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PRESSURE TYPE IN
RELATION TO FOG FREQUENCY

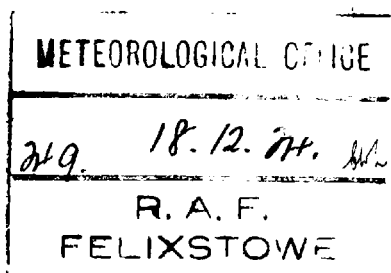
AT

SCILLY DURING SUMMER
MONTHS

BY

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PRESSURE TYPE IN RELATION TO FOG FREQUENCY AT SCILLY DURING SUMMER MONTHS

By E. G. BILHAM, B.Sc., D.I.C.

In connexion with an investigation of the conditions associated with fogs at sea during summer months, I have had occasion to tabulate the occurrences of fog at St. Mary's, Scilly, during the prevalence of different types of pressure distribution. The complete investigation promises to be somewhat prolonged, and as fog in that region is a phenomenon of considerable importance to seamen, it was thought desirable to put together the results of the tabulation in a separate form.

The observations used were those for St. Mary's, Scilly, published in the *Daily Weather Report* during the fourteen years, 1905 to 1918. The selection of this period was governed by the fact that the pressure distribution at 7h. G.M.T. on each day, has been classified, tabulated and published in Col. E. Gold's* "Aids to Forecasting." The types referred to here in Roman numerals are those described and figured in that publication.

During the summer months "fog," as distinct from "mist," is reported at St. Mary's, Scilly, on one day in seven, and if we include cases of "mist" the frequency is at least twice as great. The seaman's proceedings are embarrassed if he cannot see the horizon from the deck of the ship, and it would therefore have been very desirable to include all such cases in the inquiry. To have done this, many cases when "mist" was reported ought to have been included, but unfortunately it was not possible to be certain that the reports of mist were completely homogeneous. Until very recently, the terms "mist" and "fog" have not been rigorously defined and there has been much diversity of practice by different observers. The conclusion adopted was that a report of "fog" made it certain that conditions were such as to impede navigation, but that no such certainty could be assumed when "mist" was reported. In this inquiry, therefore, only days when "fog" was definitely reported were included. The day was taken as beginning at 7h. G.M.T., it being considered a day of fog when "f" appeared in the "present weather" or "past weather" columns of the *Daily Weather Report* at any time before 7h. on the following day.

The dates upon which fog occurred at Scilly having been extracted from the *Daily Weather Report*, the type of pressure distribution was obtained for each of the days, by reference to Table I of "Aids to Forecasting." The number of occasions of fog accompanying each of the different types could then be tabulated. As they stand, however, the figures so obtained are of little significance, because the relative frequencies of the different types are widely variable. A "frequency-ratio" was therefore calculated for each type by dividing the number of

* "Aids to Forecasting: Types of pressure Distribution." Met. Office *Geophysical Memoirs* No. 16, 1920. M.O. 220f.

occasions on which fog occurred by the total frequency of that type during the whole period.* The latter data are given for each month in Table III of "Aids to Forecasting." The effect of a given type on the probability of fog could then be seen by comparing the frequency-ratio for the type with the mean probability as determined from all the data. Results obtained in this way for each of the months, June, July and August and for the three months combined are given in the tables which follow.

The total number of days dealt with was $14 \times (30 + 31 + 31)$, or 1288, and there were 192 fogs, giving a mean probability of $\frac{192}{1288}$ or 0.149. The normal chances against fog are therefore 0.851 to 0.149 or nearly 6 to 1. Of the 192 fogs, 61 occurred in June, 60 in July and 71 in August, giving probabilities of 0.145, 0.138 and 0.164 respectively with probable errors of the order 0.01.

The number of fogs in individual months varied from none in August 1905 to 12 in June, 1915. In individual years, the number for the three months combined varied from 8 in 1909 to 24 in 1914. The complete figures are given in Table I.

TABLE I.—FREQUENCY OF FOGS AT ST. MARY'S, SCILLY, IN 24 HOURS COMMENCING 7H. G.M.T.

MONTHLY TOTALS.

Year	June	July	August	Total
1905 - - -	3	8	0	11
1906 - - -	4	6	9	19
1907 - - -	5	3	3	11
1908 - - -	5	3	1	9
1909 - - -	1	3	4	8
1910 - - -	6	6	8	20
1911 - - -	5	1	5	11
1912 - - -	2	5	8	15
1913 - - -	5	1	6	12
1914 - - -	7	8	9	24
1915 - - -	12	3	6	21
1916 - - -	1	6	2	9
1917 - - -	3	5	3	11
1918 - - -	2	2	7	11
Total - - -	61	60	71	192

Table II. gives in Columns 3, 5 and 7, the frequency ratio for each type for June, July and August separately. The values of the frequency-ratio are seen to vary from nil to above 0.5.

* The "frequency ratio" for a given type multiplied by 100 gives the percentage of days of fog during the prevalence of that type. When a day of fog was tabulated under two types, half a day was credited to each of the types.

Some types such as IV, V, XII and XIV give consistently high or low values in each of the three months, but in many cases, for example IVA, VA and XIA, there are considerable differences. In some cases it might be possible to assign physical explanations to these discrepancies, for the general conditions in August, differ from those of June. It is obvious, however, that chance plays a large part when the number of observations is small as it is in many cases. For that reason, no attempt will be made here to trace the variation in the fog-probability with a given type in the different months. The separate monthly values are only given because they will be of value in estimating the reliability of the final figures.

TABLE II.—FOG FREQUENCY IN RELATION TO TYPE OF PRESSURE DISTRIBUTION.

Type	June		July		August		Combined Results		
	Type Frequency	Fog-frequency ratio	Type Frequency	Fog-frequency ratio	Type Frequency	Fog-frequency ratio	Type Frequency	Fog-frequency ratio	Comparison of three months
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
I	51	·137	78	·077	50	·170	179	·120	— — +
IA	15	·033	30	·200	14	·214	59	·161	— + +
II	18	·195	20	·200	15	·200	53	·198	+ + + *
III	15	·100	27	·093	23	·087	65	·092	— — — *
IV	29	·345	12	·238	51	·333	122	·303	+ + + *
IVA	8	·313	10	·050	11	·318	29	·224	+ — +
V	15	·167	13	·310	22	·364	50	·290	+ + + *
VA	12	·125	8	·562	13	·077	33	·212	— + —
VI	5	·200	2	·250	7	·143	14	·179	+ + —
VIA	12	·083	16	·125	17	·294	45	·178	— — +
VII	20	·150	11	·091	20	·075	51	·108	+ — —
VIIA	4	·250	2	·000	9	·111	15	·133	+ — —
VIIb	16	·188	7	·214	5	·600	28	·268	+ + + *
VIIc	5	·000	2	·000	0	·000	7	·000	— — — *
VIII	10	·300	7	·286	3	·000	20	·250	+ + —
VIIIA	5	·200	7	·071	5	·400	17	·201	+ — +
VIIIb	11	·273	10	·050	10	·050	31	·129	+ — —
IX	20	·075	20	·075	8	·125	48	·083	— — — *
IXA	10	·000	11	·091	4	·000	25	·040	— — — *
IXb	20	·050	8	·125	13	·000	41	·049	— — — *
X	30	·017	29	·103	23	·087	82	·067	— — — *
XI	4	·250	7	·000	18	·111	29	·103	+ — —
XIA	33	·273	27	·148	18	·056	78	·180	+ + —
XII	4	·000	5	·000	9	·000	18	·000	— — — *
XIII	4	·000	3	·000	11	·091	18	·056	— — — *
XIIIA	3	·500	5	·500	4	·250	12	·417	+ + + *
XIV	21	·048	12	·000	14	·071	47	·043	— — — *
XV	20	·025	15	·100	37	·051	72	·056	— — — *
Total	420	Mean ·145	434	Mean ·138	434	Mean ·164	1,288	Mean ·149	—

In Columns 8 to 10, the results are considered as a whole. The mean ratio (fog-frequency/type-frequency) is given for each type in column 9. In the last column, a plus sign indicates a frequency-ratio above the normal, a minus sign a ratio below that value in the individual months. Thus in the case of Type I the entry "— — +" shows that the frequency-ratio came out below the normal in June, below in July and above in August. An asterisk is entered against those types for which the signs are similar in each of the three months. It seems reasonable to conclude that when this condition is complied with a definite influence of the type on the fog probability has been made out. It will be seen that about half the types have earned an asterisk. Of the remainder, the majority give values differing little from the mean.

Discussion of the Results.—It is not intended to enter upon a theoretical discussion respecting the fog-producing power of the different types. For many of the types this would hardly be possible, on account of the fact that the conditions at Scilly during their prevalence might vary through a considerable range. Fog at sea is caused by cooling below the dew point air nearly saturated with water vapour, either by mixing or by upward conduction from a cold sea surface. Both processes require a very precise adjustment of the conditions and for that reason, sea-fog is notoriously difficult to forecast. Many of the fogs reported at Scilly are, moreover, of the nature of coastal fogs rather than true sea-fogs.

The first thing that strikes the eye in looking at column 9 of Table II is that there is no very sharp separation into "foggy" and "non-foggy" types. A comparatively large number of types give frequency-ratios lying between $\cdot 10$ and $\cdot 20$. Five types give values of $0\cdot 25$ or above, but of these, one (VIII) fails to pass the test of agreement in sign between the monthly values. Only two types give values of $0\cdot 30$ or above, the highest being XIIIa with a value of $0\cdot 417$. Even with this type, the odds are slightly in favour of clear weather, or at least, weather not thick enough to be reported as "f."

At the other end of the scale, we find eight types which give less than half the average frequency of fog, and two of these, VIIc and XII failed to yield a single fog in 14 years. Both are rather rare types, however, VIIc occurring only seven times during the period. Total immunity from fog during their prevalence is, therefore, not satisfactorily established. The seven least foggy types (VIIc, IXa, IXb, XII, XIII, XIV and XV), give a total of 228 observations with only 10 fogs. On the whole, it would appear, therefore, that the clear-weather types have emerged quite conspicuously as a result of this analysis: more so than the foggy types. This is not very surprising perhaps, in view of the fact that the formation of fog is conditioned by factors which are only indirectly related to the pressure distribution. It must be remembered that the types

are merely isobaric types and if there were any such which gave a very high frequency of fog at Scilly, they would inevitably have been discovered in the ordinary process of forecasting. Though forecasting by type alone would be a failure when applied to the incidence of fog at Scilly, the results given here should be of some utility since we have found at any rate a few types in which there is about double the normal risk of fog, and a good many in which the probability of fog is negligible.

The most important foggy and clear weather types are shown in the accompanying diagrams and some notes follow.

Foggy Types.—

Type XIII A.—Large area of high pressure with a number of small maxima. Chances 1·4 to 1 against fog at Scilly. This type actually gave the highest percentage of fogs, but occurred only 12 times during the period of 14 years. The fogs were usually general round the British coasts, and most of the cases which failed to give fog at Scilly, gave fog on some part of the coast. July 23rd, 1916, is a good example.

Type IV.—Ridge of high pressure over British Isles, with lows to north-west and north-east. Chances slightly above 2 to 1 against fog at Scilly. Having regard to its frequency of occurrence this is the most important type so far as fog at Scilly is concerned. The fog often occurs in combination with rain or drizzle. Its persistence depends upon the energy of the oncoming low, but as it is a "steering line" phenomenon, it is usually rather brief. In a good many cases, however, it lasts two days. See the charts for August 1912, especially 16th and 17th and 22nd to 25th.

Type V.—Depressions moving from SW to NE with centres keeping north-west of the British Isles. Chances slightly above 2 to 1 against fog at Scilly. The remarks under Type IV apply also to this type. Not often very persistent, but on July 9th, 1912, a fog which lasted four days began with Type V.

Type VII B.—High over Scandinavia, low far to south-west of the British Isles. Chances 2·7 to 1 against fog at Scilly. This type results in a slow northward movement of warm moist air from the Bay and a high fog frequency at Scilly is therefore not surprising. The type is rare in July and August. The charts for August 13th and 14th, 1914, show examples of fog during the prevalence of Type VII B.

Type II.—High over France, westerly isobars over British Isles. Chances 4 to 1 against fog at Scilly. The fogs associated with this type are not usually persistent and occur chiefly when the type is one of transition between I and IV or V. (It is often difficult to differentiate this type from IV.) A persistent fog which subsequently affected all the western coasts of the British Isles occurred during the prevalence of Type II on August 18th and 19th, 1918.

Plate I.

To face page 178.

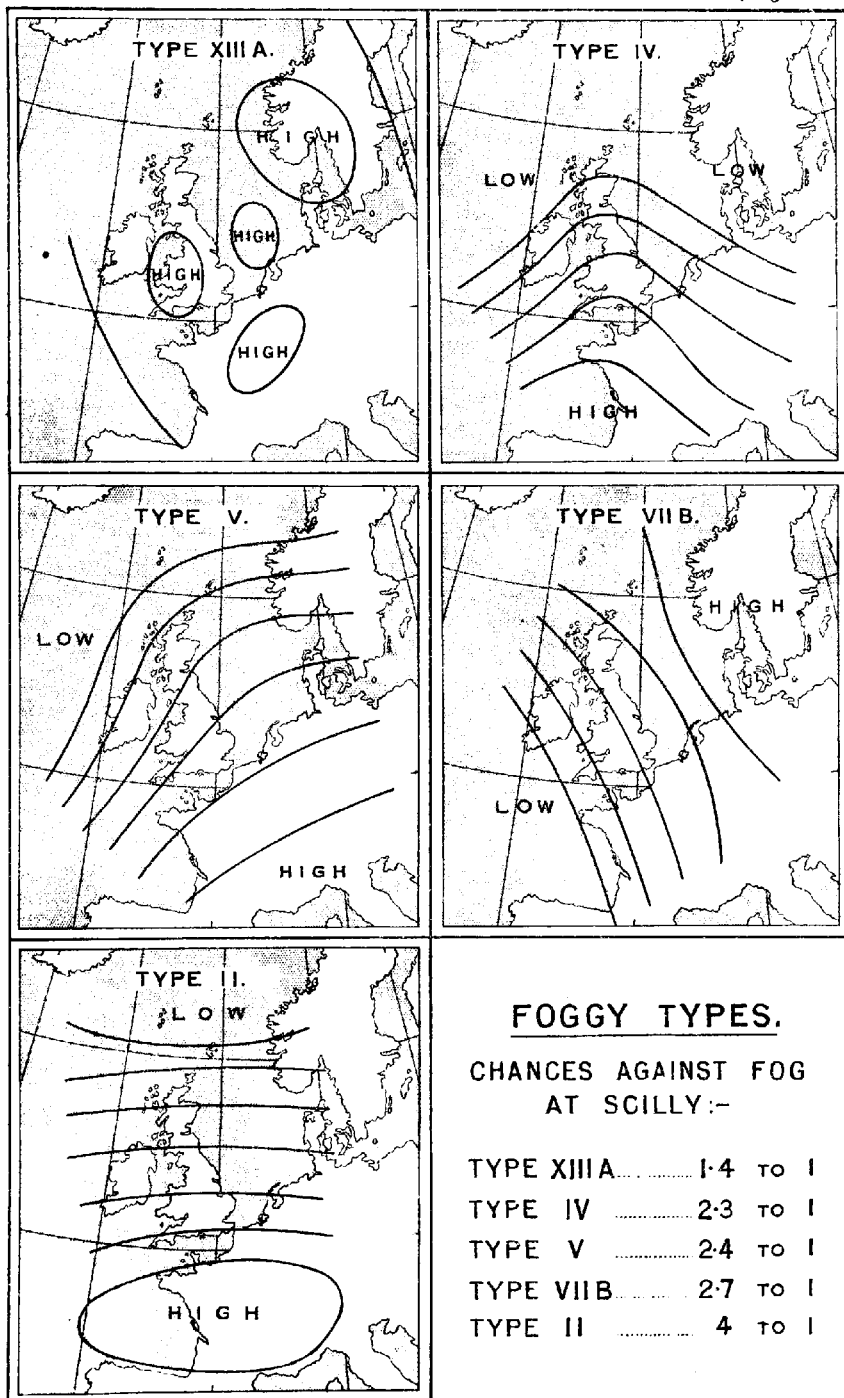


Plate II.

To face page 178.

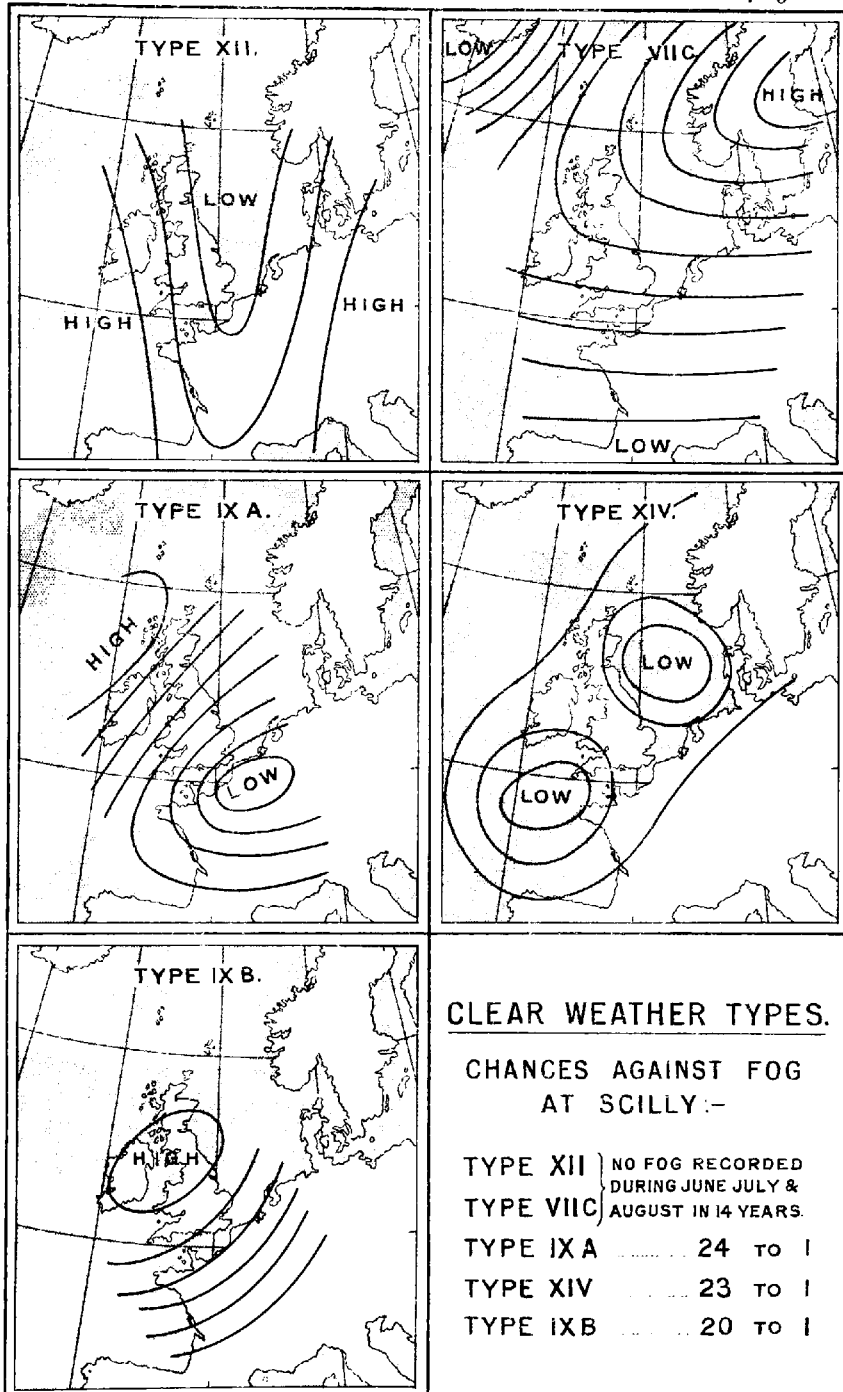
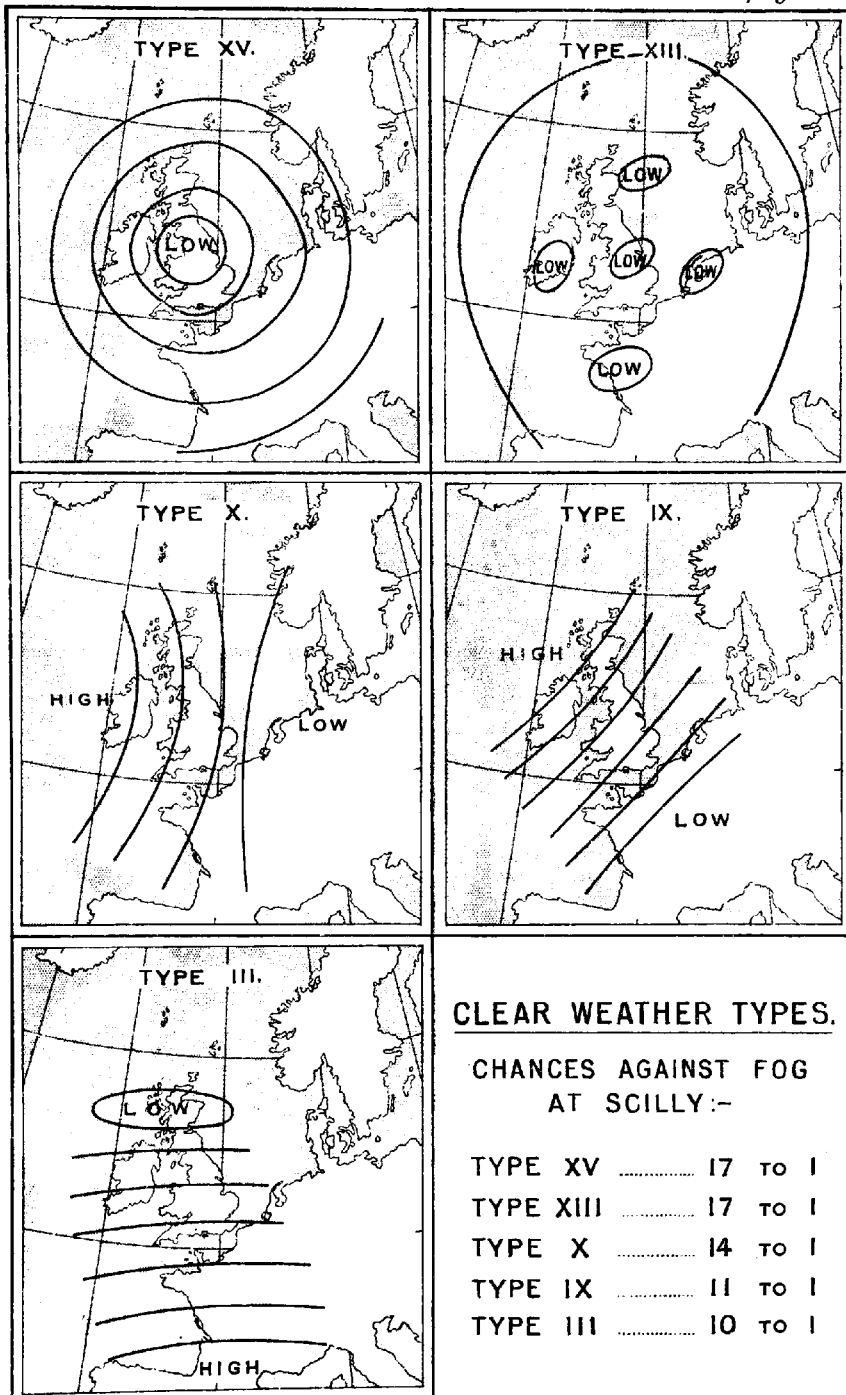


Plate III.

To face page 178.



Clear Weather Types.—

Type XII.—V-shaped depression. Total immunity from fog at Scilly. The rear of a V-shaped depression is well-known to be a region of high visibility. The causes are discussed in Shaw's *Memorandum on Atmospheric Visibility** and need not be further considered here.

Type VIIc.—High over Scandinavia, lows over Iceland and the Mediterranean. Occurred only 7 times in the 14 years, and gave no fog at Scilly. Since this type brings dry air from the Continent towards Scilly, a low fog frequency is to be expected.

Type IXA.—Similar to IX, but depression farther north, increasing the north-east gradient. Chances 24 to 1 against fog at Scilly. The remarks on Type IX apply to this type *a fortiori*.

Type XIV.—Dumb-bell depressions. Chances 23 to 1 against fog at Scilly. The remarks on Type XIII are also applicable to this type.

Type IXB.—Anticyclone over the British Isles; north-easterly gradient over southern England, the Channel and France. Chances 20 to 1 against fog at Scilly. The remarks under IX apply to this type.

Type XV.—Depression centred over British Isles. Chances 17 to 1 against fog at Scilly. Scilly is in the north-westerly current in the rear of the depression and immunity from fog is to be expected for the reasons given in Shaw's *Memorandum on Atmospheric Visibility*."

Type XIII.—Large area of low pressure with a number of shallow minima. Chances 17 to 1 against fog at Scilly. The contrast between this case and XIIIa is very striking. The immunity from fog at Scilly during the prevalence of XIII would seem to be dependent upon the fact that XIII is a thundery type in summer and favourable for active convection.

Type X.—High off west of Ireland, low far to eastward of British Isles. Chances 14 to 1 against fog at Scilly. This is the most common of the clear weather types. Since it results in air movement from north to south which will normally be associated with a rising temperature, low fog-probability is to be expected.

Type IX.—High to north-westward of the British Isles; straight north-easterly isobars. Chances 11 to 1 against fog at Scilly. The comparative immunity from fog at Scilly with this type is to be attributed to the fact that the air reaching Scilly will usually have passed across England and will arrive with low relative humidity. The air will, moreover, normally be of polar origin and have a low humidity to start with.

* See *Forecasting Weather* 2nd edition, 1923. Chapter XVI.

Type III.—Straight westerly isobars with low over Scotland and high far to the southward. Chances 10 to 1 against fog at Scilly. This type is of fairly common occurrence, and gives slightly less than the normal frequency of fog. The difference between this type and II (which gives double the frequency of fog at Scilly) seems to arise from the fact that it gives the air a trajectory more nearly parallel with the sea surface isotherms.