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THE EFFECT OF THE LABRADOR CURRENT
UPON THE SURFACE TEMPERATURE OF THE NORTH ATLANTIC;
AND OF THE LATTER UPON AIR TEMPERATURE AND
PRESSURE OVER THE BRITISH ISLES.

PART II.

(CONCLUDED FROM GEOPHYSICAL MEMOIRS, No. 1).

• BY

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THE EFFECT OF THE LABRADOR CURRENT UPON THE SURFACE TEMPERATURE OF THE NORTH ATLANTIC; AND OF THE LATTER UPON AIR TEMPERATURE AND PRESSURE OVER THE BRITISH ISLES.

PART II.

THE first part of this Memoir, which was published in 1912,* relates to the lustrum 1903–1907, and may be regarded as a sequel to a paper pertaining to a comparison of the changes in the strength of the Trade Winds of the Atlantic in each of the five years 1902–1906, with average results; and of changes in the Surface Temperature of the North Atlantic during each of the five years 1903–1907, with normal values.

The latter was the initial step in an endeavour to trace a connexion, through the agency of the Equatorial Currents, between variations in the strength of the Trade Winds of the Atlantic and subsequent variations in air temperature and barometrical pressure over our islands.

The weather conditions that prevailed during the spring, summer, and autumn of the year 1911 having been exceptional, diagrams with accompanying notes for the months of January to October, were added for the purpose of affording comparison with corresponding results of previous years. The months of November and December could not then be included, because the data required were not available in time for publication.

In this, the second part of the Memoir, the investigation is extended to the end of the year 1912, with the last two months of the previous year completed, and is brought to a close.

With reference to the opinion I ventured to express in the earlier part of the Memoir, that the presence of ice in the North Atlantic can have no effect upon the climatic conditions of our islands, because it is the cold Labrador Current that lowers the temperature of the ocean, not the ice it brings south, I should mention that this opinion is not shared with all oceanographers. Commenting upon the statement, the eminent Swedish philosopher, Professor Otto Pettersson, one of the highest authorities upon the subject, writes as follows :—

It seems clear to me that the existence of icebergs and floes at the west side of the Atlantic can exercise no influence on our climate by itself, but indirectly it may have influence. First, it keeps the water of the Labrador and Greenland Currents cold, at zero or below zero (C.), so long as there is ice in their waters; secondly, the melting of the ice in sea water produces a thin film of sweet or brackish cold water which spreads widely over a quarter or one-fifth part of the surface of the great northern basin of the Atlantic; and thirdly, there is a transformation of the heat, stored up in the Gulf Stream water, at its encounter with the ice, which means propulsive energy of the surface and deep water.

In the prosecution of this part of the investigation, I have been ably assisted by Mr W. E. Whitehouse (Gilchrist Student of Geography) of University College of

* Meteorological Office, Geophysical Memoirs, No. 1.

Wales, Aberystwyth, who, for a short course of study and research, attended at the Meteorological Office in the months of August and September, 1912, and to whose kindness and skill I am indebted for the drafts of diagrams on Plates 60, 61, 62.

The decline in sea temperature in April and May 1912, and the still more marked fall that occurred in July and August of that year, while attributable mainly to a reduction in the strength of the Gulf Stream and an increase in the activity of the Labrador Current, were obviously also in a measure the result of an invasion of the North Eastern Atlantic by the East Greenland Current in the months of April and May, and again in August and October.

In order, therefore, that more definite knowledge regarding this cause of defect in sea temperature in the northern part of the ocean might be acquired, the Director of the Danish Meteorological Institute in Copenhagen, Captain Carl Ryder, was kind enough to furnish a large number of sea surface temperature observations, taken on board Danish vessels trading between Denmark and ports in Iceland and the south-east and south-west coasts of Greenland during the nine months of March to November, 1912.

By means of these data it has been possible to supplement the sea temperature results relating to the Florida Strait-Valencia Zone by information with reference to a zone situated between Cape Farewell, Greenland, and the Orkney islands: *i.e.* between the meridians of 46° W. and the Greenwich meridian, and between the parallels of 58° N. and 60° N., which came directly under the influence of the East Greenland Current.

The total number of observations which thus became available for this purpose amounts to 1562 for the nine months; the total number for each month ranging from 46 in March to 262 in July; and upon these observations are based the results which are shown by the additional curve on Plate 64.

Without these data, several points upon which they throw light would be inexplicable; and it appears probable that had similar information been procurable for the previous years to which this inquiry relates, they would have assisted materially in the elucidation of many of the large departures from the normal in air temperature that do not show that correlation with sea surface temperature results which is, as a rule, exhibited.

If, in connexion with long-period forecasts of weather in these islands, sea surface temperature data be utilised at any future time, it will be necessary that a larger number of recent reliable observations be available weekly, for all parts of the North Atlantic, than are at present obtainable.

Without such a complete and continuous record it is not possible to interpret with accuracy the changes that occur in the intricate distribution of sea surface temperature, or to follow the movements of the respective water layers of Equatorial and Arctic origin. It is desirable, moreover, that sea temperature observations should be supplemented by observations for salinity, because from the latter the origin of water layers can frequently be traced with greater facility.

1908. (PLATE 60.)

Ice in small quantities was present in the North Atlantic in the first month of this year. The quantity became somewhat larger in February; remained about the

same in March; afterwards increasing rapidly until May, when icebergs or field ice, or both, were charted in no less than 46 one-degree squares. A slight diminution in the number of ice reports occurred in the following month, but in July such reports became much less frequent, the number of one-degree squares in which ice was charted falling to 23. The quantity of ice subsequently fluctuated, but at the same time lessened steadily until October, after which month it decreased so rapidly that in December the steamer routes were clear of this danger to navigation.

Sea Temperature at the surface in the south-western portion of the Florida-Valencia Zone, as indicated by the position of the 70° isotherm, was slightly above the normal in January, owing, doubtless, to a brief increase in the activity of the Gulf Stream; but in the north-eastern portion it was slightly below. In February these conditions became reversed, but, while in March and April the excess of temperature noticeable in the south-western arm of the ocean in the first month had been transferred to the middle of the zone, which is represented by the 60° isotherm, and which extended $8\frac{1}{2}^{\circ}$ east of its average limit, at the close of the former month and at the commencement of the latter, in the north-eastern and south-western parts of the ocean, the surface remained at about its normal temperature.

Associated with the rapid increase in ice frequency, which attained its maximum in May, a general fall in sea temperature took place in that month, occasioned by the increase in volume of the Labrador Current, which usually takes place in the spring. This fall in surface temperature continued during the two following months in the neighbourhood, and immediately to the south west, of our southern shores, but a recovery of temperature was shown elsewhere in June: the advance of the 70° isotherm 6° east of its average limit for the month at the end of July pointing to a considerable influx of warm Gulf Stream water. Although fluctuations are shown to have occurred subsequently, and a general, but temporary, fall of temperature was noticed in September, yet, as a whole, the surface of the ocean between Florida Strait and the south of Ireland during the remainder of the year was warmer than is usual at that season.

Air Temperature below the normal at Valencia and at Shields, in January, rose $1\frac{1}{2}^{\circ}$ above the normal in the following month, afterwards falling until the latter half of April. At Sumburgh Head, where it was slightly above the normal in January, and about the normal in February and March, it fell below in April. A general but temporary increase of temperature was registered in May, when at Shields it rose 3° above the normal, and at Valencia 2° above. In the three months that followed, the air temperature, while somewhat lower than the average at the northern stations, was slightly higher at the southern. In September the conditions became reversed, and next month a sudden and decided rise of temperature occurred at the three stations, the excess at the northern and eastern being about 5° , and at the southern 4° . Subsequently air temperature declined rapidly; and, while at Sumburgh Head it recovered somewhat at the end of November, at Valencia and Shields it continued to fall until the close of the year.

Pressure is shown to have been somewhat higher than the average at the three stations in January, and to have diminished at Sumburgh Head in the following month, and at Shields during the two following months, while at Valencia it increased during those months, but diminished in March. Subsequently, although fluctuations in pressure took place frequently at those stations during the six months that

followed, the departures from the averages were not large, pressure being slightly above the normal in April, below the normal in May and September, slightly above again during the intervening months, but in October it increased decidedly at the northern stations in this month, but fell as decidedly in November; not, however, until the close of the year at Valencia.

1909. (PLATE 61.)

Ice.—Field ice was present in small quantities in the North Western Atlantic during the second half of January, but icebergs were not reported until about the middle of February. The quantity of ice increased after that time until May; rapidly during March, slowly in April, rather rapidly in May. From the close of May to about the middle of November the quantity diminished somewhat quickly, and during the following two months slowly; after that the diminution was accelerated, and in November a few bergs were observed, but ice of no other description.

Sea Temperature in January was found to be slightly below the normal in the South Western Atlantic, but somewhat above to the northeastward. After about the middle of the month a general decline in sea temperature occurred, which continued until the second half of February, when a decided increase took place: the 60° and 70° isotherms advancing 4° to the eastward of their average positions, and the 55° isotherm 1° to the eastward. Under the influence of an expansion of the cold Labrador Current, sea temperature then declined considerably until May, except in the South Western Atlantic, where it showed a slight but temporary recovery in April. The surface temperature of the ocean increased generally in the next month, and remained above the normal until November, the 70° isotherm as charted advancing so much that in August it was as much as 8° to the eastward of its average position. During the last two months of the year the surface temperature, as a whole, was found to be below the normal.

Air Temperature responded to the fall in sea temperature, which took place in January and February, but did not recover until April. In March it fell at Shields as much as 4° F. below the normal, and at Valencia and Sumburgh Head nearly 3° below.

Subsequently, responding, for the most part, to the modifications in sea temperature, but exhibiting a marked lag, air temperature rose slightly above the normal at the two last mentioned stations in April and May, albeit declining at the east coast station; fell decidedly below in June; recovered in August at Valencia and Sumburgh, but remained below at Shields; fell temporarily in the following month at the two former stations, while gradually recovering at the latter; rose above the normal at all three stations in October; after which it declined, and continued below for the remainder of the year.

Pressure rose at Sumburgh Head from about the average in January to rather more than 0.2 inch above the average in February; while at Valencia and Shields it was slightly above during both these months. Pressure diminished rapidly at the three stations in March, afterwards increased at Sumburgh and Shields until May, and at Valencia until June. A decrease in pressure took place at the three stations in July; and a recovery during the next two months was followed by a decrease in October; an increase in November; and again a decrease in the last month of the year.

1910. (PLATE 62.)

Ice.—The first ice reported in 1910 was field-ice. It was seen on the 25th of February, and before the close of the month symbols denoting the danger in this form were charted in six one-degree squares; but icebergs were not observed until the 8th of March.

The quantity of ice increased, rather slowly, until May, after which month it diminished steadily until August. The last of the field-ice was passed on the 7th of June; the number of icebergs, however, again increased during September and part of October, subsequently becoming fewer, and after the 15th of November no ice was seen in the North Atlantic until the close of the year.

Sea Temperature in the south-western and north-eastern portions of the North Atlantic was below the normal in January, the defect being due, probably, to a decrease in the volume of the Gulf Stream on the one hand, and an increase in the activity of the Labrador Current on the other.

Presumably from similar causes the following changes ensued: a rise in sea temperature was recorded during February, when the 60° isotherm advanced 2° east of its average limit for the period, the 55° and 70° isotherms remaining at this time considerably west of their respective limits. The latter, however, advanced to its average position in March and 2° to the east of this position in April, while the former again retreated in the third month, but advanced in the fourth, reaching its average position at the close of the month.

The temperature in the south-western arm of the ocean decreased in May, the 70° isotherm retreating nearly 10° west of its average limit. At the same time the abnormally warm water that had occupied this area in April, and had drifted north-eastward, now occasioned a rise of sea temperature nearer our shores; with the result that the 60° isotherm is shown 4° to the east of its average position.

Subsequently the fluctuations in sea surface temperature, although well marked, were not large: the values registered, as a whole, being below the normal in June; above the normal in July; below in August; above during the two following months; about the same as the normal in November; and above in the closing month of the year; except in the south-western arm of the ocean, where it was below the normal.

Air Temperature in January was as much as 5° below the normal at Sumburgh Head, but only slightly below at Valencia and Shields. While at the northern and eastern stations, it rose steadily during the two following months, it declined slightly at the western station until February. In March it was 1½° above the normal at Shields, but only slightly above at Valencia and Sumburgh Head.

The decline in air temperature at all three stations in April synchronises with the defect in the surface temperature of the northern half of the ocean during that month, and its rise in May with the spread eastward of the relatively warm water from the south-west, which is indicated by the advance of the 60° isotherm in that month, and was heralded by the advance eastward of the 70° isotherm in the previous month.

So far the influence of the ocean upon the temperature of the air over our islands is fairly apparent, but in the three months that follow it becomes less noticeable.

In June the air temperature at the three stations was not far from the normal, and the same may be said as regards Valencia in the month following; while at Sumburgh Head only a slight defect is indicated. At Shields, however, a decided fall

occurred; and, although the temperature rose at that station in August, and no change took place in that month at Valencia, at both stations it remained somewhat in defect.

Associated, apparently, with modifications in sea temperature, a decline in air temperature is indicated in September; a marked increase in October; as marked a reduction in the following month, when the defect amounted to as much as 6° at Shields, and 3° at each of the other stations; then a rapid rise in December.

Pressure, which had increased considerably since December of the previous year, but was still below the average in January at all three stations, diminished, and in the following month the departures from the average were -0.4 inch at Valencia, and rather more than -0.5 inch at Sumburgh Head, and at Shields. Pressure increased rapidly in March to $+0.15$ inch at the western and northern stations, and to 0.25 inch at the eastern; but next month it again decreased, and remained below the average until September, except at Sumburgh, where it differed little from the average in July and August. In September and October it increased to above the average, and in the two last months of the year fell below.

1911. (PLATE 63.)

Ice.—The quantity of ice in the North Atlantic increased in this year from January to May, rapidly to April; and decreased rapidly after May until July. There occurred a brief increase in the quantity of ice during August; followed by a quick decrease in September; after which month the diminution was less rapid until after November, when it again increased.

Sea Temperature in the northern half of the ocean is shown to have been slightly in excess of the normal in January; but, as indicated by the 70° isotherm, in defect, but increasing, in the southern half. Subsequently it increased to above the normal in the South-Western Atlantic until the end of February and declined to the north-eastward during that month. The conditions were reversed in March, a fall in temperature taking place to the south-west, and a rise to the north-eastward. Over the area represented by the 60° and 70° isotherms temperature rose in April, but declined to the north-eastward. After April sea temperature was in excess of the normal until October, except in the south-west portion of the ocean, when the 70° isotherm retreated to the west of its average limit in August. The temperature in this part, however, quickly recovered; the 70° isotherm, which was nearly 9° of longitude to the east of its average limit at the end of May, again advanced, and was 7° east of it in October, and 9° in December, but retreated rapidly towards the close of the month. Increased activity of the Labrador Current in the two closing months of the year reduced the sea temperature for the most part below the normal in the northern portion of the ocean, although south of the 44th parallel it temporarily rose more than 2° above.

Air Temperature, since the closing month of the previous year, remained about the normal at Valencia, and in excess of the normal at the two other stations—until February at Valencia and Shields, and until March at Sumburgh Head. At the end of March the meteorological station in the Shetlands was transferred from Sumburgh Head to Lerwick. After March, temperature declined slightly at Valencia and Lerwick; but increased to above the normal at the eastern station; and at the western and northern stations after April; being largely in excess at those stations in May.

It declined generally in June, but was nevertheless still above the normal in that month. Increasing again towards the end of June, temperature rose considerably higher than the normal in July and August, except at Lerwick, where it was moderately in excess in the former month, fell to about the normal in September, was slightly below it in October and in November at the northern and eastern stations, and more decidedly in defect at the western. Temperature rose above the normal in the last month of the year; when the excess was more than 4° at Lerwick and nearly 3° at Shields.

To sum up the conditions, as regards temperature, that prevailed during this abnormal year: in the months of January and February, from the close of April to the close of September, and again in December, the temperature of the air over Great Britain and Ireland was in excess of the average; moreover, during the months of May, July, August, and December it was greatly in excess. In October the temperature was about the same as the average, and in March, April, and November only can it be said to have been in defect.

Pressure, above the average in January, remained for the most part above until the end of October, except at Lerwick in February, and again in June; and at Valencia in August, in those months it fell considerably below the average at those stations, although it had been 0.35 inch above in May at Lerwick. Pressure stood higher than the average in August, September, and October, except at Lerwick, where in September it was in agreement with the average. It diminished sharply in November, and continued in defect to the close of the year.

Observations contributed to the Meteorological Office by the captains of whaling ships, who had been cruising in East and West Greenland Seas during the whaling season, afford evidence of unusually boisterous weather in those regions during the summer of the year under notice. Gales were frequent, and the wind on many occasions attained to the force of a whole gale; it was in fact reported to have on one occasion reached hurricane force.

This stormy, and, therefore, open weather, which doubtless was conducive to the disruption of ice in the north polar region adjoining the Atlantic, may be accounted for by the distribution of pressure prevailing during that period. Areas of high barometer were frequently present over the North Atlantic, south of the 55th parallel, also over the west of Europe.

Under these conditions a large percentage of the depressions arriving from the west were deflected to the north-eastward, and in numerous instances the centres of the "lows" moved from the north-west arm of the Atlantic across or to the north of Iceland, ultimately disappearing in the Arctic, beyond the North Cape.

1912. (PLATE 64.)

Ice.—In January ice was observed in twenty 1° squares. The quantity of ice increased next month, and decreased slightly in March. From that month to May the quantity again increased; rapidly to April, in which month ice was reported in an area represented by no less than eighty-six 1° squares. In June there occurred only a slight reduction in the quantity of ice reported, but after that month the number of reports declined more quickly for a month, and then rapidly to September, when on all but sixteen 1° squares of the chart the symbols for ice of any description were absent.

Sea Temperature.—The temperature of the sea surface, which fell below the normal at the close of the previous year, continued in defect during the first three months of the year under notice, except in the south-western portion of the North Atlantic, where it rose above the normal after the middle of February. The temperature then increased so quickly that in less than a month the 70° isotherm was charted 8° to the east of its average limit for March. In the more northern portions of the ocean, the surface temperature, although in defect until after March, rose from the middle of February until April, and in that month the charted results exhibited, for the most part, an excess of temperature over the North Atlantic generally. The abnormally warm water, of equatorial origin, that was advancing north-eastward, and had been most noticeable in the South Western Atlantic in March, and between the 40th and 50th parallels of latitude in the following month, reached the North Eastern Atlantic in May, flooding the coastal waters off our southern shores, while a decided reduction of surface temperature was taking place in other parts of the ocean.

At the end of May, and in the beginning of June, the 70° isotherm had retreated 6° to the west of its average limit for those months, but a slight temporary recovery of temperature was observed between the 40th and 50th parallels up to the middle of the latter month, when under the cooling influence of the Labrador Current the surface temperature rapidly declined: the 60° isotherm in August having retreated as much as 13° of longitude to the west of its average limit. In the south-west arm of the ocean the temperature rose during June and July, reaching the average towards the close of the latter month, when it declined, but recovered in September. It again declined during the two months that followed, in the latter of which it became considerably in defect; and, although the sea surface temperature increased in the second half of November, it continued to be below the normal to the end of the year.

To the north-eastward the isotherm of 60° , and subsequently that of 55° , indicated a decided defect in surface temperature to the end of the year; albeit fluctuations are shown which harmonise with the temperature of the surface water to the south-westward, as indicated by the 70° isotherm.

For the zone between South Greenland and the Orkneys sufficient data are wanting for the purpose of comparison with normal results, until March, when the surface temperature is shown to have been slightly above the normal. It declined during the following two months, when it stood $1\frac{1}{2}^{\circ}$ below the normal; but it rose to and remained $\frac{1}{2}^{\circ}$ below the normal in June and July; fell under the influence of the East Greenland Current in August; recovered somewhat in the month following; and exhibited similar fluctuations as those which obtained in August and September during the two remaining months, for which sufficient data are available.

Air Temperature.—Throughout the greater part of this year the curves of air temperature resemble, in a marked degree, those relating to sea surface temperature.

In January the temperature of the air was about 0.5° below the normal at Lerwick and Shields, and the same as the normal at Valencia. It increased at the northern station in the two following months; declined slightly at the south-western station in February, then rose slowly until May; while at the northern station it fell in April, but continued to be above the normal in that and the following month. At Shields and Valencia there occurred a fall in temperature from May to August; except at the latter station, where the results showed a check in the fall during July.

At Lerwick, a similar fall in air temperature was checked after June until August, a rise occurring in the intermediate month which may be accounted for by the spread north-eastward of a layer of relatively warm water, indicated by the sea isotherm of 55° , which reached our south-western coasts in the previous month, and arrested the fall in air temperature at Valencia.

In September, the temperature at Valencia, which had decreased in August to $4\frac{1}{2}^{\circ}$ below the normal, increased rapidly, and continued to do so during the remainder of the year, in the last two months of which it was above the normal. The fall in temperature at Shields also was checked in August; and at the same time it was arrested somewhat at Lerwick; while at the east coast station it did not change materially until the end of the following month, when it rose quickly, then remained steady for a month, and again rose rapidly in the closing month of the year. At the northern station the fall was maintained until September, after which the temperature fluctuated: being $2\frac{1}{2}^{\circ}$ above the normal in October; $1\frac{1}{2}^{\circ}$ below in November; and $1\frac{1}{2}^{\circ}$ above in the last month of the year.

The air temperature over the British Isles during the summer and autumn of 1912, in contrast with that prevailing during the same seasons of the previous year, is found, therefore, to have been below the normal in June to November inclusive, except at the northern station in July and October and at the south-western station in November, at which places it rose slightly above in the respective months. It was above the normal in February to May inclusive, except at Valencia, where the excess did not obtain until March. It was equal to, or nearly equal to, the normal in January, and above in December; at Valencia above in November also.

Pressure.—At Lerwick, pressure was 0.2 inch above the average in January; at Shields about the same as the average; while at Valencia it is found to have been 0.15 inch below. The pressure diminished next month at the three stations: at Lerwick 0.45 inch, at Shields 0.3 inch, and at Valencia about 0.3 inch; and although subsequently it increased, it was about 0.3 inch in defect in March.

In the month following, pressure increased rapidly: to 0.3 inch above the average at the south-western station, 0.25 inch above at the eastern, and 0.17 inch above at the northern; but diminished during the two following months. In June, pressure is found to have been below the average at the three stations; in July above at the northern and eastern, and, although higher than in the previous month, below at the south-western. It was below the average in the month following; decidedly above in September; about the same as the average at the northern and eastern stations; and slightly below at the south-western in October; above at Valencia in the following month; about equal to the average at Shields; and below at Lerwick. In the last month of the year pressure was 0.15 inch in defect at the eastern and south-western stations; 0.3 inch in defect at the northern station.

It will be noticed that the foregoing remarks upon the diagrams on Plates 7 to 11 are, for the most part, supplementary to the information afforded by the curves, and that only occasionally do they point to a reason for a departure from the average conditions of the elements to which the curve relates.

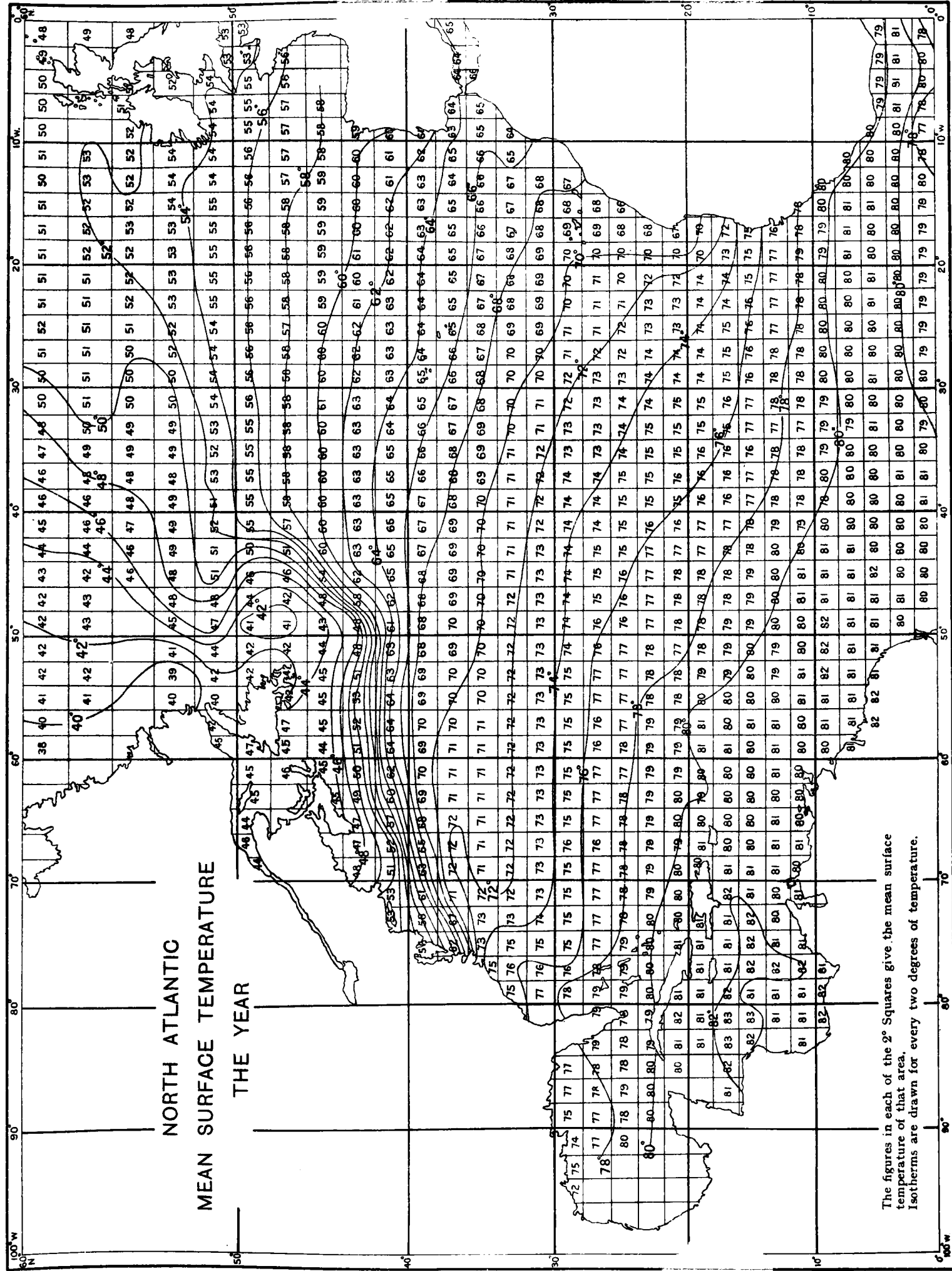
It is conceivable that the majority of the larger departures from the normal in sea surface temperature, which are shown as having obtained in the North Atlantic during each of the five years 1908–1912, might be traced to departures from the average in the strength of the Atlantic Trade Winds during each of the years they

preceded. Such a relation appeared to be indicated in similar results relating to the previous years of the decade to which reference has already been made.

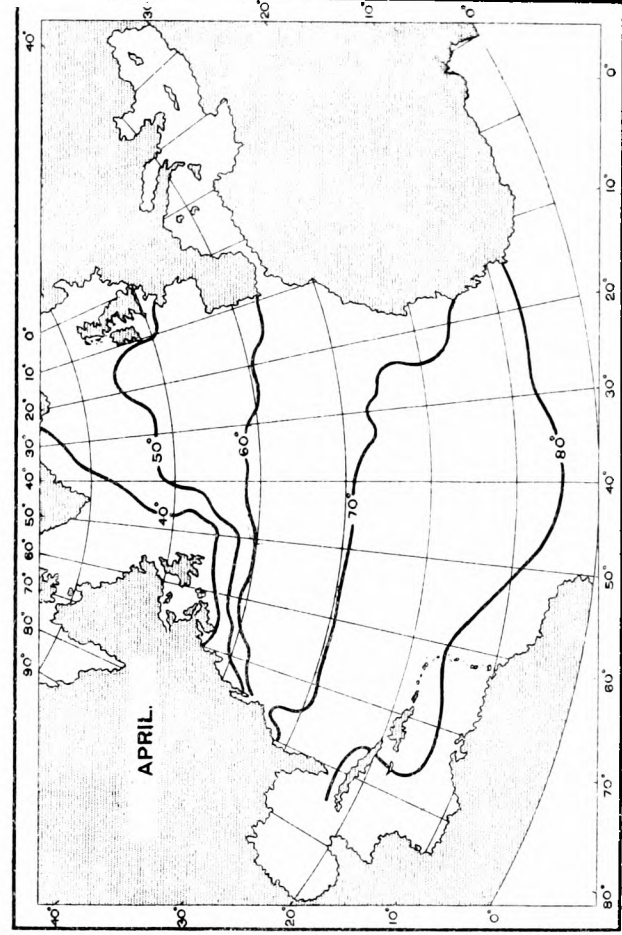
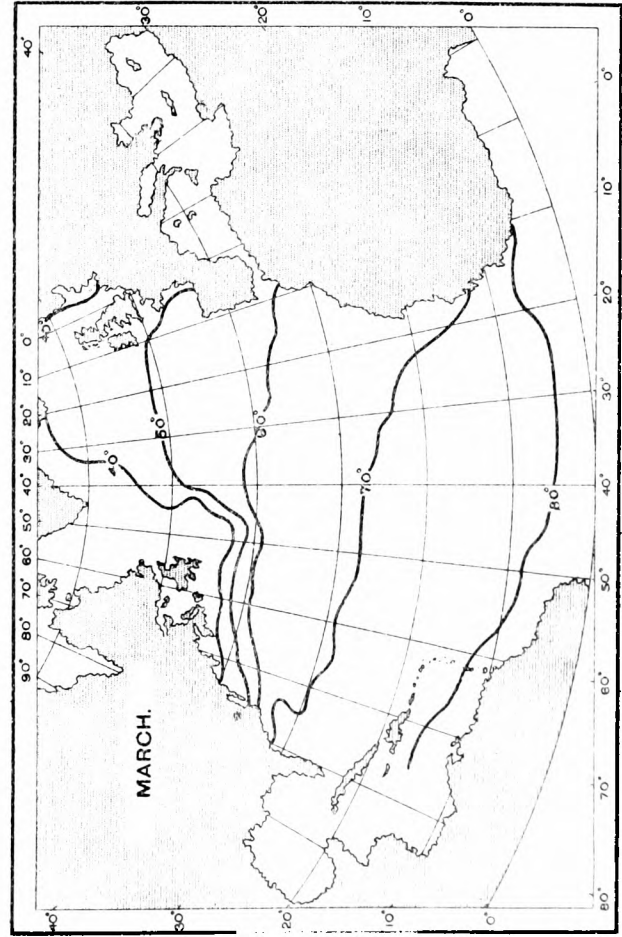
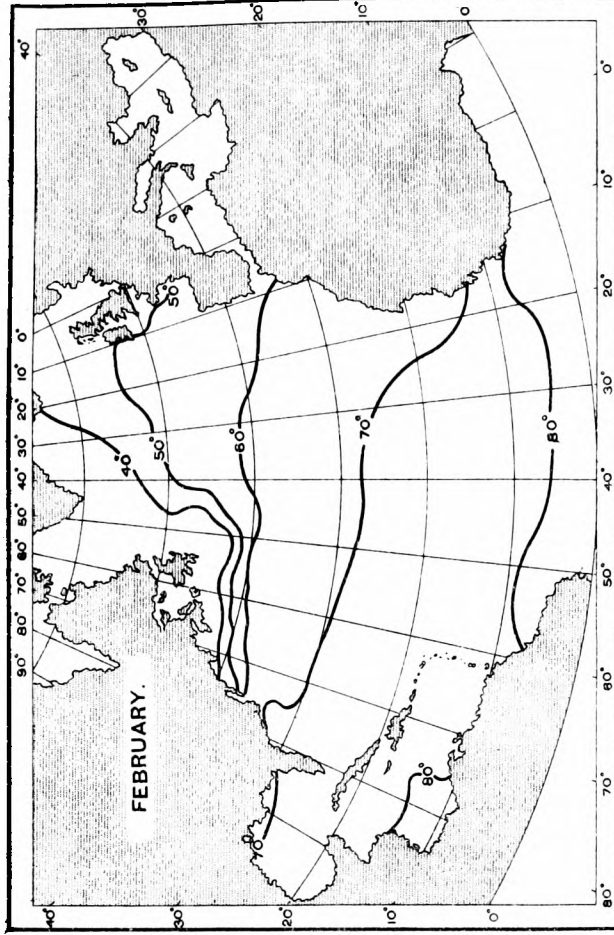
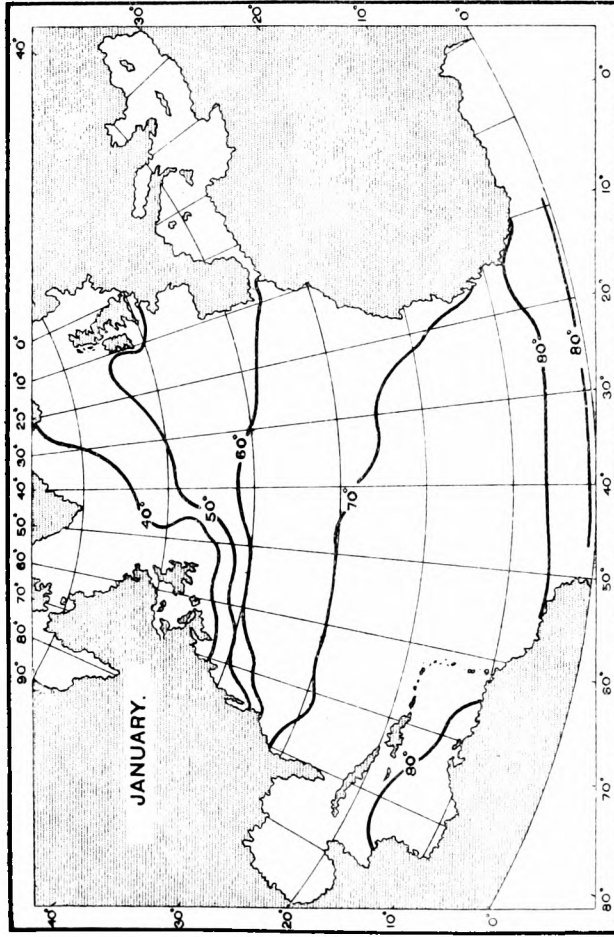
Again, as regards ice frequency in the North Atlantic, a connexion could probably be found to exist between variations in the influx of relatively warm water of equatorial origin to higher latitudes in that ocean, in each of the years under notice, and variations in the quantity of ice in the North Western Atlantic in each succeeding year of the lustrum 1909-1913.

Investigations such as these, which would involve the collation and discussion of a mass of data, are not, however, within the scope of this brief memoir.

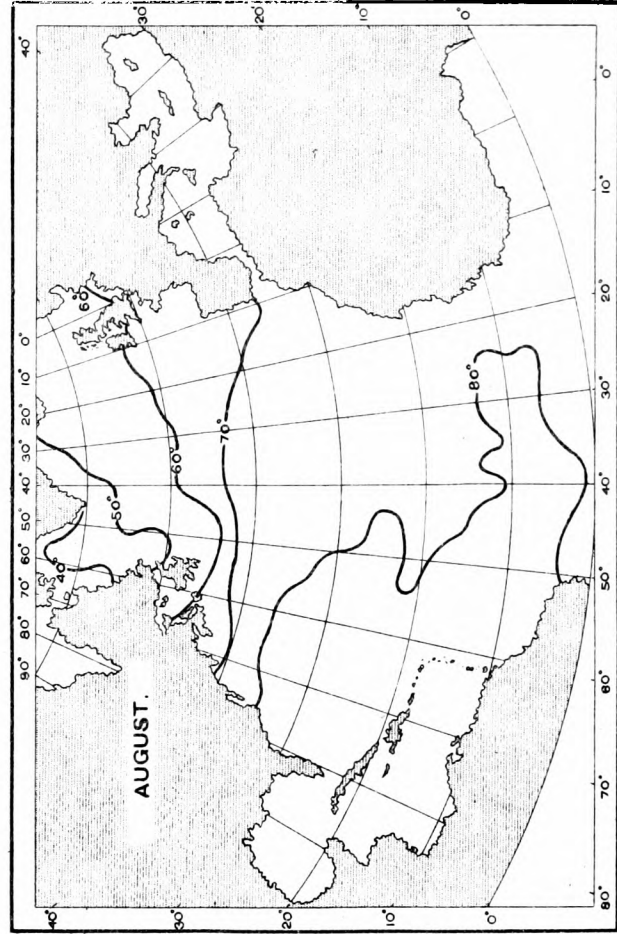
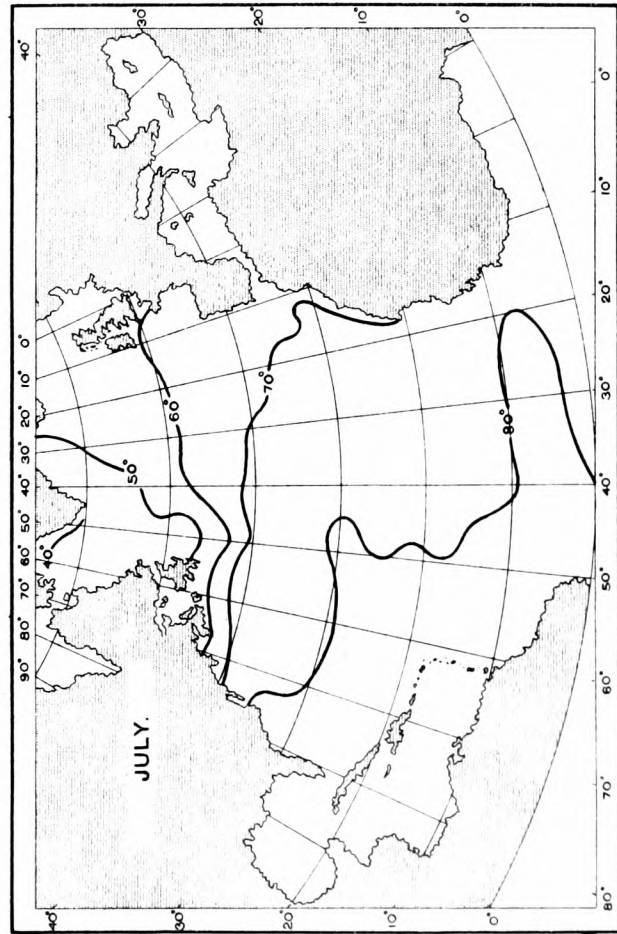
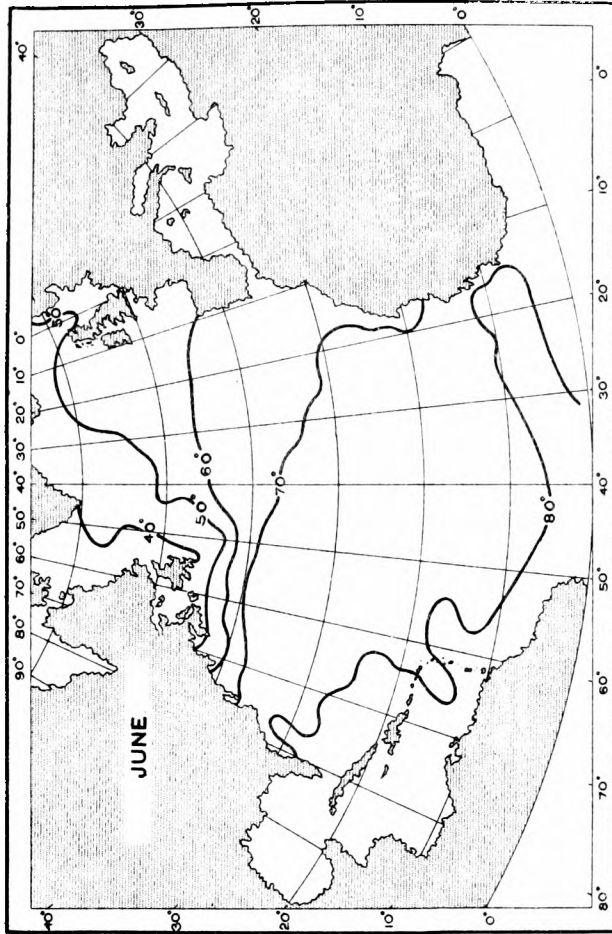
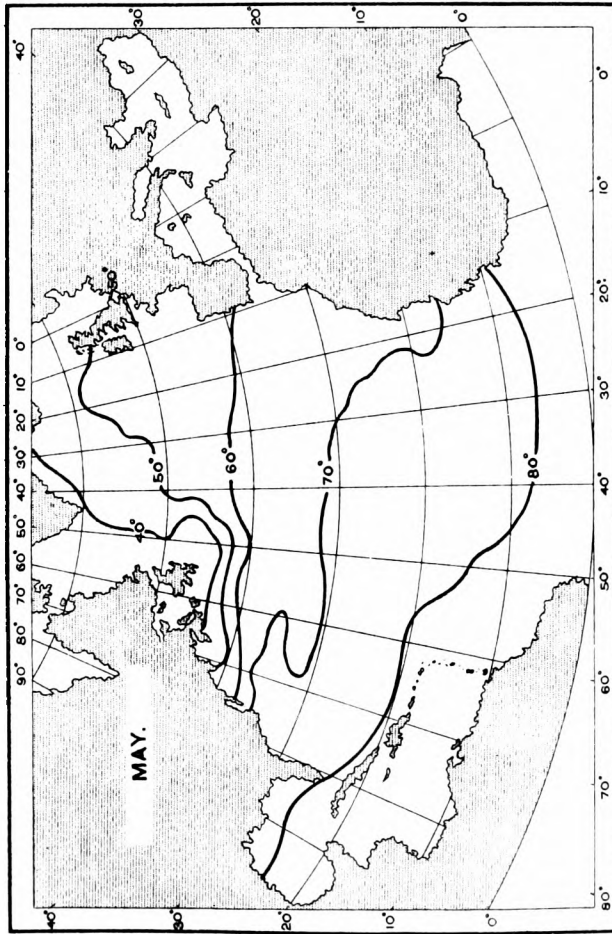
It has been suggested to me that the absence of correlation, usually indicated, between the fluctuations in sea surface temperature of the North Eastern Atlantic, and corresponding fluctuations in air temperature and barometrical pressure over our islands, might sometimes be explained by reference to the influence of passing depressions or anti-cyclones; but it must be borne in mind that when high or low pressure systems visit our neighbourhood, they become part of those weather conditions that are assumed to be mutually related to sea temperature distribution, and cannot, therefore, be detached from the conditions they characterise.



MEAN SEA SURFACE ISOTHERMS OF THE NORTH ATLANTIC.

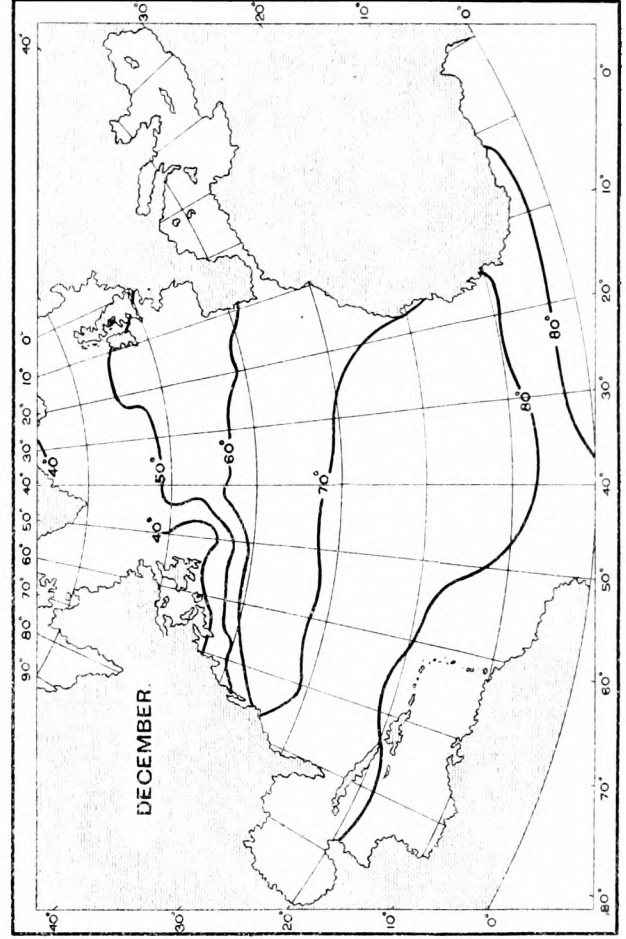
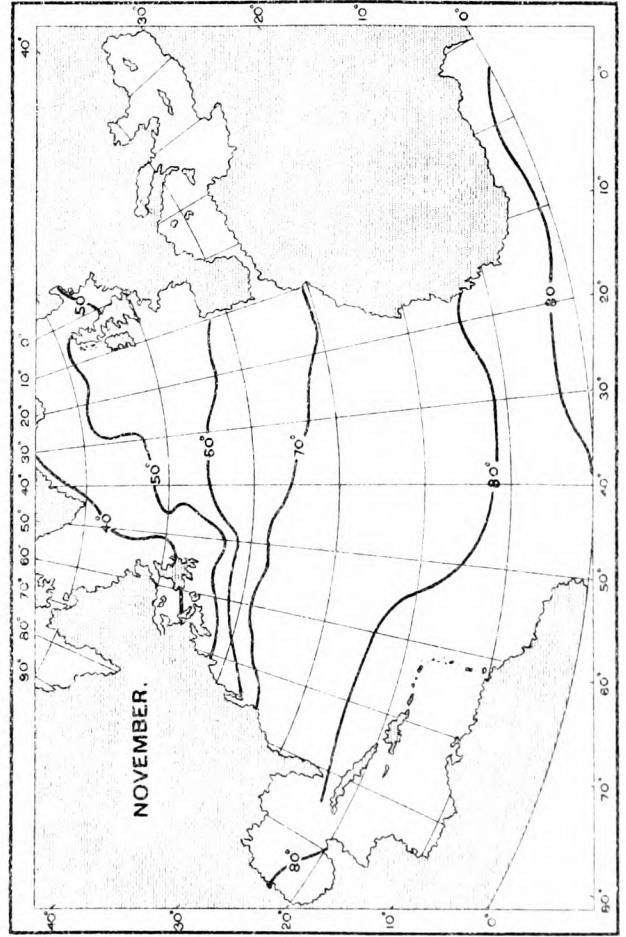
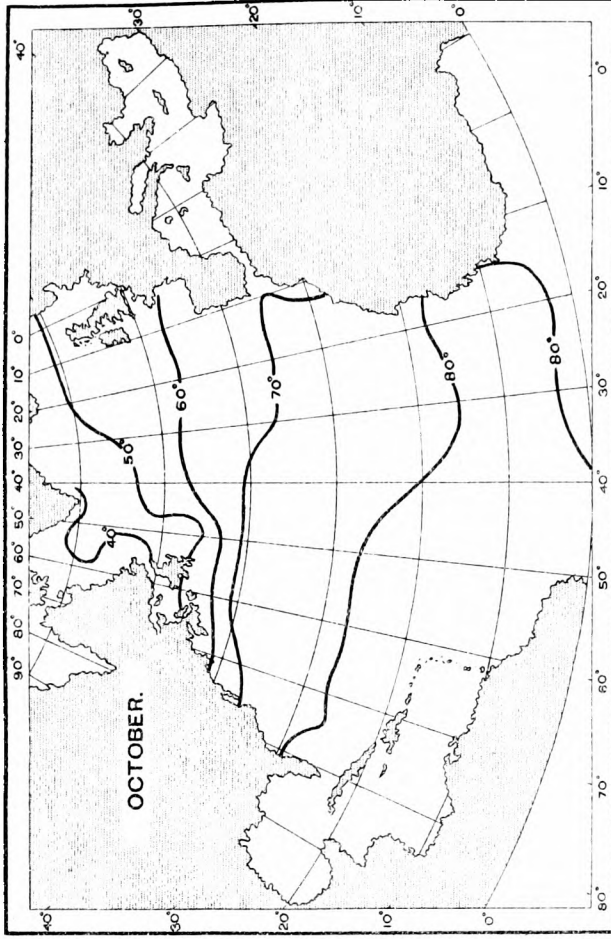
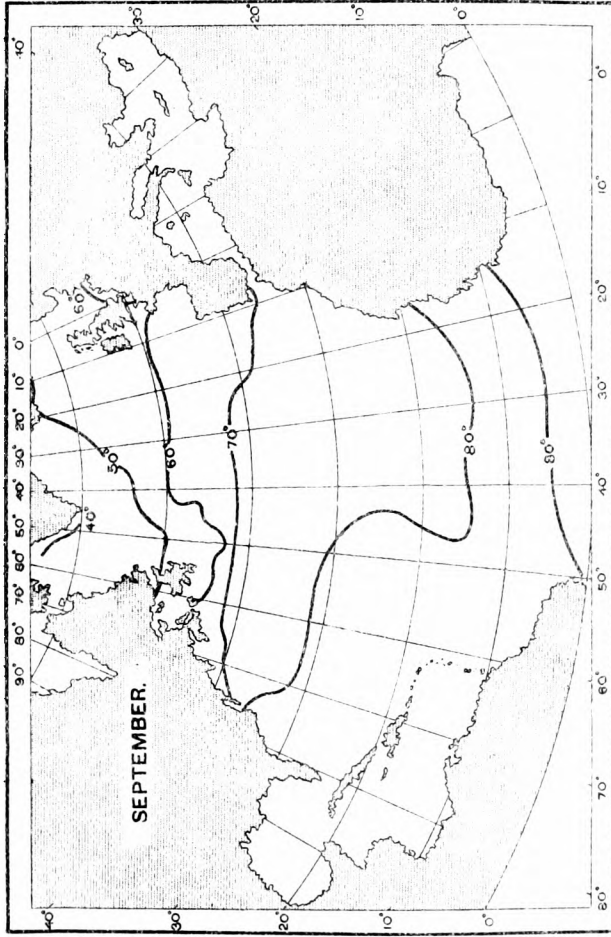


MEAN SEA SURFACE ISOTHERMS OF THE NORTH ATLANTIC.

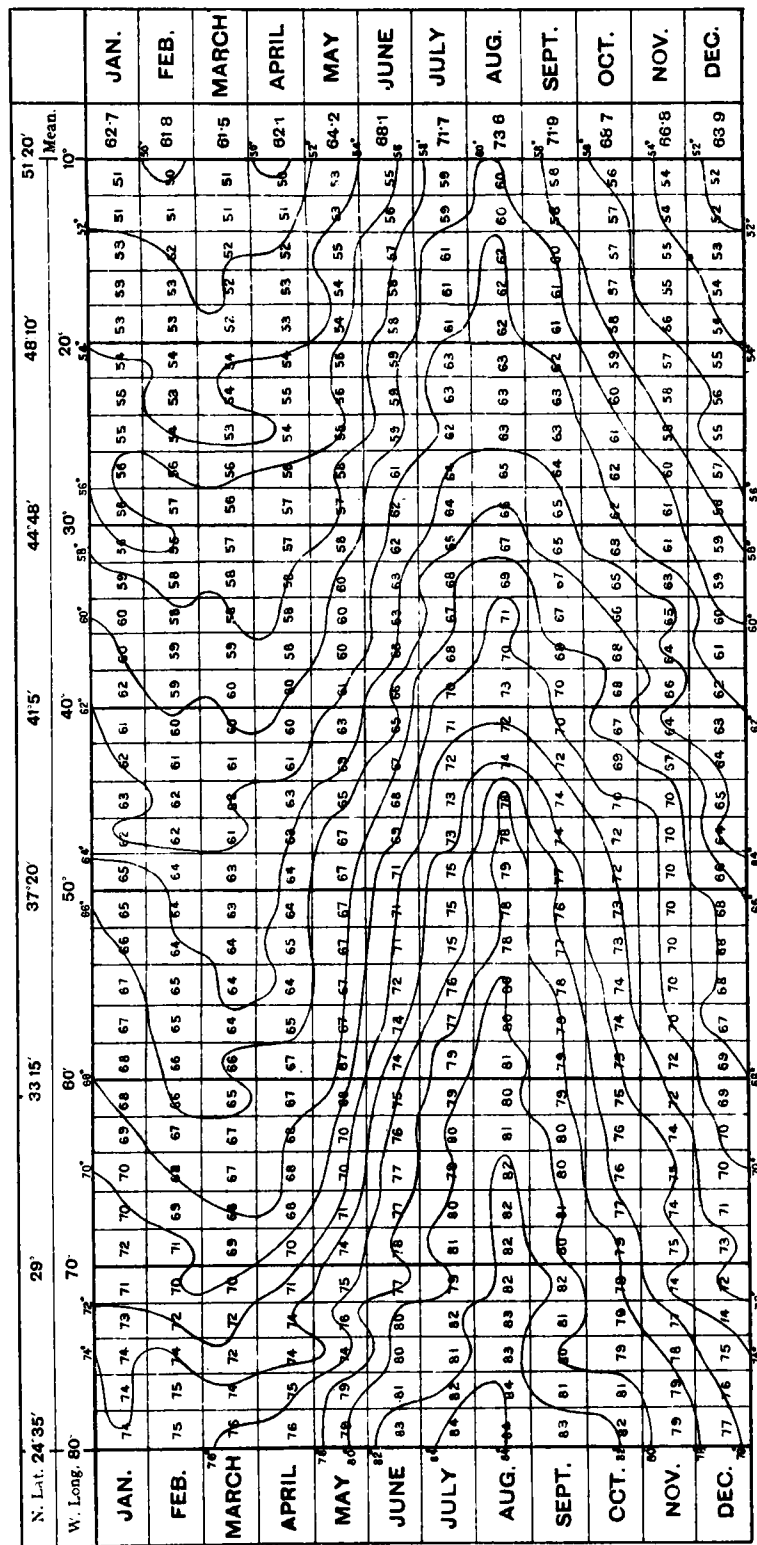


MEAN SEA SURFACE ISOTHERMS OF THE NORTH ATLANTIC.

PLATE 57.

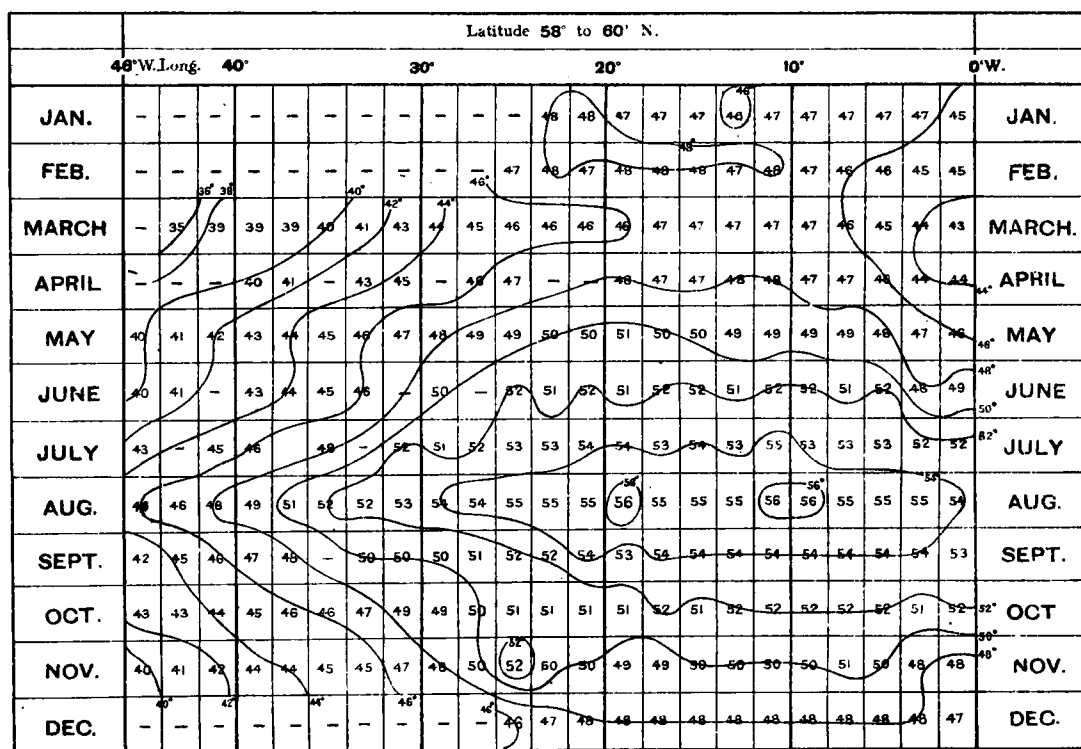


AVERAGE TEMPERATURES.



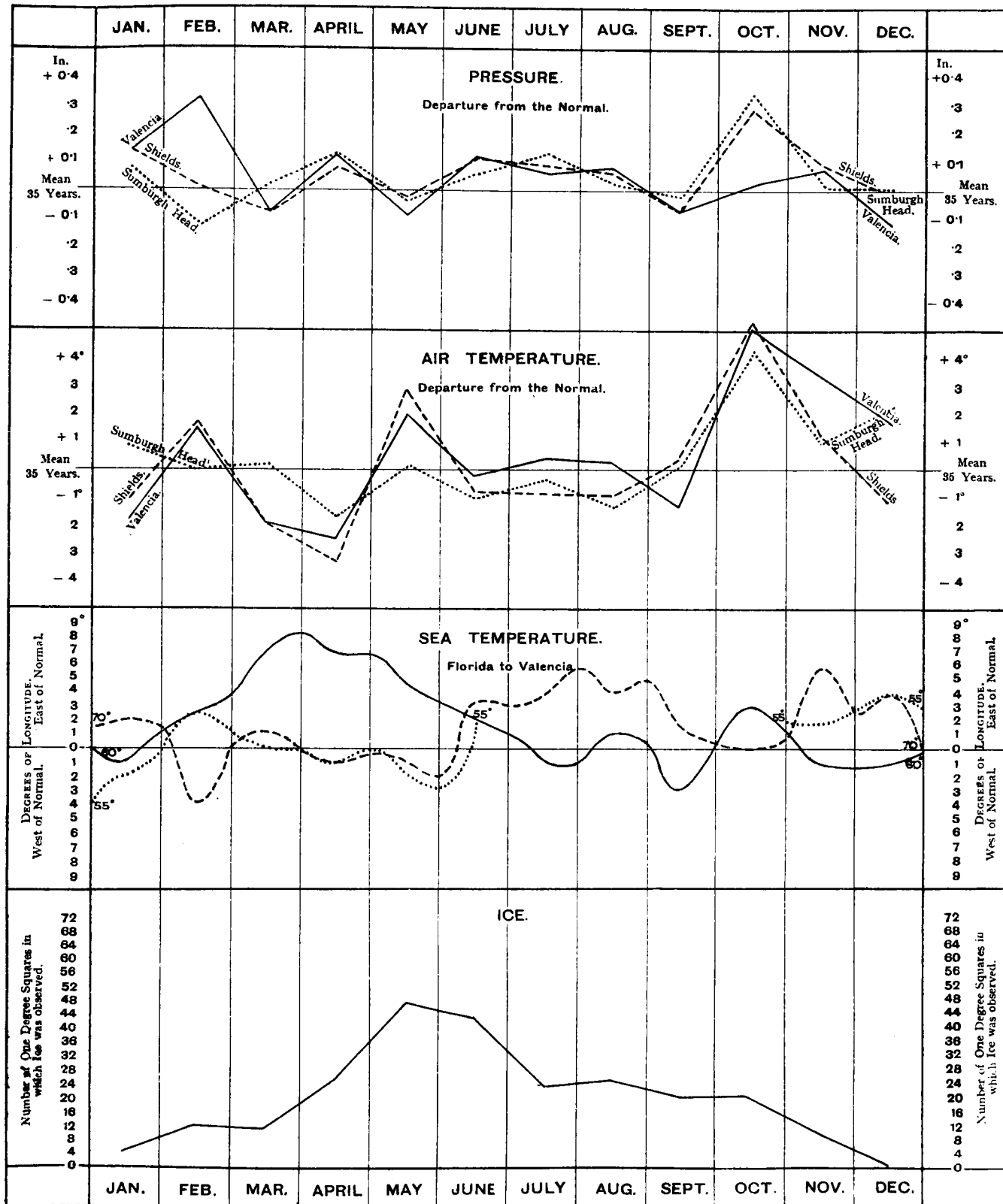
THERMO-ISOPLETHS FOR SURFACE TEMPERATURE.
GREENLAND TO ORKNEY ISLANDS.

AVERAGE TEMPERATURES.



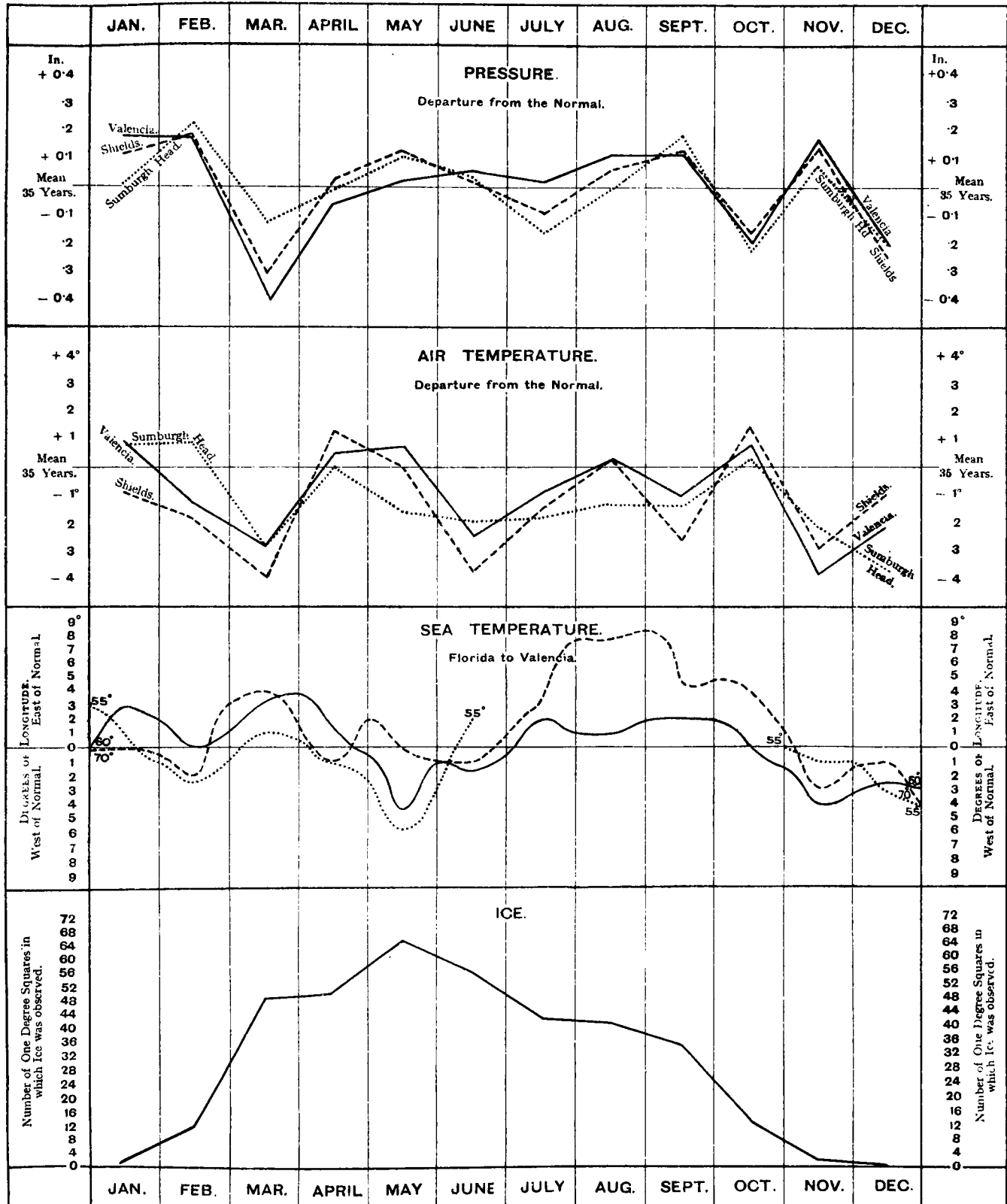
ICE FREQUENCY AND DEPARTURES FROM THE NORMAL OF METEOROLOGICAL ELEMENTS.

1908.

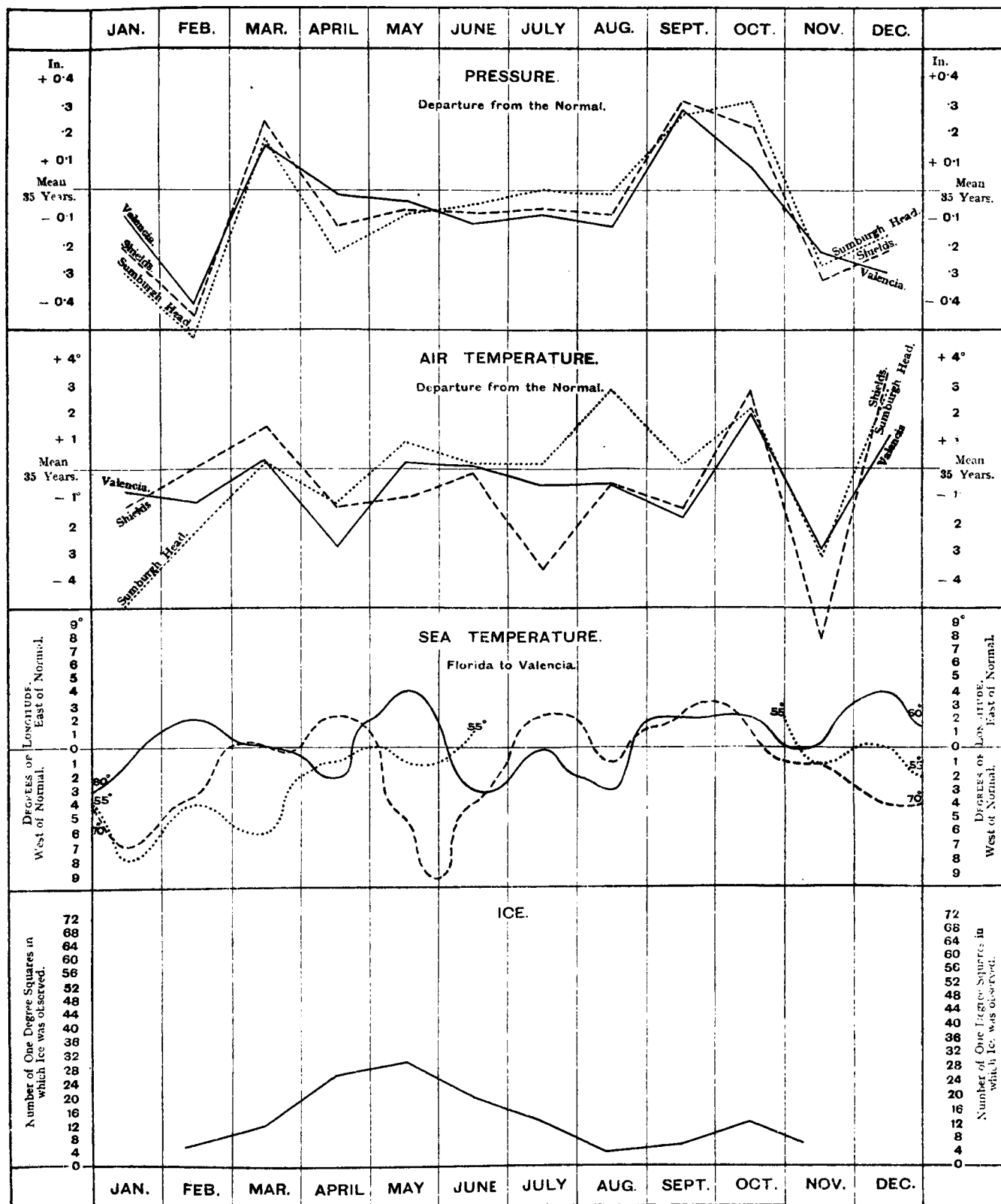


ICE FREQUENCY AND DEPARTURES FROM THE NORMAL OF METEOROLOGICAL ELEMENTS.

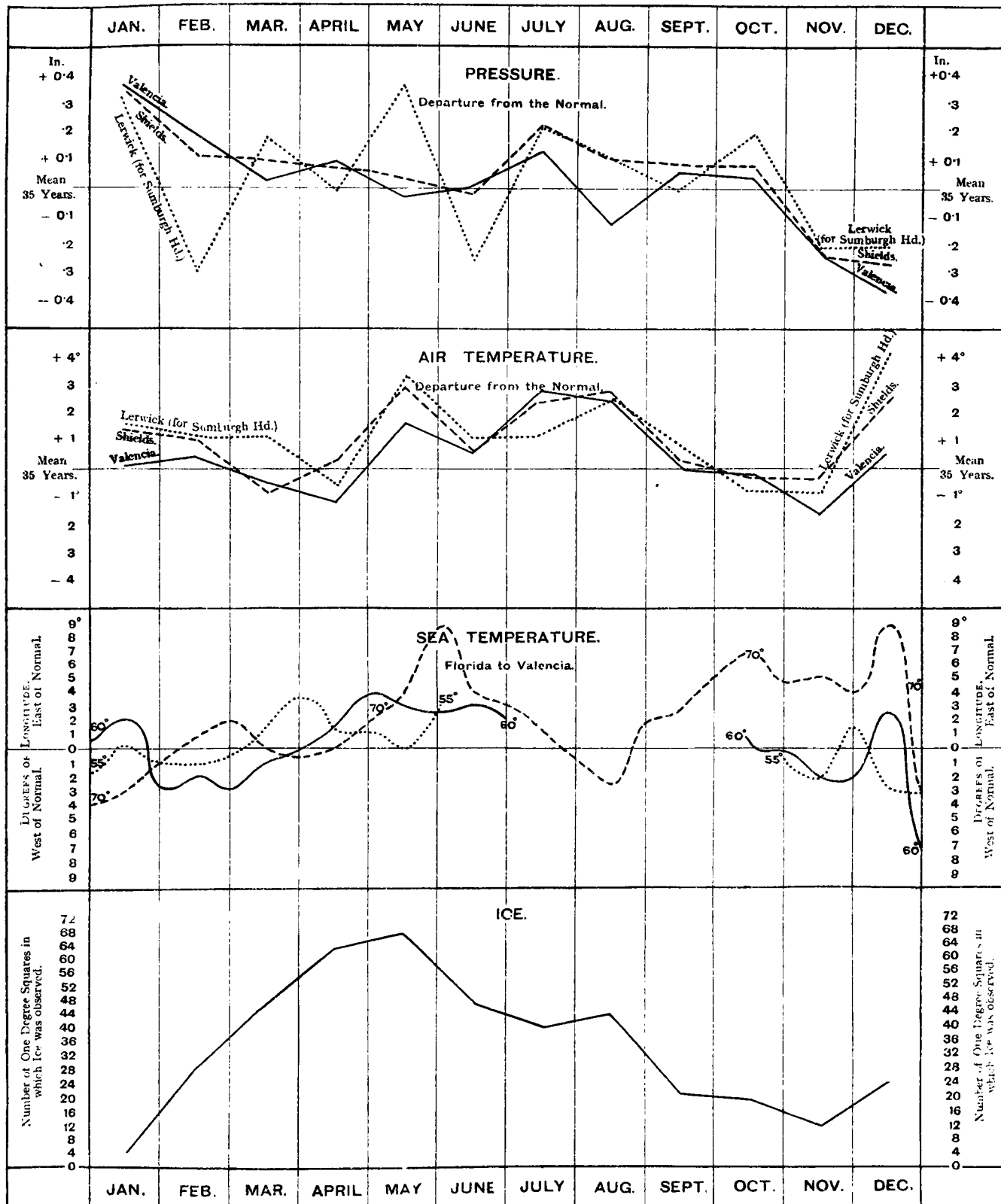
1909.



ICE FREQUENCY AND DEPARTURES FROM THE NORMAL OF METEOROLOGICAL ELEMENTS.
1910.



ICE FREQUENCY AND DEPARTURES FROM THE NORMAL OF METEOROLOGICAL ELEMENTS.
1911.



1912.

