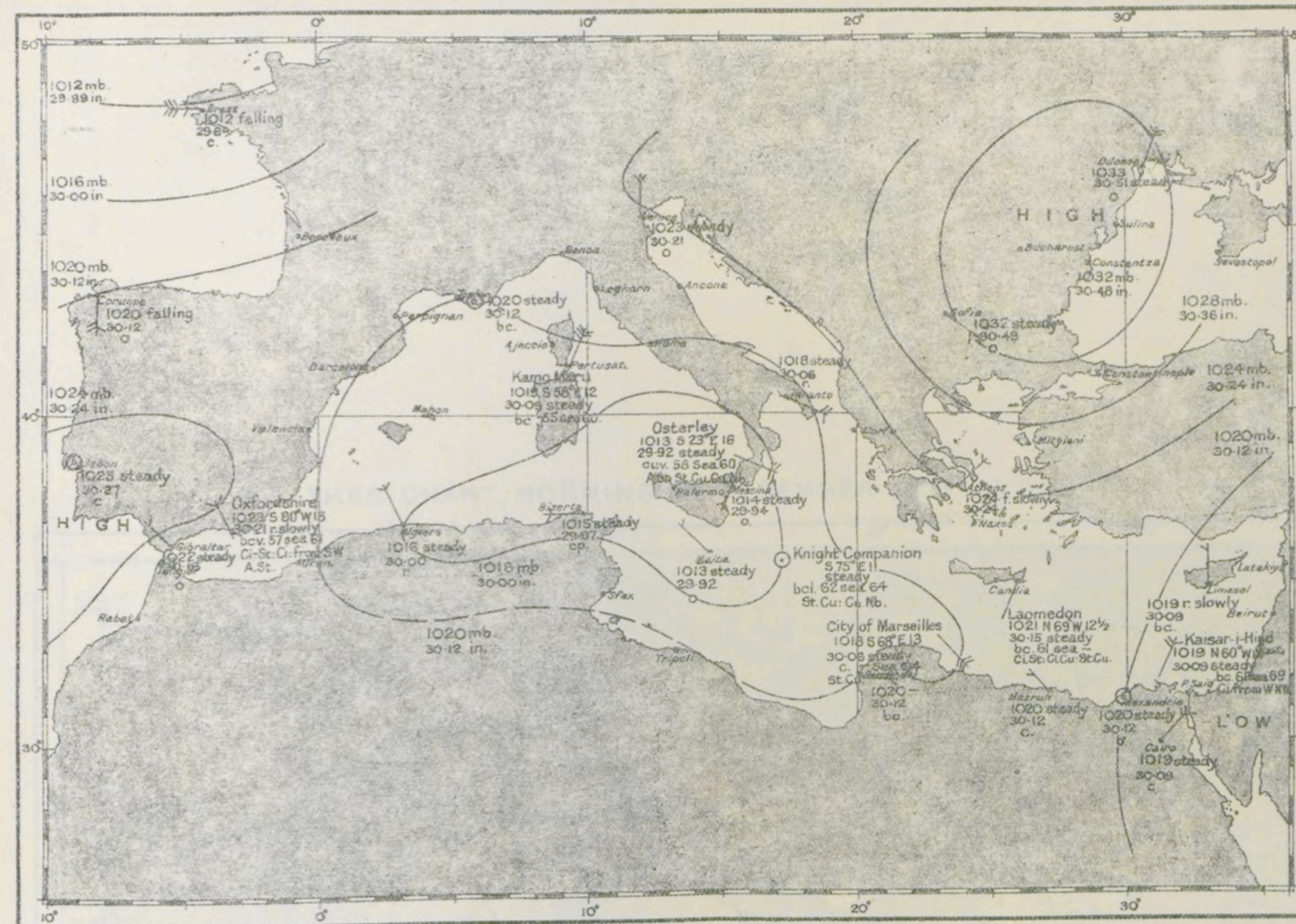


Chart XIII. "WIRELESS AND WEATHER."

WEATHER CHART, MORNING OF DECEMBER 16TH 1924.

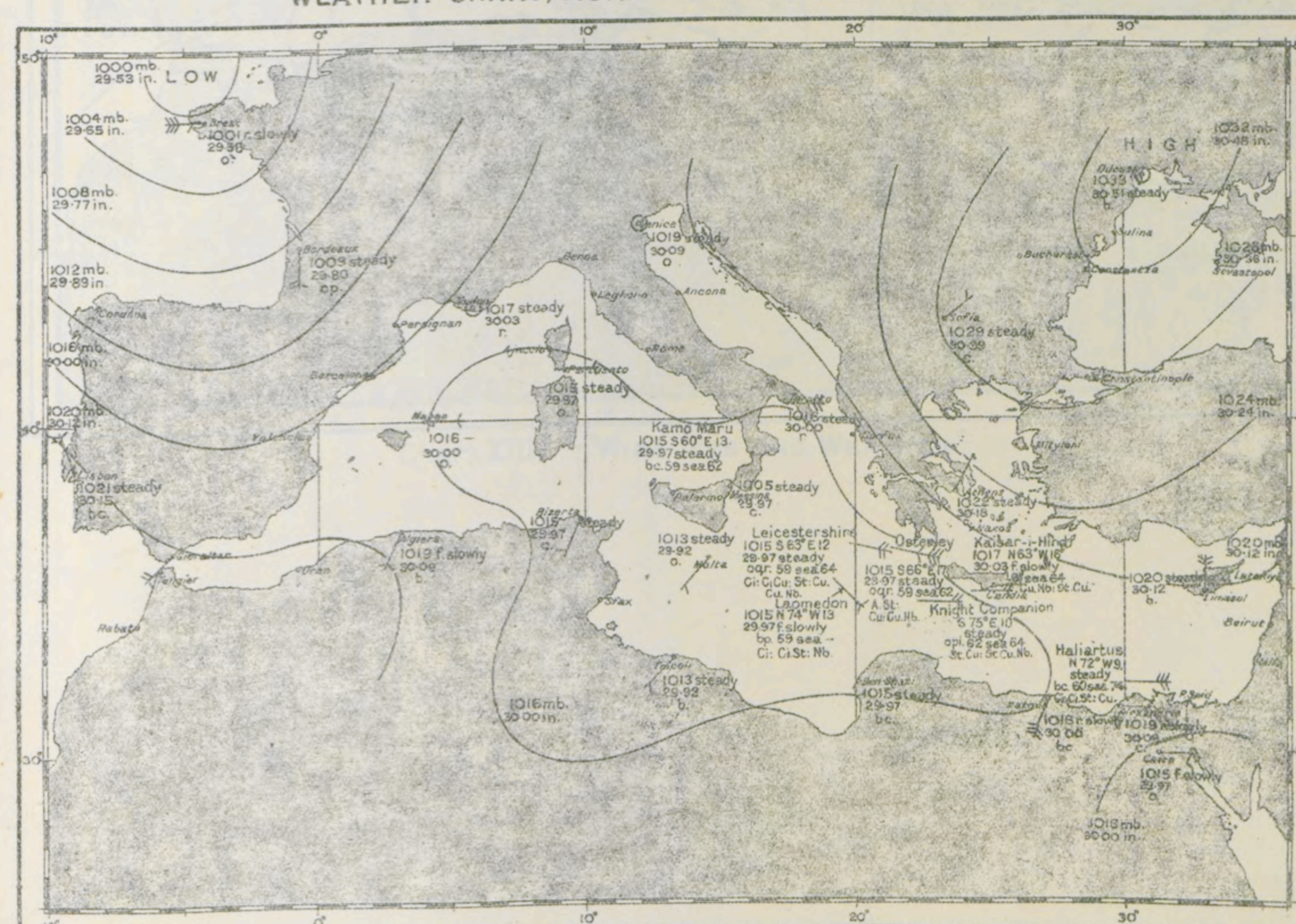


Chart XIV – "WIRELESS AND WEATHER."

WEATHER CHART, MORNING OF DECEMBER 15TH, 1924.

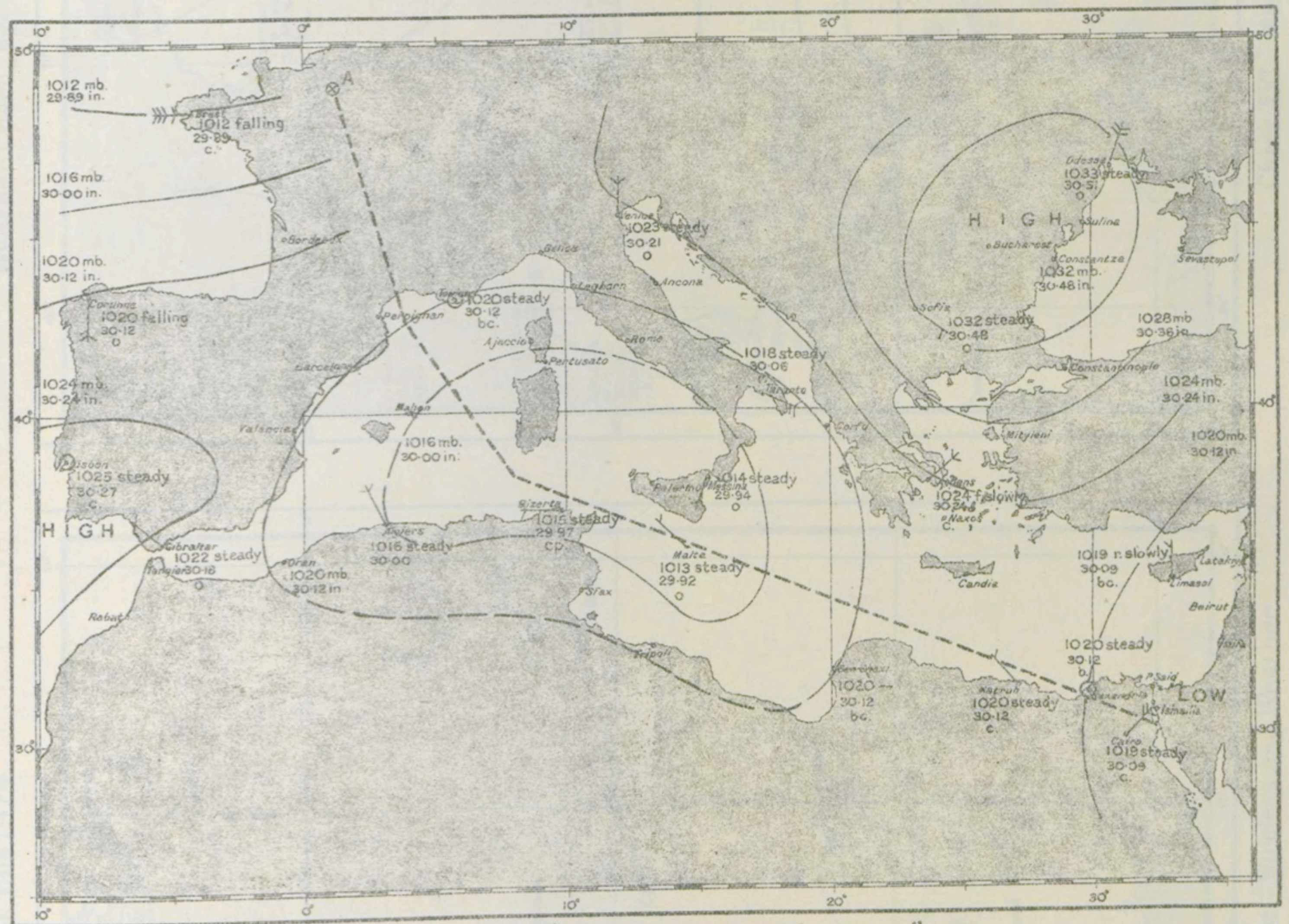


Chart XIIIa. "WIRELESS AND WEATHER".

0900. G.M.T. August 19th, 1924

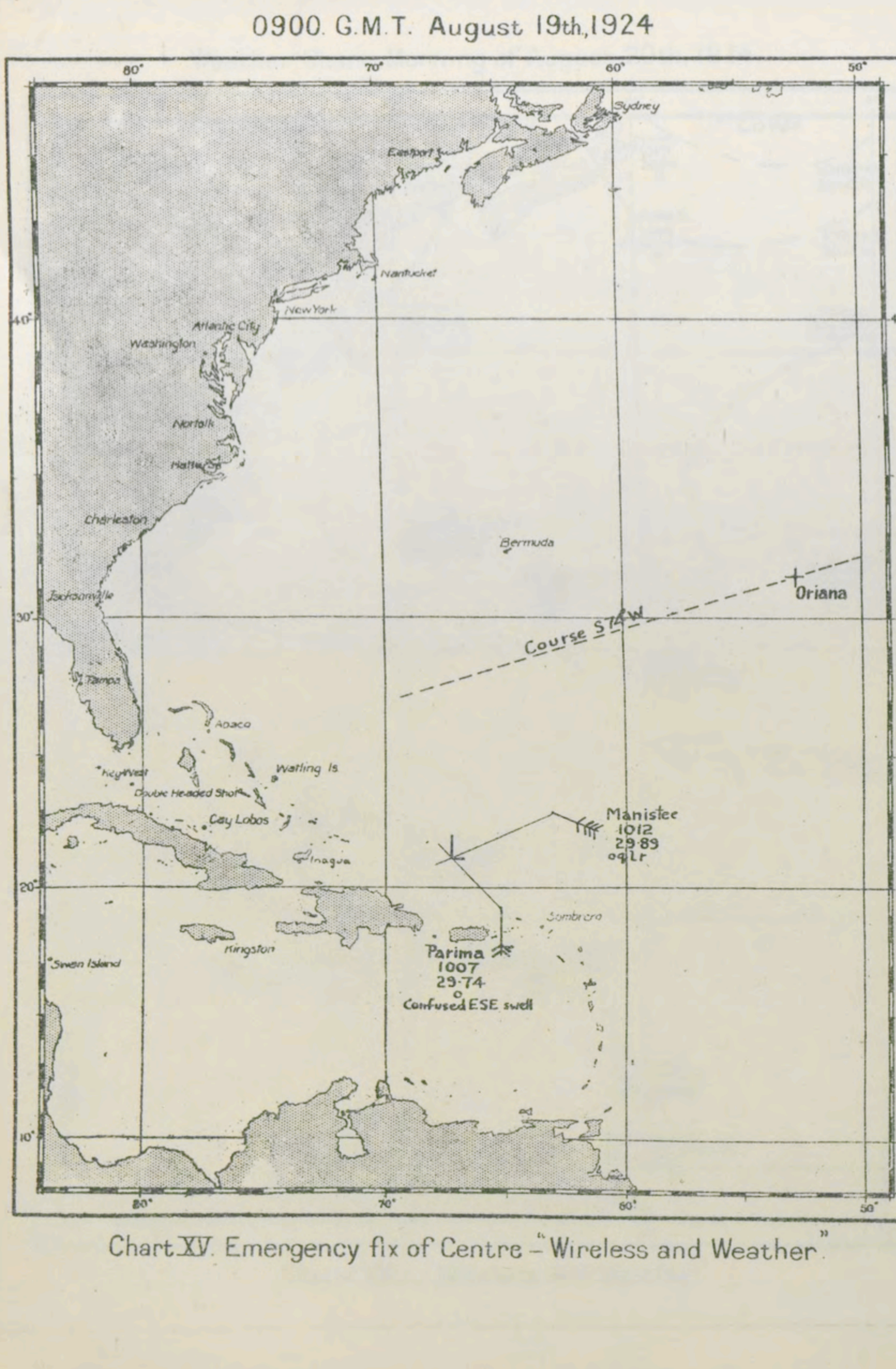


Chart XV. Emergency fix of Centre – "Wireless and Weather."

Weather Chart, Morning of August 19th., 1924.

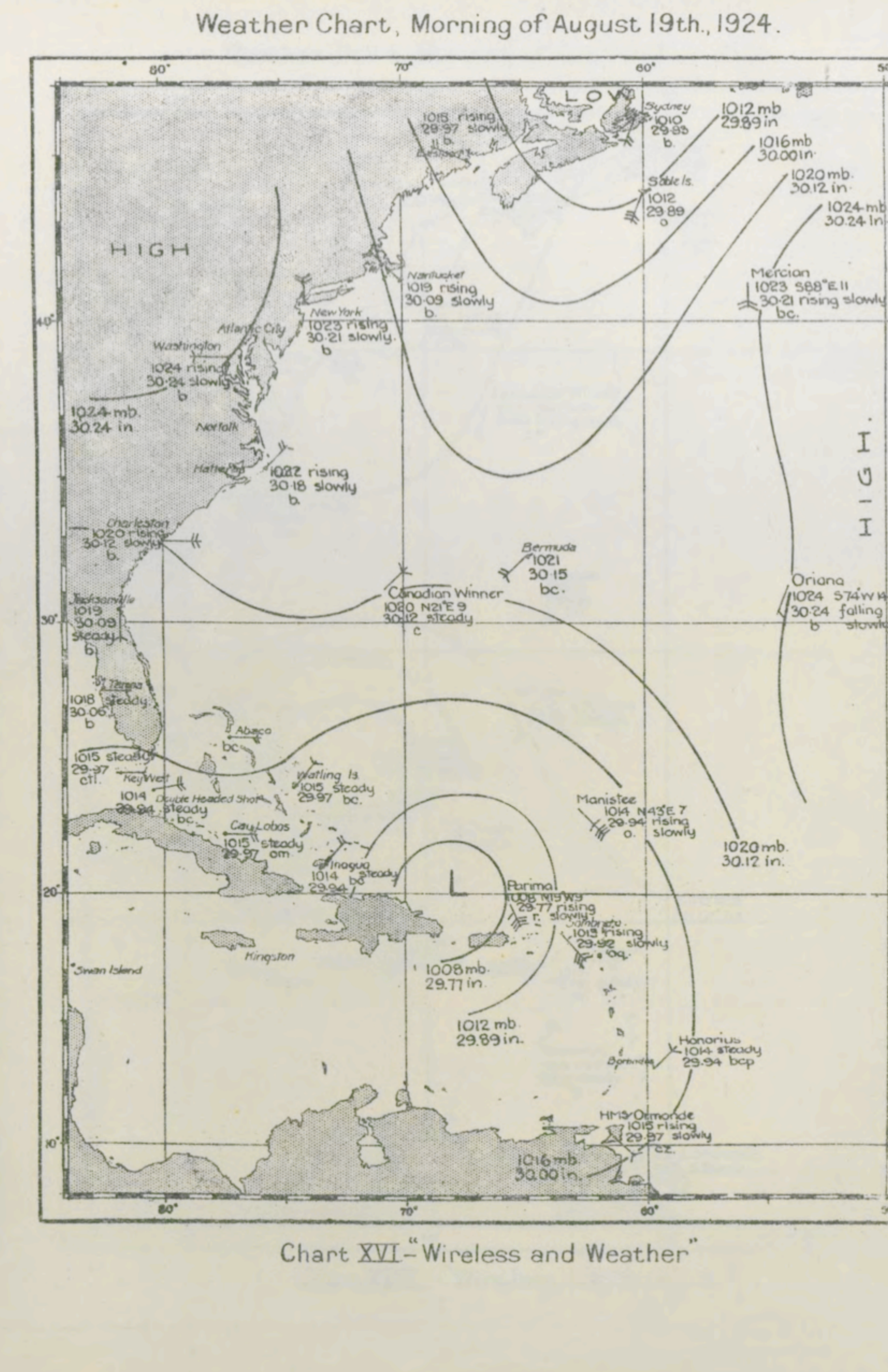


Chart XVI – "Wireless and Weather"

Weather Chart, Morning of August 20th, 1924.

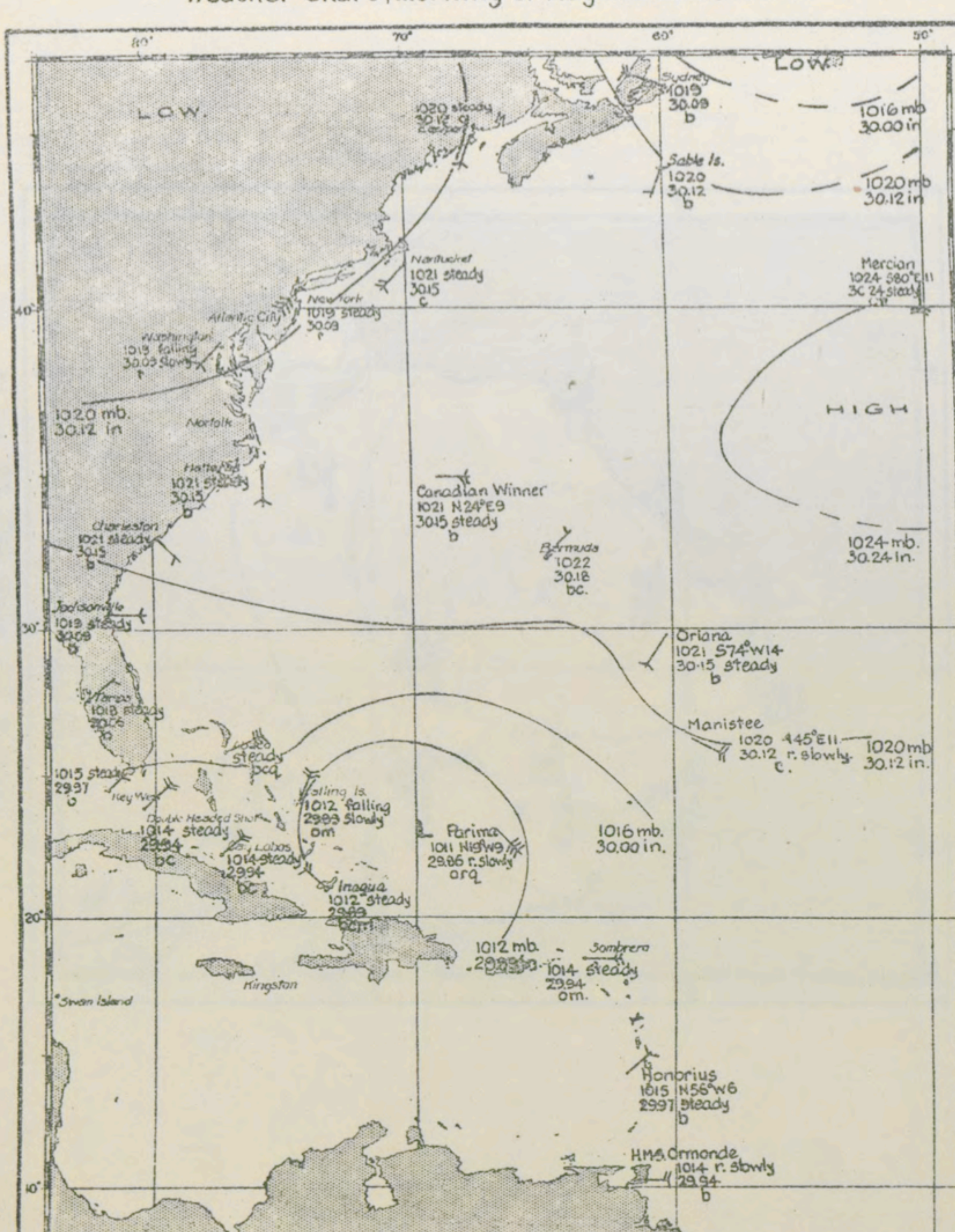


Chart XVII, "Wireless and Weather"

Weather Chart, Morning of August 21st, 1924.

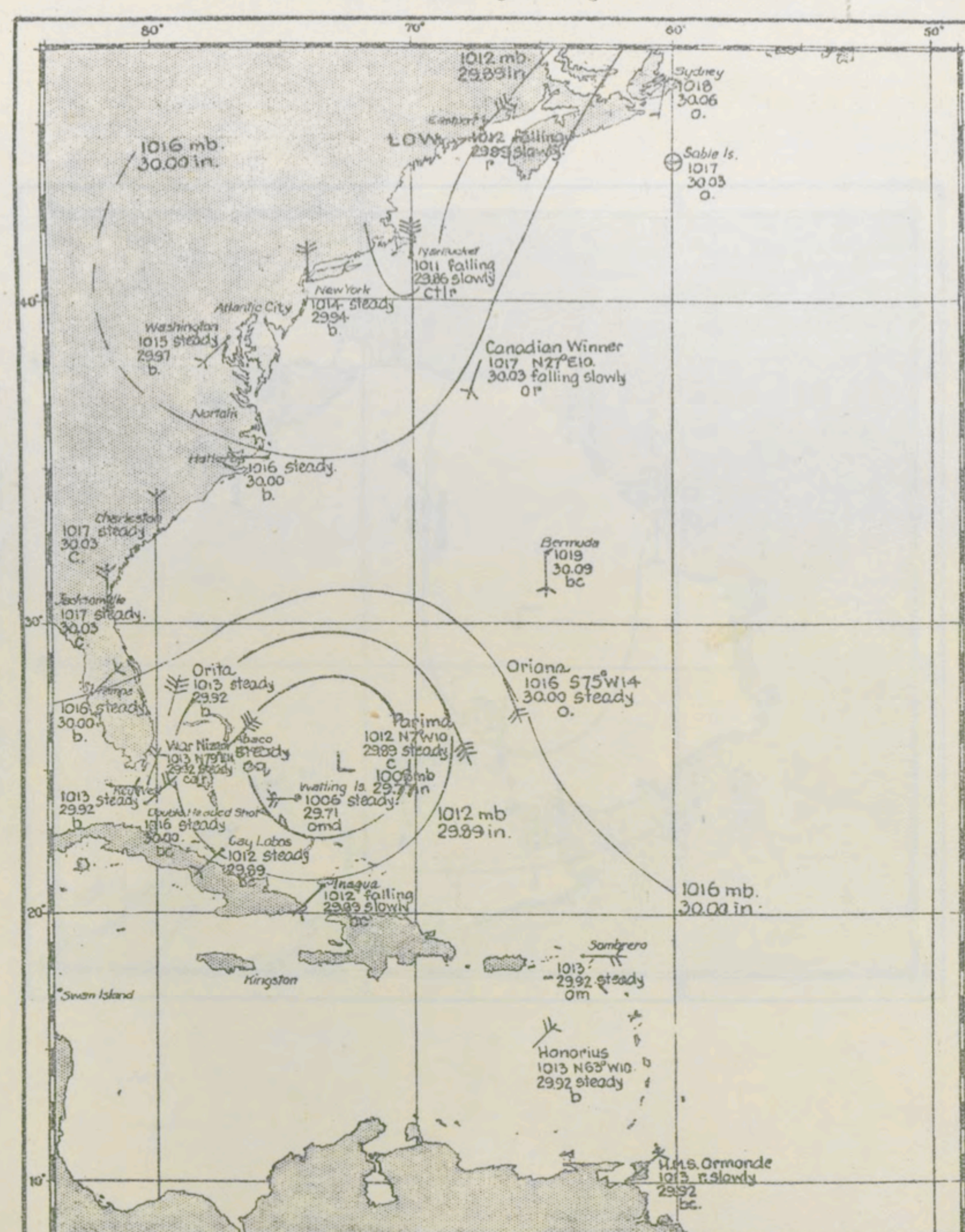


Chart XVIII, "Wireless and Weather"

Weather Chart, Morning of May 2nd, 1923.

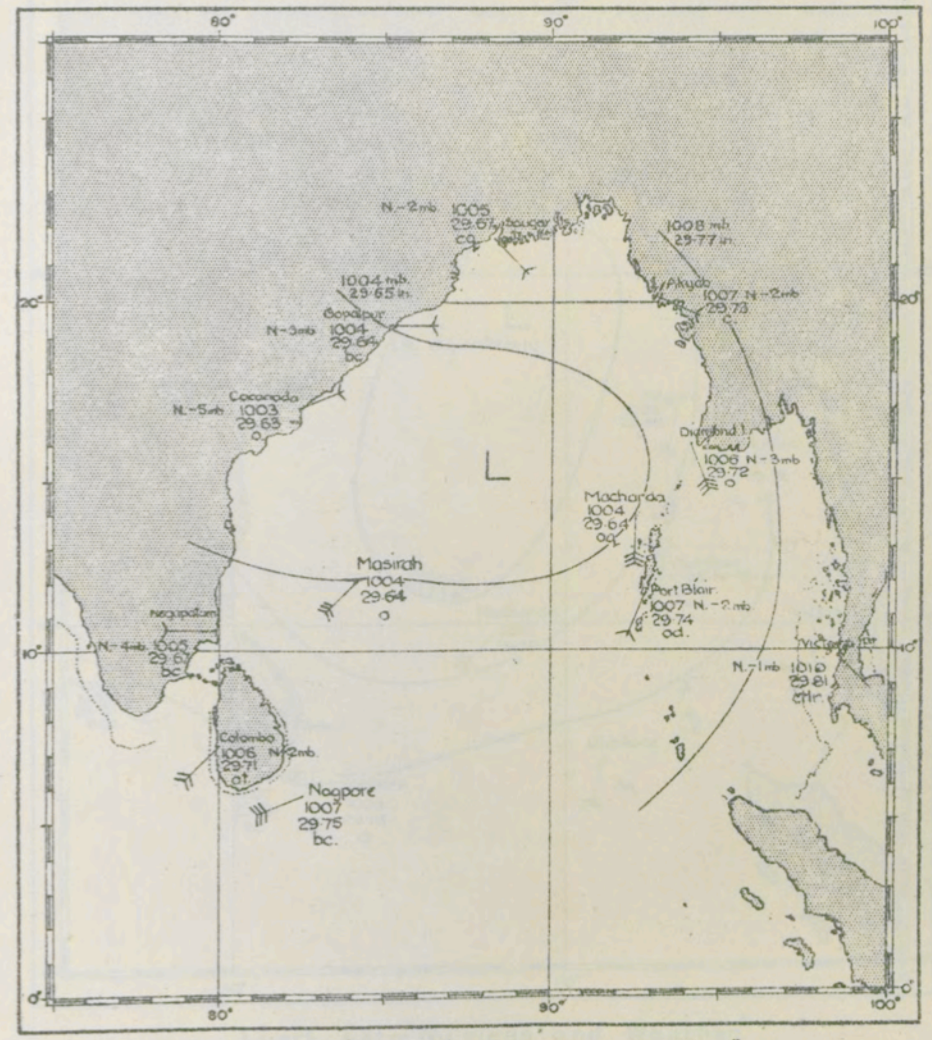


Chart XIX.—"Wireless and Weather."

Weather Chart, Morning of May 3rd, 1923.

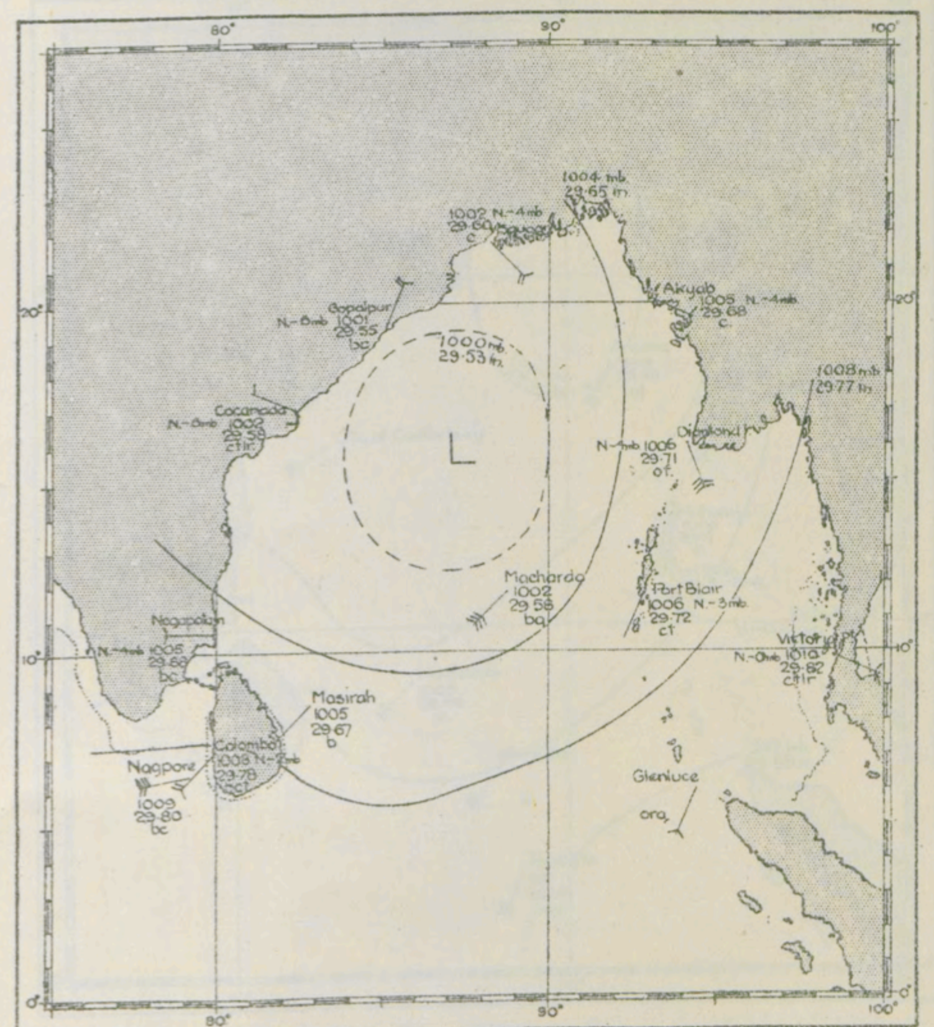


Chart XX.—"Wireless and Weather."

Weather Chart, Morning of May 4th, 1923.

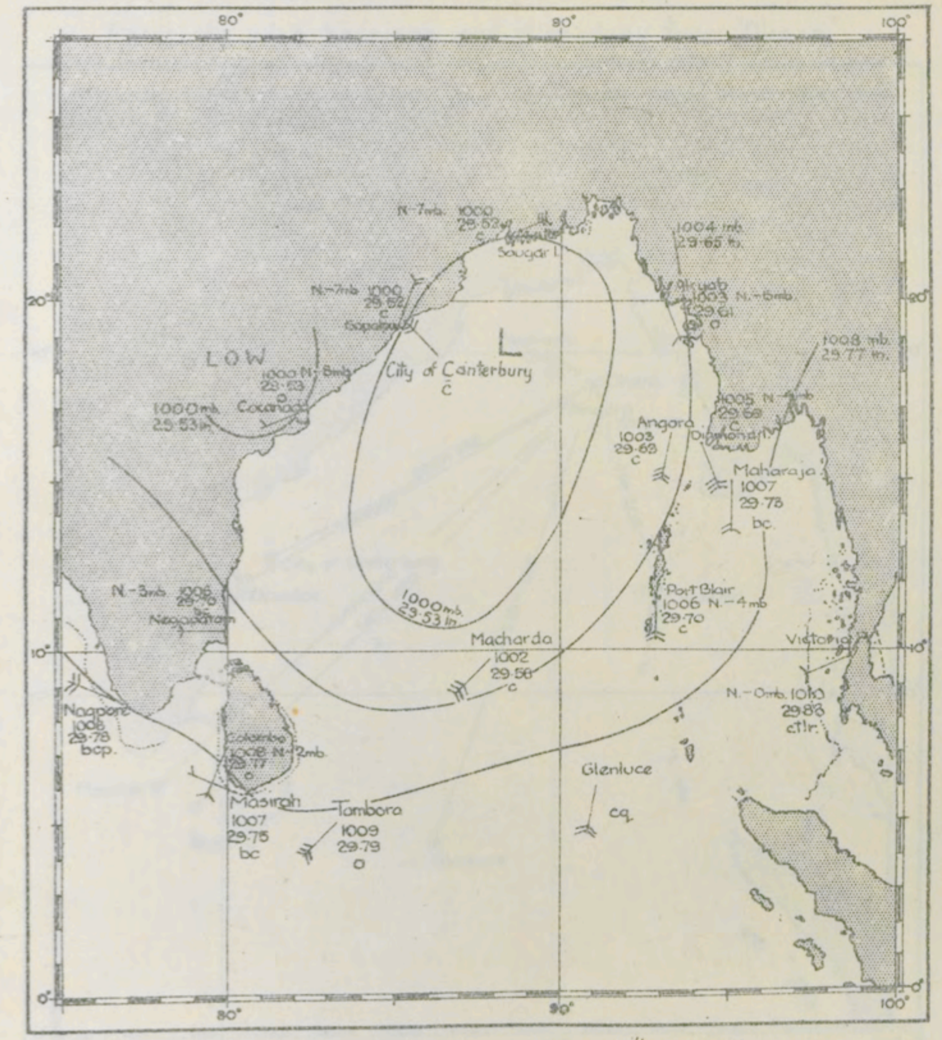


Chart XXI—"Wireless and Weather."

Weather Chart, Morning of May 5th, 1923.

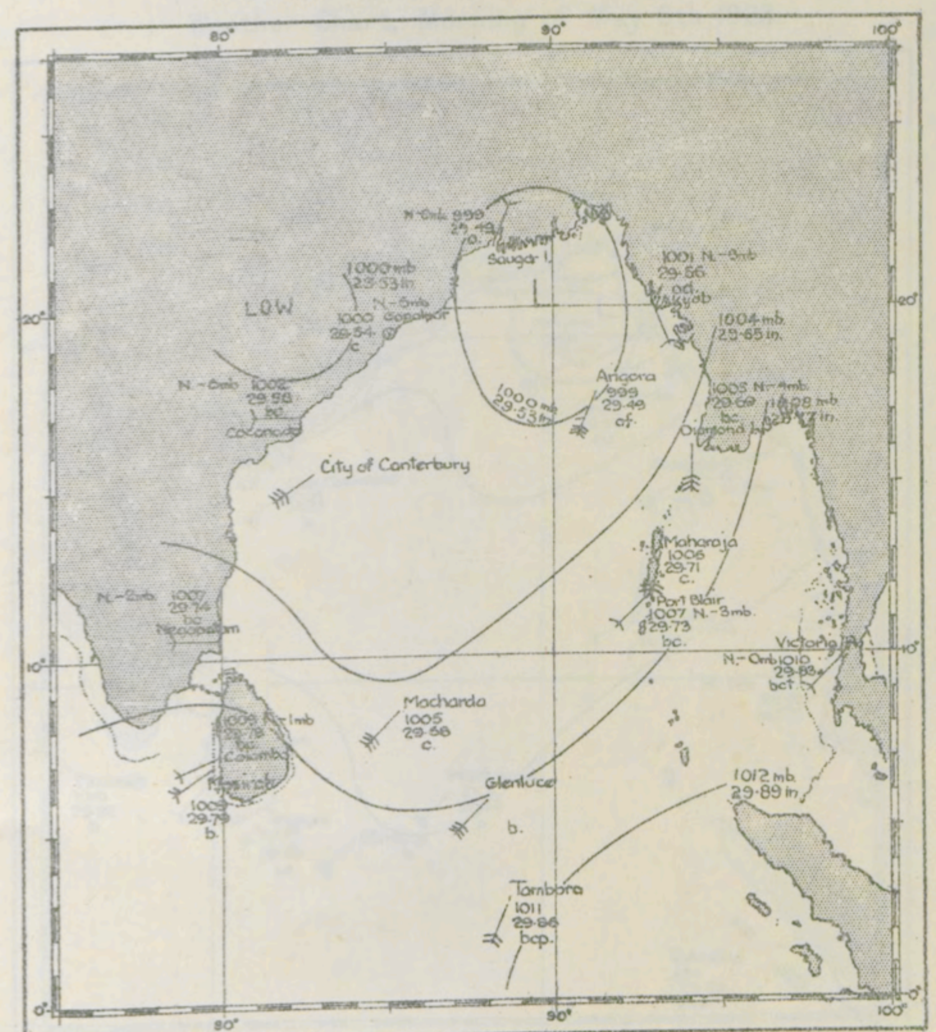


Chart XXII—"Wireless and Weather."

1224 G.M.T. May 5th., 1923.

Positions with bearings and distances from "Okara."

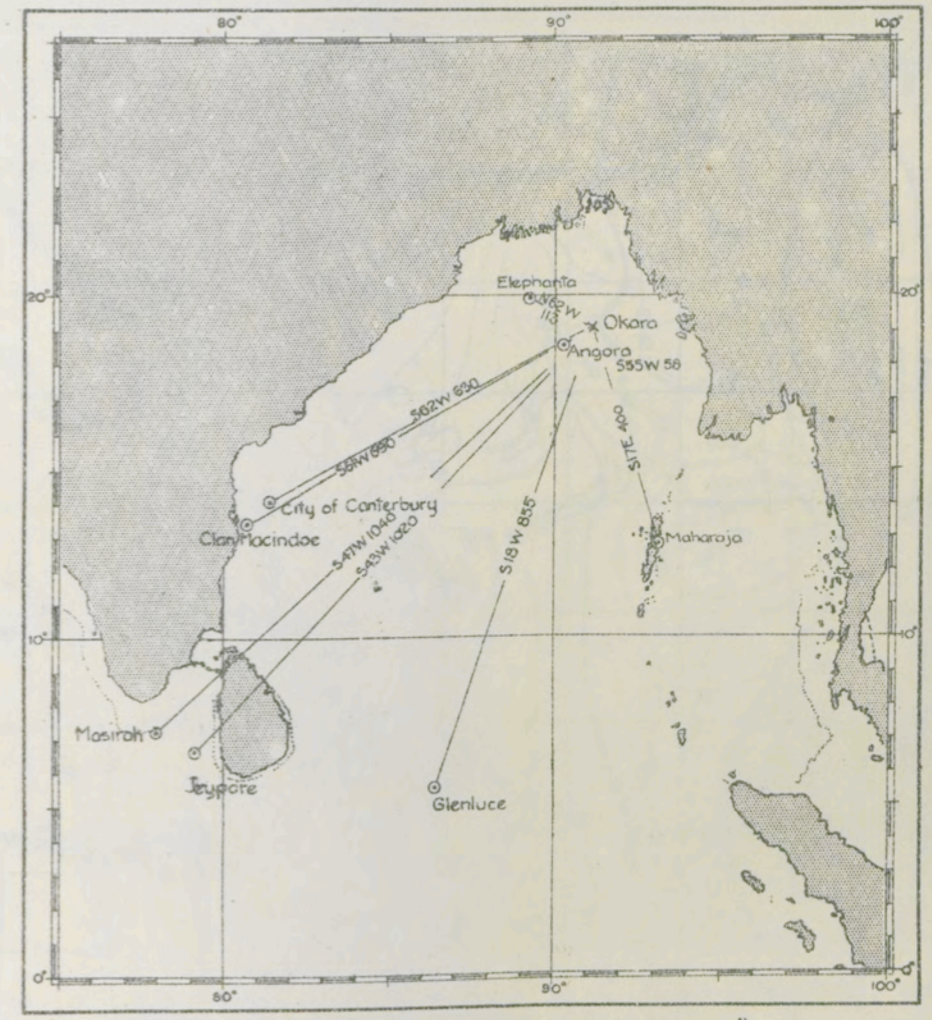


Chart XXIII—"Wireless and Weather."

Weather Chart, Morning of May 6th., 1923.

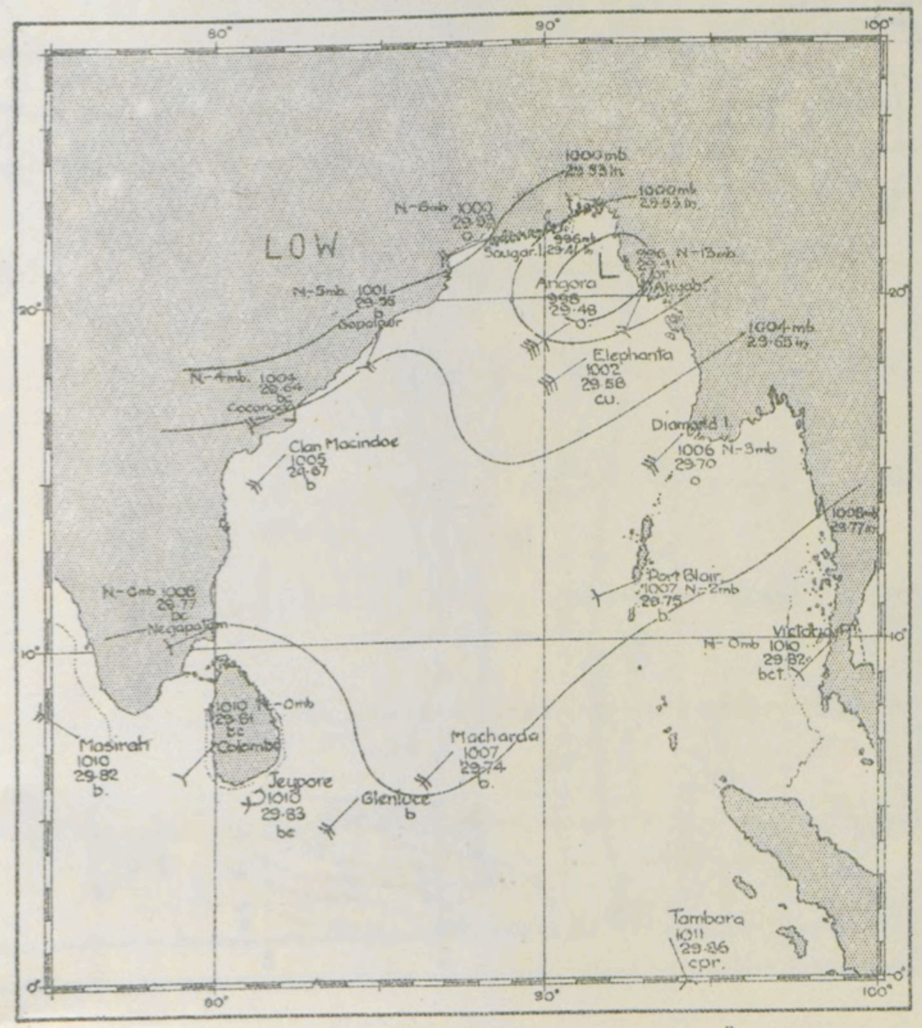
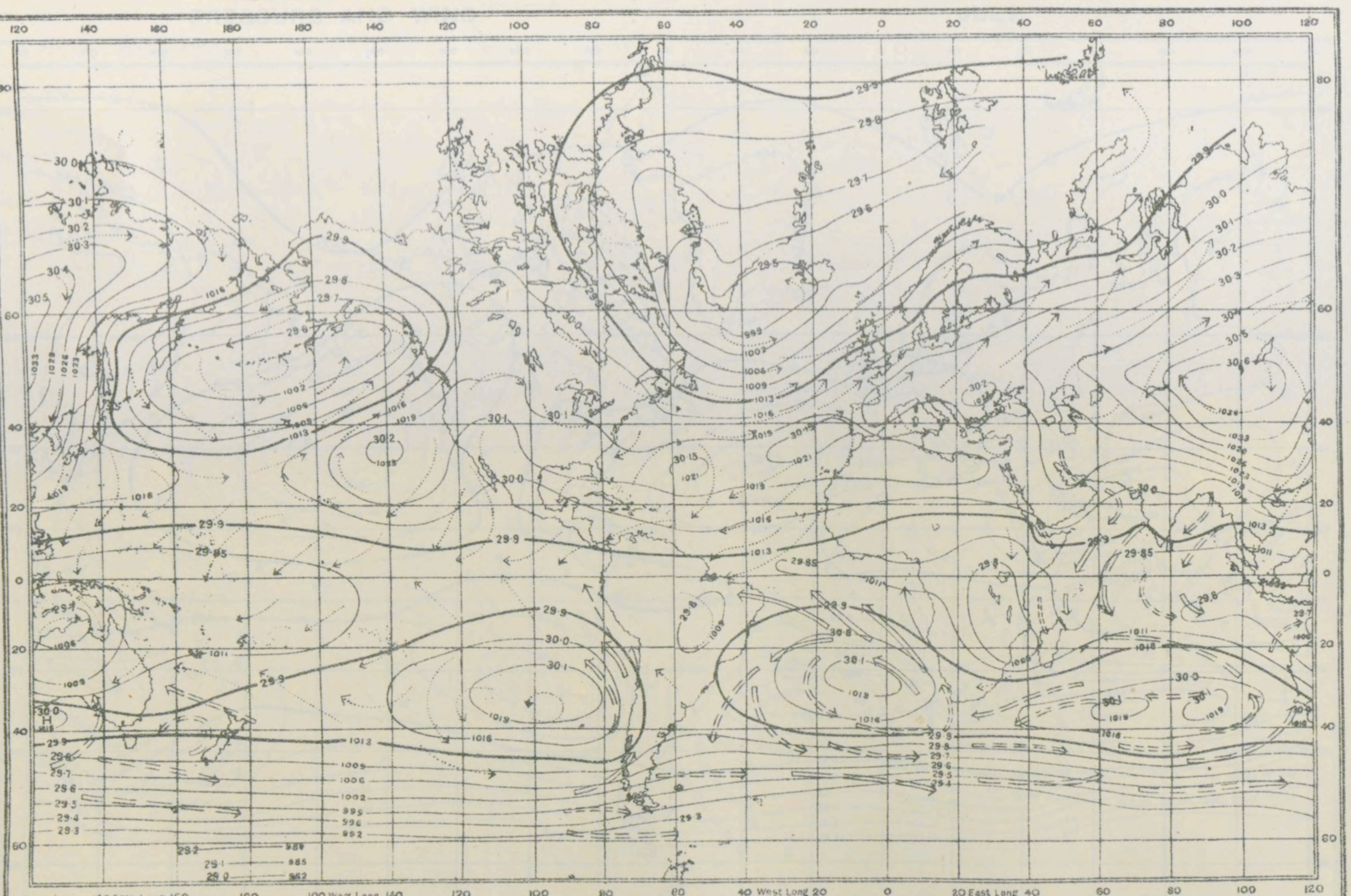


Chart XXIV.—"Wireless and Weather."

Chart XXV —"Wireless and Weather."

PRESSURE AND WIND JANUARY.



WIND { STEADINESS — Frequency less than 50% of all observations; FORCE { Light 1-3; Moderate 4-7; Strong 8 or above

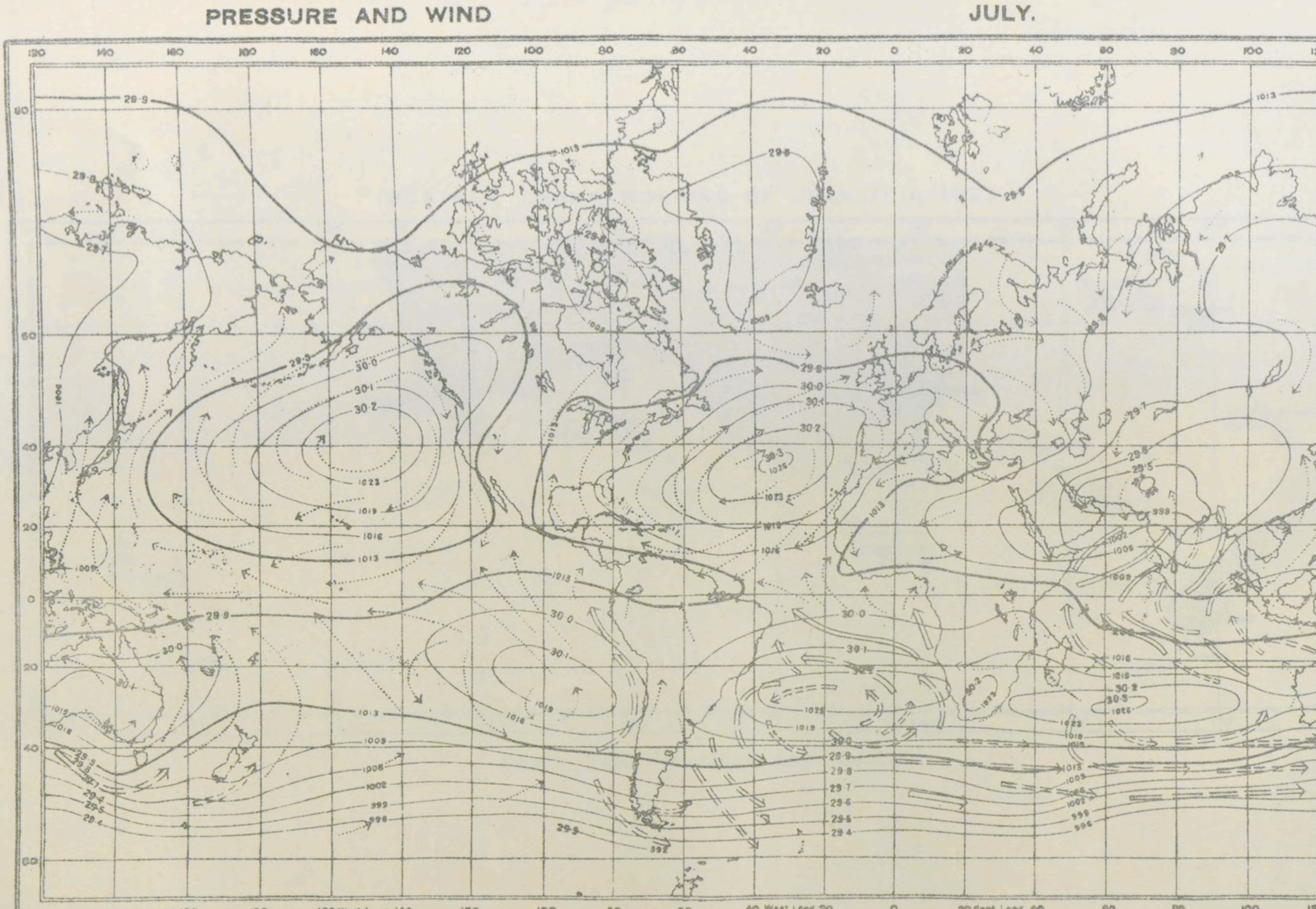
Frequency 50 to 75%

Frequency above 75%

Direction only

Chart XXVI "Wireless and Weather."

PRESSURE AND WIND — JULY.



WIND { STEADINESS — Frequency less than 50% of all observations; Frequency 50 to 75%; Frequency above 75%; Direction only

FORCE { Light 1-3; Moderate 4-7; Strong 8 or above

WEATHER CHART, MORNING OF JULY 11 TH, 1923.

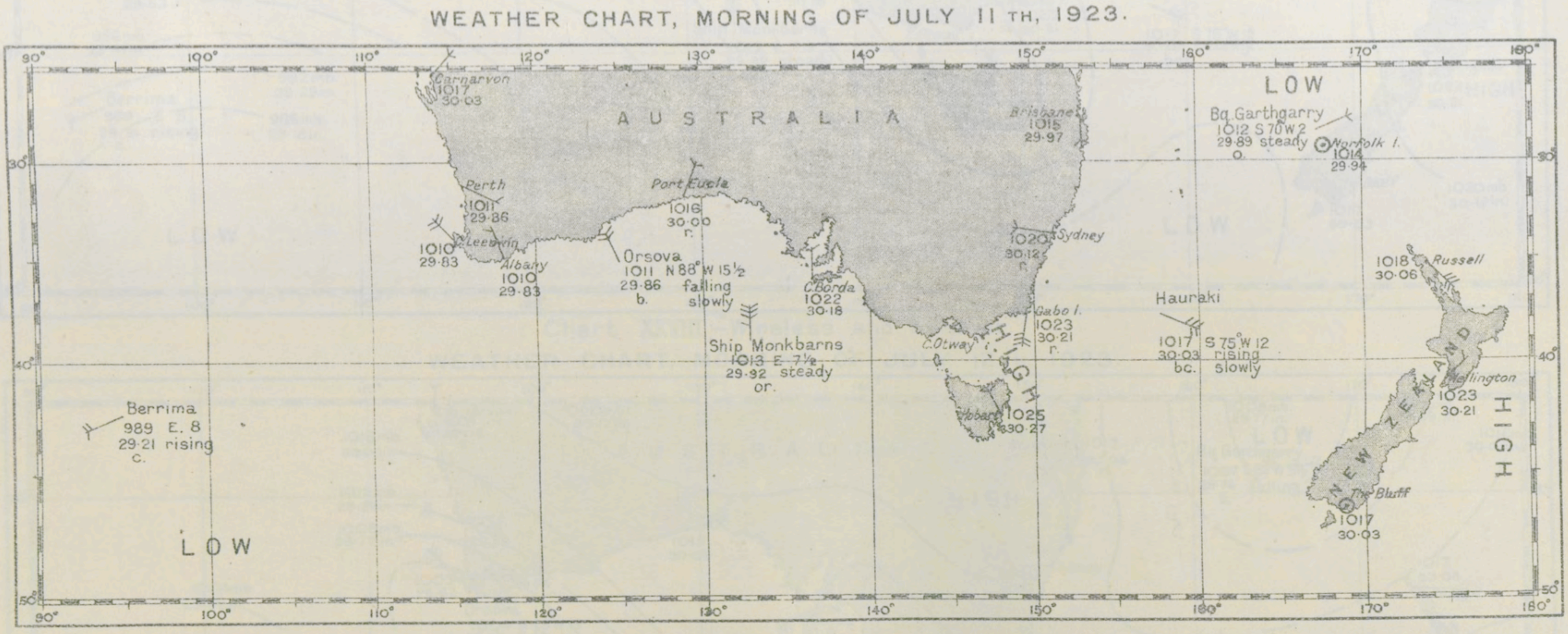


Chart XXVII "Wireless and Weather."

WEATHER CHART, MORNING OF JULY 11 TH, 1923.

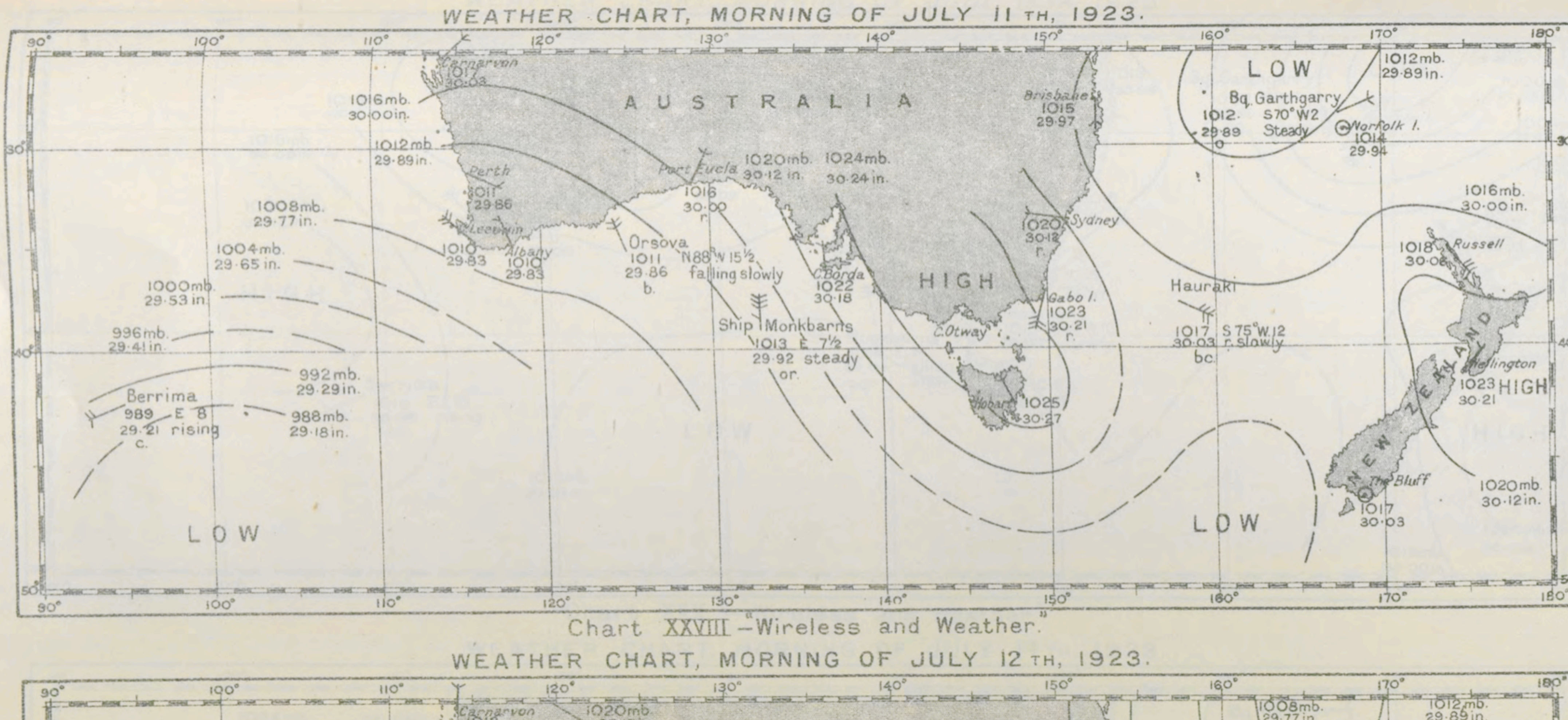


Chart XXVIII —"Wireless and Weather."

WEATHER CHART, MORNING OF JULY 12 TH, 1923.

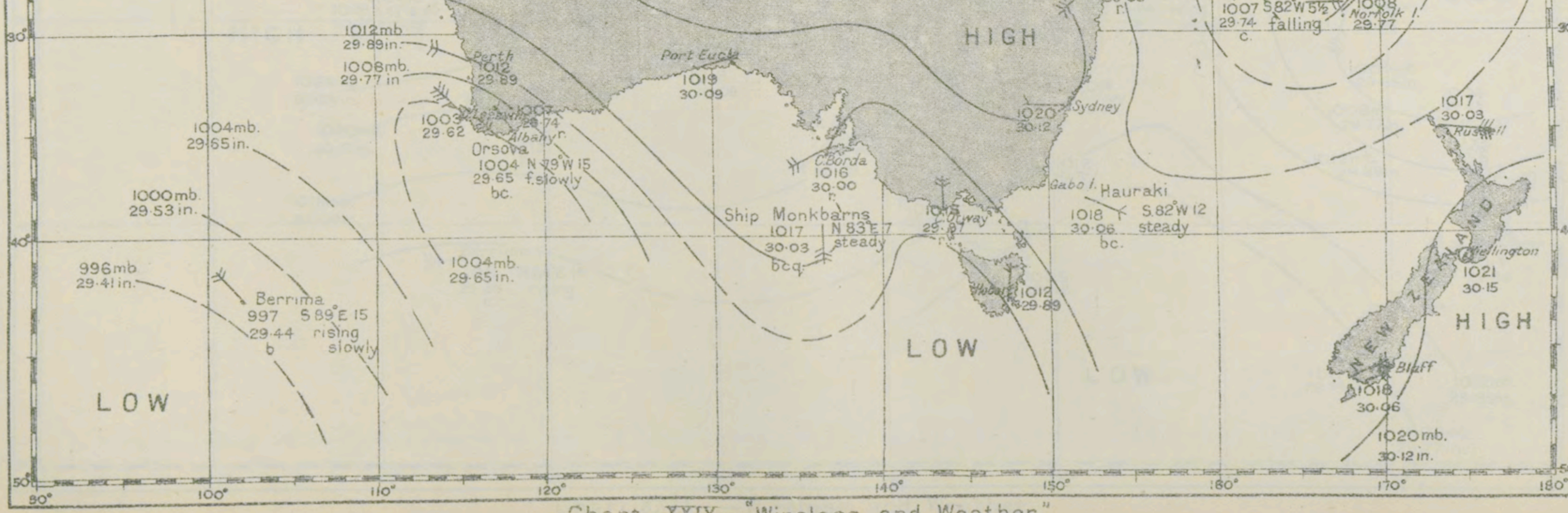


Chart XXIX —"Wireless and Weather."

WEATHER CHART, MORNING OF JULY 13TH, 1923.

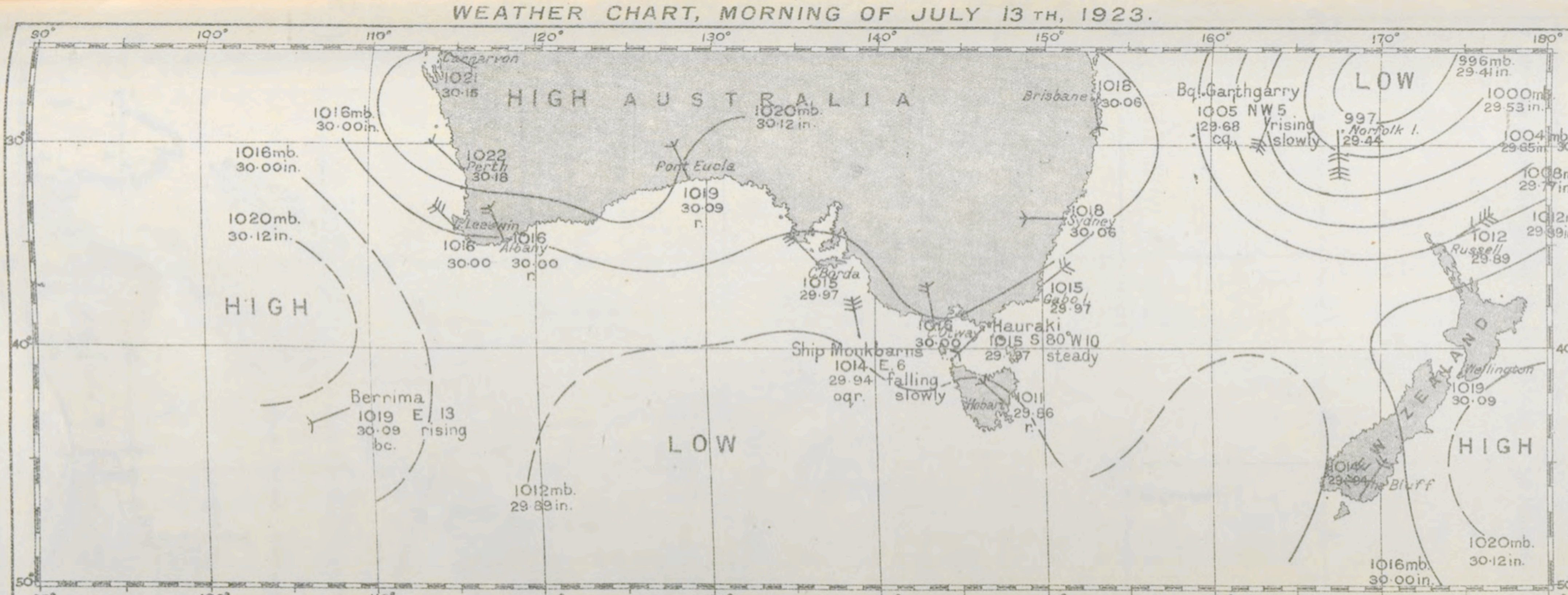


Chart XXX —"Wireless and Weather."

WEATHER CHART, MORNING OF JULY 14TH, 1923.

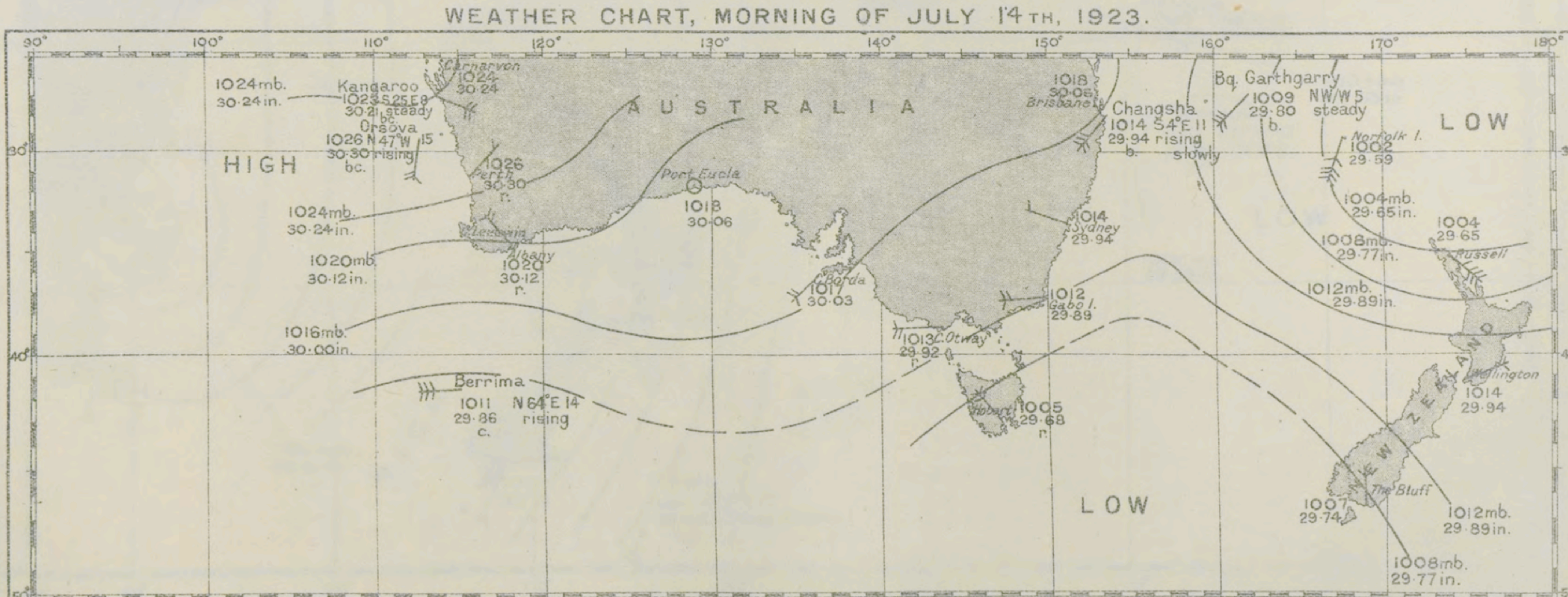


Chart XXXI —"Wireless and Weather."

WEATHER CHART, MORNING OF JULY 11TH. (EASTERN) 1925.

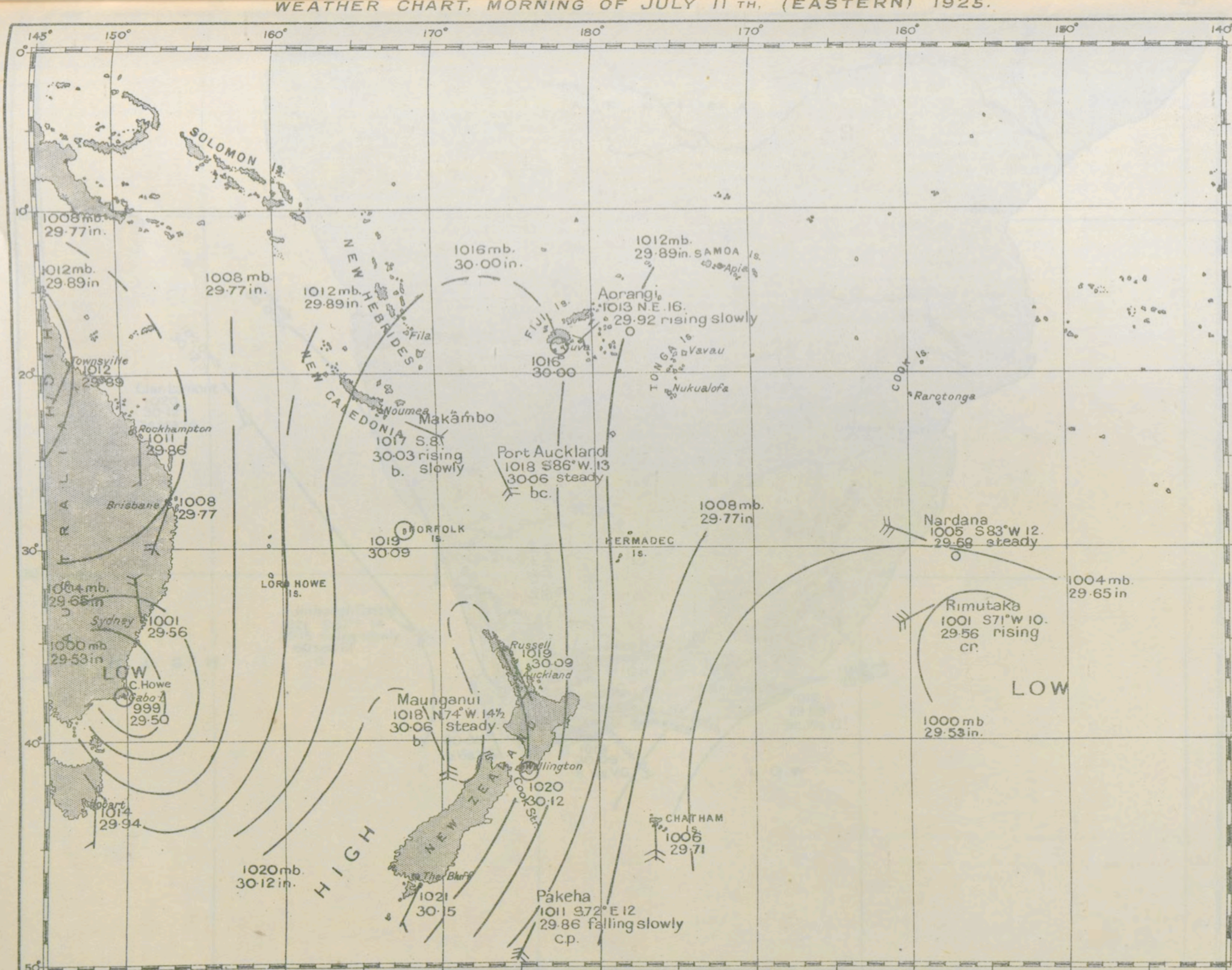


Chart XXXII "Wireless and Weather."

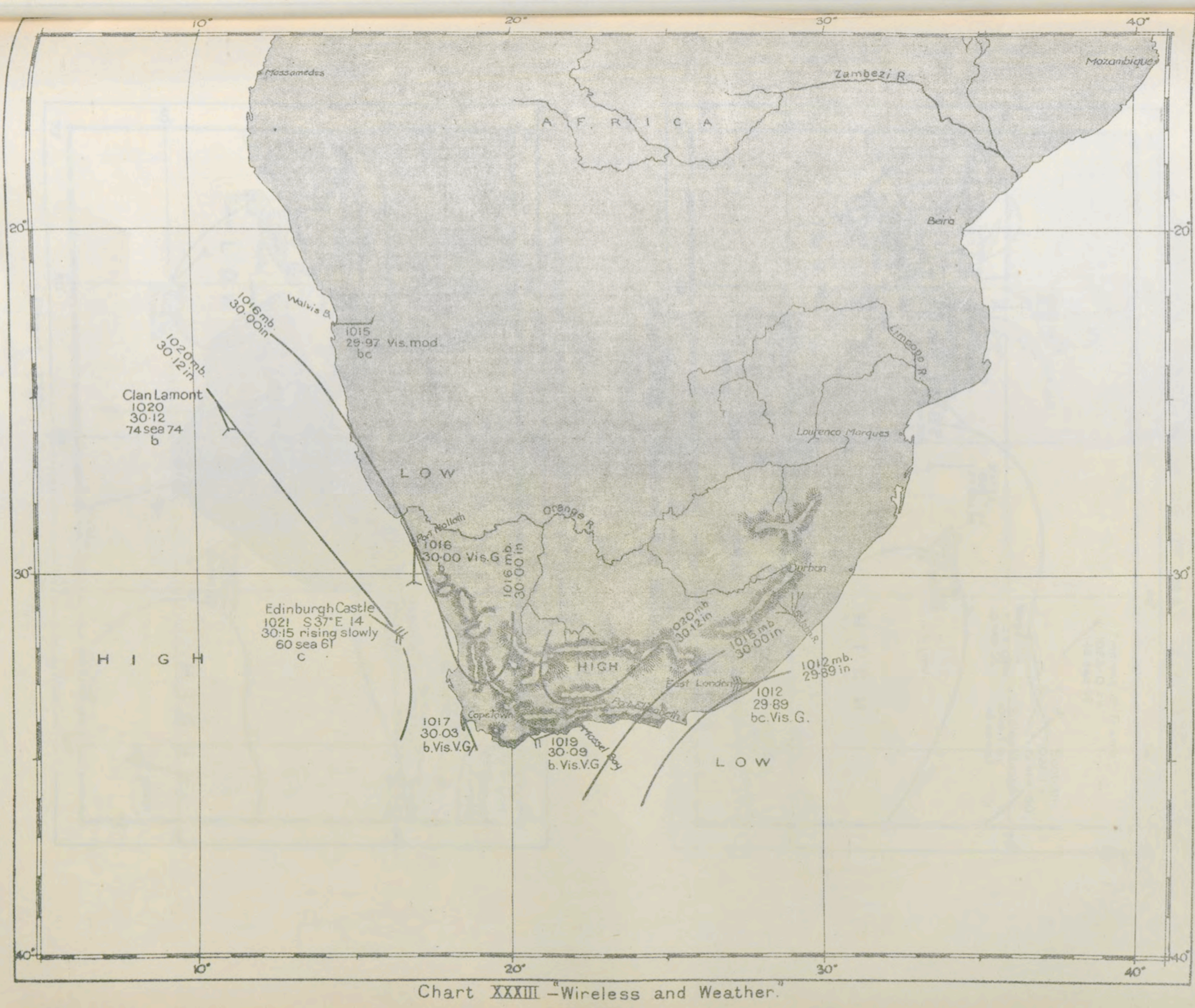


Chart XXXIII "Wireless and Weather."

WEATHER CHART, MORNING OF MAY 19TH. 1920.

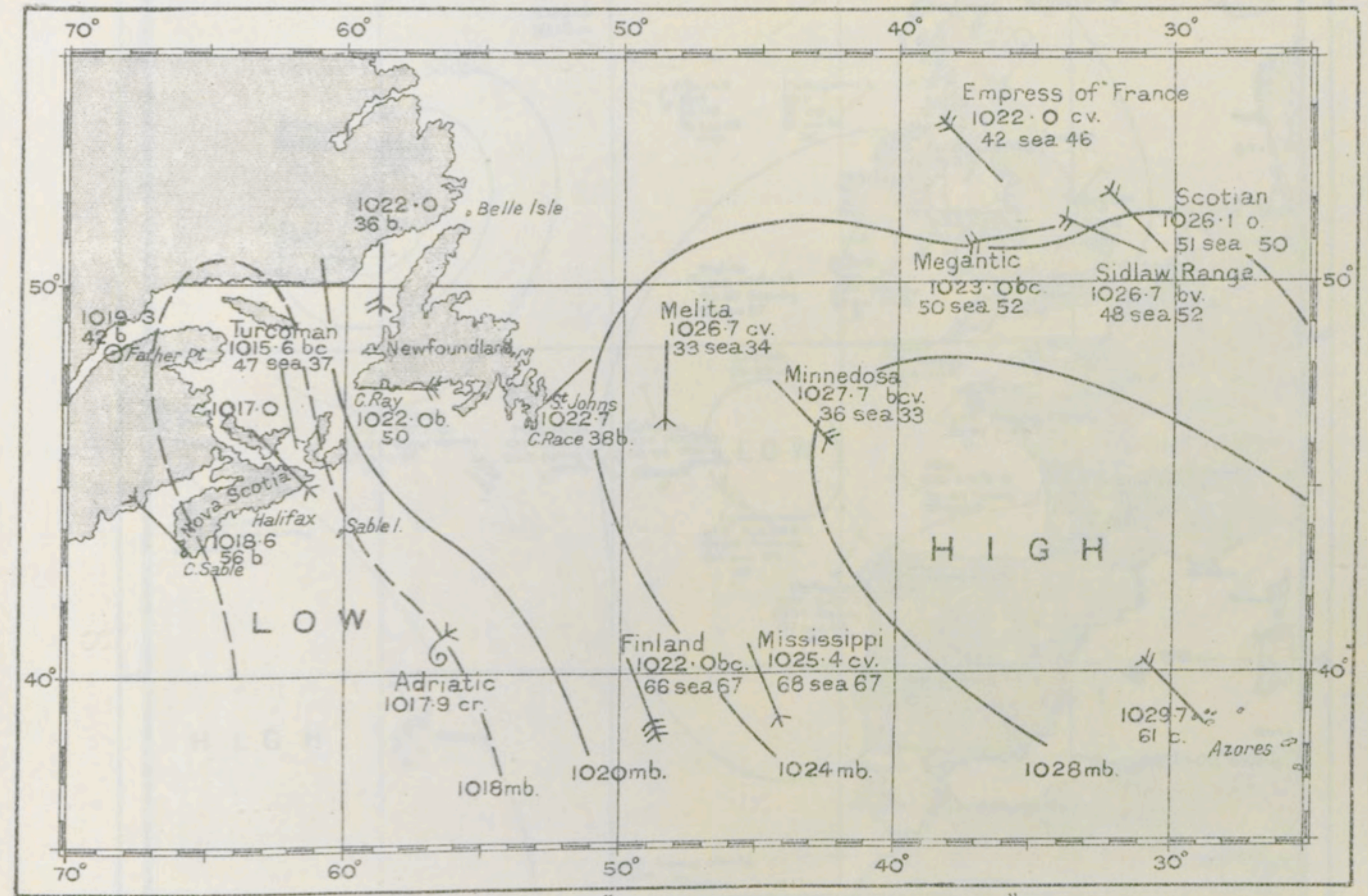


Chart XXXIV. — "Wireless and Weather."

WEATHER CHART, EVENING OF MAY 19TH. 1920.

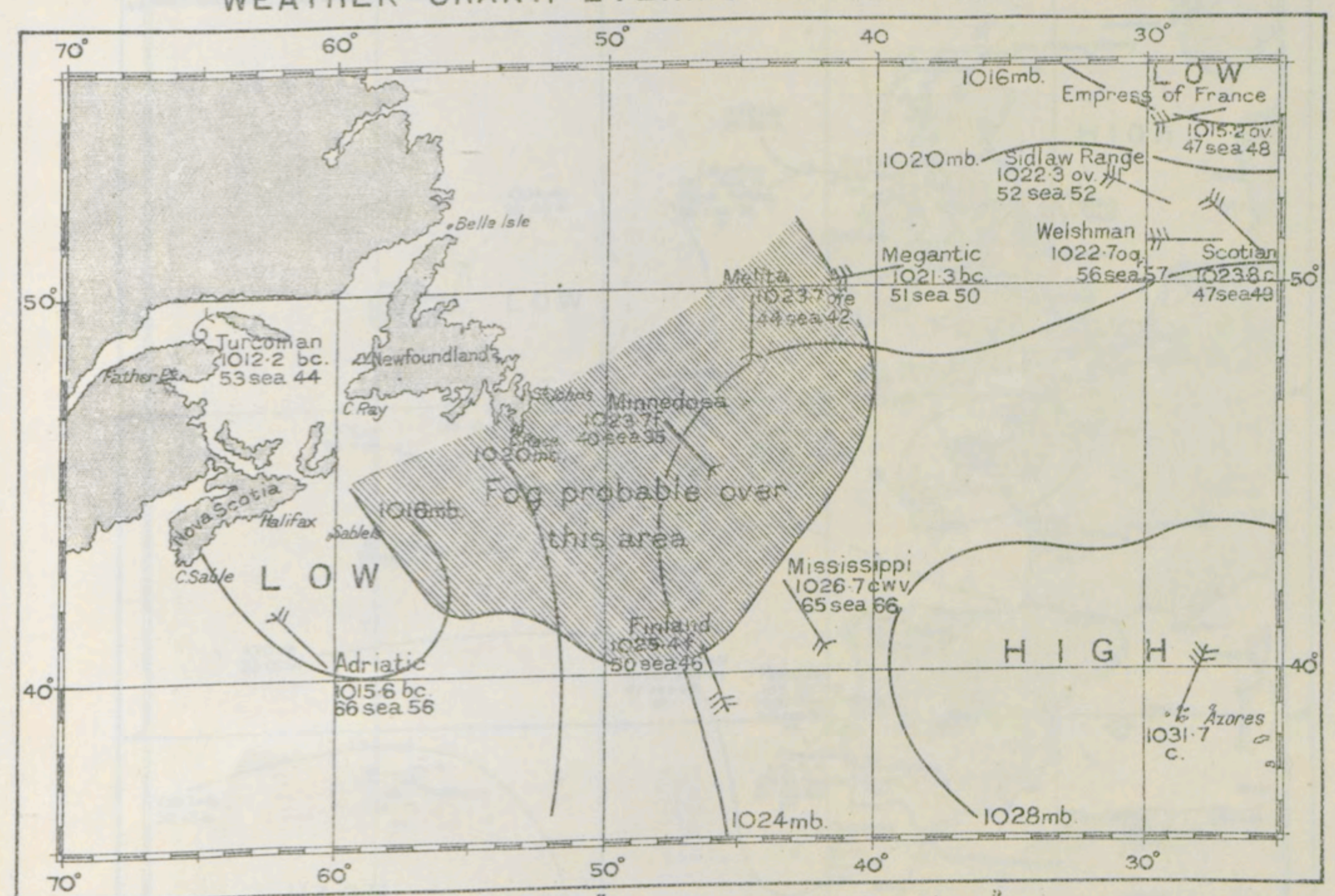


Chart XXXV. — "Wireless and Weather."

WEATHER CHART, MORNING OF AUGUST 5TH. 1922.

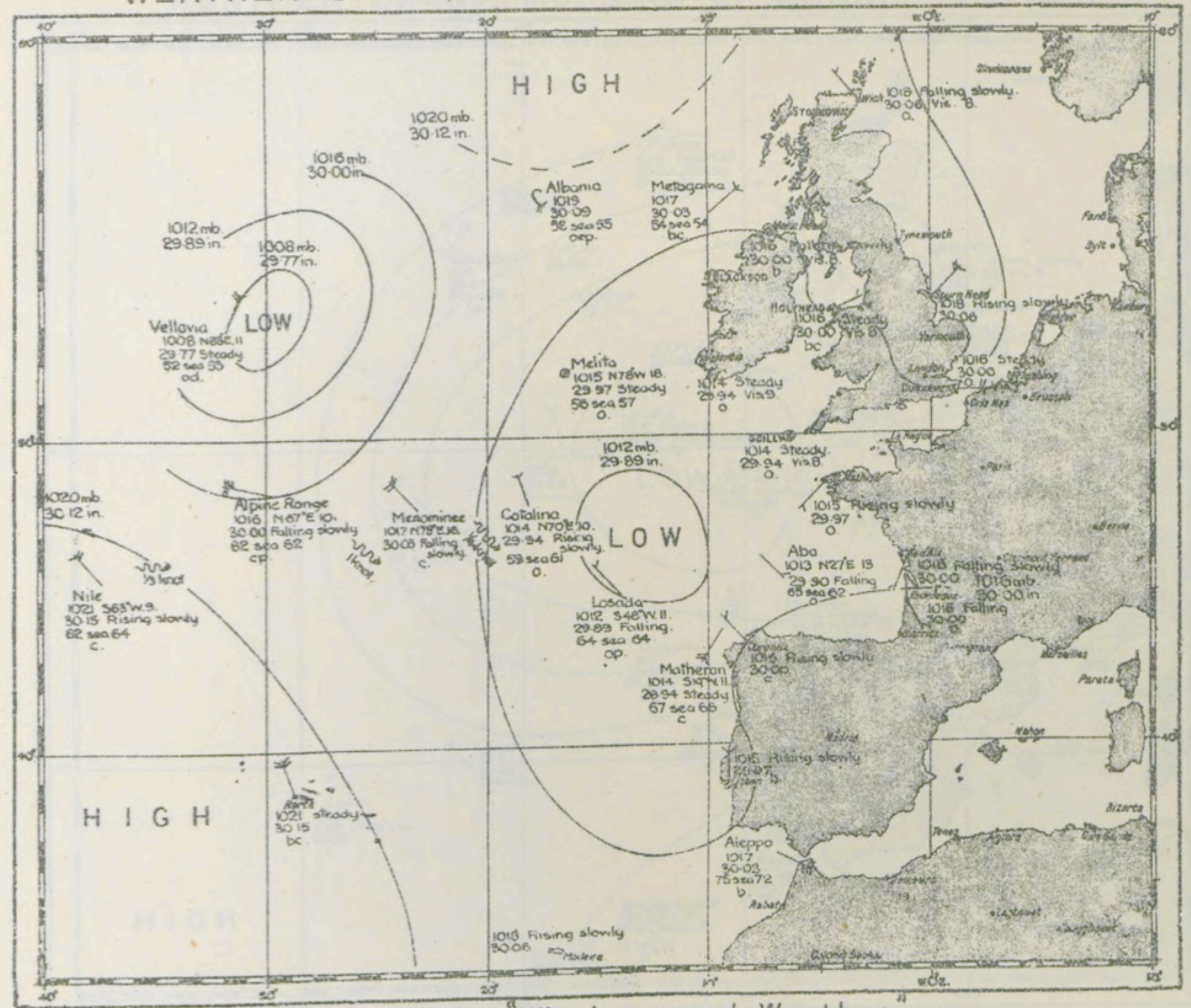


Chart XXXVI. "Wireless and Weather"

WEATHER CHART, MORNING OF AUGUST 6TH. 1922.

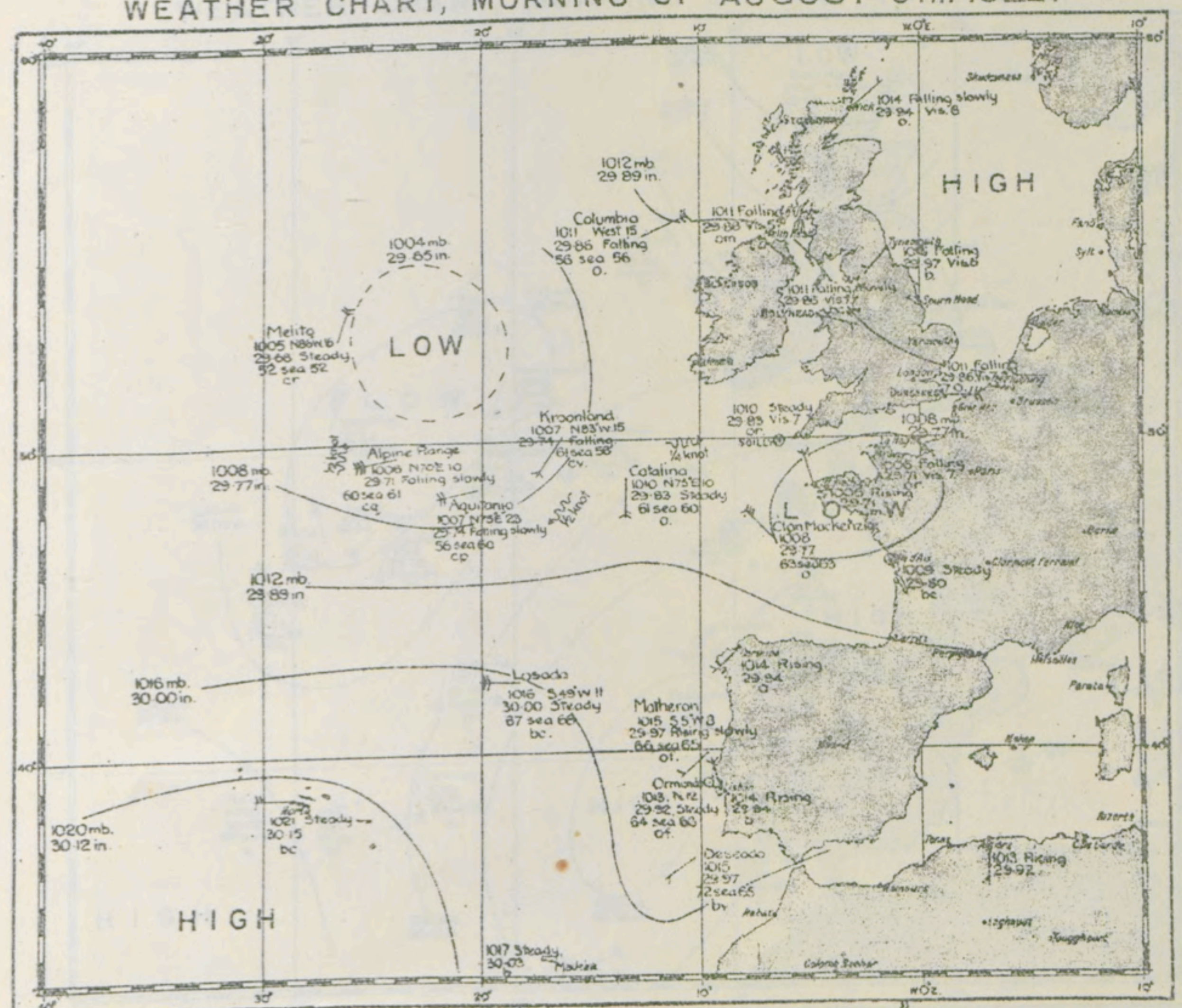


Chart XXXVII. "Wireless and Weather."

WEATHER CHART, MORNING OF AUGUST 7TH. 1922.

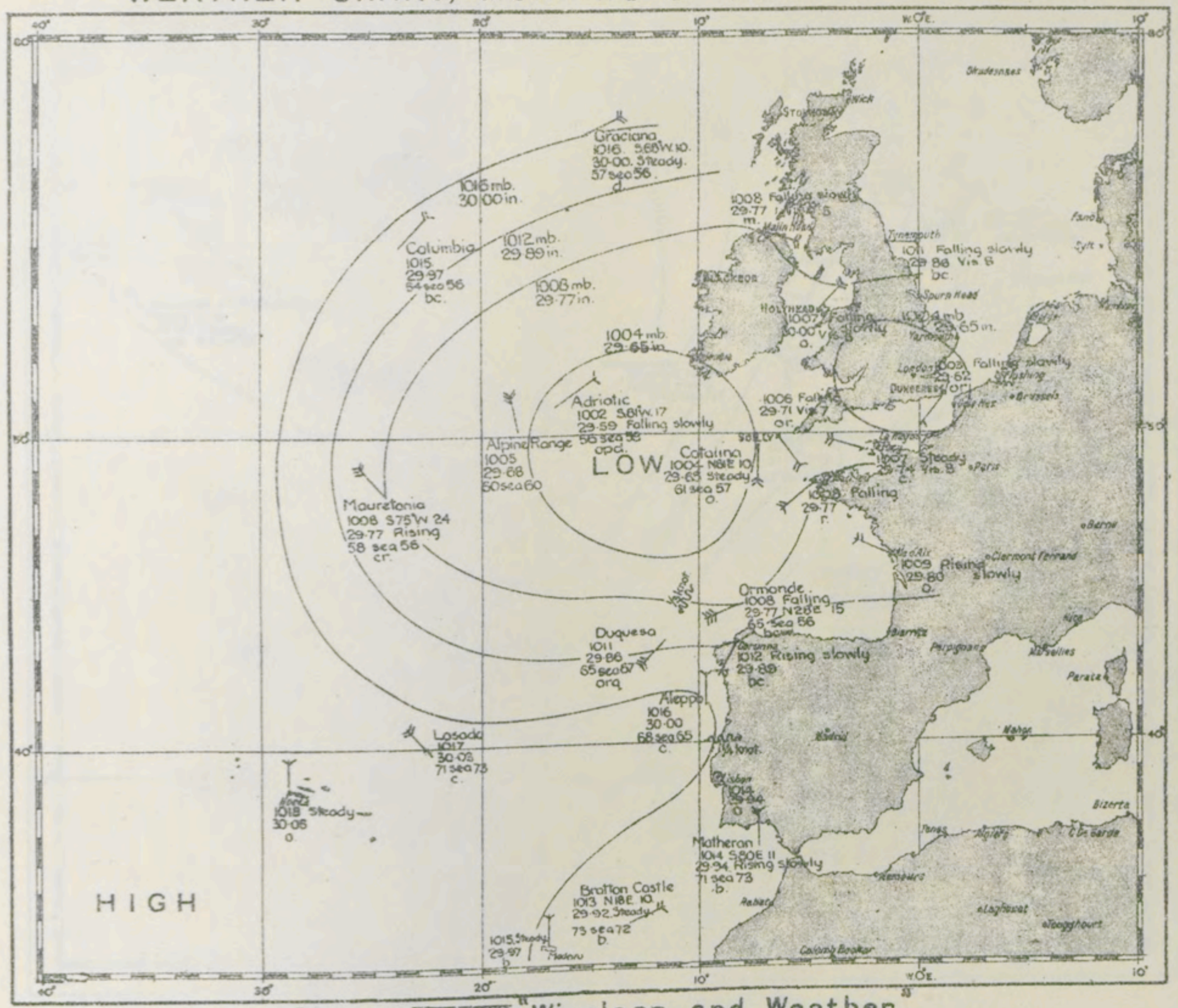


Chart XXXVIII.–"Wireless and Weather."

WEATHER CHART, MORNING OF MAY 19TH. 1922.

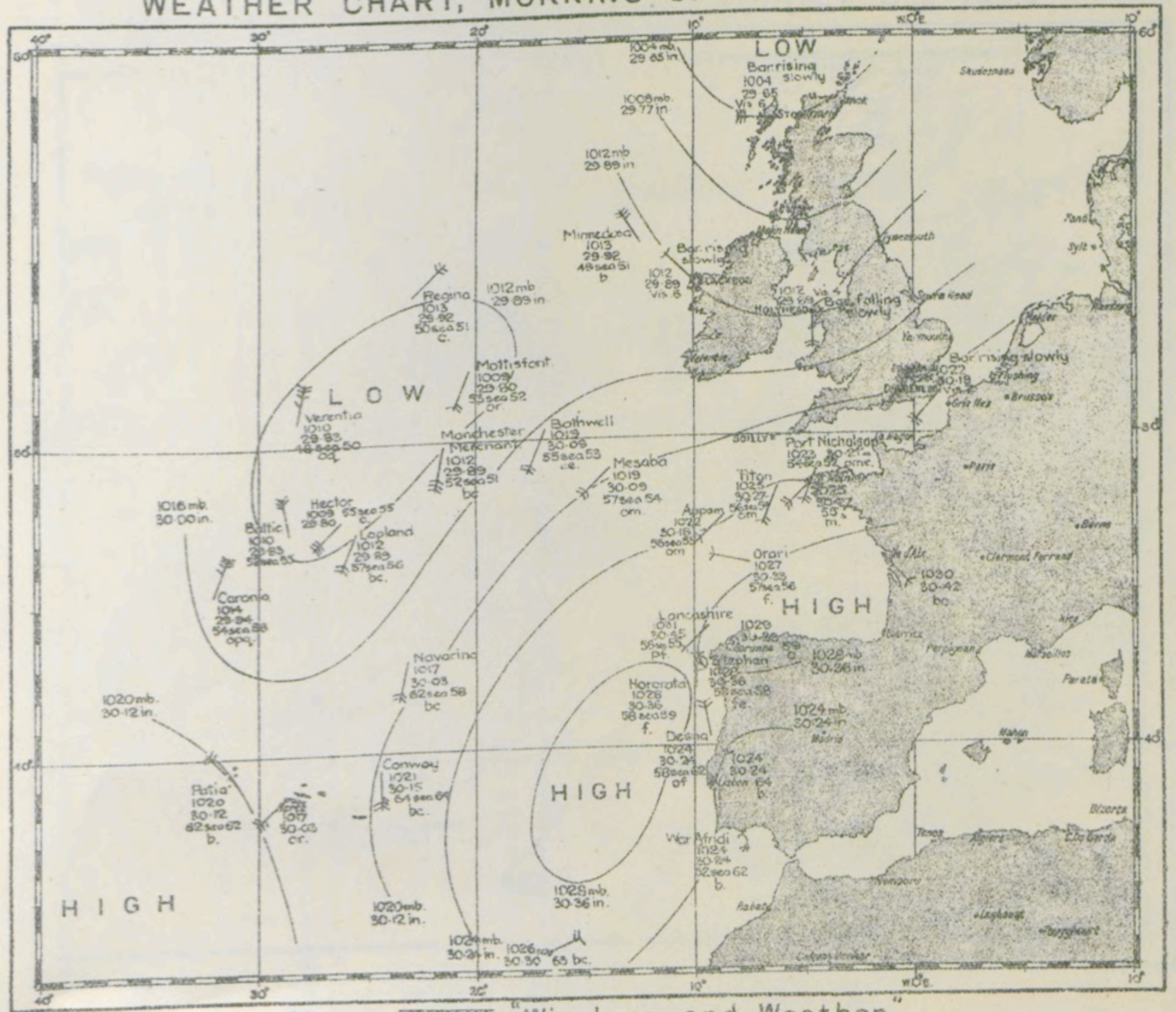


Chart XXXIX.–"Wireless and Weather."

WEATHER CHART, MORNING OF AUGUST 8TH. 1923.

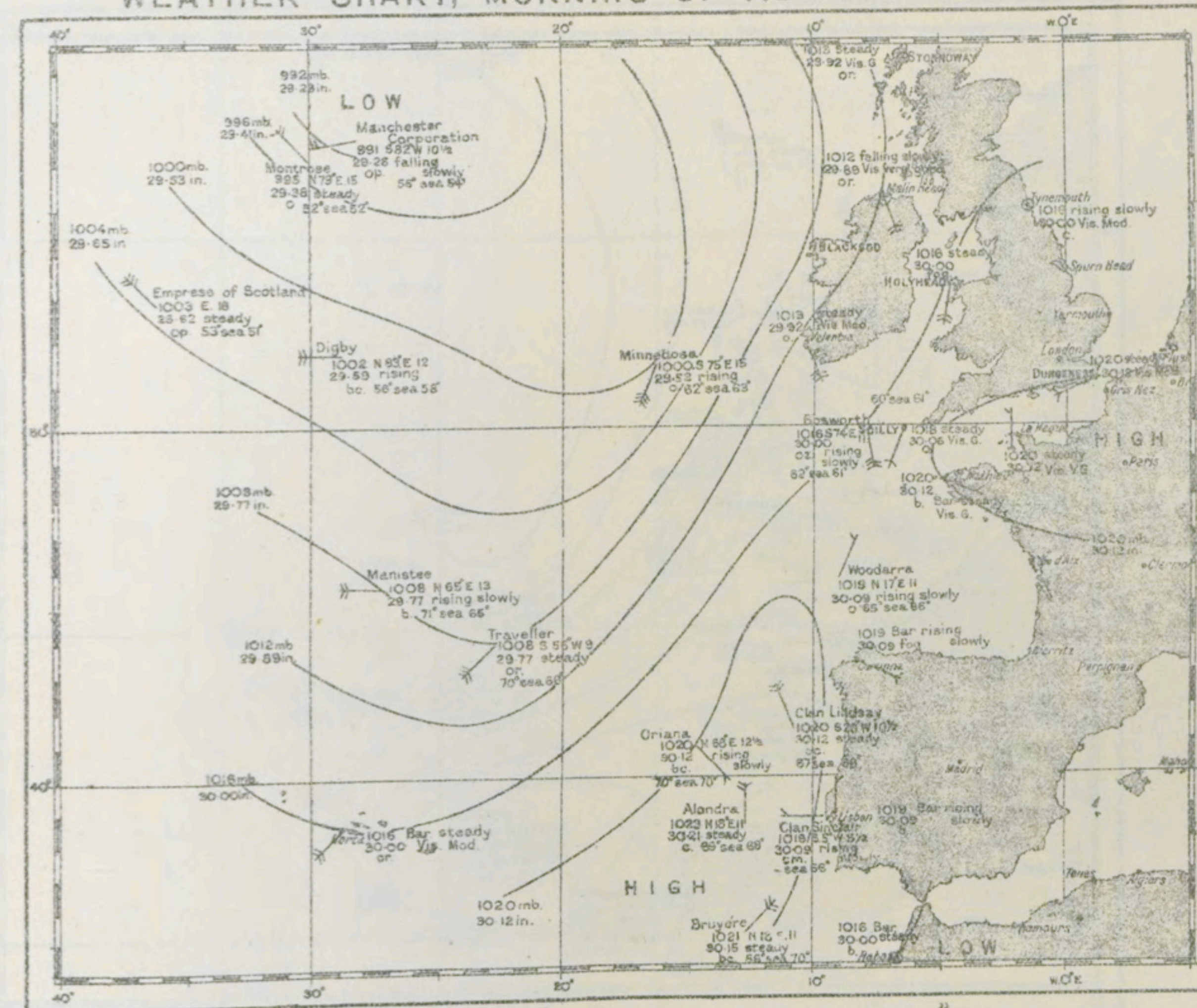


Chart XL. —"Wireless and Weather."

WEATHER CHART, MORNING OF AUGUST 9TH. 1923

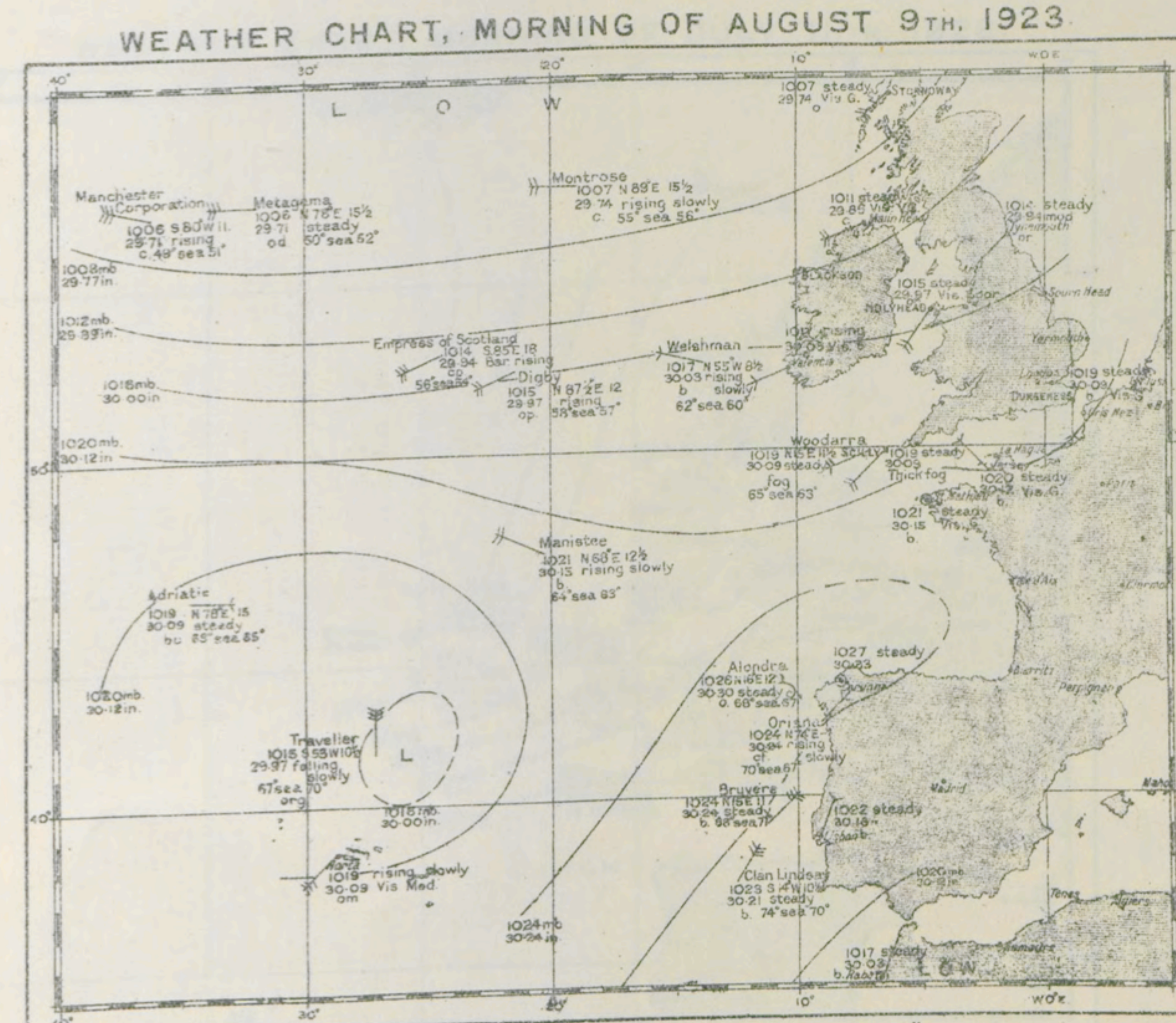


Chart XLI. —"Wireless and Weather."

WEATHER CHART, MORNING OF JULY 10TH, 1926.

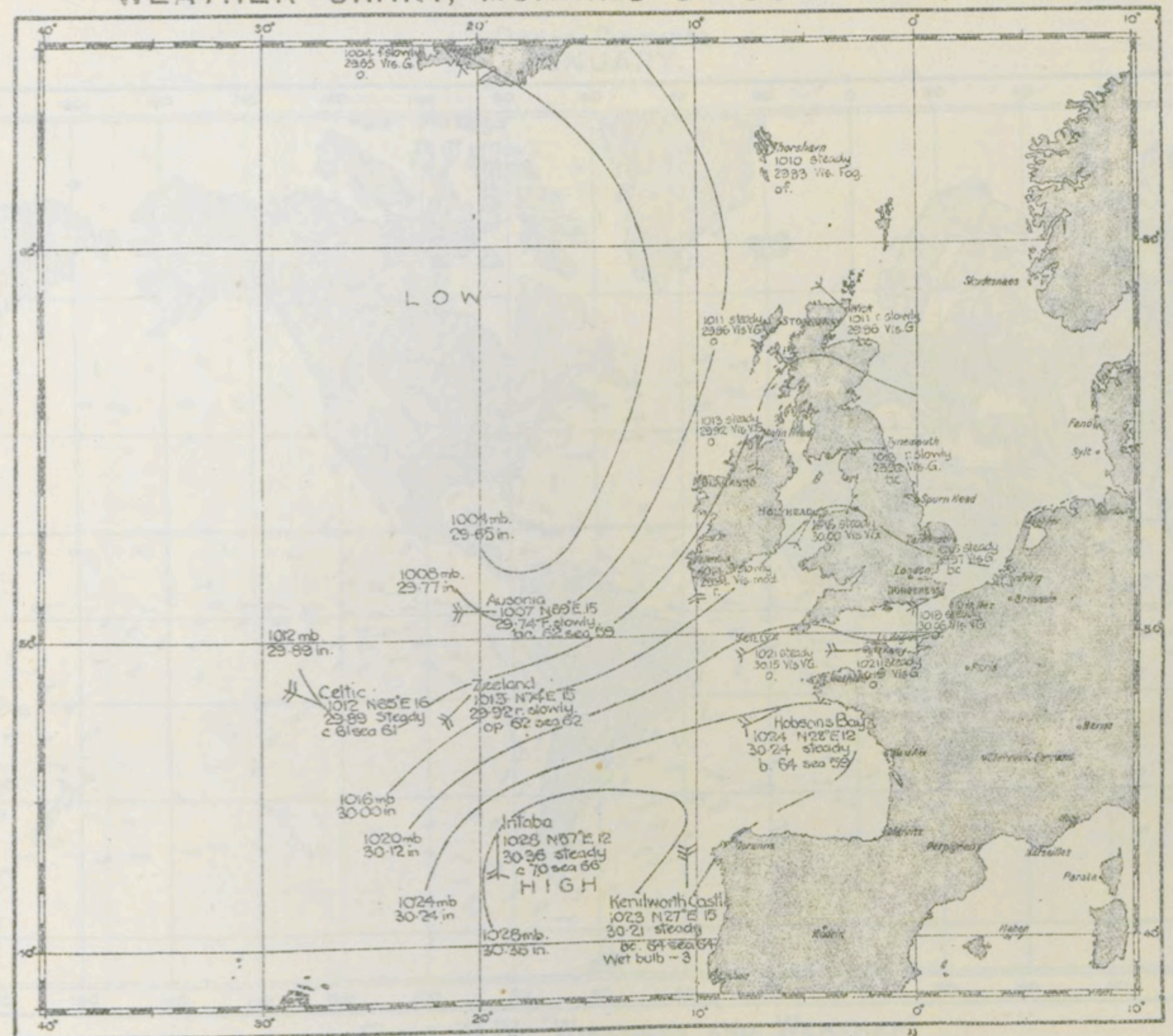


Chart XLII.—"Wireless and Weather."

WEATHER CHART, MORNING OF JULY 11TH, 1926.

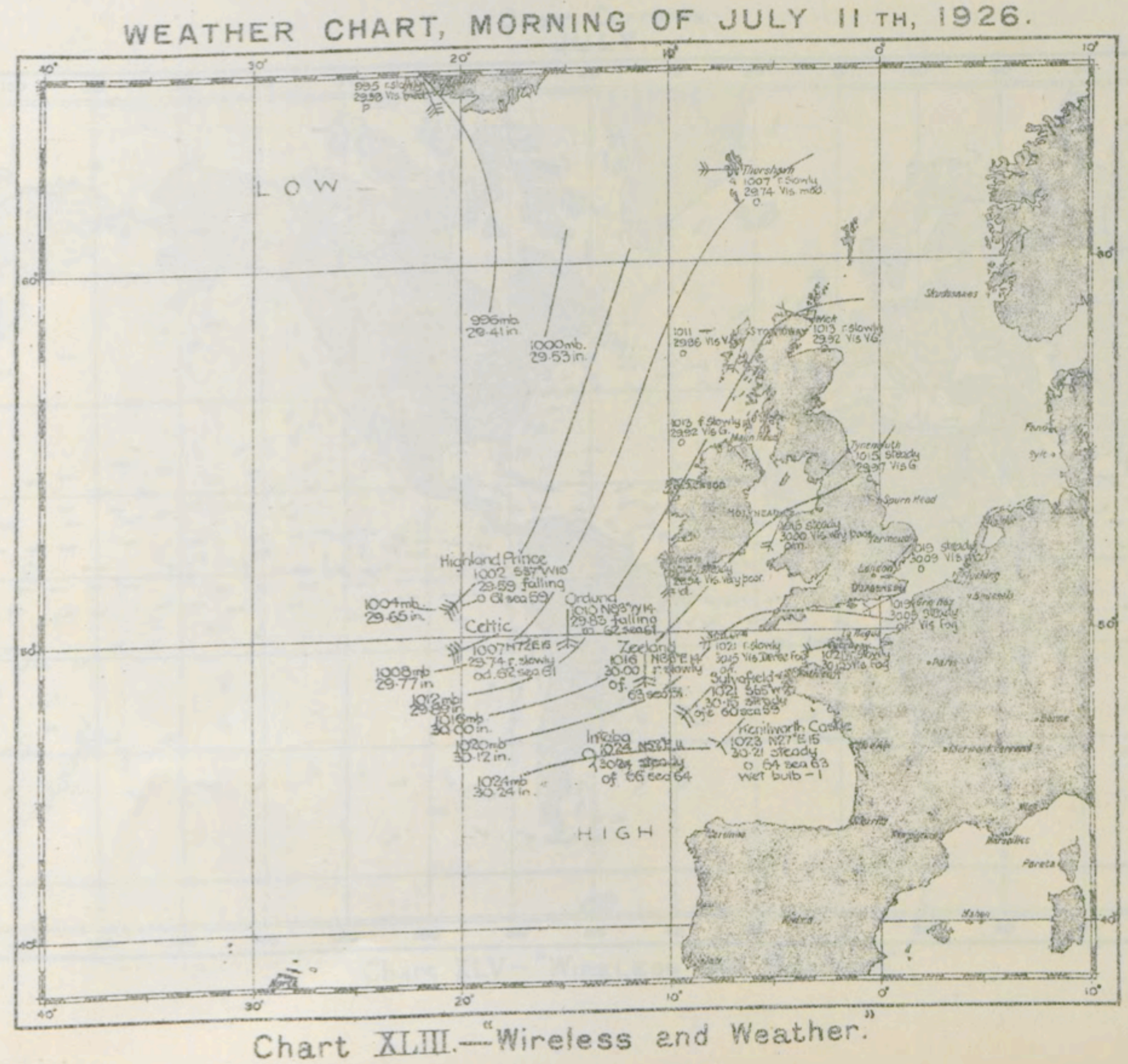


Chart XLIII.—"Wireless and Weather."

Ocean Currents.
JANUARY.

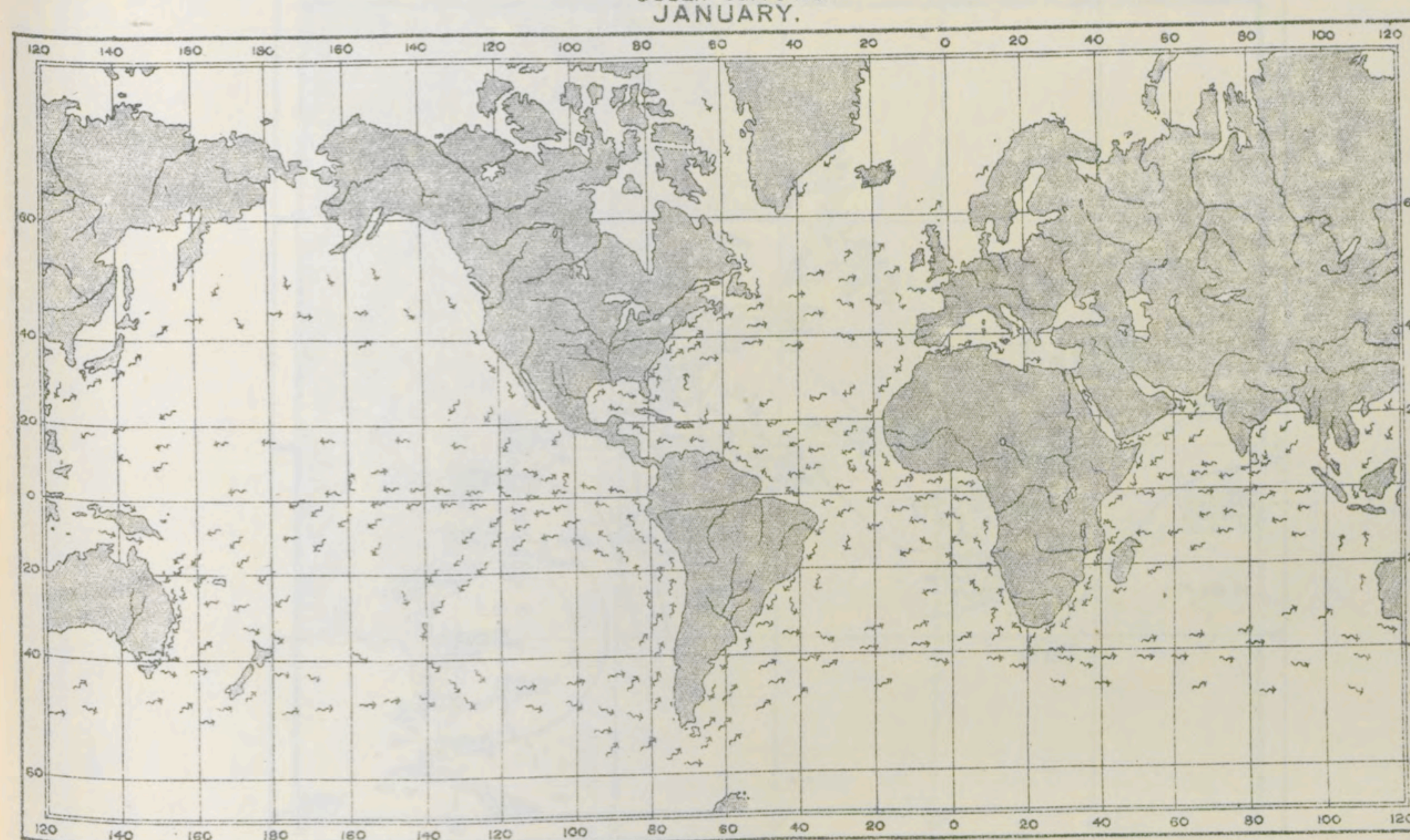


Chart XLIV–"Wireless and Weather."

Ocean Currents.
JULY.

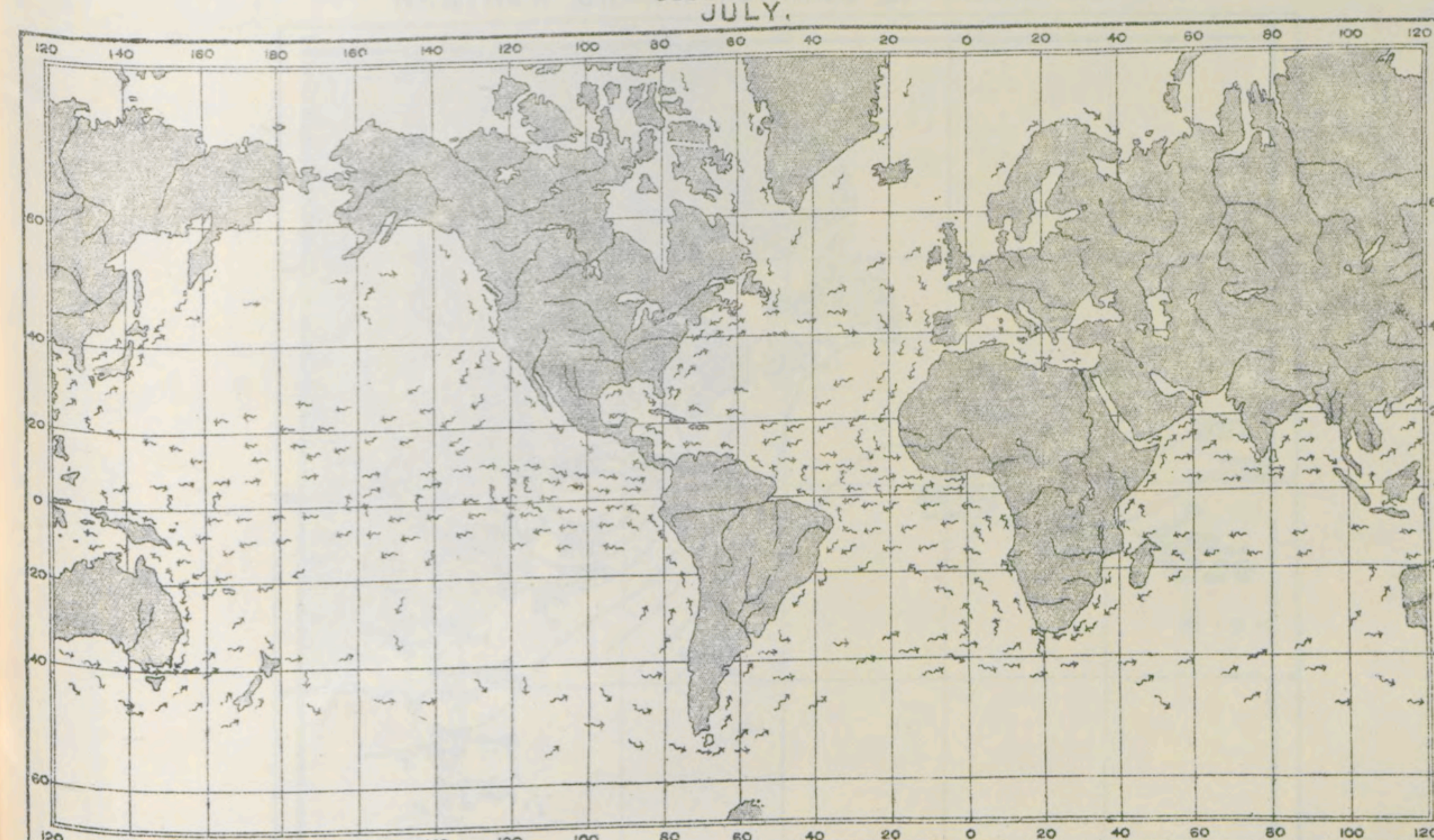


Chart XLV–"Wireless and Weather."

WEATHER CHART, MORNING OF AUGUST 25TH 1924.

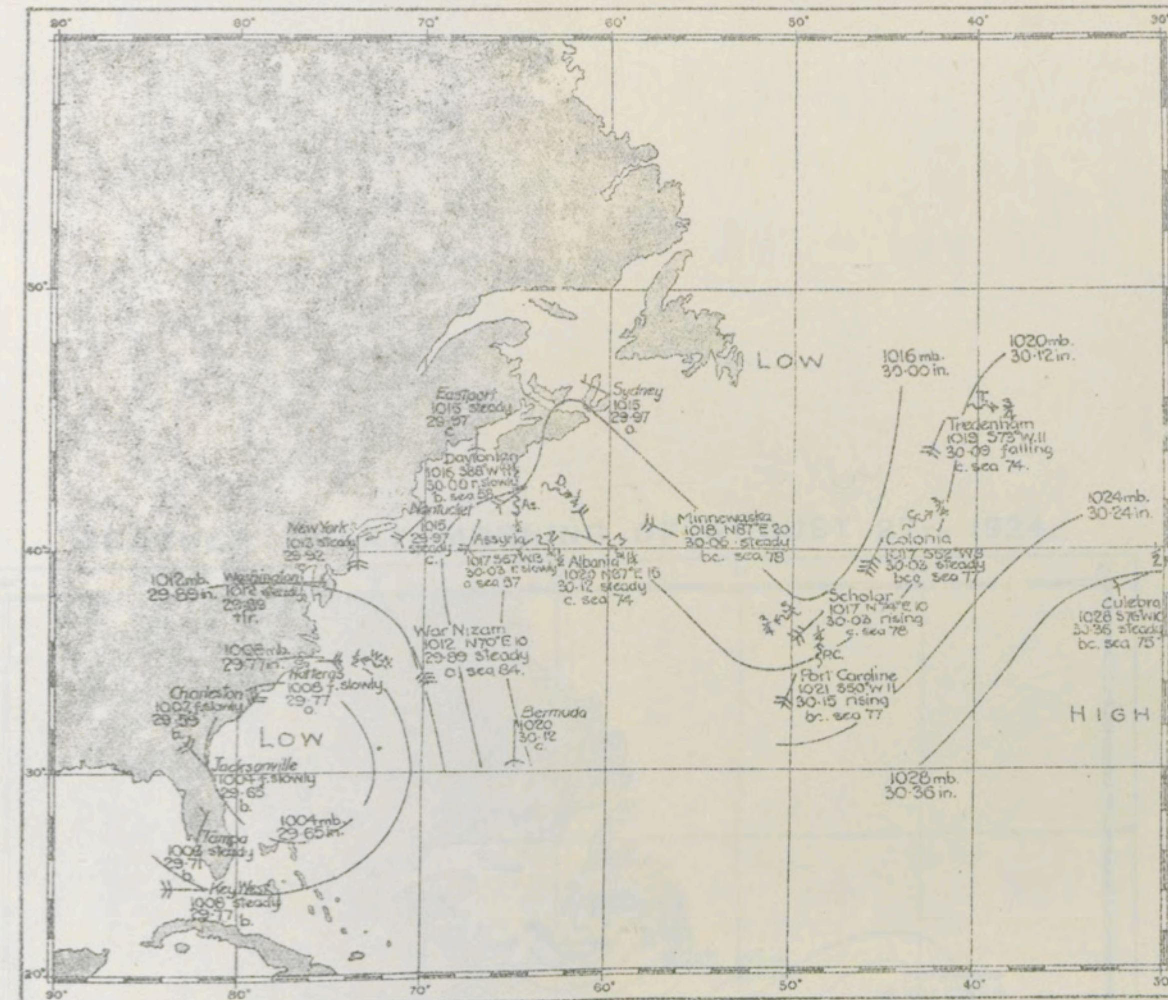


Chart XLVI —"Wireless and Weather."

WEATHER CHART, MORNING OF AUGUST 26TH 1924.

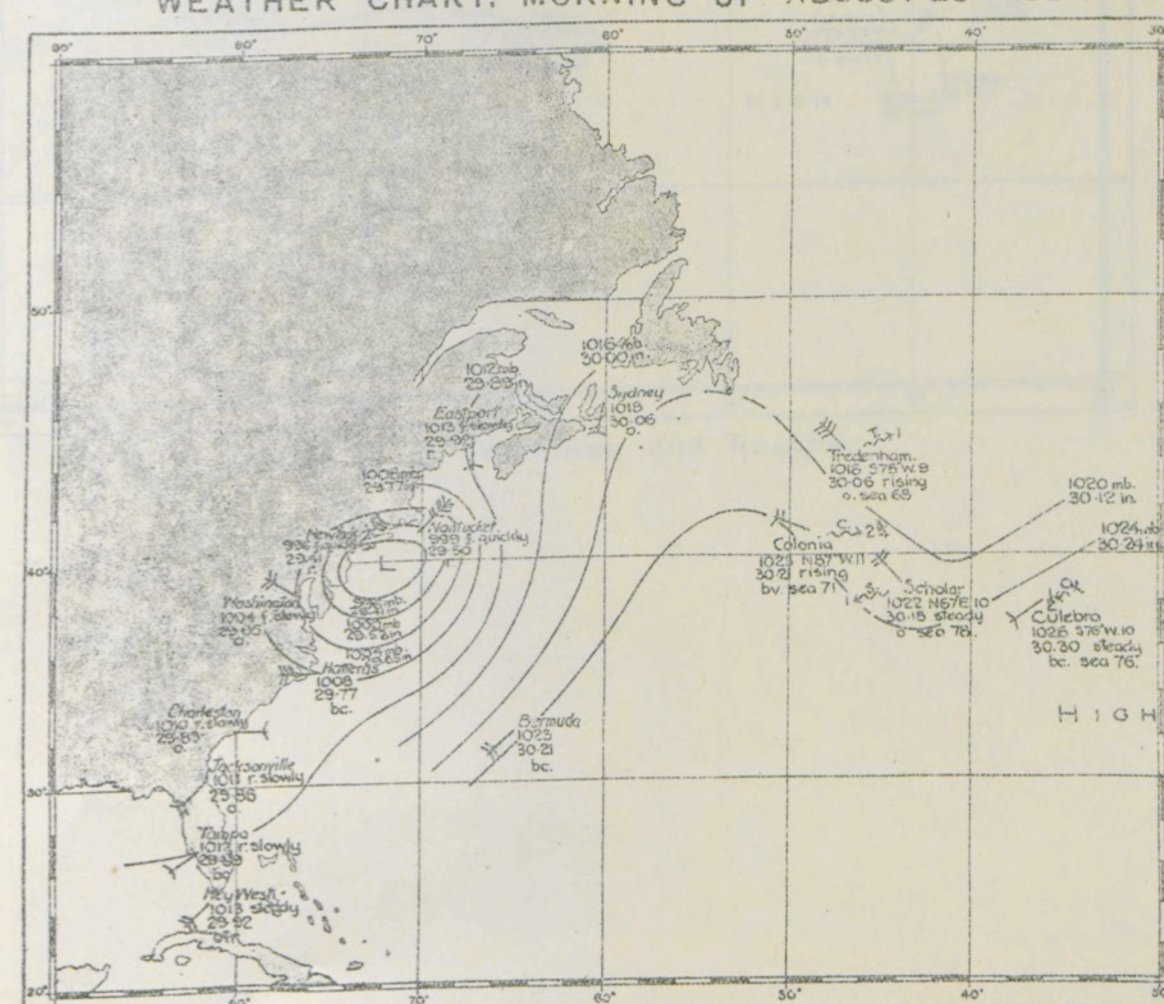


Chart XLVII —"Wireless and Weather."

WEATHER CHART, MORNING OF AUGUST 27TH. 1924.

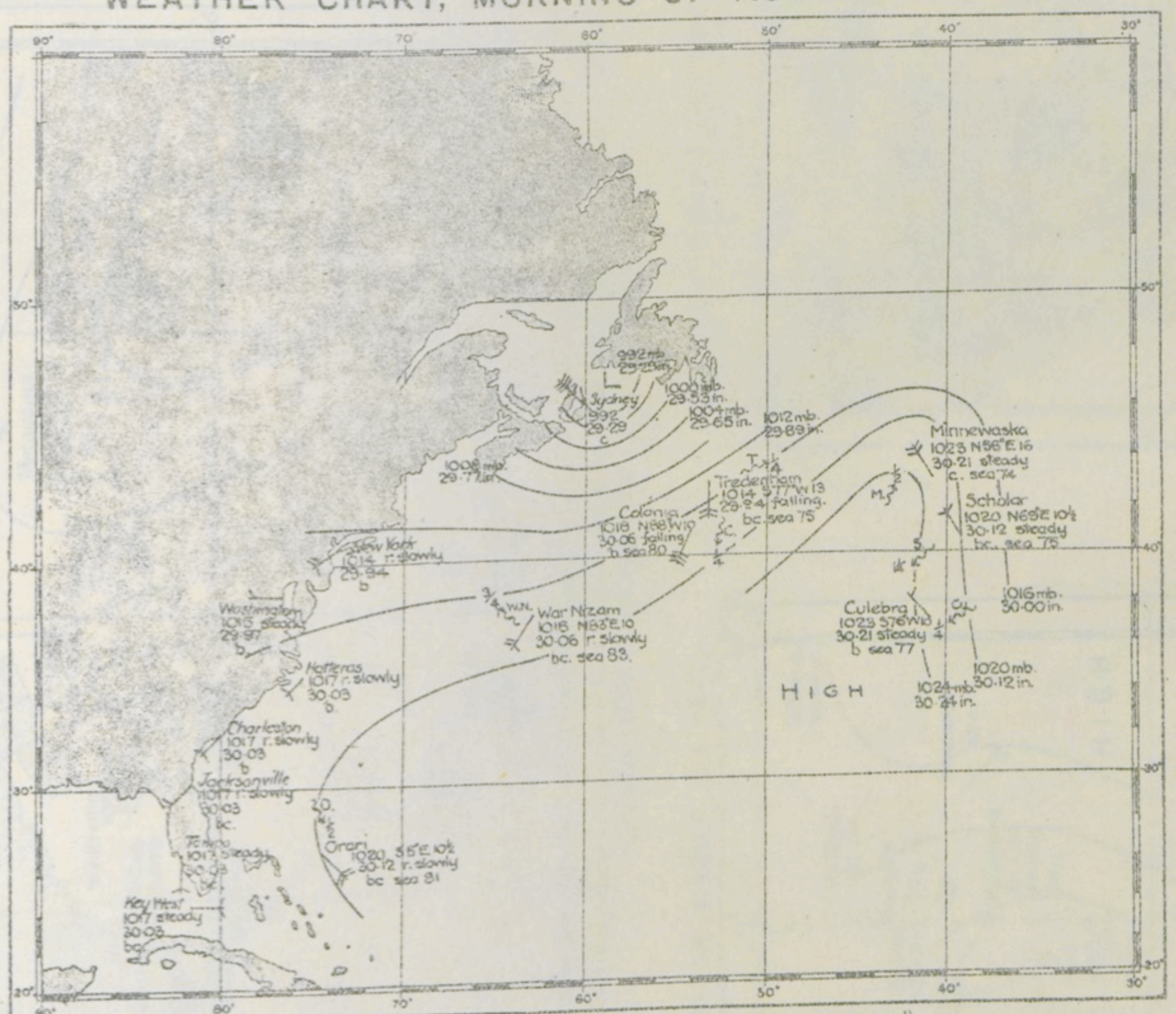


Chart XLVIII—"Wireless and Weather."

WEATHER CHART, MORNING OF DECEMBER 11TH. 1921.

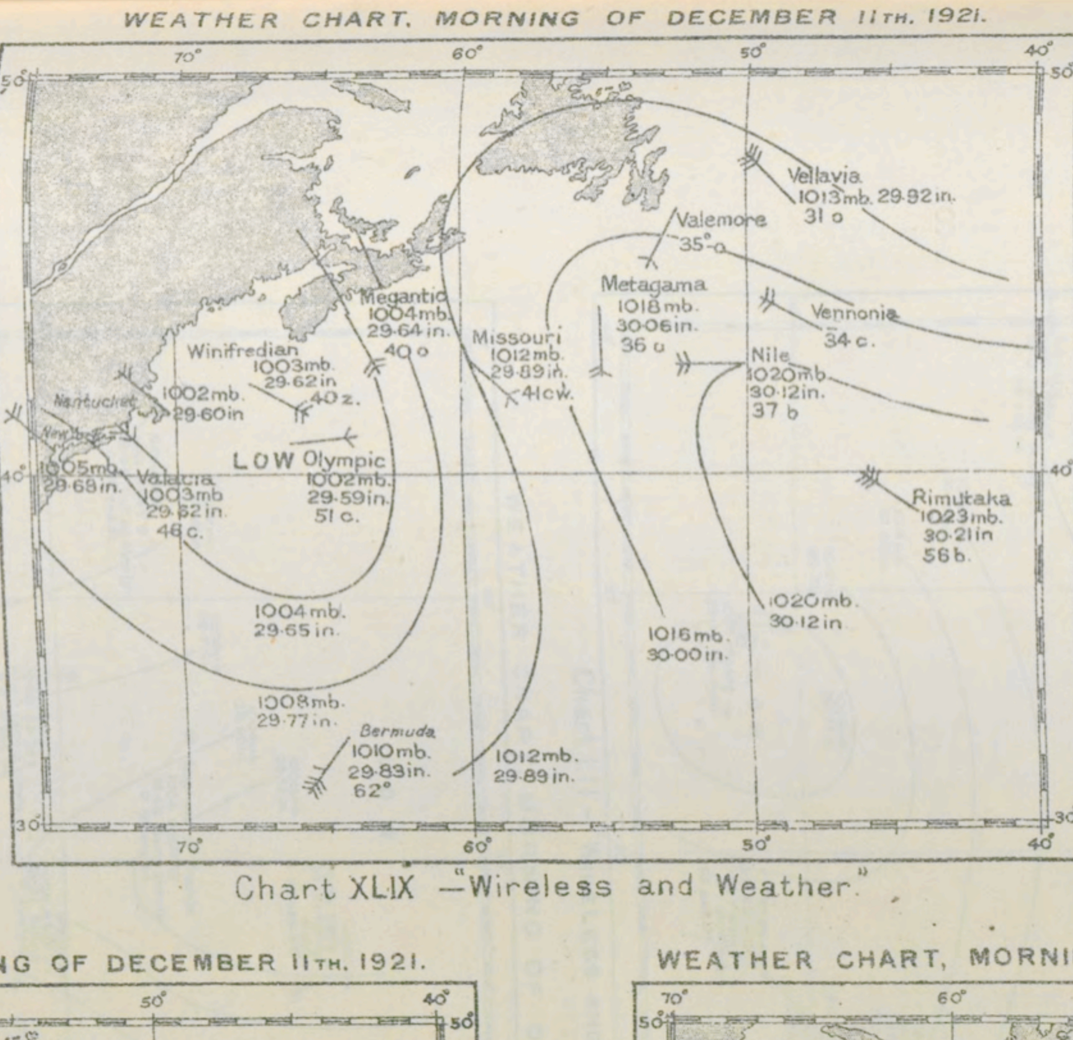


Chart XLIX "Wireless and Weather."

WEATHER CHART, EVENING OF DECEMBER 11TH. 1921.

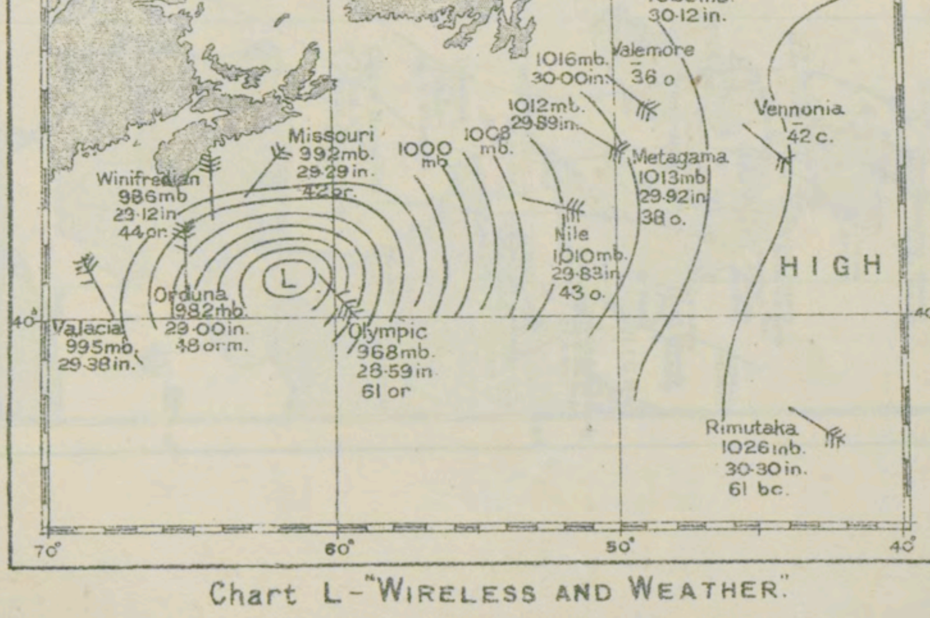


Chart L-"WIRELESS AND WEATHER."

WEATHER CHART, MORNING OF DECEMBER 12TH. 1921.

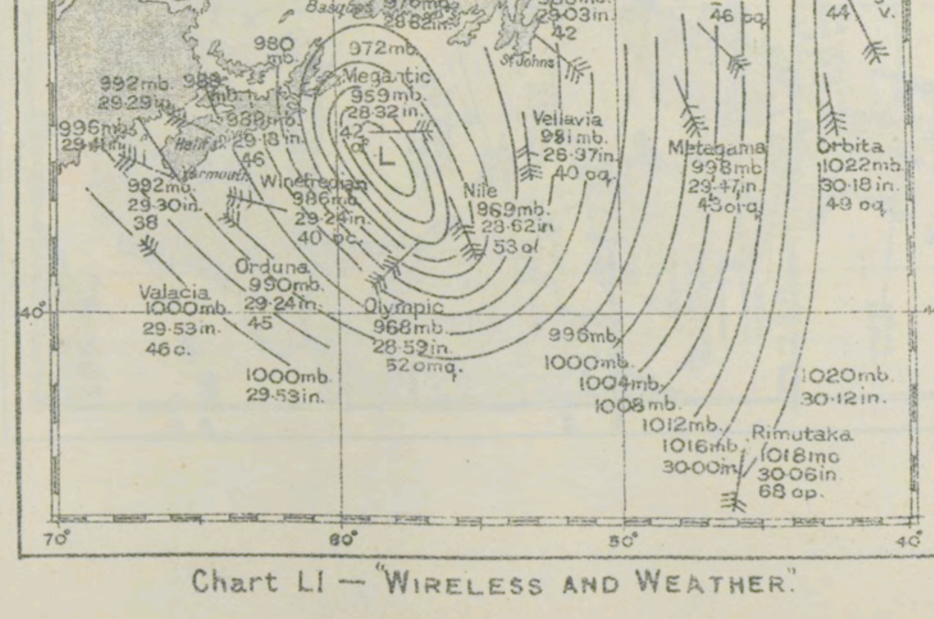


Chart LI — "WIRELESS AND WEATHER."

WEATHER CHART, MORNING OF OCTOBER, 17TH., 1923.

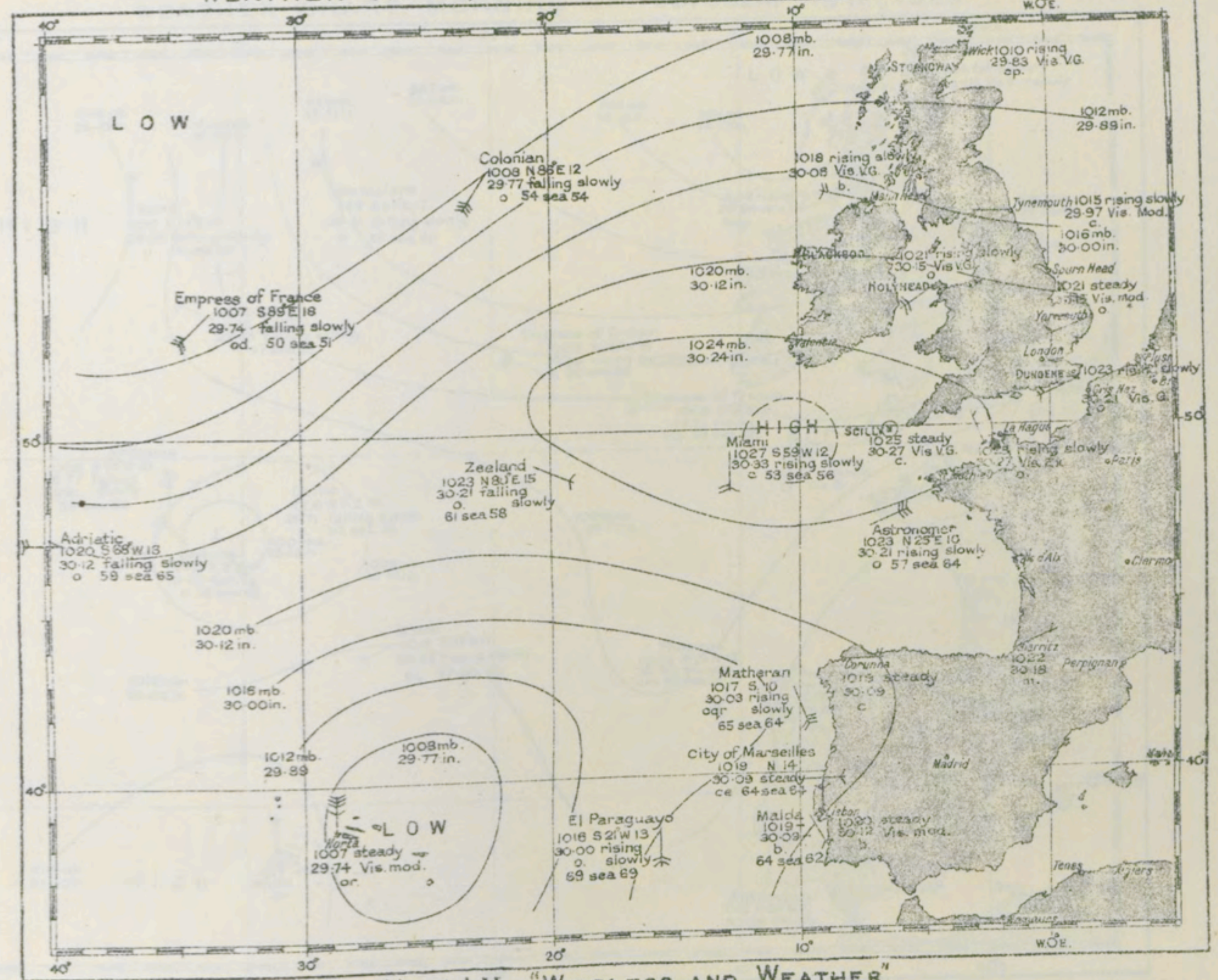


Chart LII – "Wireless and Weather"

WEATHER CHART, MORNING OF OCTOBER, 18TH., 1923.

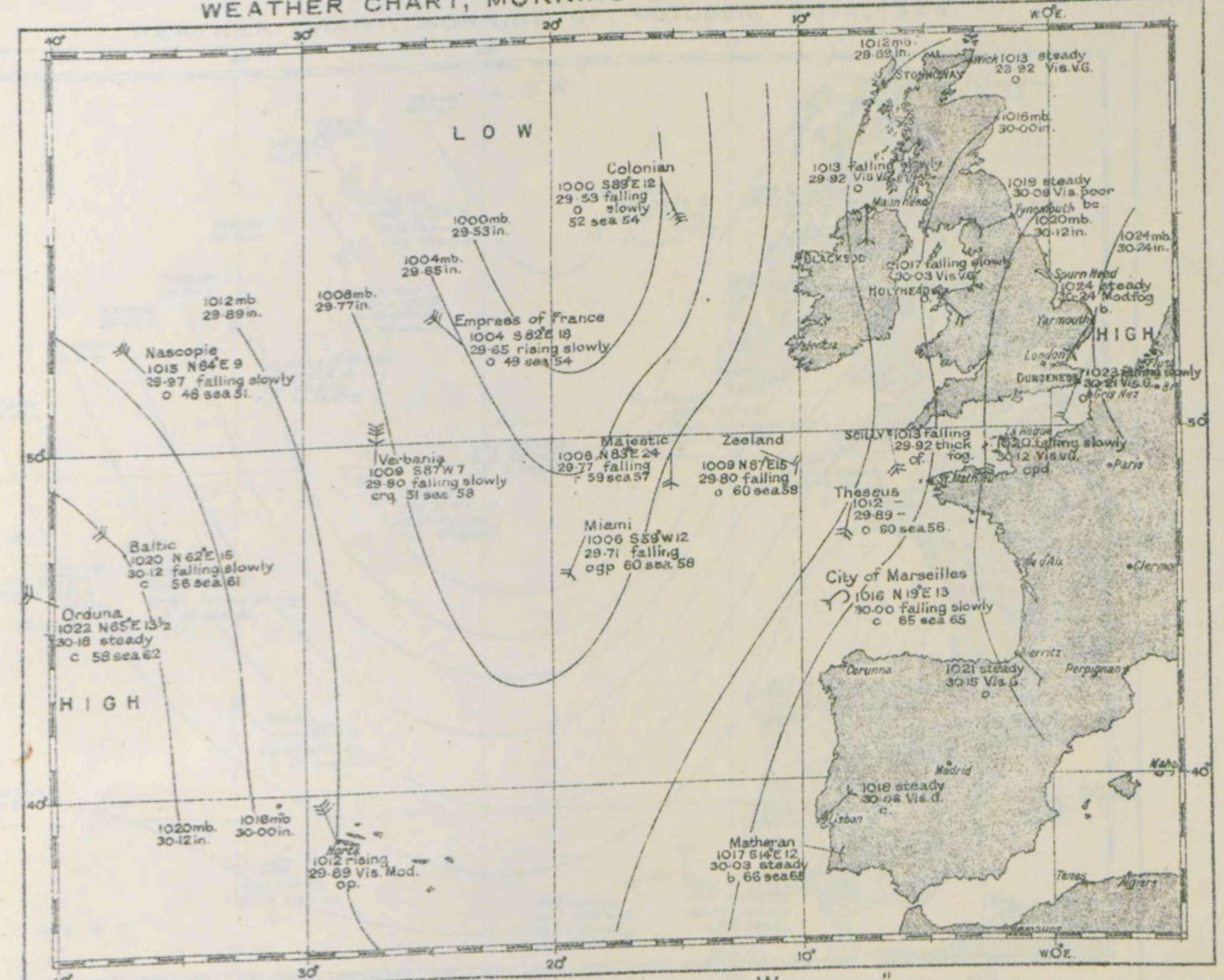


Chart LIII – "Wireless and Weather"

WEATHER CHART, MORNING OF OCTOBER, 19TH., 1923.

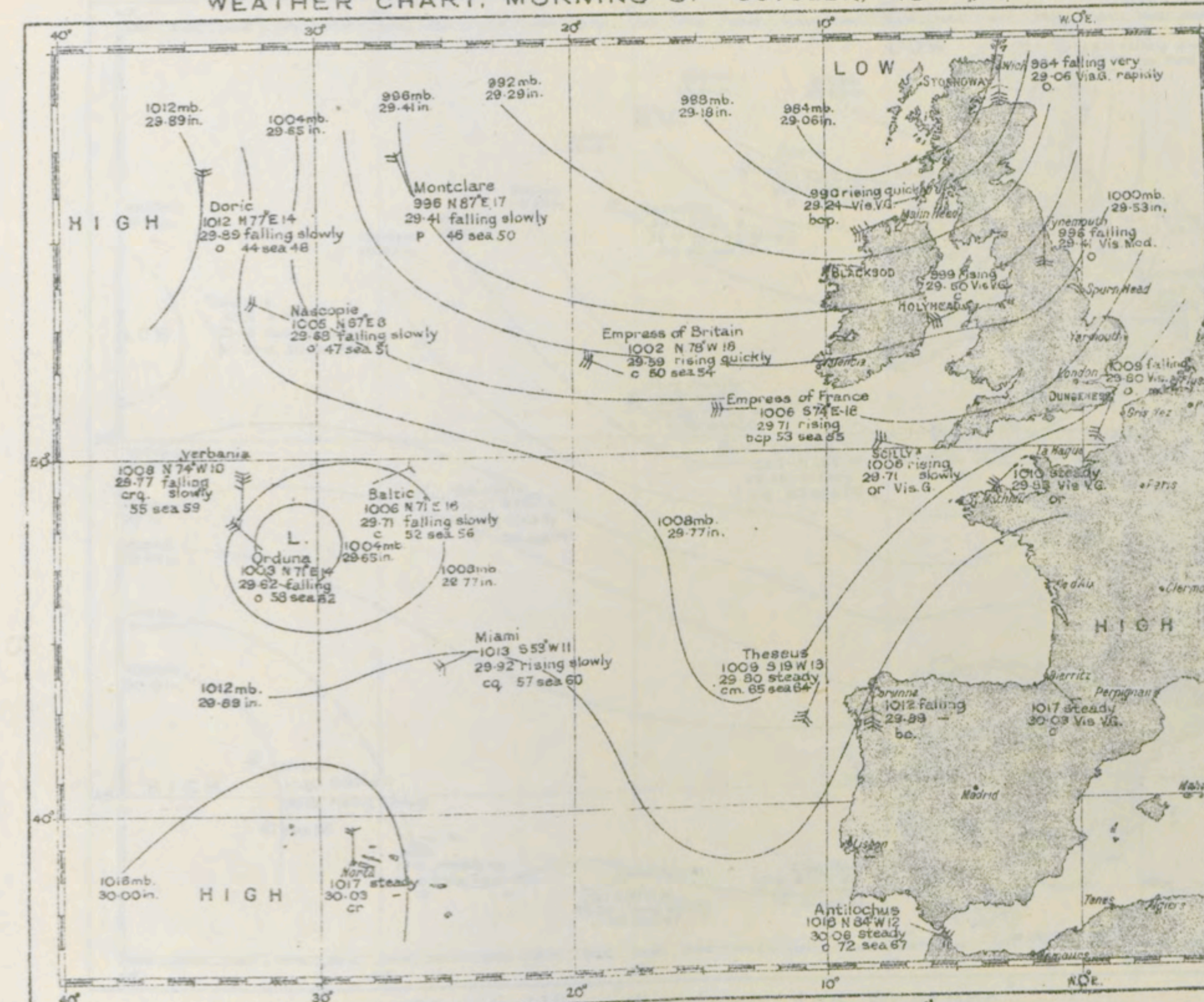


Chart LIV — "Wireless and Weather."

WEATHER CHART, MORNING OF OCTOBER, 20TH., 1923.

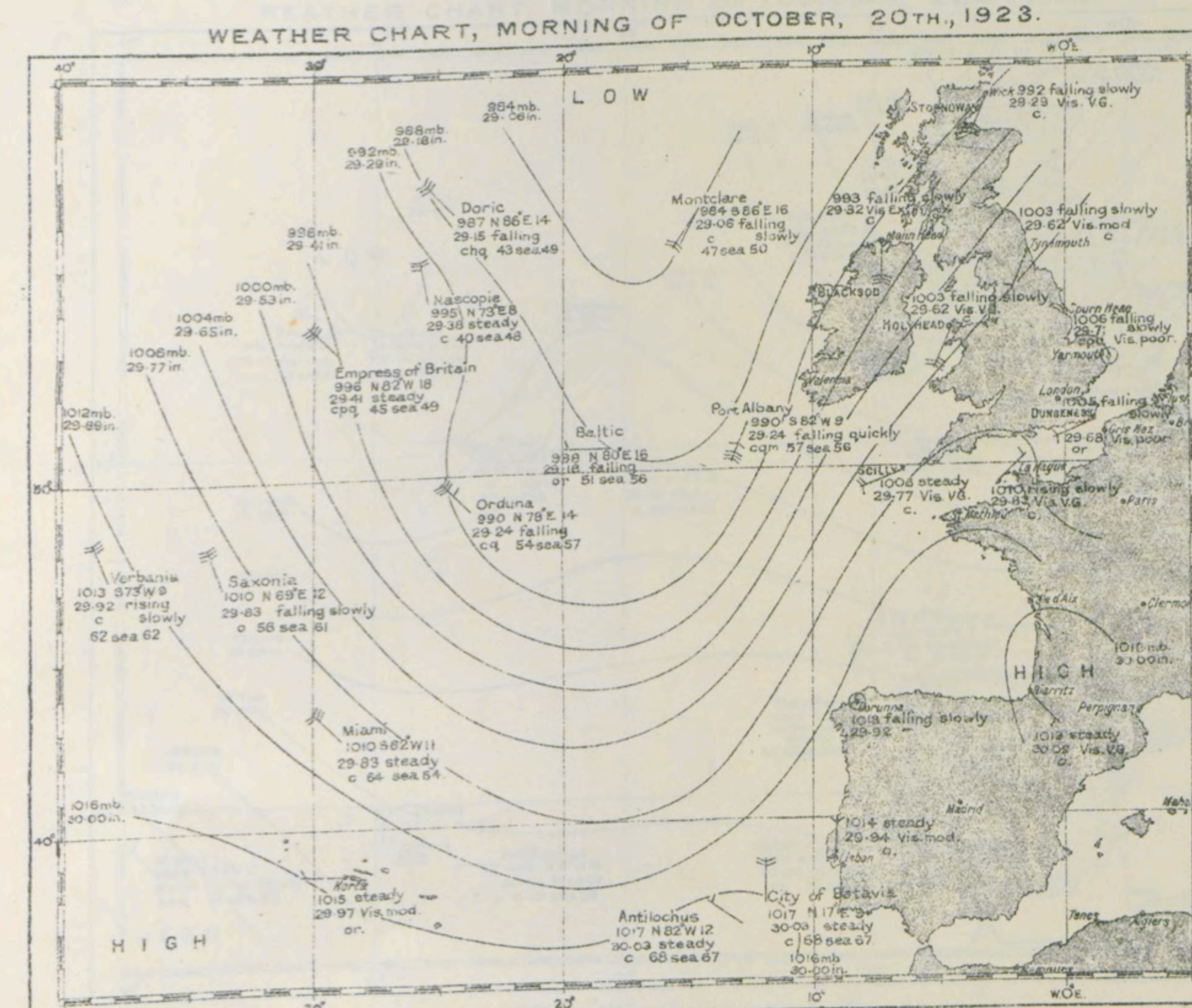


Chart LV — "Wireless and Weather"

WEATHER CHART, MORNING OF OCTOBER 21st., 1923.

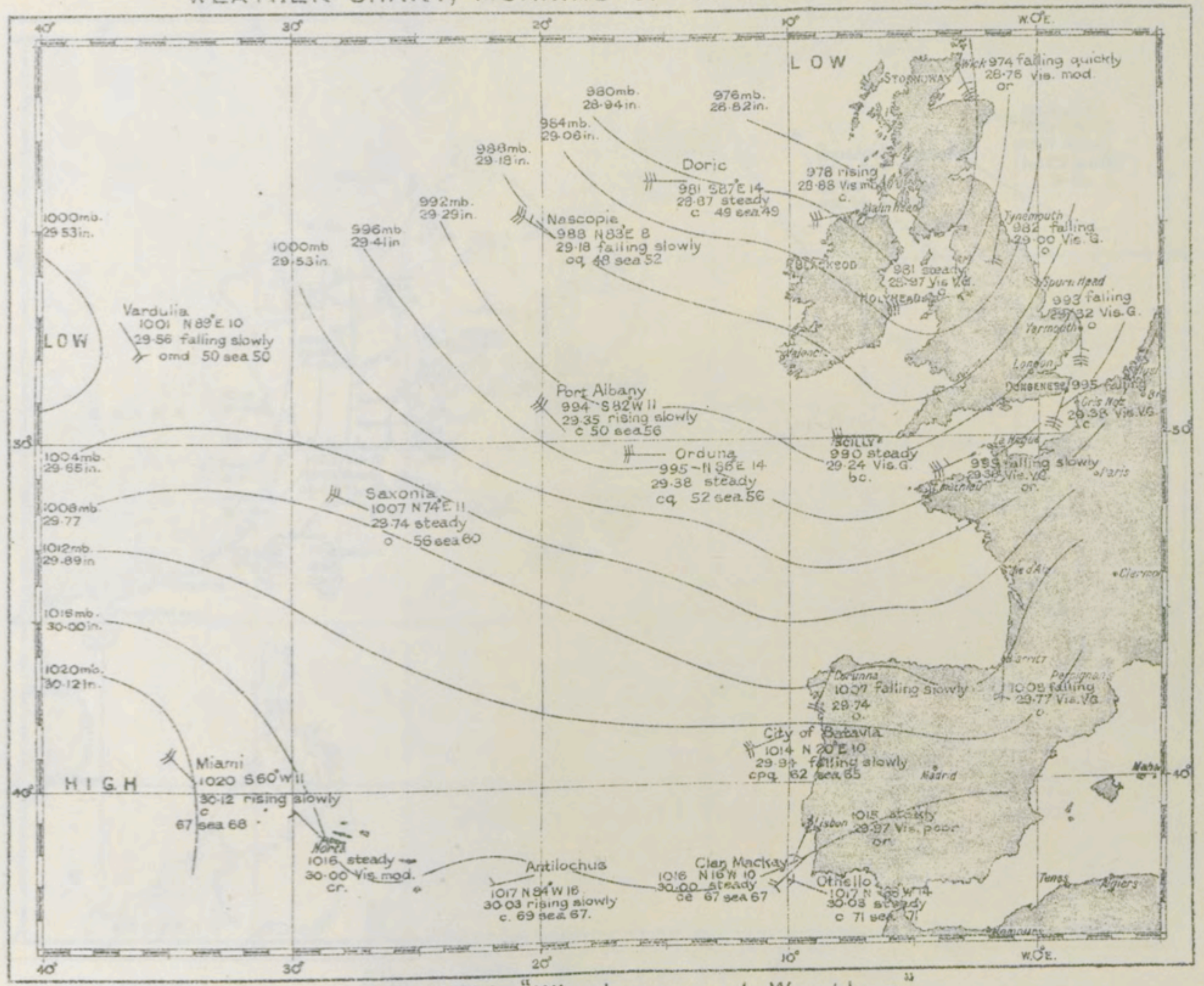


Chart LVI —"Wireless and Weather."

WEATHER CHART, MORNING OF OCTOBER, 22nd., 1923.

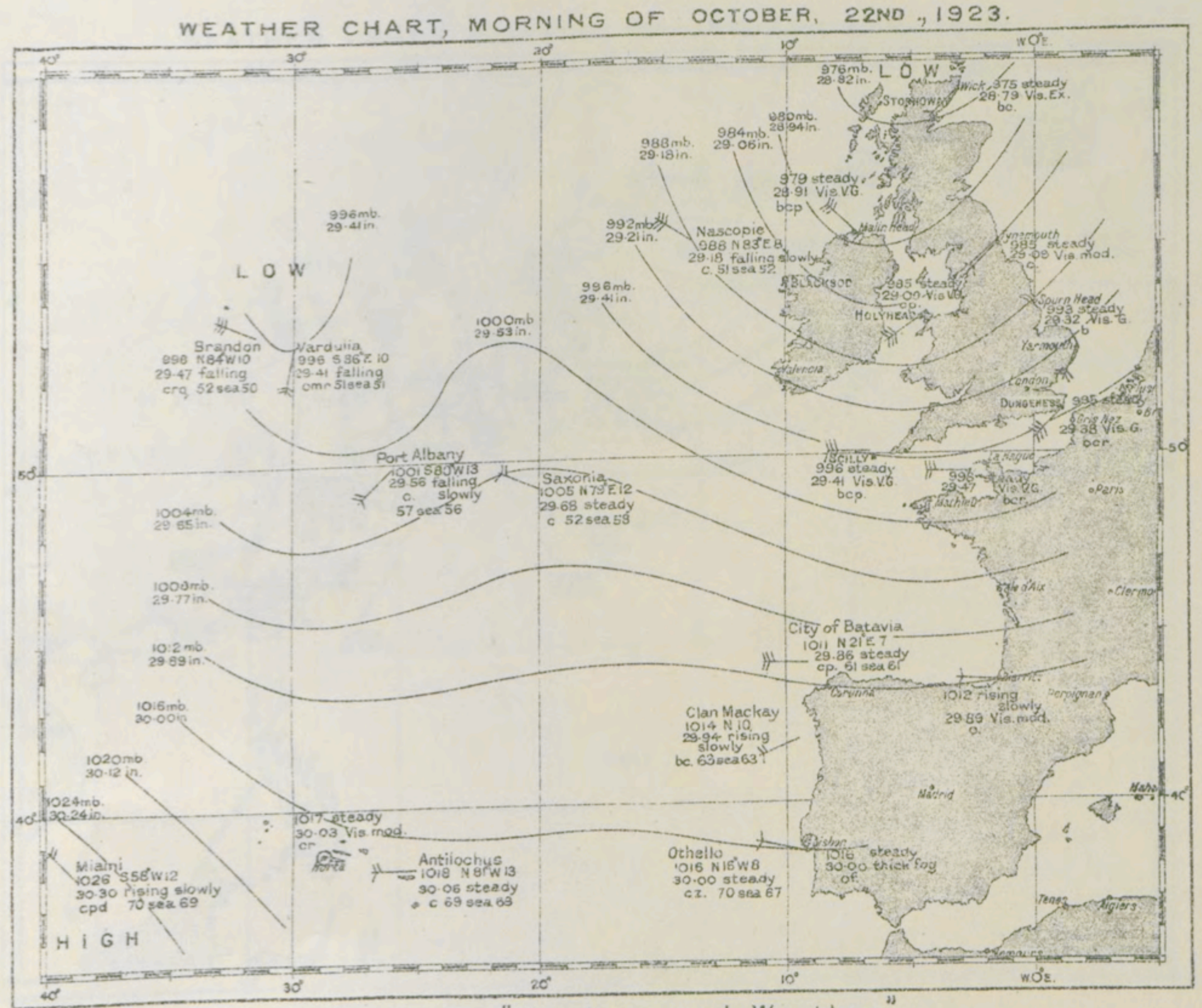


Chart LVII —"Wireless and Weather."

WEATHER CHART, MORNING OF JANUARY 19TH., 1926.

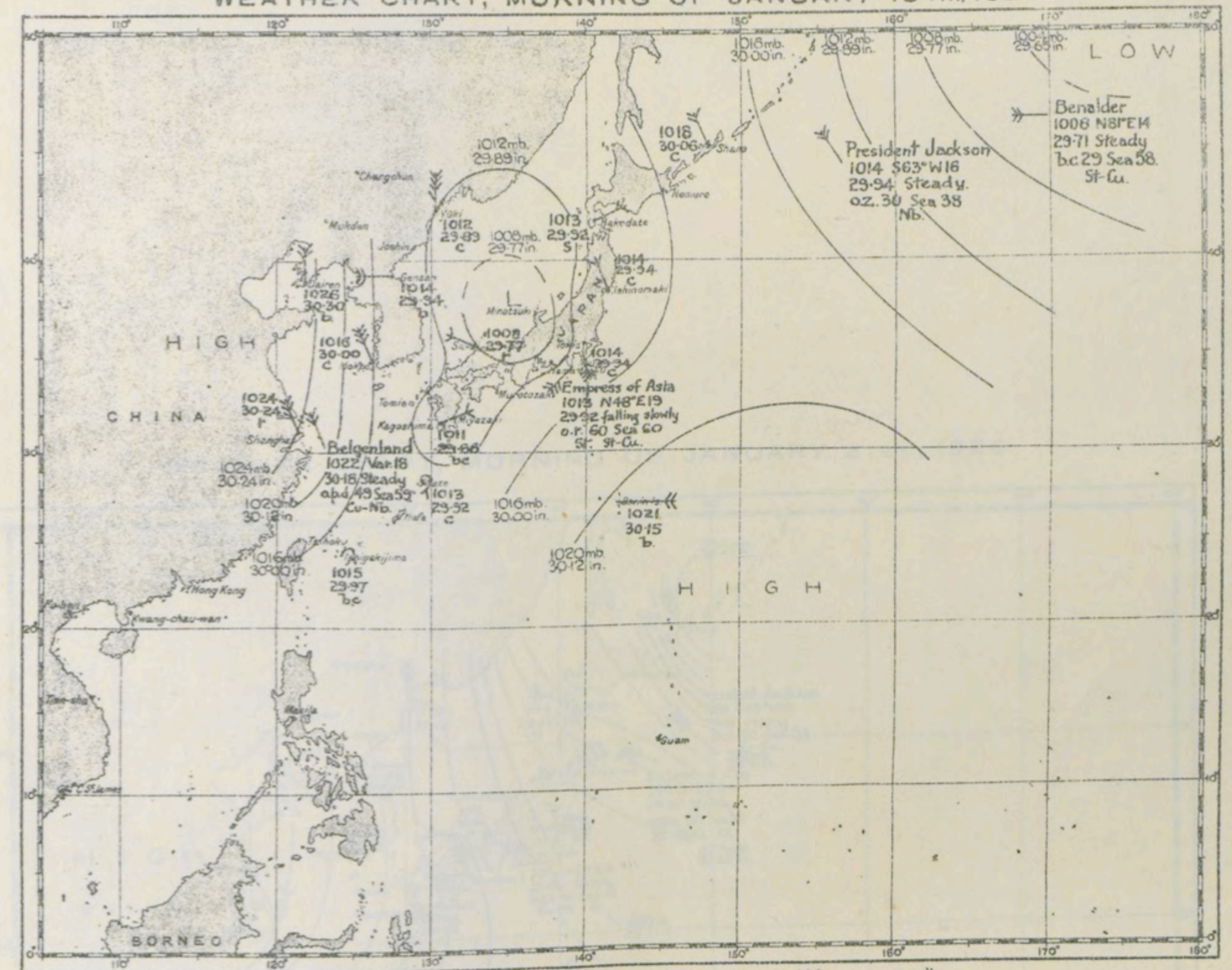


Chart LVIII—"Wireless and Weather".

WEATHER CHART, MORNING OF JANUARY 20TH., 1926.

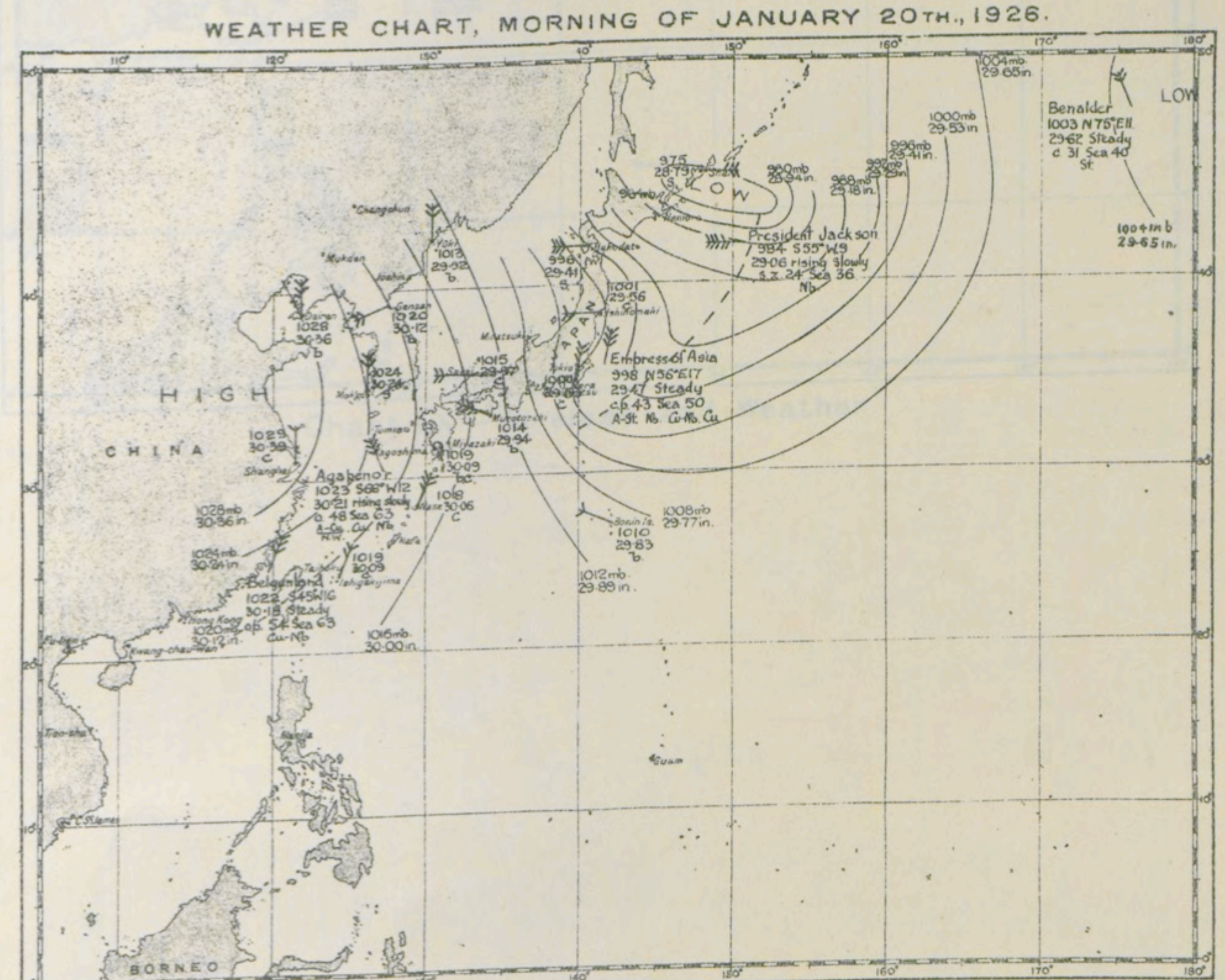


Chart LIX—"Wireless and Weather".

WEATHER CHART, MORNING OF JANUARY 21st., 1926.

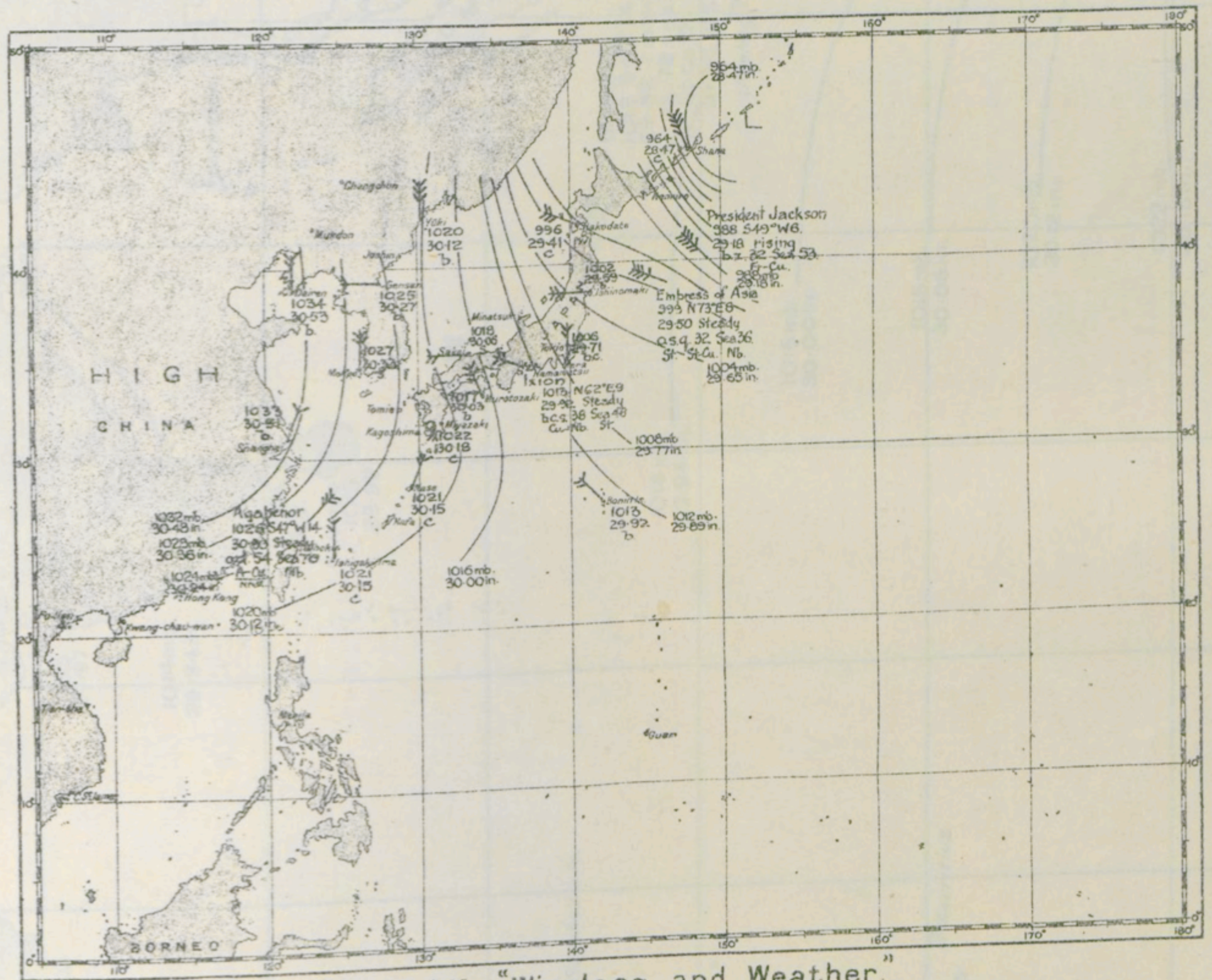


Chart LX—"Wireless and Weather"

WEATHER CHART, MORNING OF NOVEMBER 7TH. 1923.

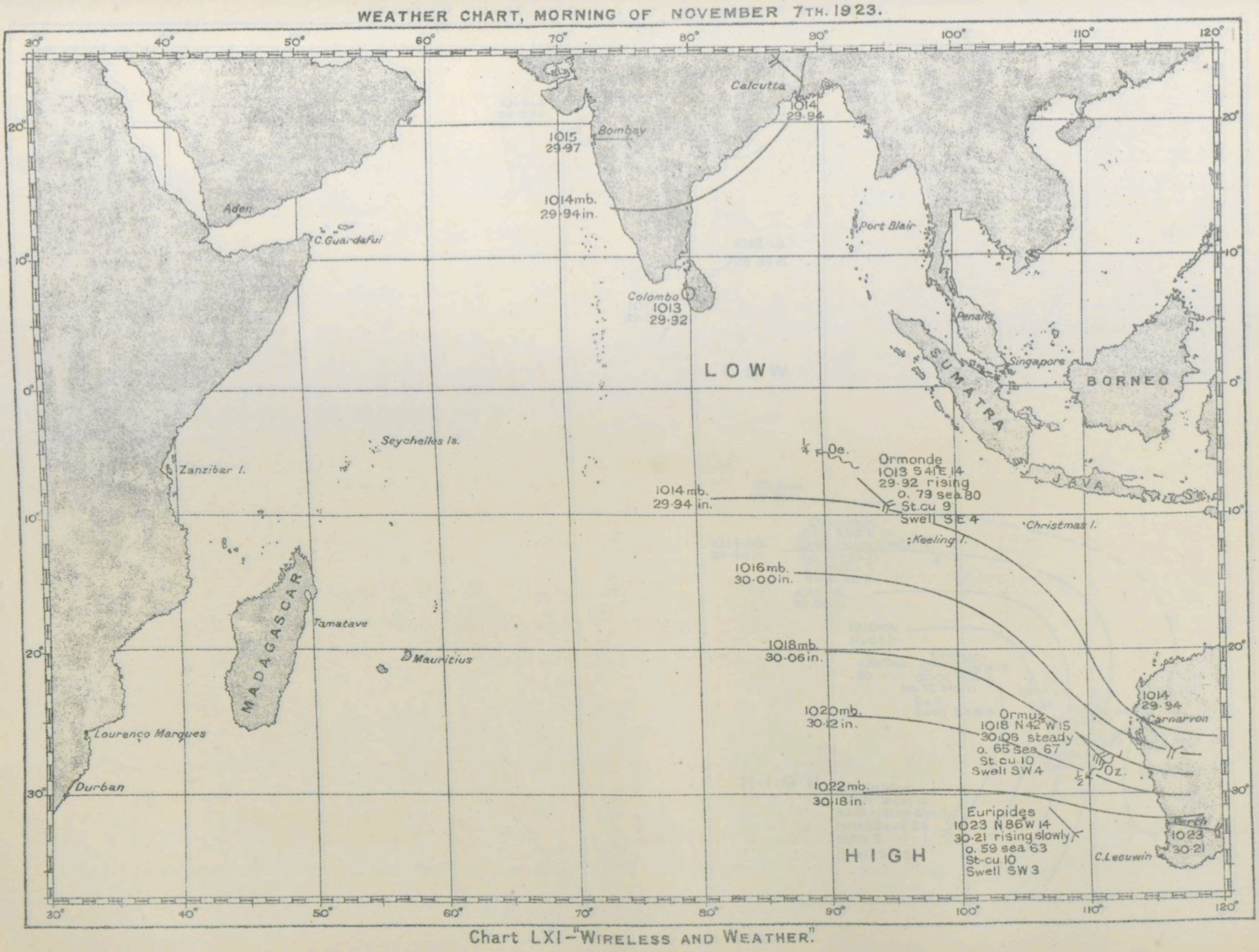


Chart LXI—"WIRELESS AND WEATHER."

WEATHER CHART, MORNING OF NOVEMBER 8TH. 1923.

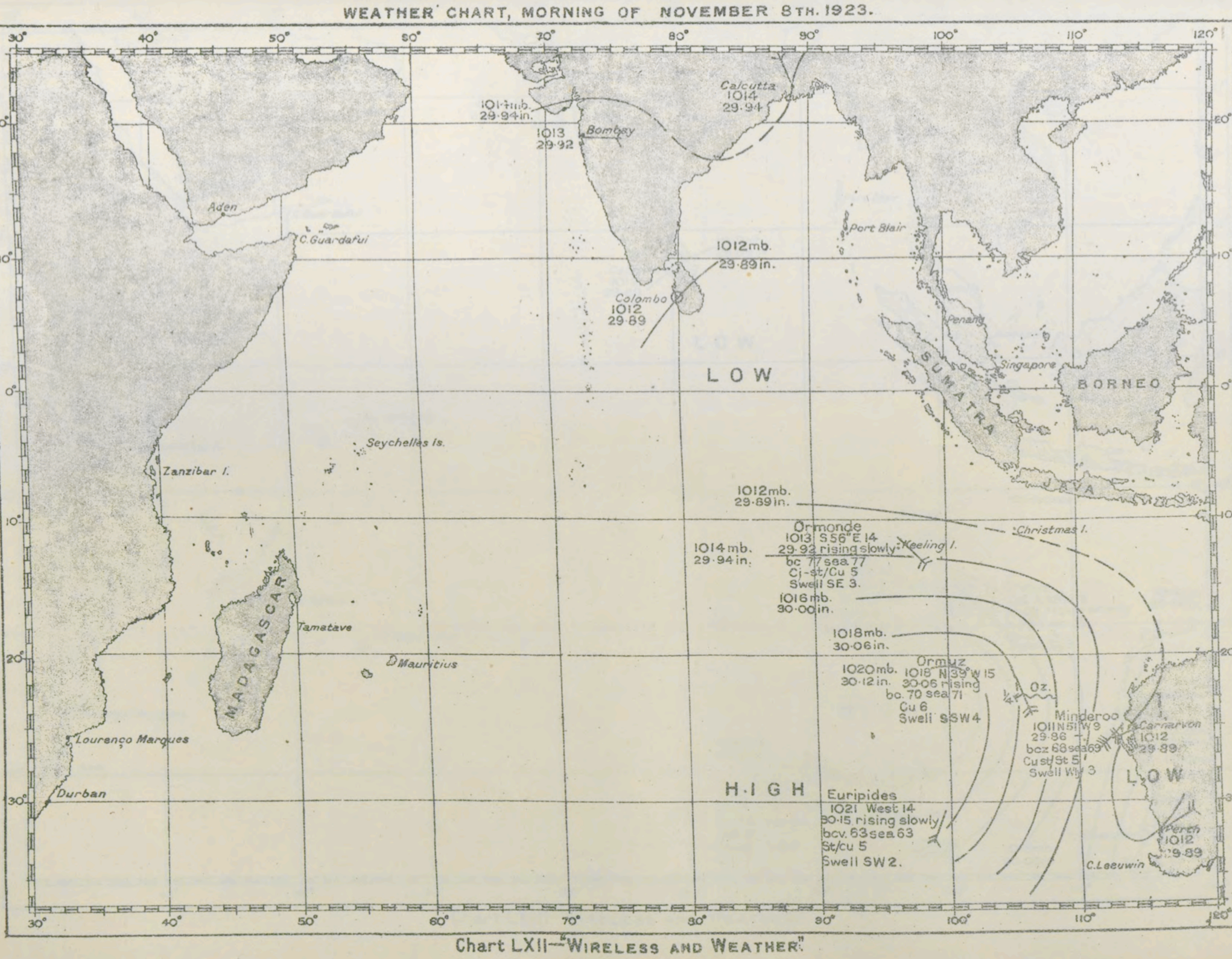


Chart LXII—"Wireless and Weather."

WEATHER CHART, MORNING OF NOVEMBER 9TH. 1923.

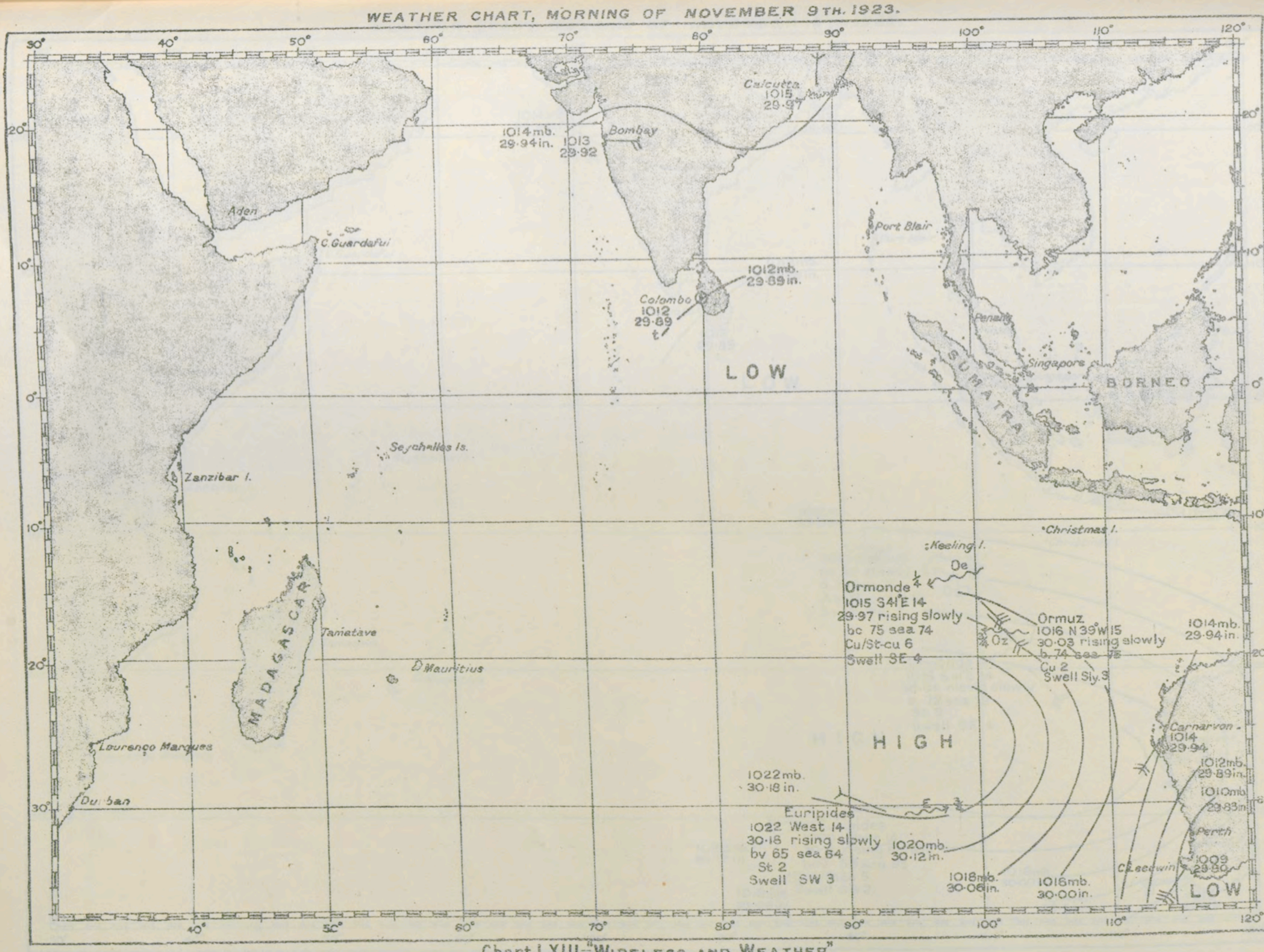


Chart LXIII "Wireless and Weather."

WEATHER CHART, MORNING OF NOVEMBER 10TH. 1923.

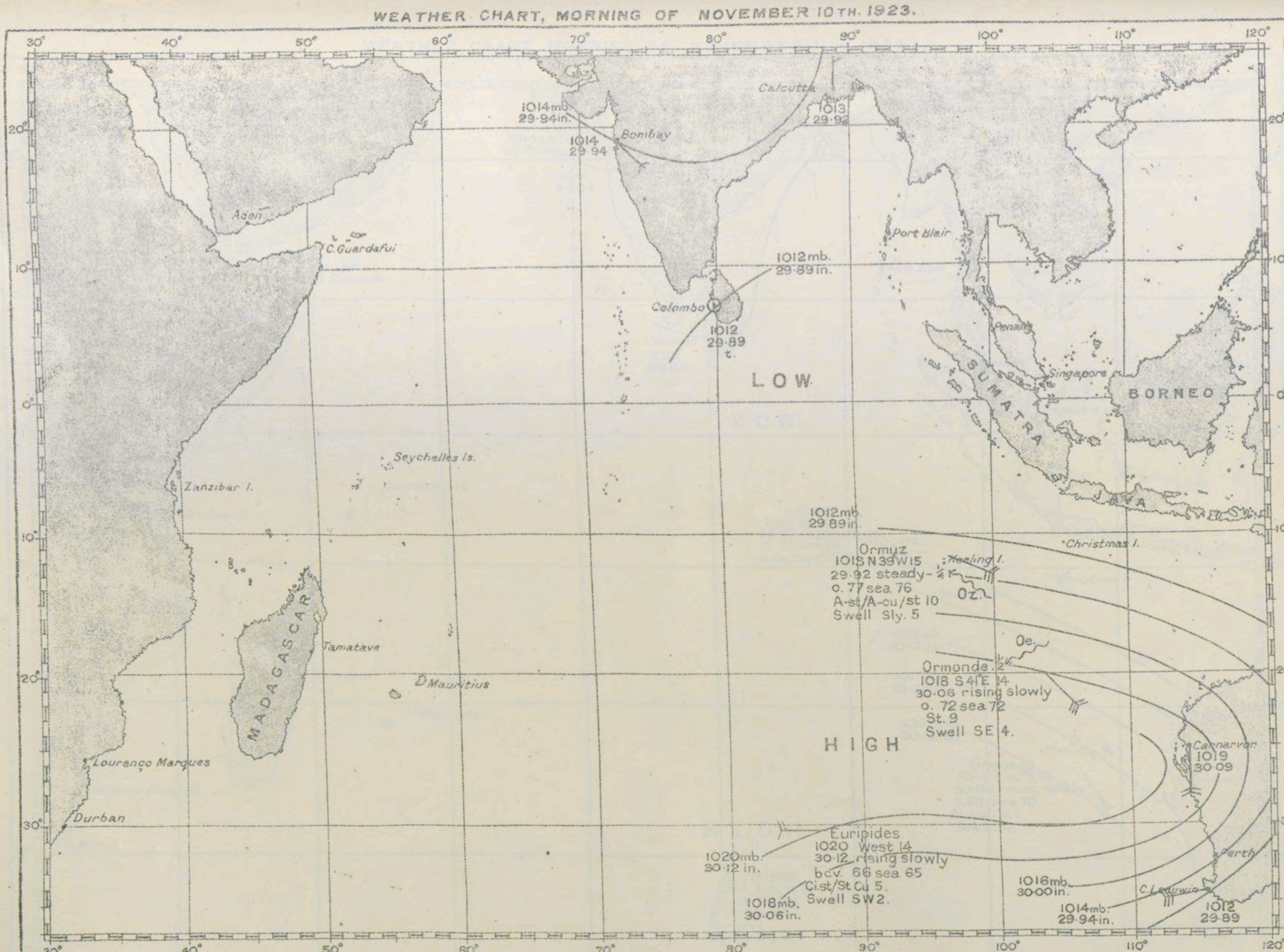


Chart LXIV—"WIRELESS AND WEATHER."

WEATHER CHART, MORNING OF NOVEMBER 11TH. 1923.

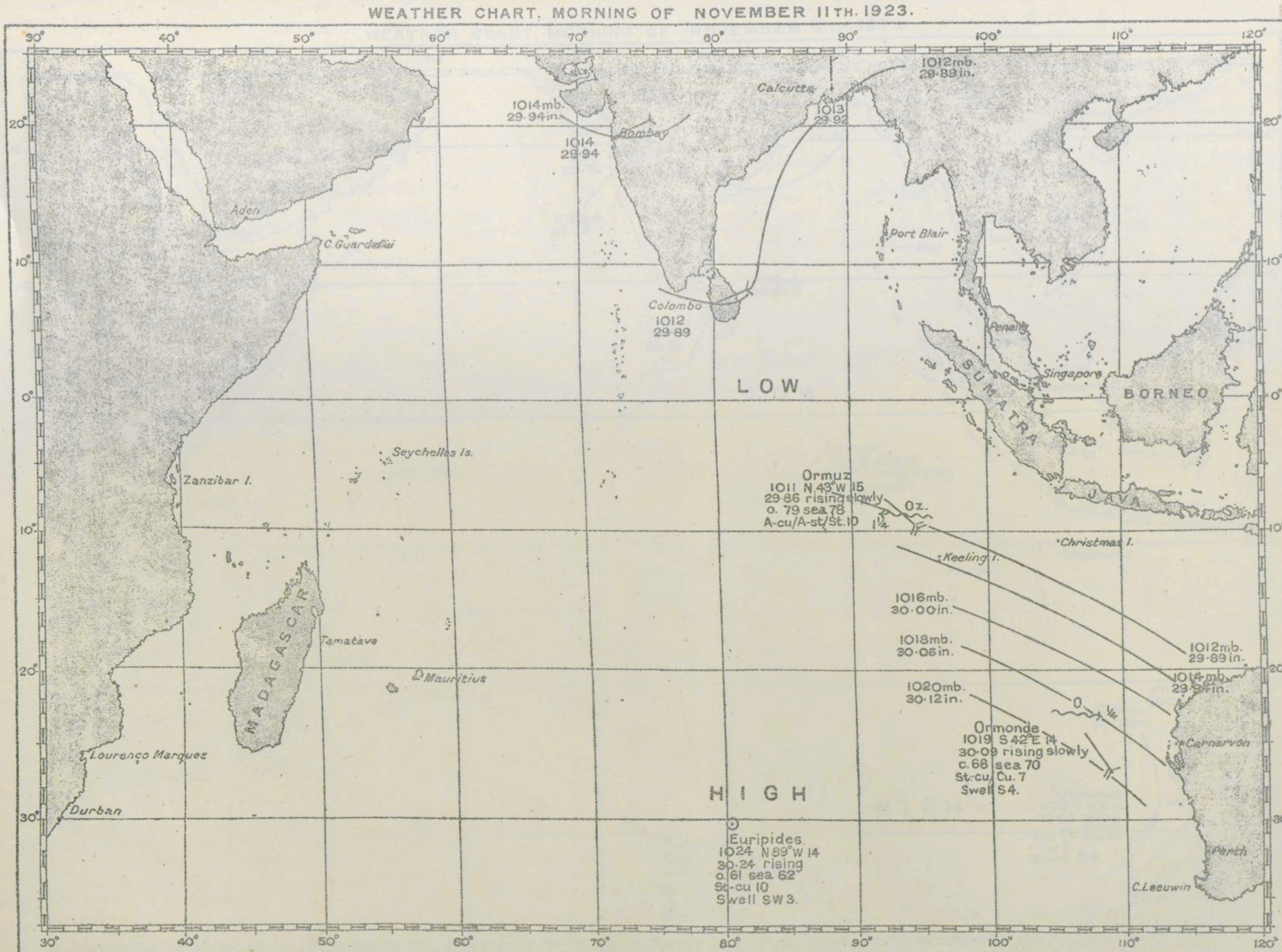


Chart LXV—"Wireless and Weather."

WEATHER CHART, MORNING OF NOVEMBER 12TH. 1923.

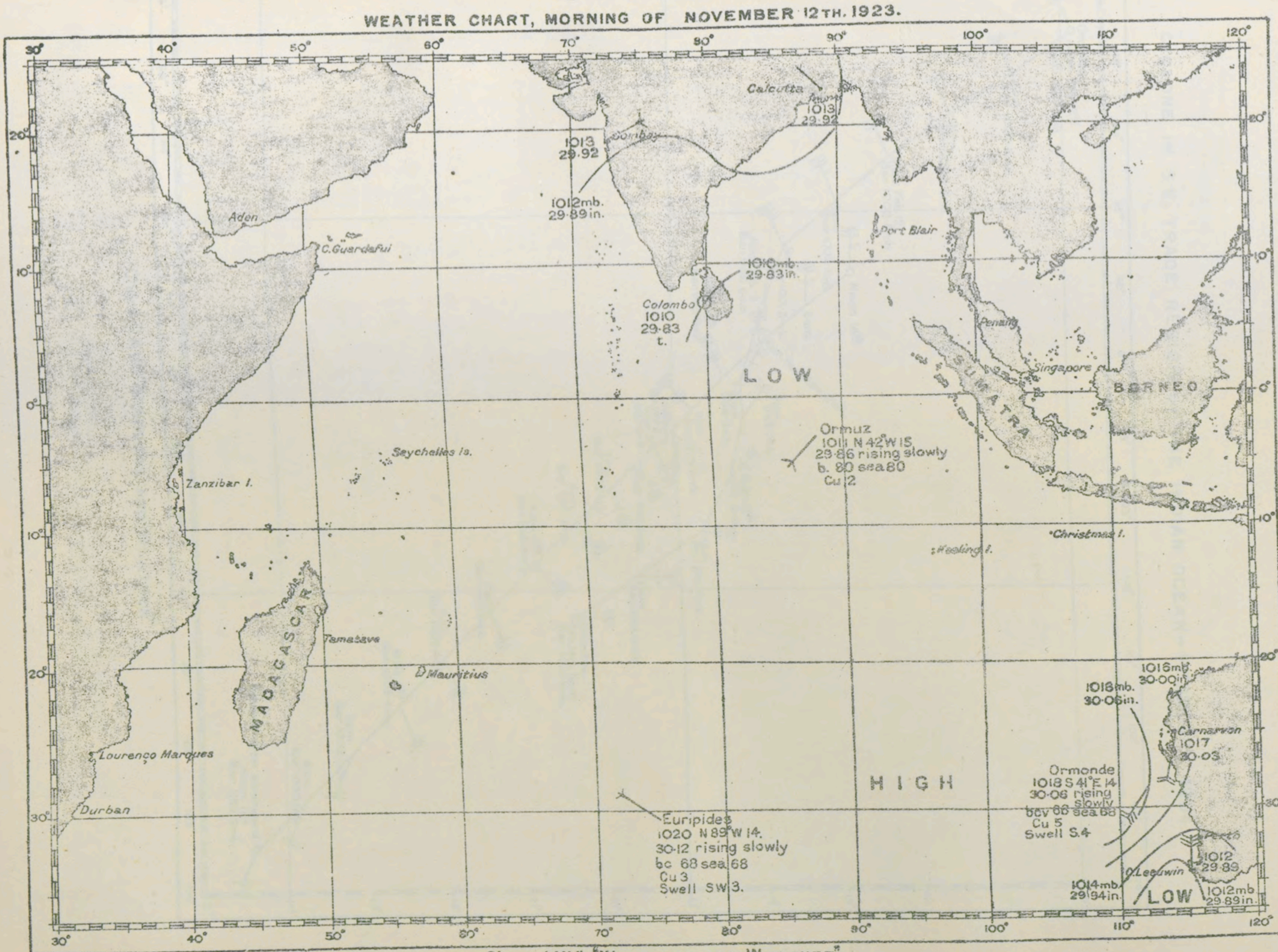


Chart LXVI—"Wireless and Weather."

CYCLONE IN S.E. TRADE REGION OF THE INDIAN OCEAN—FEBRUARY 1904.

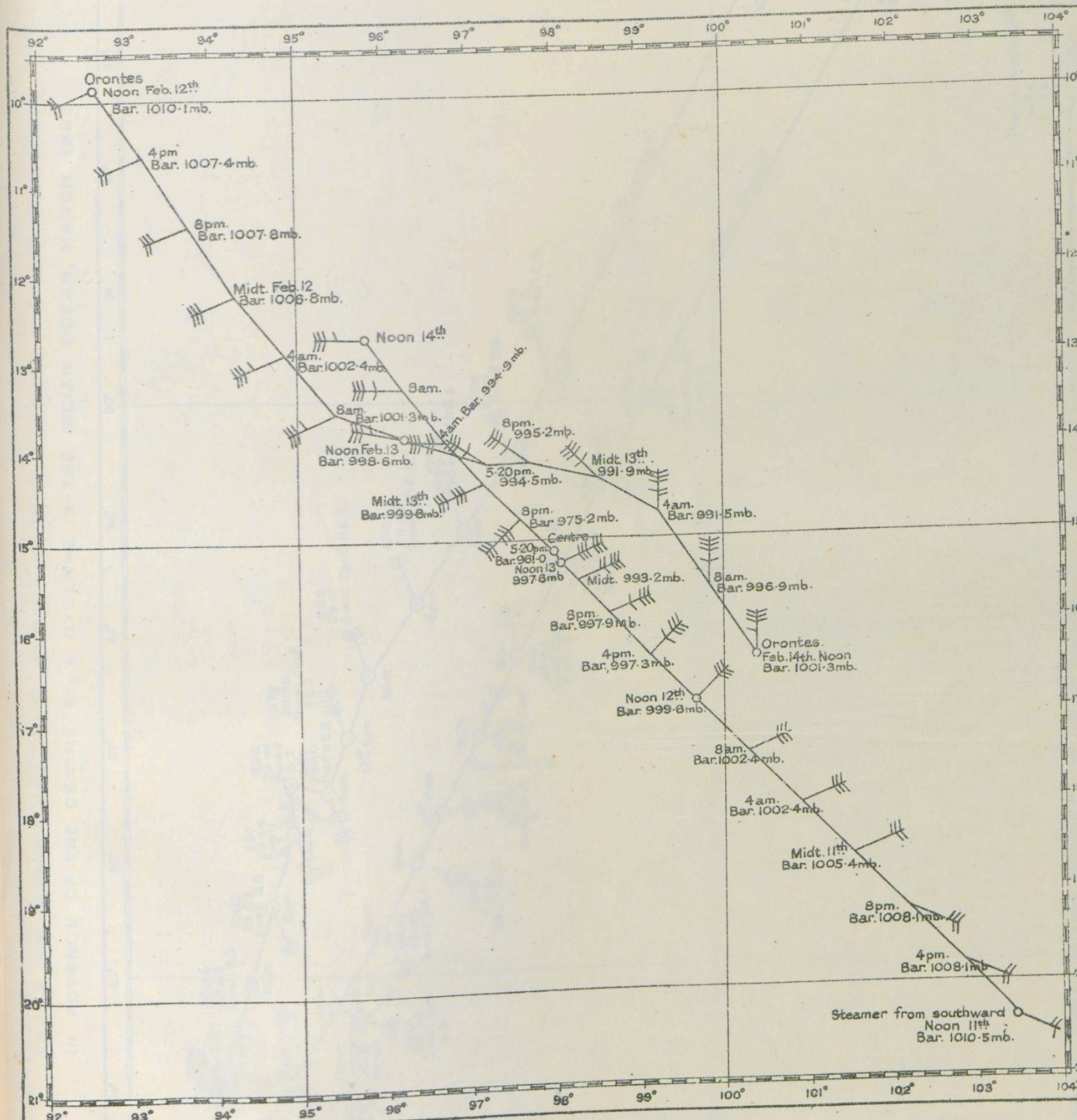


Chart LXVII—"Wireless and Weather."

TRACK OF "SURREY" AND "PORT ALBANY" PASSING THROUGH THE HURRICANE WINDS IN ADVANCE OF THE CENTRE OF A CYCLONE IN THE INDIAN OCEAN, MARCH 1923.

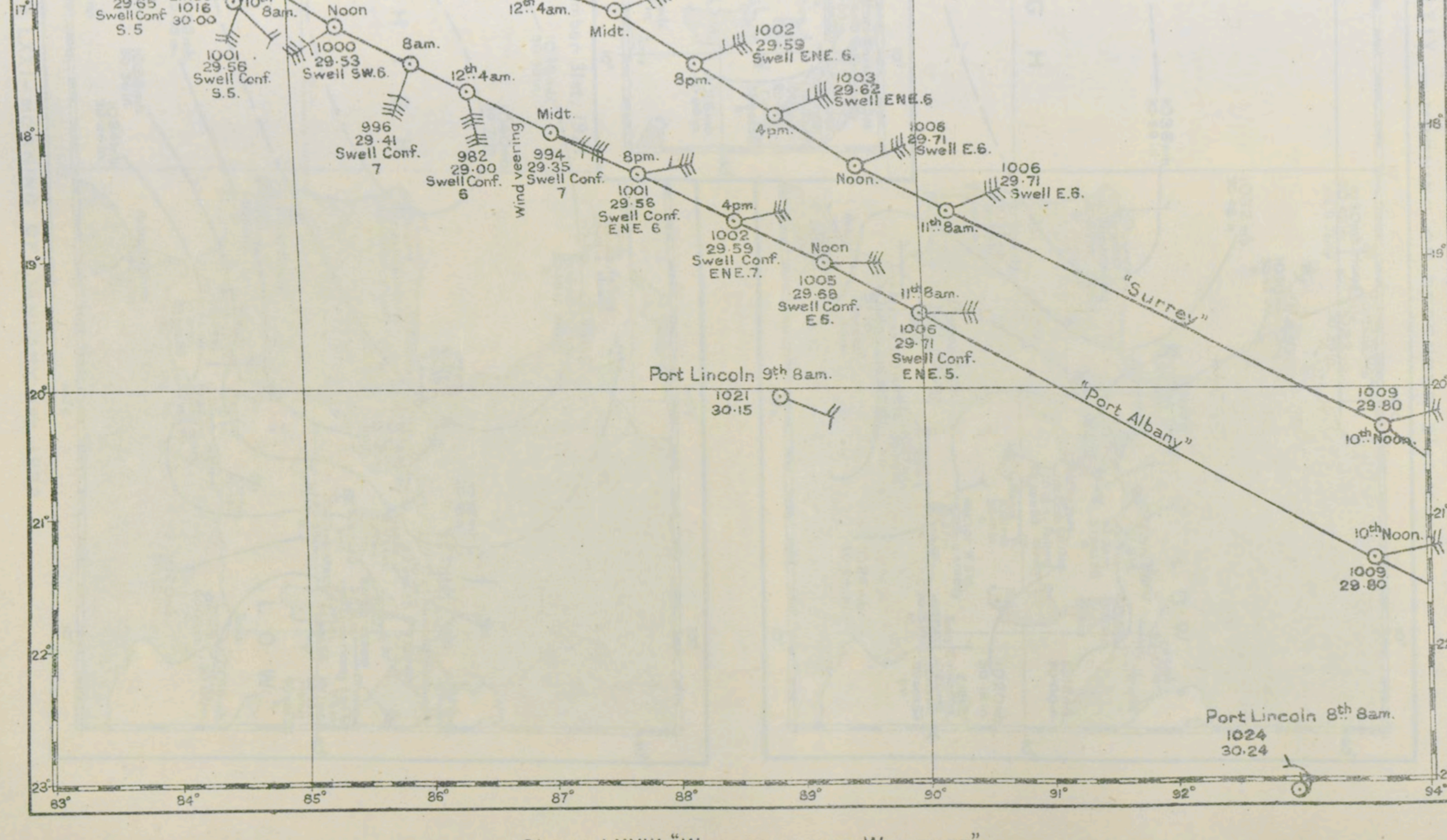
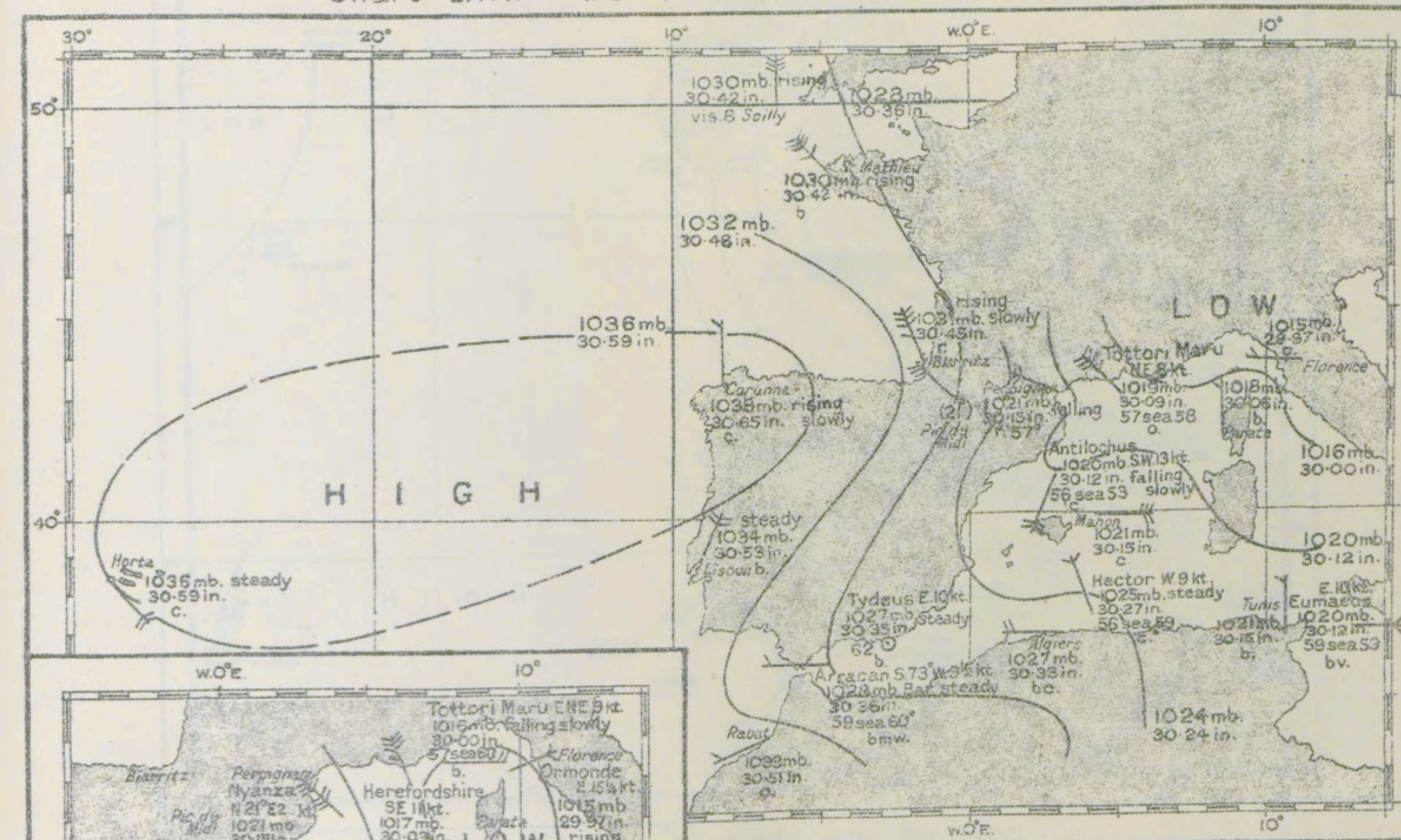


Chart LXVIII-"Wireless and Weather."

Chart LXIX — MORNING OF DECEMBER 31ST. 1921.



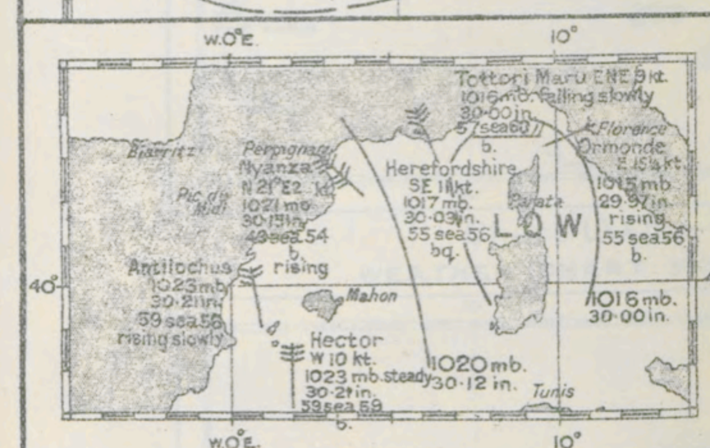


Chart LXX — Evening of December 31st, 1921.

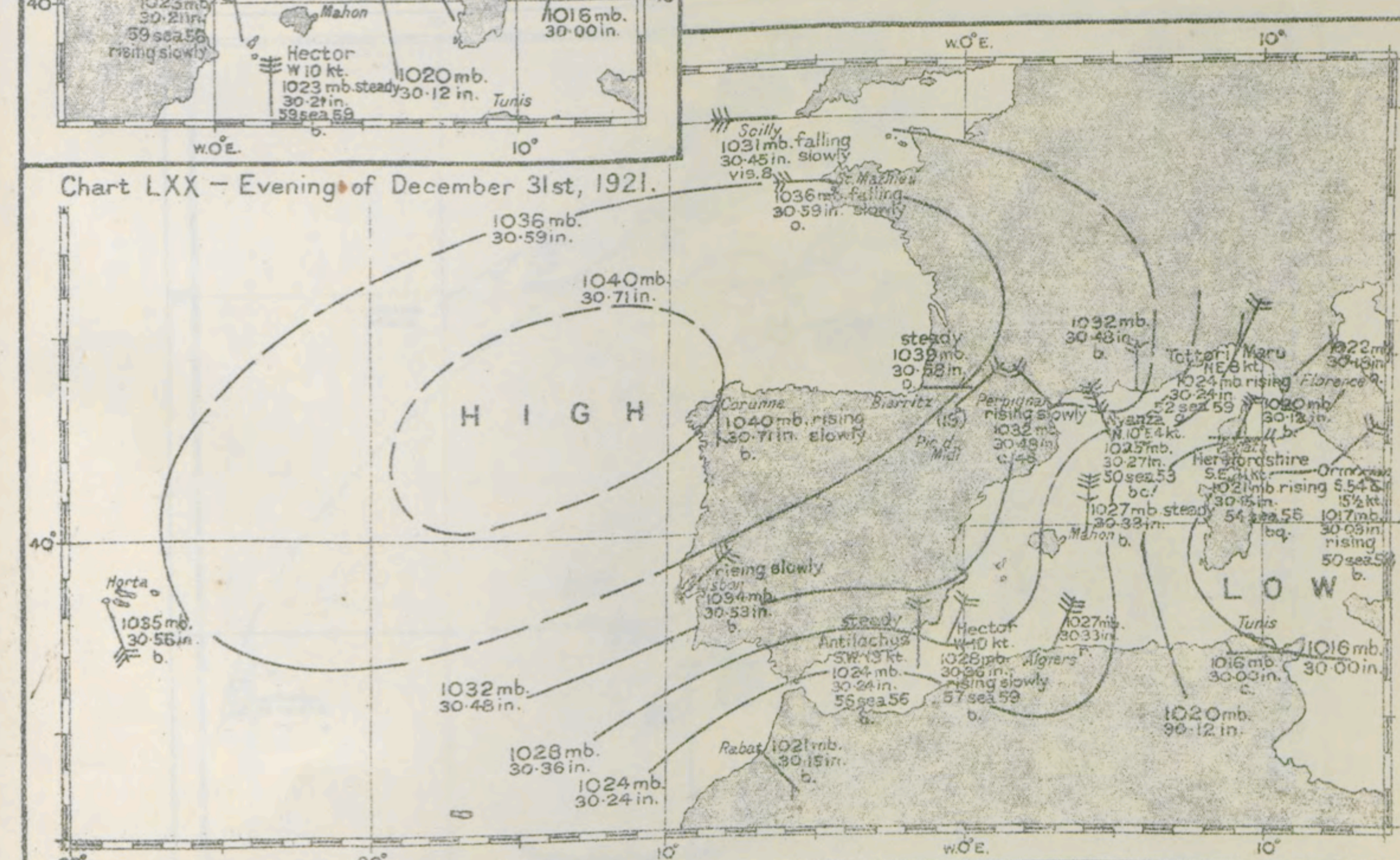


Chart LXXI — MORNING OF JANUARY 1ST. 1922.

WEATHER CHART MORNING OF DECEMBER 28TH. 1923.

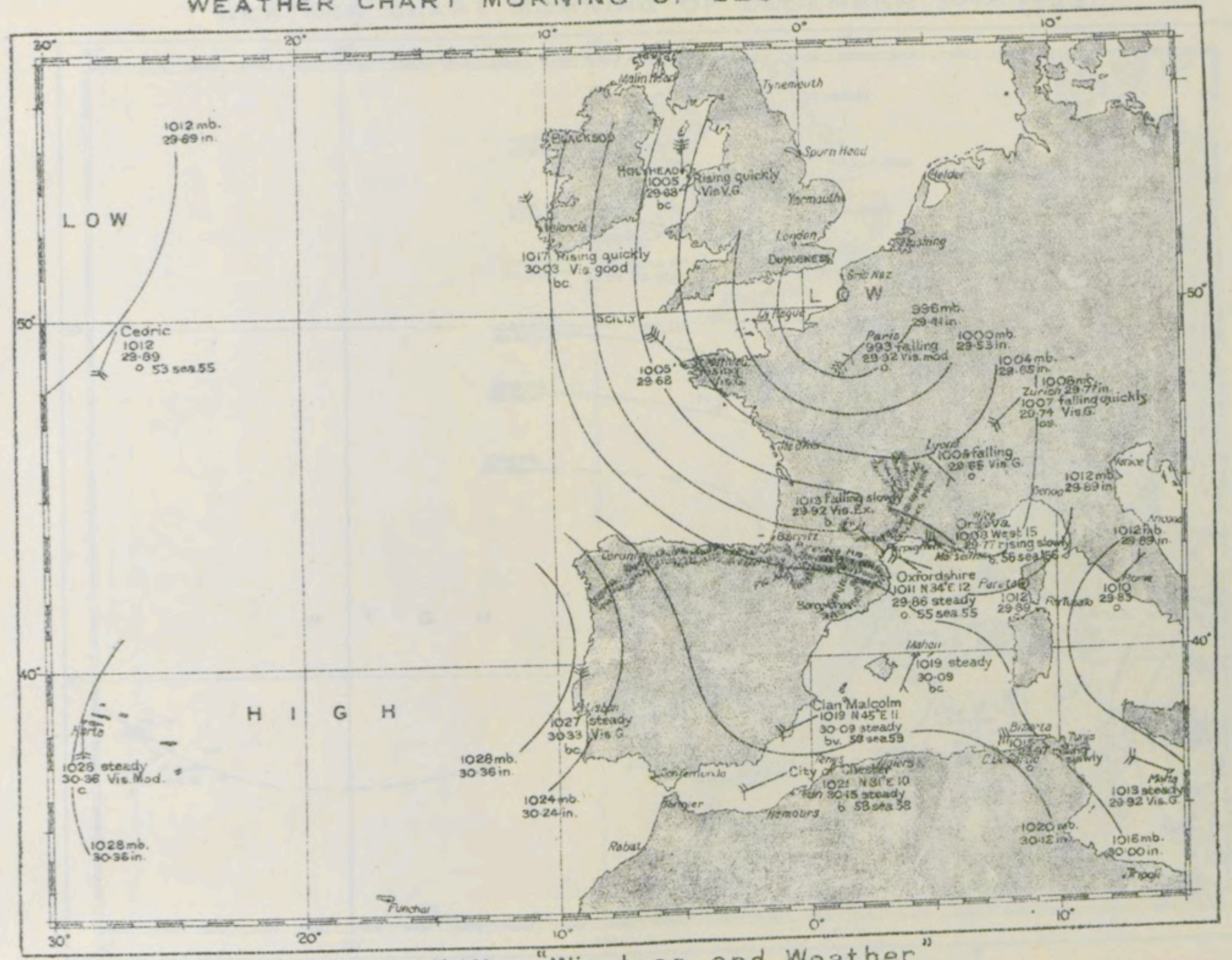


Chart LXXII.—"Wireless and Weather."

WEATHER CHART MORNING OF DECEMBER 29TH. 1923.

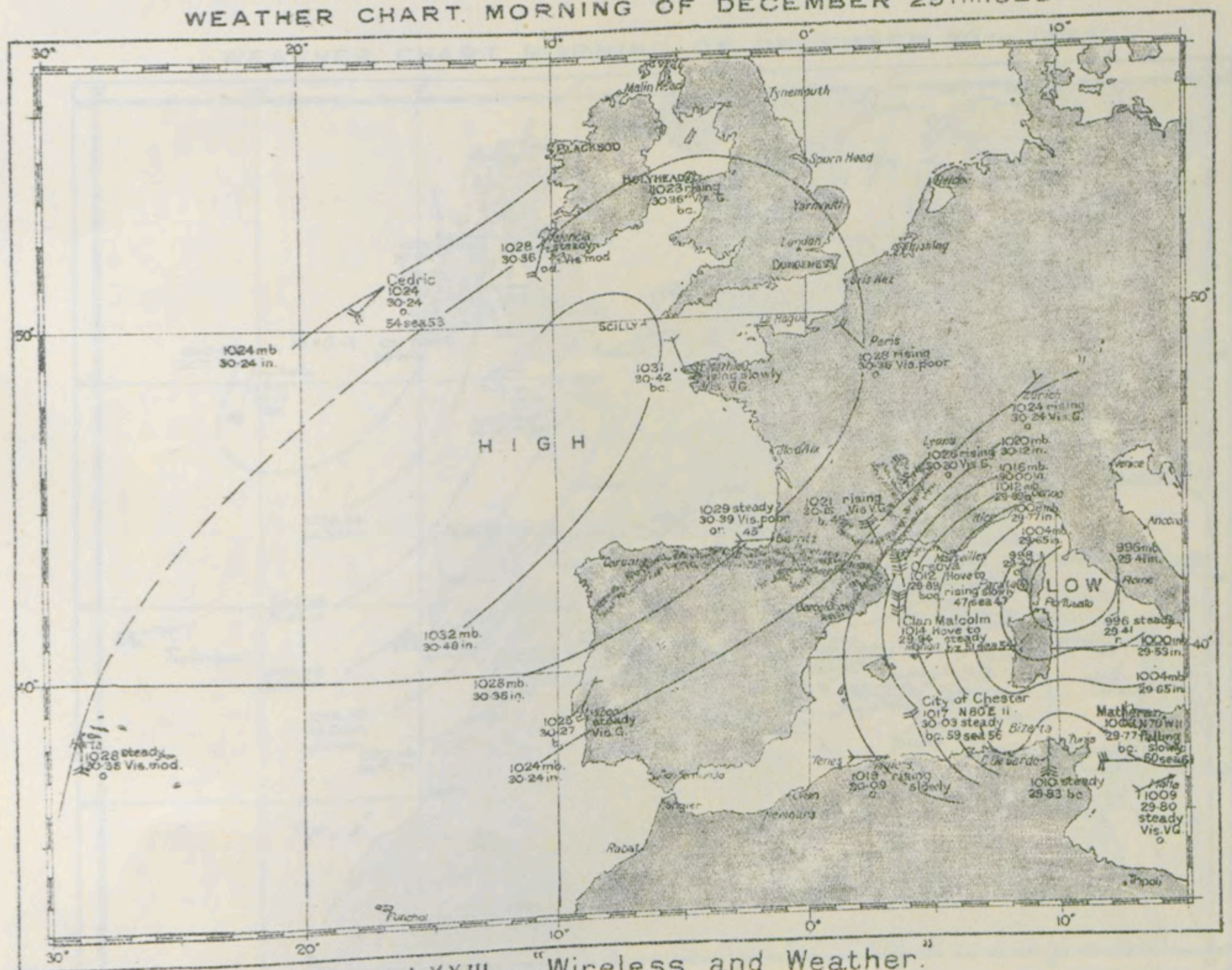


Chart LXXIII.—"Wireless and Weather."

WEATHER CHART MORNING OF DECEMBER 30TH. 1923.

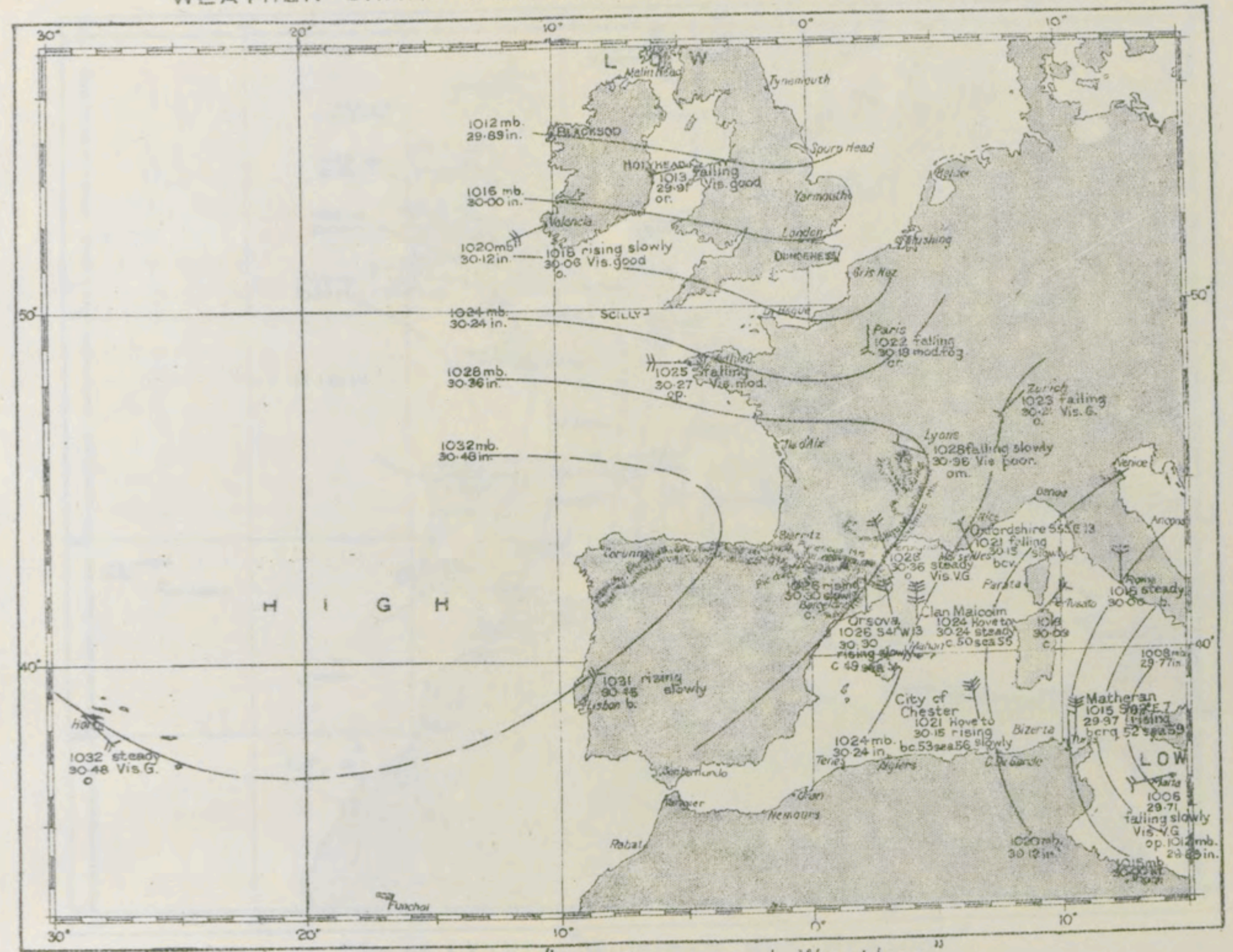


Chart LXXIV —"Wireless and Weather."

WEATHER CHART MORNING OF DECEMBER 20TH. 1923

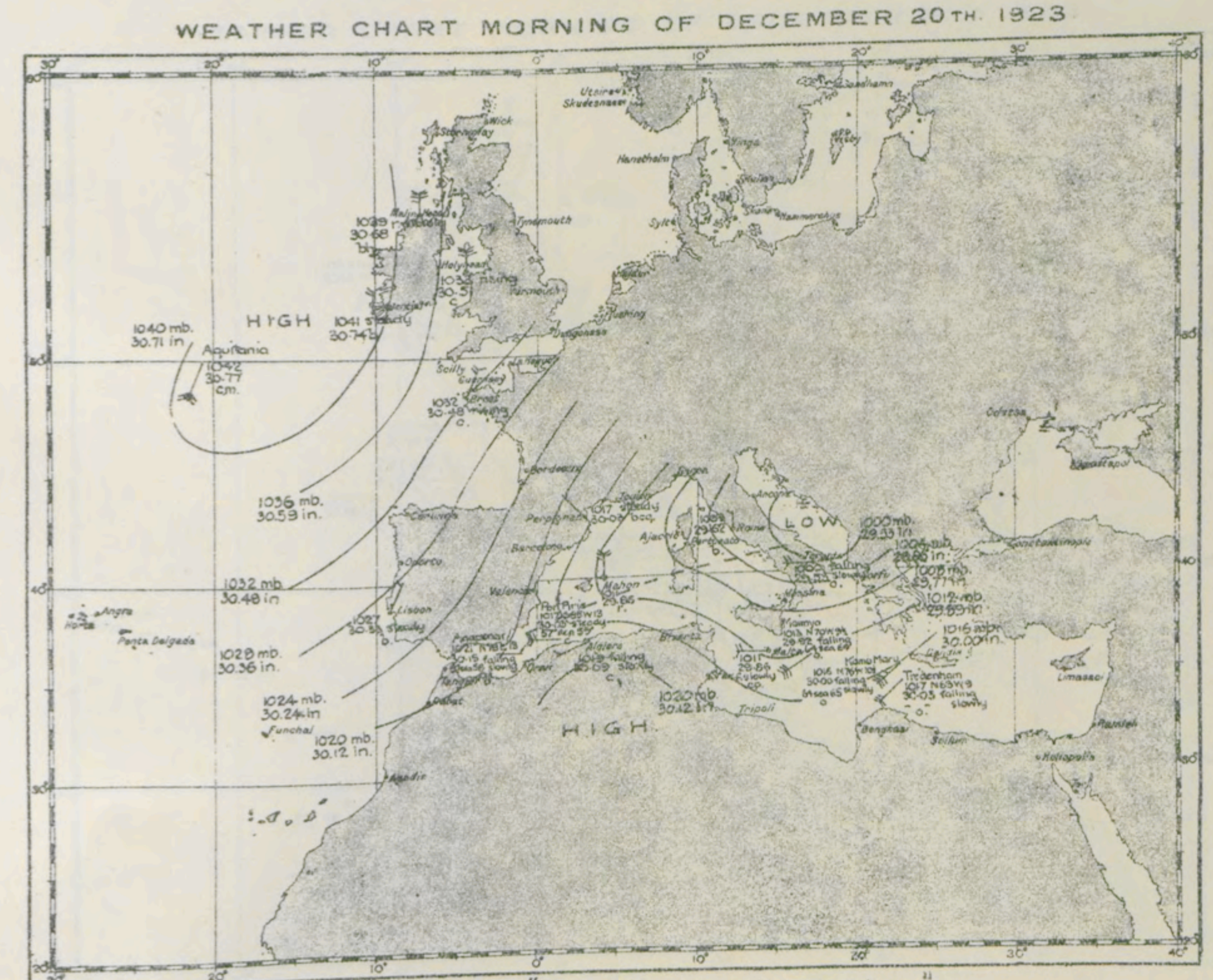


Chart LXXV —"Wireless and Weather."

WEATHER CHART MORNING OF DECEMBER 21ST. 1923

Chart LXXVI — "Wireless and Weather."

WEATHER CHART MORNING OF DECEMBER 22ND 1923.

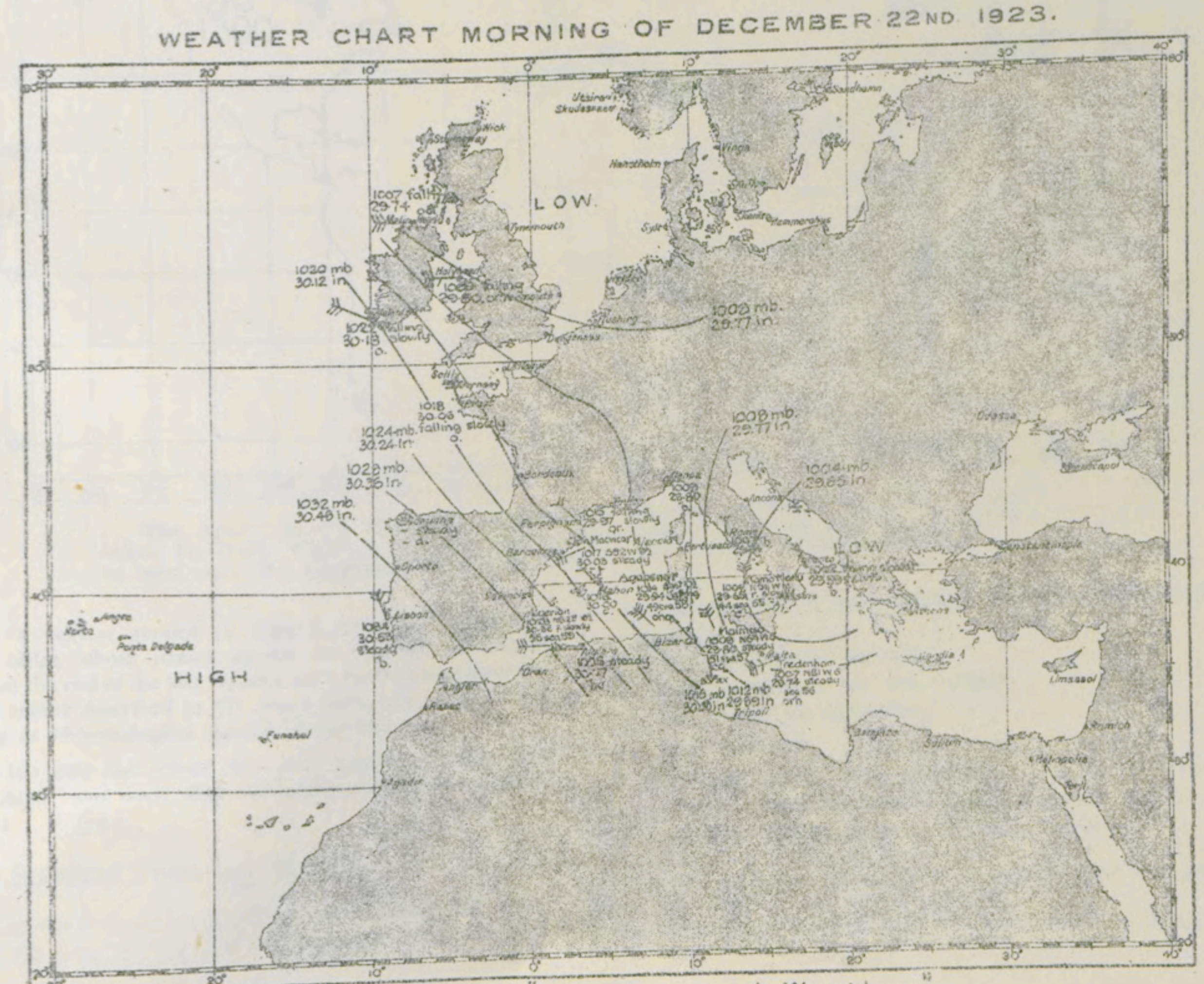


Chart LXXVII — "Wireless and Weather."

APPENDIX I.

SHIPS' WIRELESS WEATHER SIGNALS.

WEATHER Reports between ships at sea and from ships to Weather offices are of three kinds:—

(1) Those which give information of conditions experienced during a passage or part of a passage with conditions prevailing at the time the message was drafted, no attempt being made to synchronise with other observations.

(2) Those which are based upon observations made at arranged times so that they provide synchronised data in a **standard form but *not* in code.**

(3) Those which are based upon observations made at arranged times so that they provide synchronised data *in code.*

(2) and (3) are essential for the system which is explained in this book.

In order that synchronised data may be available over ocean areas, observations made for the purpose of Wireless Weather Reports should be taken at the same time as those of the nearest land weather service. These times are given upon the accompanying Chart of the World and on page 17 in the chapter on "Time." Universal times have been agreed to by the International Meteorological Committee which may be adopted later.

fixed times transmission of reports may follow as convenient. The reports should be addressed to "All Ships," and made on the wave-length which the Captain considers most efficient for the purpose, usually 600 m. spark or 2,400 m. C.W.

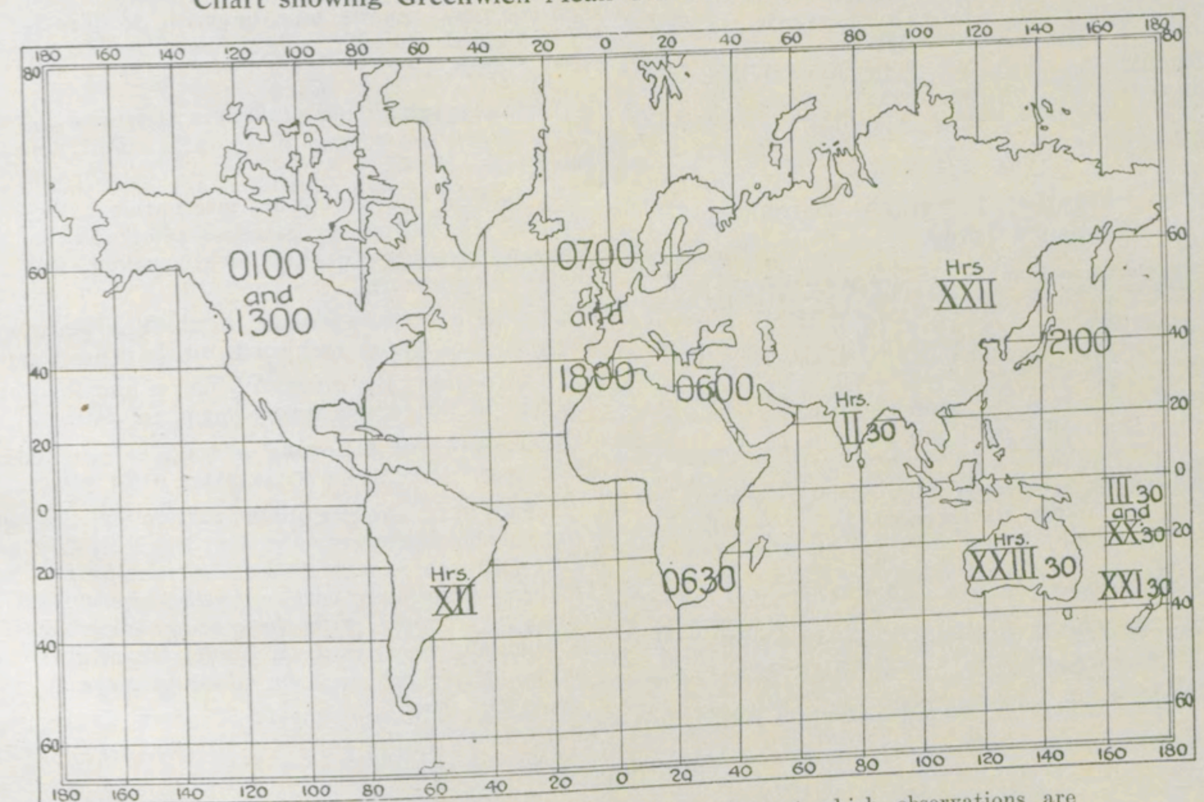
Wireless Weather Reports should always contain—

The position at which the observations were taken,
The corrected barometer reading.
The direction and force of the wind,
The present weather,*
The Greenwich mean time of observation,
The date and name of ship sending.

Other information will usually be desired by receiving ships in the following order of importance:—

Course and speed of ship during last two, three or four hours,
Tendency or change of the barometer in the last two, three or four hours,

Chart showing Greenwich Mean Times of Shore Observations.



The Arabic figures represent Greenwich mean time at which observations are taken for Daily Weather Reports. Where observations for these reports are timed by local time, the approximate Greenwich mean time is given in Roman figures.

In order to ensure a regular service of reports which all ships may receive, each of the ships whose names appear in the list of Regular Observing Ships given at the end of the last Number of "The Marine Observer" is invited to make the report described in (2) above, daily and to enter it in her Meteorological Log or Meteorological Report, Form 911.

Thus ships on the list with the letters M.L., M., and W.T., after their names are "Selected ships" and upon them the efficiency of this voluntary service mainly depends.

(2) Standard Form not in Code.

TIMES of observation must not be confused with times of transmission of reports. So long as the observations are taken at these

Current found with latitude and longitude of positions From and To,
Temperature of the air,
Temperature of the sea surface,
Swell and its direction,
Past weather.

Without using a code, messages may be conveniently framed giving these elements briefly and concisely with sufficient standardisation to enable them to be easily read.

* For the purpose of Aircraft it is important that exact information of cloud types and amount should be given.
The direction of movement of the Upper Clouds is of great importance.

For this purpose the following scales are recommended:—

The Beaufort Scale of Wind Force.

Admiral Beaufort's numbers.	Seamen's description of wind.	Admiral Beaufort's numbers.	Seamen's description of wind.
0	Calm.	7	Moderate gale.
1	Light air.	8	Fresh gale.
2	Light breeze.	9	Strong gale.
3	Gentle breeze.	10	Whole gale.
4	Moderate breeze.	11	Storm.
5	Fresh breeze.	12	Hurricane.
6	Strong breeze.		

The Beaufort Notation of Weather.

(It is best to write words in the Message.)

b	Blue sky.	p	Passing showers.
c	Cloudy.	q	Squalls.
d	Drizzle.	r	Rain.
e	Wet air.	rs	Sleet.
f	Fog.	s	Snow.
fe	Wet fog.	t	Thunder.
g	Gloomy.	tl	Thunderstorm.
h	Hail.	u	Ugly.
kq	Line squall.	v	Unusual visibility.
l	Lightning.	w	Dew.
m	Mist.	z	Dust haze.
o	Overcast sky.		

The International Weather Telegraphy Barometric Tendency Table.

Barometer steady. (The barometer has not fallen or risen more than ½ millibar in 3 hours).

Do.	rising slowly.	(The barometer has	risen	1 to 1½	mb.	('03-'04 in.)	in last 3 hours).
Do.	rising.	Do.	do.	2 to 3½	„	('06-'10 in.)	do.
Do.	rising quickly.	Do.	do.	4 to 6	„	('12-'18 in.)	do.
Do.	rising very rapidly.	Do.	do.	over 6	„	('18 in.)	do.
Do.	falling slowly.	Do.	fallen	1 to 1½	„	('03-'04 in.)	do.
Do.	falling.	Do.	do.	2 to 3½	„	('06-'10 in.)	do.
Do.	falling quickly.	Do.	do.	4 to 6	„	('12-'18 in.)	do.
Do.	falling very rapidly.	Do.	do.	over 6	„	('18 in.)	do.

For a simplified table *see* Chapter I., p. 5.

Example of Plain Language Wireless Weather Report in standard form, not in code, recommended.

To CQ.

Weather 0745N 8333E Barometer corrected 2980 SSW4 cloudy cirrus upper strato cumulus lower eight-tenths 0230 GMT thirty-first July course N56E 12 rising slowly current N32E 2 knots from 6N82E to 7N83E air 83 sea 83 swell moderate SW past weather overcast lightning Yorkshire.

NOTE.—The date appears in the middle of this message, the most important elements appearing before it. If abbreviation is desired omit all after date.

---

(3) North Atlantic "Decode."

The main groups of the code used by a limited number of ships for reporting to the Meteorological Office having been internationalised, the following Decode is published for the information of ships who are able to intercept these reports.

The reports are addressed to *Weather London* (Meteorological Office, London) and to *Government Observer, Washington, D.C.* (United States Weather Bureau). Those addressed to *Weather London* are made to Devizes W/T Station, call sign GKU, the ship reporting, first calling Devizes on the wavelength of 2,013 metres (C.W.) unless otherwise instructed by Devizes and passing her report on a wavelength designated by Devizes. (The position of the transmitting station at Portishead is Latitude 51° 28′ 40.7″ N., Longitude 2° 47′ 30.3″ W.) Those addressed to *Government Observer, Washington, D.C.*, are made to any of the following U.S. Navy radio stations at Bar Harbour, Me., call sign NBD, New York, N.Y., call sign NAH, Norfolk, Va., call sign NAM, or Charleston, S.C., call sign NAO, on a wavelength of 2,100 metres (C.W.). The respective transmissions take place as soon as possible after observation time.

Observations made between the 100-fathom line, British Isles, and 40° W. Longitude are reported to *Weather London*.

Observations made between Longitude 40° W. and a line, Belle Isle—Virgin Rocks—Sable Island—Cape Hatteras are reported to *Government Observer, Washington, D.C.*

The times of observation are:—

European *land* 0100, 0700, 1300 and 1800, G.M.T.

American *land* 0100, G.M.T. = 8 p.m. 75th Meridian Time.
and 1300, G.M.T. = 8 a.m. 75th Meridian Time.

Ships at Sea from the 100-Fathom Line British Isles to 40° W. Longitude.

0700 and 1800, G.M.T.

Ships at Sea from Longitude 40° W. to a Line Belle Isle—Virgin Rocks—Sable Island—Cape Hatteras.

0100 and 1300, G.M.T.

Additional reports may be made to *Weather London* eastward of Longitude 40° W., containing observations made at 0100 and 1300, G.M.T.

A message consisting of figures addressed to *Weather London* or *Government Observer, Washington D.C.*, may be decoded as follows:—

As the first four groups are international, these groups, in weather reports transmitted by wireless telegraphy to weather offices of maritime countries by ships of all nations, may usually be decoded in the same manner.

Rule up a form, a sample of which is given opposite, and write the groups of figures and words, in the order received, in the spaces.

To save space, the groups of figures and their meanings have been inserted in the sample decode form, in *italics*.

Example:—The following message intercepted: *Weather London* 41458 30807 24162 11404 09111 21542 67104 68691.

These figures having been written in the appropriate spaces, errors made in transmission may be checked by adding together the figures in each *column* of the first four groups, *neglecting the tens.* If the message has been correctly transmitted, the sums of the columns will agree with the corresponding figures of Group 5. If the sums differ, write down (under the original figures in Group 5) the numbers which must be *added* to make them agree.

Note.—In all adjustments of check figures, tens and carrying figures must be disregarded entirely; thus for purposes of the check system 9 + 4 = 3, not 13.

Next add together the figures in each group 1 to 5, separately (neglecting tens). These sums should agree with the figures from left to right in Group 6. If they differ, write down (under the original figures in Group 6) the numbers which must be *added* to make them agree.

Group 5 now indicates the *columns* in which there are errors with the numbers to be added to the figures which are in error.

Group 6 indicates the *groups* in which these errors occur.

In the example given we find that 0 in the second column of Group 2 should be 3, and that 4 in the third column of Group 4 should be 8.

In the remaining groups of the message a *double* check is not provided, but the fifth figure in each group will represent the sum of the first four figures, neglecting tens, and if it does not agree it will be known that one or more figures are in error.

The message is next decoded by means of the Tables and Instructions given on the Decode Form.

DECODE FORM.

Code.	Code Figures. Column Numbers. 1	2	3	4	5	Distinguishing Letter.	Number of Group.	Name of Element and how to decode the Figures. Addressed to " ".	Message decoded.
International Weather.	*4*	*	*	*	*	P	1	Day of Week, Table I *	*Wednesday.*
	*	*1*	*	*	*	Q		Name of Latitude and Longitude, Table II.	*North and West.*
	*	*	*4*	*5*	*	LL		Latitude, degrees.	*45°.*
	*	*	*	*	*8*	L		Latitude, approx. minutes (multiply code fig. by 6).	*48′*
	3	~~*0*~~	*	*	*	ll	2	Longitude, degrees.	*33°.*
	*	*3* *	*8*	*	*	l		Longitude, approx. minutes (multiply code fig. by 6).	*48′.*
	*	*	*	*0*	*7*	GG		Greenwich Mean Time to nearest hour.	*07.*
	2	*4*	*	*	*	BB	3	Barometer, prefix 9 or 10 to code figures and, if desired, convert to inches. (*See* Special Table, p. viii.)	*1024mb.*
	*	*	*1*	*6*	*	DD		Wind direction true, Table III.	*South.*
	*	*	*	*	*2*	F		Wind force, Table IV.	*2.*
	1	*1*	*	*	*	ww	4	Present weather, Table V.	*No change, Cloudy.*
	*	*	~~*4*~~	*	*	v		Visibility. Table VI.	*Very good.*
	*	*	*8* *	*0*	*	K		Swell. Table VII.	*Slight.*
	*	*	*	*	*4*	d		Swell—direction from, Table VIII.	*South.*
Check.	*0*	*	*	*	*	x	5	Sum of Column 1, less tens.	
	*	*9*	*	*	*	x		Sum of Column 2, less tens.	
	*	*+3* *	*1*	*	*	x		Sum of Column 3, less tens.	*Check corrected.*
	*	*	*+4* *	*1*	*	x		Sum of Column 4, less tens.	
	*	*	*	*	*1*	x		Sum of Column 5, less tens.	
	2	*	*	*	*	y	6	Sum of Group 1, less tens.	
	*	*1*	*	*	*	y		Sum of Group 2, less tens.	
	*	*+3* *	*5*	*	*	y		Sum of Group 3, less tens.	*Check corrected.*
	*	*	*	*4*	*	y		Sum of Group 4, less tens.	
	*	*	*	*+4* *	*2*	y		Sum of Group 5, less tens.	
British M.O. Weather.	*6*	*	*	*	*	C	7	Cloud predominating, Table IX.	*Strato-Cumulus.*
	*	*7*	*	*	*	N		Cloud amount, Table X.	*Seven-tenths.*
	*	*	*1*	*	*	W		Past weather, Table XI.	*Cloudy.*
	*	*	*	*0*	*	U		Unusual phenomena. (*See* Special Table, p. viii.)	*None.*
	*	*	*	*	*4*	y		Sum of Group 7, less tens.	*Group correct by check*
	6	*8*	*	*	*	TT	8	Air temperature, degrees.	*68° F.*
	*	*	*6*	*9*	*	tt		Sea temperature, degrees.	*69° F.*
	*	*	*	*	*1*	y		Sum of Group 8, less tens.	*An error in this group.*
								Space for word if wind force greater than 9.	

The message now reads—*Wednesday, Latitude 45° 48′ N., Longitude 33° 48′ W., G.M.T. 07 hours, Barometer 1024mb, Wind south force 2, Cloudy weather, Visibility very good, slight swell from south (column check corrected) (Group check corrected), Cloud St.-Cu, amount* $\frac{7}{10}$*ths; past weather, cloudy; No unusual phenomena; (Group correct by check) Air temperature 68° F., Sea temperature 69° F. (An error in group).*

* Tables I—XI (International Code) will be found on pp. xiii-xv, Appendix III.

SPECIAL WEATHER TELEGRAPHY TABLES, NOT INTERNATIONAL CODE.

U.—Unusual Phenomena.

Code Figure.

0 = None of the following remarks appropriate.
1 = Appearances indicate that a tropical storm has formed.
2 = Appearances indicate that a tropical storm is forming.
3 = Heavy squalls during last three hours.
4 = Squally weather.
5 = Barometer *falling* very rapidly (more than 2 millibars an hour).
6 = Barometer *rising* very rapidly (more than 2 millibars an hour).
7 = Wind has *increased* decidedly during the last hour.
8 = Wind has *decreased* decidedly during the last hour.
9 = Unusually red sunset (or sunrise).

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.	Mb.	In.	Mb.	In.
925	27·32	940	27·76	960	28·35	980	28·94	1000	29·53	1020	30·12	1040	30·71
926	27·35	941	27.79	961	28·38	981	28·97	1001	29·56	1021	30·15	1041	30·74
927	27·38	942	27·82	962	28·41	982	29·00	1002	29·59	1022	30·18	1042	30·77
928	27·41	943	27·85	963	28·44	983	29·03	1003	29·62	1023	30·21	1043	30·80
929	27.44	944	27·88	964	28.47	984	29·06	1004	29·65	1024	30·24	1044	30·83
930	27·46	945	27·91	965	28·50	985	29·09	1005	29·68	1025	30·27	1045	30·86
931	27·49	946	27·94	966	28·53	986	29·12	1006	29·71	1026	30·30	1046	30·89
932	27·52	947	27·97	967	28·56	987	29·15	1007	29·74	1027	30·33	1047	30·92
933	27·55	948	28·00	968	28·59	988	29·18	1008	29·77	1028	30·36	1048	30·95
934	27·58	949	28·03	969	28·62	989	29·21	1009	29·80	1029	30·39	1049	30·98
935	27·61	950	28·05	970	28·65	990	29·24	1010	29·83	1030	30·42	1050	31·01
936	27·64	951	28·08	971	28·67	991	29·26	1011	29·86	1031	30·45	1051	31·04
937	27·67	952	28·11	972	28·70	992	29·29	1012	29·89	1032	30·48	1052	31·07
938	27·70	953	28·14	973	28·73	993	29·32	1013	29·92	1033	30·51	1053	31·10
939	27·73	954	28·17	974	28·76	994	29·35	1014	29·94	1034	30·53	1054	31·13
		955	28·20	975	28·79	995	29·38	1015	29·97	1035	30·56		
		956	28·23	976	28·82	996	29·41	1016	30·00	1036	30·59		
		957	28·26	977	28·85	997	29·44	1017	30·03	1037	30·62		
		958	28·29	978	28·88	998	29·47	1018	30·06	1038	30·65		
		959	28·32	979	28·91	999	29·50	1019	30·09	1039	30·68		

APPENDIX II.

THE BRITISH WIRELESS "WEATHER SHIPPING" BULLETIN.

C.W. ISSUES.

W/T Station, **Air Ministry.** Latitude 51° 27′ 50″ N.
Longitude 0° 01′ 35″ E.
Call sign **G.F.A.**
Wave length 4,100 metres, C.W.
Times of transmission 0900 G.M.T.* and 2000 G.M.T.

The message issued at 0900 G.M.T. is based upon 0700 G.M.T. observations. The message issued at 2000 G.M.T. is based upon 1800 G.M.T. observations.

During the time of S.O.S. lookout, from 0915 to 0918, and 2015 to 2018, there will be a pause in the transmission of these weather signals.

These messages are preceded by the words "Weather shipping" and consist of six parts. Part II. is in code, the remaining parts in plain language.

Part I. is a general inference of weather conditions over the British Isles, which usually includes information of the pressure system, with whereabouts, which influences the weather.

Part II. is a report in code giving actual observations, with station number, of barometric tendency, weather, visibility, barometric pressure, direction and force of wind, at the ten British stations shown upon the accompanying Chartlet numbered from 1 to 10 (the initial 1 being omitted in the case of Station 10).

* All times are G.M.T., the day commencing at Midnight, and the hours reckoned from 00 to 23.

Two stations not shown on the Chartlet also follow in this part. They are No. 1, Reykjavik, Latitude 64° 09′ N., Longitude 21° 55′ W. (approx.) and No. 2, Thorshavn, Latitude 62° 03′ N., Longitude 6° 45′ W. (approx.) preceded by the word "Foreign."

Parts III., IV. and V. are forecasts of wind and visibility for the 12 hours following the time of observations for the areas shown upon the Chartlet.

Part VI. commencing "*outlook*" is a general statement as to expectation of weather after the period of the forecasts, when it can be made.

Note.—In order to avoid ambiguity between the words Ireland and Iceland, the latter word is always repeated whenever it occurs in Part I.

Explanation of Chartlet.

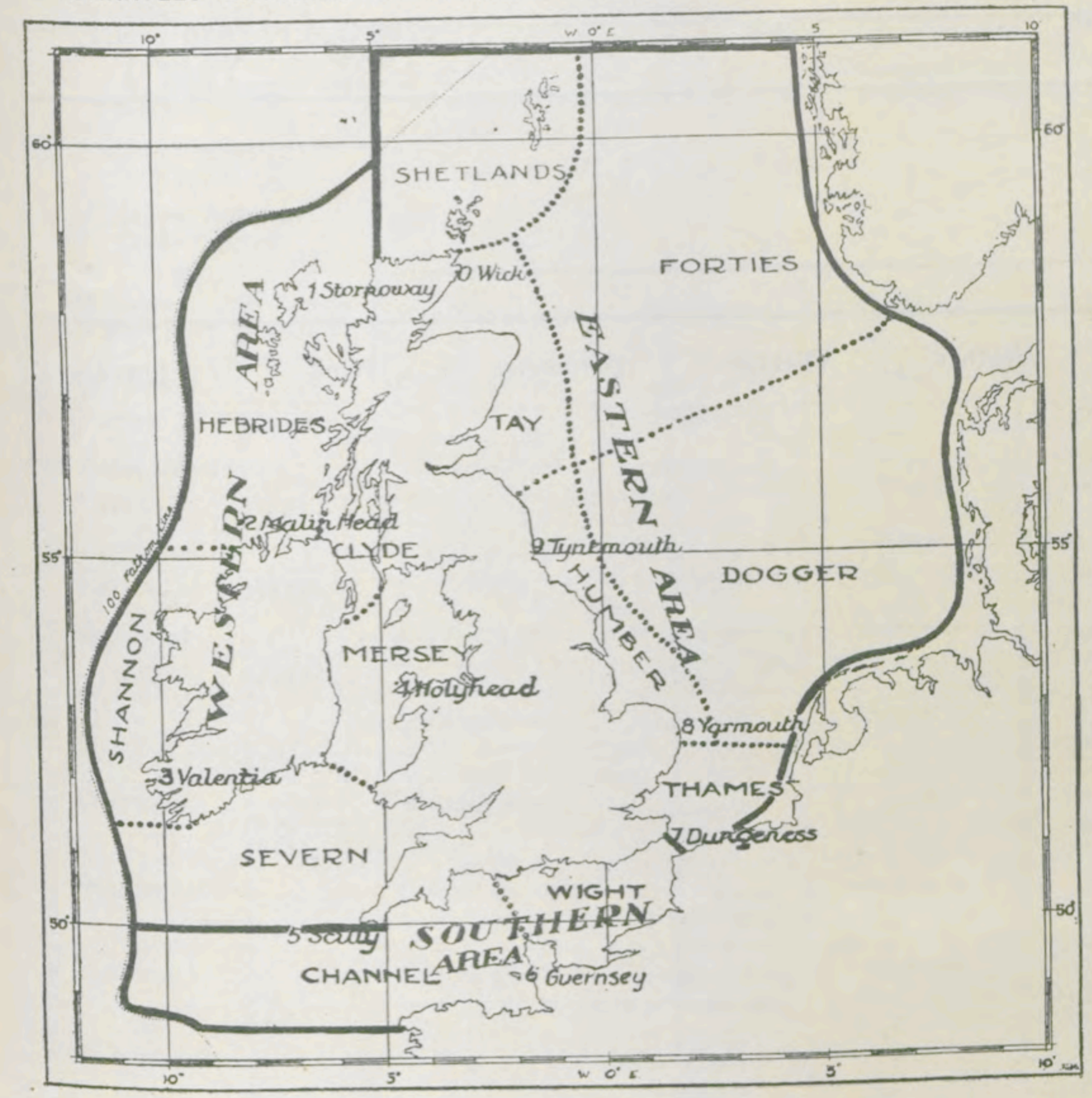
The numbers before the names of the stations indicate their code number (in the event of any station being substituted, the name of the substitute will be given in the message in place of this figure).

The boundaries of the areas are defined by the plain black lines and the coast line.

These areas are sub-divided into districts, named after islands, rivers or banks within them, so that they may be readily memorised. The boundaries of these districts should only be taken as an approximate indication of their extent.

These districts are for the purpose of giving information of different weather within an area, without unduly lengthening the wording of a message.

Chartlet showing Stations, Forecast Areas and Districts.



WESTERN AREA.

The sea and coasts eastward of the hundred fathom line from Cape Wrath to Scilly.

DISTRICTS.

HEBRIDES.—That part of Western which lies N. and W. of Bloody Foreland, Rathlin I. and Islay.

SHANNON.—West coast of Ireland from Bloody Foreland to the Fastnet.

SEVERN.—South Coast of Ireland, Bristol Channel, and approaches.

MERSEY.—The Irish Sea and approaches.

CLYDE.—The North Channel and approaches to Clyde.

SOUTHERN AREA.

The English Channel from Dover to the 100 fathom line.

DISTRICTS.

CHANNEL.—West of Portland.

WIGHT.—East of Portland.

EASTERN AREA.

The North Sea south of Lat. 61° N., and east of Long. 5° W. to the north and to the Straits of Dover in the south.

DISTRICTS.

THAMES.—Thames Estuary and its approaches.

HUMBER.—East coasts from Yarmouth to Tweed.

TAY.—East coast of Scotland, including Moray Firth.

SHETLANDS.—Orkneys and Shetlands.

FORTIES.—Eastward to Norway and N. of line Tweed to Naze.

DOGGER.—Eastward to coast of Denmark and S. of line Tweed to Naze.

DESCRIPTION OF CODE AND INSTRUCTIONS FOR DECODING PART II.

The code is arranged in five-figure groups, which are paired. Each pair of groups refers to one station, and contains an odd and an even group.

Odd Groups. **The 1st Figure** indicates the station to which the pair of groups refers. From 1 to 9 and 0 for British stations. The Foreign groups being numbered 1 and 2 as above and indicated by the word "Foreign."

The 2nd Figure gives the Barometric tendency, **Table XII.**, Appendix III, p. xv.

The 3rd and 4th Figures give the weather, **Table V.**, Appendix III, p. xiv.

The 5th Figure gives the visibility, **Table VI.**, Appendix III, p. xiv. Caution is necessary in the use of these visibility reports owing to the conditions of view to seaward at some stations. The two foreign stations' visibility reports are landward.

Even Groups. **The 1st and 2nd Figures** indicate the last two whole figures of the corrected barometer reading in millibars.* To convert to inches, see **Special Table**, Appendix I, p. viii.

Even Groups (*continued*). **The 3rd and 4th Figures** give the True Direction of the Wind, **Table III.**, Appendix III, p. xiii.

The 5th Figure gives the force of the wind by Beaufort scale. All forces 9 and above, as 9.

In all cases when a figure cannot be given, a hyphen (– - - - - –) is given to preserve the order.

It will be of assistance in memorising the code if the following initial letters of the various elements are committed to memory.

	$I_n K' ww V_s$	BB DD F.
Thus	I_n = Station.	BB = Barometric Pressure.
	K′ = Barometric tendency.	DD = Wind Direction.
	ww = Weather.	F = Wind Force.
	V_s = Visibility.	

It will be noticed that the above symbols and their meanings are taken from the Abridged Key to the International Code (Appendix III).

Though at first decoding may be tedious a little practice will show that this can be done with ease and rapidity. A form ruled and used as suggested in the specimens shown on pp. X and XI will be of great assistance.

* 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.

For the purpose of decoding and recording the W/T Weather Bulletin for all coasts, the following form may be ruled and used with advantage. The code figures should be entered under the names of the Stations. An example is recorded and decoded on this form opposite.

Day............ Month............ Year............ 0700 G.M.T. 1800 G.M.T. (Delete observation time which does not apply.)

Weather Shipping.

Part I
INFERENCE

Part II Station Reports Code figures Key (Odd Groups $I_nK'wwV_s$; Even Groups BBDDF)	Bar Tendency	Weather	Visibility	Barometer	Wind	Force
1 Stornoway						
2 Malin Head						
3 Valentia						
4 Holyhead						
5 Scilly						
6 Guernsey						
7 Dungeness						
8 Yarmouth						
9 Tynemouth						
0 Wick						
Foreign						
1 Reykjavik						
2 Thorshavn						

Part III District		FORECAST	Part VI. OUTLOOK
Western Area	Hebrides, Clyde, Mersey, Severn, Shannon		
Part IV			
Southern Area	Channel, Wight		
Part V			
Eastern Area	Thames, Humber, Dogger, Tay, Shetlands, Forties		

Day......*Friday, 3rd.* Month......*December.* Year......*1920.* 0700 G.M.T. ~~1800~~ G.M.T. (Delete observation time which does not apply.)

Weather Shipping.

Part I
INFERENCE

A deep depression over the North Channel which is moving E.N.E. will cause strong winds or gales in all districts with much rain at first. Improving weather will spread across the country in its rear.

Part II Station Reports Code figures Key (Odd Groups $I_nK'wwV_s$; Even Groups BBDDF)	Bar Tendency	Weather	Visibility	Barometer	Wind	Force
1 Stornoway *17535 99041*	*Falling quickly*	*r mod. but has decreased*	*poor*	*999 mb. 29·50 in.*	*N.E.*	*1*
2 Malin Head *2155– 93283*	*Rising slowly*	*r. continuous*	—	*993 mb. 29·32 in.*	*N.W.*	*3*
3 Valentia *34117 12266*	*Rising very rapidly*	*c. or o. no apparent change*	*good*	*1,012 mb. 29·89 in.*	*W.N.W.*	*6*
4 Holyhead *46356 97208*	*Falling*	*p. heavy with rain*	*moderate*	*997 mb. 29·44 in.*	*S.W.*	*8*
5 Scilly *55167 13267*	*Falling slowly*	*c. or o. after rain or drizzle*	*good*	*1,013 mb. 29·92 in.*	*W.N.W.*	*7*
6 Guernsey *65417 19185*	*Falling slowly*	*d. slight continuous*	*good*	*1,019 mb. 30·09 in.*	*S.S.W.*	*5*
7 Dungeness *77124 15206*	*Falling quickly*	*c. or o. cloud has increased*	*very poor*	*1,015 mb. 29·97 in.*	*S.W.*	*6*
8 Yarmouth *87526 14186*	*Falling quickly*	*r. slight but has increased*	*moderate*	*1,014 mb. 29·94 in.*	*S.S.W.*	*6*
9 Tynemouth *97275 99206*	*Falling quickly*	*f. or m. apparently overcast*	*poor*	*999 mb. 29·50 in.*	*S.W.*	*6*
0 Wick *0856– 00146*	*Falling very rapidly*	*r. moderate but has increased*	—	*1,000 mb. 29·53 in.*	*S.S.E.*	*6*
Foreign						
1 Reykjavik *1112– 96162*	*Rising slowly*	*c. or o. cloud has increased*	—	*996 mb. 29·41 in.*	*S.*	*2*
2 Thorshavn *2012– 05000*	*Steady*	*c. or o. cloud has increased*	—	*1,005 mb. 29·68 in.*	—	*Calm*

Part III District		FORECAST	Part VI. OUTLOOK
Western Area	Hebrides, Clyde	*Strong northerly winds, moderating, visibility moderate.*	*Western area, temporary improvement.*
	Mersey, Severn, Shannon	*Westerly gale, veering and moderating, visibility becoming good.*	
Part IV			
Southern Area	Channel, Wight	*Strong westerly to north-westerly winds. Visibility becoming good. Visibility poor.*	
Part V			
Eastern Area	Thames, Humber	*South-westerly gales, visibility poor.*	*Eastern area, northerly gales.*
	Dogger, Tay	*Southerly winds, strong to gale, backing, visibility poor.*	
	Shetlands	*Fresh easterly winds, visibility moderate.*	
	Forties	*Southerly winds, strong to gale, backing, visibility poor.*	

A Sample Message.

Call Sign:—CQ CQ CQ V GFA GFA GFA (repeated twice).
Weather Shipping.
Inference.—A deep depression over the North Channel which is moving East North East will cause strong winds or gales in all districts with much rain at first. Improving weather will spread across the country in its rear.

Station Reports.	*17535*	*99041*	*2155–*	*93283*	*34117*	*12266*
	46356	*97208*	*55167*	*13267*	*65417*	*19185*
	77124	*15206*	*87526*	*14186*	*97275*	*99206*
	0856–	*00146*	*Foreign*	*1112– 96162*	*2012–*	*05000*

Forecasts.—Western Area Districts Mersey Severn Shannon westerly gale veering and moderating visibility becoming good Districts Clyde Hebrides strong northerly winds moderating visibility moderate full stop Southern area strong westerly to north westerly winds District Wight visibility poor District Channel visibility becoming good full stop Eastern Area Districts Dogger Humber Thames southwesterly gales visibility poor Districts Tay Forties southerly winds strong to gale backing visibility poor District Shetlands fresh easterly winds visibility moderate full stop Outlook Eastern Area northerly gales Western Area temporary improvement.

Though these reports are intended for the use of ships at sea, they will be found useful to shipping and seamen at the ports, if intercepted by local wireless receiving stations and passed to Mercantile Marine Offices and Harbour Masters.

SPARK ISSUES.

Certain portions of the "Weather Shipping" Bulletin described above are broadcast by coast W/T stations **on spark** as follows. The a.m. issues refer to 7 a.m. observations and p.m. issues refer to 6 p.m. observations, all times are G.M.T

For the Western Area.

Valentia, Lat. 51° 56′ N., Long. 10° 21′ W. (approx.), call sign **GCK** wavelength 600 metres spark. At 0948 G.M.T. and at 2048 G.M.T.

Seaforth, Lat. 53° 28′ N., Long. 3° 01′ W. (approx.), call sign **GLV** wavelength 600 metres spark. At 0930 G.M.T. and at 2030 G.M.T.

Commencing **Western Area** followed by ten groups of figures which indicate observations made at the five stations numbered 1 to 5 in the "Weather Shipping" Bulletin followed by the word **Forecast** after which the 12-hour forecast for the Western Area will be given.

For the Southern Area.

Niton, Lat. 50° 35′ N., Long. 1° 17′ W. (approx.), call sign **GNI**, wavelength 600 metres spark. At 0930 G.M.T. and at 2030 G.M.T.

Commencing **Southern Area** followed by six groups of figures which indicate observations made at the three stations numbered 5, 6 and 7 in the "Weather Shipping" Bulletin, followed by the word **Forecast**, after which the 12-hour forecast for the Southern Area is given.

For the Eastern Area.

Cullercoats, Lat. 55° 02′ N., Long. 1° 26′ W. (approx.), call sign **GCC**, wavelength 600 metres spark. At 0948 G.M.T. and at 2048 G.M.T.

Commencing **Eastern Area**, followed by eight groups of figures which indicate observations made at the four stations numbered 7, 8, 9 and 0 in the "Weather Shipping" Bulletin, followed by the word **Forecast**, after which the 12-hour forecast for the Eastern Area is given.

WIRELESS TELEPHONY (R/T) ISSUES.

Certain portions of the "Weather Shipping" Bulletin are broadcast from the British Broadcasting Corporation's station at **Daventry** by Wireless Telephony as follows:—

Daventry. Latitude 52° 15′ N., Longitude 1° 08′ W. (approx.), call sign **5XX**, wavelength 1,600 metres (R/T), at 1030 and about 2130 G.M.T., on weekdays, and at 1030 and about 2100 G.M.T. on Sundays.

This station broadcasts Parts I, III, IV and V of the "Weather Shipping" Bulletin, *i.e.*, a general inference, followed by 12-hour forecasts for the Western, Southern and Eastern Areas, based on observations at 0700 G.M.T. for the a.m. issue and on observations at 1800 G.M.T. for the p.m. issue.

When British Summer time is in operation the above times of issue should be retarded one hour.

As changes in the Time of issue of Parts I, III, IV and V through the British Broadcasting Corporation's station at **Daventry** are occasionally necessary at short notice, mariners are referred to the "Radio Times," the official organ of the British Broadcasting Corporation, which is published weekly for notice of the exact times of issue of this message; these are also given in the daily press.

It should be noted that the times given in the "Radio Times" are G.M.T. only when summer time is not in operation.

It should also be noted that forecasts for the General Public and Farmers are broadcast by Daventry, and as these are for land areas it is necessary to distinguish them from the parts of the "Weather Shipping" Bulletin which give information to Mariners.

For particulars of Wireless Weather Signals on all coasts of the World, see the last Volume of "The Marine Observer" and "The Admiralty List of Wireless Signals." Corrections to the latter are given in Notices to Mariners.

WIRELESS GALE WARNINGS FOR THE BRITISH ISLES.

Spark Issues.

These warnings are broadcast in plain language and refer to the area which lies within about 150 miles of the station broadcasting the warning.

The warnings are broadcast on a wavelength of 600 metres (spark) preceded by the **International Safety Signal TTT (— — —)** repeated at short intervals 10 times on full power; the warning being broadcast **one minute later, once only.**

Stations broadcasting these warnings.

Station.	Call Sign.	Latitude. (approx.)	Longitude. (approx.)
Niton (Isle of Wight) ...	**GNI**	50° 35′ N.	1° 17′ W.
Land's End	**GLD**	50° 07′ N.	5° 40′ W.
Fishguard	**GRL**	52° 01′ N.	4° 59′ W.
Seaforth (Liverpool) ...	**GLV**	53° 28′ N.	3° 01′ W.
Wick	**GKR**	58° 26′ N.	3° 06′ W.
Cullercoats	**GCC**	55° 02′ N.	1° 26′ W.
Valentia (Ireland) ...	**GCK**	51° 56′ N.	10° 21′ W.
Malin Head (Ireland) ...	**GMH**	55° 22′ N.	7° 20′ W.

Example.—"*Gale Warning.—Deep depression off N.W. Ireland moving East. Gales from S.E., backing North, probable North of Lat. 54°. Southerly gales veering N.W. other coasts.*"

Should the warning be broadcast during the period when one-operator ships do not keep watch it will be repeated in the next watch-keeping period for one-operator ships at either of the following times:—

Stations	G.M.T.	Stations	G.M.T.
Wick ... / **Land's End** / **Seaforth** ... / **Malin Head**	0800, 1200, 1600 or 2000.	**Cullercoats** ... / **Niton** ... ... / **Fishguard** ... ... / **Valentia (Ireland)**	0818, 1218, 1618 or 2018.

Gale warnings broadcast at 0800, 0818, 2000 or 2018 G.M.T. will follow the navigational warning, if one is broadcast.

Note.—For locating depressions the use of the words Ireland or Iceland is frequent and in order that they shall not be confused when Iceland is appropriate it will be repeated thus—Iceland Iceland.

Wireless Telephony (R/T) Issues.

Gale warnings will be broadcast as necessary by Radio Telephony, by the British Broadcasting Corporation's station at Daventry, call sign 5XX, on the wavelength of 1,600 metres as follows:—

Weekdays.

Immediately after the time signals at 1300 and 1600 G.M.T. and immediately following the ordinary weather report broadcast at 1830 G.M.T. Gale warnings issued at 1300 G.M.T. will be repeated both at 1600 and 1830 G.M.T. and a warning issued at 1600 G.M.T. will be repeated at 1830 G.M.T.

Sundays. At 1530 G.M.T. only.

When British Summer Time is in operation the above times should be retarded one hour.

The warnings will be made in the following manner by word of mouth:—

"*The Meteorological Office issued the following gale warning to shipping at 1430 G.M.T. to-day:—'Secondary depression off S.W. Ireland moving North-eastward, Southerly gales expected South of line from Exmouth to Spurn Head.'*"

These R/T gale warnings are simply a repetition of the W/T gale warnings at fixed times convenient to the B.B.C.

Changes in the times of issue by R/T of these gale warnings for shipping are necessary at short notice. Mariners are, therefore, referred to "The Radio Times," the official organ of the British Broadcasting Corporation, published weekly, for the exact times of issue. The times given in "The Radio Times" are only G.M.T. when summer time is not in operation.

APPENDIX III.

ABRIDGED KEY TO THE INTERNATIONAL CODE.

In view of the extension in the use of the International Code by weather services, the descriptions (where the International Code is used) are now published in a concise form by using key letters. Those used for marine work are given below with the necessary decode tables.

The Key Letters and their Meanings.

A = Form of *predominating cloud lowest* in the Table of cloud forms.

a = Form of *predominating cloud highest* in the Table of cloud forms when more than one type of cloud exists.

BBB = Pressure in millibars and tenths (initial 9 or 10 omitted), or millimetres and tenths (initial 7 omitted). The values refer to sea level and include all corrections for index error, temperature and gravity.

BB = Pressure in whole millibars or whole millimetres (initial 9, 10 or 7 omitted).

b = Amount of barometric tendency during the three hours preceding the time of observation expressed in half-millibars or half-millimetres. For tendencies 10–19 the *second* figure only is reported and 33 is added to the wind direction number (DD). For tendencies 20–29 the second figure only is reported and 67 is added to the wind direction number. Tendencies greater than 29 are reported as 29.

bb = Amount of barometric tendency during the three hours preceding the time of observation expressed in half-millibars or half-millimetres.

C = Form of predominating cloud, according to the Table of cloud forms, when only one form is reported, as from ships at sea. (*See* Table IX.)

c = Characteristic of barometric tendency during the period of three hours preceding the time of observation. (*See* Table XIII.)

DD = Direction of the wind (True) near the surface. (*See* Table III.)

d = Direction (True) from which swell comes. (*See* Table VIII.)

d_s = Direction of Ship's movement on scale (0–8) in which 2 = E, 4 = S, &c.

F = Force of the wind on the Beaufort Scale. (Forces above 9 are reported as 9, with the actual force in a word at the end. (*See* Table IV.)

GG = Greenwich Mean Time of observation (01 = 1 a.m., 12 = noon, 13 = 1 p.m., &c.)

H = Relative humidity of the air. (*See* Table XIX.)

h = Height of base of lower predominating cloud present. (*See* Table XXI.)

I_I I_I = Index number of station.

jj = Meaning varies according to time of observation and between inland and coastal stations, as follows:—

		Inland Stations.	Coastal Stations.
At 0700 G.M.T.	...	jj = mm	jj = SV.
At 1800 G.M.T.	...	jj = MM	jj = SV.

K = The characteristic of the swell *in the open sea*. (*See* Table VII.)

K′ = Amount and characteristic of barometric tendency expressed by a single figure. (*See* Table XII.)

L = Amount of sky (scale 0–10) covered by cloud form A and all forms of the same layer (*i.e.*, low, medium or high) as A, if "a" refers to a different layer.

LLL = Latitude in degrees and tenths, the tenths being obtained by dividing the number of minutes by 6 *and neglecting the remainder.*

lll = Longitude in degrees and tenths, the tenths being obtained as for latitude LLL.

MM = Maximum temperature in the interval of 11 hours ending at 18 h. G.M.T. (or at one of the hours 1 h., 7 h., 13 h., 18 h. G.M.T., following not less than 4 hours after noon, local time).

mm = Minimum temperature in the interval of 13 hours ending at 7 h. G.M.T. (or at the hour 13 hours after the time of reporting the maximum temperature).

N = *Total amount of sky covered with cloud.* (*See* Table X.)

P = Day of the week. (*See* Table I.)

Q = Quarter of globe in which ship is situated. (*See* Table II.)

RR = Rainfall (at 7 a.m. for preceding 13 hours and at 6 p.m. for preceding 11 hours). (*See* Table XVII.)

R = Amount of rainfall for the preceding 24 hours. (*See* Table XVI.)

r = Time of commencement of precipitation. (*See* Table XVIII.)

S = State of the sea and swell (coast stations). (*See* Table XX.)

TT = Temperature of the air in whole degrees Fahrenheit or Centigrade (50 added to negative values).

tt = Temperature of the sea (surface water) in whole degrees.

TTT = Temperature of air in degrees and tenths Fahrenheit or Centigrade (500 added to negative values).

ttt = Temperature of the sea (surface water) in degrees and tenths.

V = Visibility or distance at which objects can be seen in daylight (or at which lights can be seen at night). (*See* Table XIV.)

v = Visibility at sea from ships at sea. (*See* Table VI.)

V_s = Visibility towards the sea (from coast stations). (*See* Table XIV.)

W = Past weather—the weather in the interval preceding the time of observation. This interval is 5, 6, or 7 hours for reports at 1h., 7h., 13h., and 18h., G.M.T. (*See* Table XI.)

ww = The actual weather at the time of observation with which is combined, whenever possible, the general character of the weather. (*See* Table V.)

w_1 = The initial figure of the code ww, thus indicating the general state of the weather. (*See* Table XV.)

YY = Day of month.

INTERNATIONAL CODE, WEATHER TELEGRAPHY TABLES.

Table I.

P.—Day of the Week.

Code Figure.	Code Figure.
1 = Sunday.	5 = Thursday.
2 = Monday.	6 = Friday.
3 = Tuesday.	7 = Saturday.
4 = Wednesday.	

Table II.

Q.—Quarter of the Globe.

Code Figure.	Lat.	Long.	
1	N.	W.	Barometer in millibars.
2	N.	E.	
3	S.	W.	
4	S.	E.	
5	N.	W.	Barometer in millimetres.
6	N.	E.	
7	S.	W.	
8	S.	E.	

Table III.

DD.—Two Figure Compass. True (to nearest point).

Code Figures.		Code Figures.		Code Figures.	
00	Calm.	11	S.E. by E.	22	W.S.W.
01	N. by E.	12	S.E.	23	W. by S.
02	N.N.E.	13	S.E. by S.	24	W.
03	N.E. by N.	14	S.S.E.	25	W. by N.
04	N.E.	15	S. by E.	26	W.N.W.
05	N.E. by E.	16	S.	27	N.W. by W.
06	E.N.E.	17	S. by W.	28	N.W.
07	E. by N.	18	S.S.W.	29	N.W. by N.
08	E.	19	S.W. by S.	30	N.N.W.
09	E. by S.	20	S.W.	31	N. by W.
10	E.S.E.	21	S.W. by W.	32	N.

Table IV.

F.—Wind Force.

Code Figure.	Beaufort Number.	Code Figure.	Beaufort Number.
0 = Calm ...	... Nought.	7 = Moderate gale ...	Seven.
1 = Light air	... One.	8 = Fresh gale	... Eight.
2 = Light breeze ...	Two.	9 = Strong gale	... Nine.
3 = Gentle breeze ...	Three.	9 = Whole gale	... Ten.
4 = Moderate breeze	Four.	9 = Storm ...	... Eleven.
5 = Fresh breeze ...	Five.	9 = Hurricane	... Twelve.
6 = Strong breeze...	Six.		

When force 10, 11 or 12, figure 9 transmitted, words "gale," "storm" or "hurricane" respectively, added at end of the message.

Table V.

ww.—Present Weather Scale.

The figures are grouped to refer to particular phenomena, for example 20 to 29, Fog or mist. In making these observations the following instruction is given to the observer:—

In selecting the appropriate number for reporting the general character of the weather, no account should be taken of phenomena which occurred more than one hour before the time of observation, but only of phenomena which occurred during the interval of one hour preceding the fixed time of observation.

In deciding on the appropriate term, observers should not be restricted to the difference between the conditions at the instant and the conditions one hour before, but should choose the term to give the best information of the changes taking place.

Code Figures.		Table V.	
00	Blue sky or some cloud (Cloud 0–5)	Cloud has decreased.	
01		No apparent change.	
02		Cloud has increased.	
03		Precipitation within sight.	
04		With solar or lunar halo.	
05		After fog or mist or dust storm.	
06		After rain or drizzle.	
07		After snow, sleet or hail.	
08		With or after thunder and lightning in neighbourhood.	
09		After thunderstorm.	
10	Cloudy or overcast (Cloud 6–10)	Cloud has decreased.	
11		No apparent change.	
12		Cloud has increased.	
13		Precipitation within sight.	
14		With solar or lunar halo.	
15		After fog or mist or dust storm.	
16		After rain or drizzle.	
17		After snow, sleet or hail.	
18		With or after thunder and lightning in neighbourhood.	
19		After thunderstorm.	
20	Fog or mist	But clear in zenith	Just begun.
21		And apparently overcast	
22		But clear in zenith	Intermittent.
23		And apparently overcast	
24		But clear in zenith	For some time.
25		And apparently overcast	Has become thinner.
26		But clear in zenith	For some time.
27		And apparently overcast	
28		But clear in zenith	For some time.
29		And apparently overcast	Has become thicker.
30	Passing showers	Slight with rain.	
31		„ hail or rain and hail.	
32		„ sleet.	
33		„ snow.	
34		Heavy with rain has become better.	
35		„ rain.	
36		„ rain has become worse.	
37		„ hail or rain and hail.	
38		„ sleet.	
39		„ snow.	
40	Drizzle	Slight occasional.	
41		„ continuous.	
42		„ but has increased.	
43		Moderate but has decreased.	
44		„ occasional.	
45		„ continuous.	
46		„ but has increased.	
47		Thick but has decreased.	
48		„ occasional.	
49		„ continuous.	

Code figures.		Table V.—*continued.*	
50	Rain	Slight occasional.	
51		„ continuous.	
52		„ but has increased.	
53		Moderate but has decreased.	
54		Moderate occasional.	
55		„ continuous.	
56		„ but has increased.	
57		Heavy but has decreased.	
58		„ occasional.	
59		„ continuous.	
60	Snow or snow and hail	Slight occasional.	
61		„ continuous.	
62		„ but has increased.	
63		Moderate but has decreased.	
64		„ occasional.	
65		„ continuous.	
66		„ but has increased.	
67		Heavy but has decreased.	
68		„ occasional.	
69		„ continuous.	
70	Sleet or rain and snow	Slight occasional.	
71		„ continuous.	
72		„ but has increased.	
73		Moderate but has decreased.	
74		„ occasional.	
75		„ continuous.	
76		„ but has increased.	
77		Heavy but has decreased.	
78		„ occasional.	
79		„ continuous.	
80	Hail or rain and hail	Slight occasional.	
81		„ continuous.	
82		„ but has increased.	
83		Moderate but has decreased.	
84		„ occasional.	
85		„ continuous.	
86		„ but has increased.	
87		Heavy but has decreased.	
88		„ occasional.	
89		„ continuous.	
90	Thunder-storm (or Line Squall)	Slight thunderstorm without hail.	
91		„ „ with hail.	
92		Moderate thunderstorm without hail.	
93		„ „ with hail.	
94		Heavy thunderstorm without hail	without gale.
95		„ „ with hail	
96		„ „ without hail	with gale.
97		„ „ with hail	
98		Line squall without hail.	
99		„ „ with hail.	

Table VI.

v.—Visibility from Ships at Sea.

Code Figure.			
0	Dense fog	Objects not visible at	50 yards.
1	Thick fog	„ „ „	1 cable.
2	Fog	„ „ „	2 cables.
3	Moderate fog	„ „ „	½ mile (nautical).
4	Mist or haze, or very poor visibility.	„ „ „	1 mile (nautical).
5	Poor visibility	„ „ „	2 miles (nautical).
6	Moderate visibility	„ „ „	5 miles (nautical).
7	Good visibility	„ „ „	10 miles (nautical).
8	Very good visibility	„ „ „	30 miles (nautical).
9	Excellent visibility	Objects visible more than 30 miles (nautical).	

Table VII.

K.—Swell.

Code Figure.		
0	No, or slight swell	and sea smooth to moderate.
1	Moderate swell	
2	Heavy swell	
3	Long low swell	
4	Confused swell	
5	No, or slight swell	and sea rough or above.
6	Moderate swell	
7	Heavy swell	
8	Long low swell	
9	Confused swell	

Table VIII.

d.—One figure compass. (True.)

Code Figure.	Code Figure.	Code Figure.
0 = No Swell.	3 = S.E.	6 = W.
1 = N.E.	4 = S.	7 = N.W.
2 = E.	5 = S.W.	8 = N.

Table IX.

C.—Cloud Predominating.

Code Figure.	
1—Cirrus ...	Ci.
2—Cirro-Stratus ...	Ci.-St.
3—Cirro-Cumulus	Ci.-Cu.
4—Alto-Cumulus ...	A.-Cu.
5—Alto-Stratus ...	A.-St.
6—Strato-Cumulus	St.-Cu.
7—Nimbus	Nb.
8—Cumulus or Fracto-Cumulus	Cu. or Fr.-Cu.
9—Cumulo-Nimbus	Cu.-Nb.
0—Stratus or Fracto-Stratus ...	St. or Fr.-St.

Table X.

N.—Cloud Amount.

Code Figure.	Code Figure.
0 = No cloud.	6 = Sky 6/10ths covered.
1 = Sky 1/10th covered.	7 = „ 7/10ths „
2 = „ 2/10ths „	8 = „ 8/10ths „
3 = „ 3/10ths „	9 = „ 9/10ths „
4 = „ 4/10ths „	*0 = „ overcast.
5 = „ half „	

* Usually weather reported by Table V, will indicate which 0 applies here.

Table XI.

W.—Past Weather.

	Code Figure.
Without precipitation	0 = Blue sky or blue sky and part cloudy (b or bc).
	1 = Cloudy.
	2 = Overcast continuously.
	3 = Fog or mist.
	4 = Thick fog.
Precipitation	5 = Passing showers.
	6 = Rain or drizzle.
	7 = Snow or sleet.
	8 = Hail or rain and hail.
	9 = Thunderstorm.

Table XII.

K′.—Barometric Tendency.

Code Figure.							
0	Barometer steady.	(The barometer has not fallen or risen more than ½ millibar in 3 hours.)					
1	Do.	rising slowly.	(The barometer has	risen	1 to 1½ mb.	('03–'04 in.)	in last 3 hours.)
2	Do.	rising.	Do.	do.	2 to 3½	('06–'10 in.)	do.
3	Do.	rising quickly	Do.	do.	4 to 6	('12–'18 in.)	do.
4	Do.	rising very rapidly.	Do.	do.	over 6	('18 in.)	do.
5	Do.	falling slowly.	Do.	fallen	1 to 1½	('03–'04 in.)	do.
6	Do.	falling.	Do.	do.	2 to 3½	('06–'10 in.)	do.
7	Do.	falling quickly.	Do.	do.	4 to 6	('12–'18 in.)	do.
8	Do.	falling very rapidly.	Do.	do.	over 6	('18 in.)	do.

Table XIII.

c.—Characteristic of Barometric tendency during last 3 hours.

Code Figure.		
0 = 0 or +	Steady or rising	The barometer is now higher than, or the same as, 3 hours ago.
1 = + 0	Rising then steady	
2 = + −	Rising then falling	
3 = − + or 0 +	Falling or steady then rising	
4 = Unsteady +	Unsteady but rising	
5 = −	Falling	The barometer is now lower than 3 hours ago.
6 = − 0	Falling then steady	
7 = − +	Falling then rising	
8 = 0 − or + −	Steady or rising then falling.	
9 = Unsteady −	Unsteady but falling	

Table XIV.

V and V_s.—Visibility.

Code Figure.		
0 =	Objects not visible at	50 metres (55 yards).
1 =	,, ,, ,,	200 metres (220 yards).
2 =	,, ,, ,,	500 metres (550 yards).
3 =	,, ,, ,,	1,000 metres (1,100 yards).
4 =	,, ,, ,,	2,000 metres (1¼ miles).
5 =	,, ,, ,,	4,000 metres (2½ miles).
6 =	,, ,, ,,	10,000 metres (6¼ miles).
7 =	,, ,, ,,	20,000 metres (12½ miles).
8 =	,, ,, ,,	50,000 metres (31¼ miles).
9 =	Objects visible at 50,000 metres or more.	

Table XV.

w_1.—General state of the weather (abridged).

Code Figure.	Code Figure.
0—Cloud amount 0–5.	5—Rain.
1—Cloud amount 6–10.	6—Snow or Hail and Snow.
2—Fog or mist.	7—Sleet or Rain and Snow.
3—Passing showers.	8—Hail or Rain and Hail.
4—Drizzle.	9—Thunderstorm.

Table XVI.

R.—Rainfall during preceding 24 hours.

Code Figure.	Code Figure.
0 = No rain.	5 = 11–15 mm.
1 = Trace or 0·1 mm.	6 = 16–20 mm.
2 = 0·2–2 mm.	7 = 21–30 mm.
3 = 3–5 mm.	8 = 31–50 mm.
4 = 6–10 mm.	9 = above 50 mm.

Table XVII.

RR.—Rainfall during preceding 13 or 11 hours.

Code Figures.	Meaning.
91	0·1 mm.
92	0·2 ,,
93	0·3 ,,
94	0·4 ,,
95	0·5 ,,
96	0·6 ,,

Table XVII—*continued.*

Code Figures.	Meaning.
97	Some rain, but not measurable.
98	More than 90 millimetres.
99	Measurement impossible or unreliable.

Amounts of 0·7 mm. or more are coded as whole millimetres, *e.g.*, 17·2 mm. coded as 17.

Table XVIII.

r.—Time of commencement of precipitation.

Code Figure.	
0	No rain.
1	0 to 1 hour before time of observation.
2	1 to 2 hours before time of observation.
3	2 to 3 ,, ,, ,,
4	3 to 4 ,, ,, ,,
5	4 to 5 ,, ,, ,,
6	5 to 6 ,, ,, ,,
7	6 to 8 ,, ,, ,,
8	8 to 10 ,, ,, ,,
9	Above 10 hours before time of observation.
–	No observation.

Table XIX.

H.—Relative humidity.

Code Figure.	
0	95 to 100 per cent.
9	90 ,, 94 ,,
8	80 ,, 89 ,,
7	70 ,, 79 ,,
6	60 ,, 69 ,,
5	50 ,, 59 ,,
4	40 ,, 49 ,,
3	30 ,, 39 ,,
2	20 ,, 29 ,,
1	10 ,, 19 ,,

Table XX.

S.—State of Sea and Swell (Coast Stations).

Code Figure.		
0	No swell	Calm or slight sea.
1	Moderate swell	
2	Heavy swell	
3	No swell	Moderate sea.
4	Moderate swell	
5	Heavy swell	
6	Rather rough sea.	
7	Rough sea.	
8	Very rough sea.	
9	Mountainous sea.	

Table XXI.

h.—Height of base of lower predominating cloud present.

Code Figure.	Metres.	Feet.
0	0 to 50	0 to 150
1	50 ,, 100	150 ,, 300
2	100 ,, 200	300 ,, 600
3	200 ,, 300	600 ,, 1,000
4	300 ,, 600	1,000 ,, 2,000
5	600 ,, 1,000	2,000 ,, 3,000
6	1,000 ,, 1,500	3,000 ,, 5,000
7	1,500 ,, 2,000	5,000 ,, 6,500
8	2,000 ,, 2,500	6,500 ,, 8,000
9	No low cloud.	No low cloud.

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