DEPARTMENT OF INDUSTRY AND COMMERCE
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TECHNICAL NOTE No. 18

AN ANALYSIS OF OCCASIONS OF POOR VISIBILITY AND LOW CEILING AT SHANNON AIRPORT

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Corrigenda

to

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Fig. 2 (p.9) and) Fig. 3 (p.10))	Title, line 4:	For "5 per cent" read "2½ per cent"
	Vertical Scale:	For "scale of unit percentages" read "scale of half unit percentages"
Fig. 4 (p.11) and) Fig. 5 (p.12))	Title, line 5:	For "5 per cent" read "2½ per cent"
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Dublin 29th August, 1955

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Abstract:

An analysis is made of all cases of poor visibility and low ceiling at Shannon Airport over a six year period. It is found that radiation effects are the most frequent cause of poor landing conditions at the Airport. The likely times of onset and dissipation of radiation fog at different times of the year are discussed and examples of particular synoptic situations which resulted in poor landing weather are given.

Introduction:

The hourly and half-hourly weather reports made at Shannon Airport for synoptic and aeronautical purposes over the 6 year period July, 1947-June, 1953, inclusive, were examined and a study made of all cases of poor visibility or low ceiling. For the purpose of the study all cases in which the synoptic (horizontal) visibility was less than one mile or height of cloud ceiling less than 500 feet were considered.

The definition used at Shannon Airport for synoptic visibility changed twice during the period under review. Prior to March, 1948, synoptic visibility referred to visibility in the direction of specified visibility objects. From March to December, 1948, the prevailing visibility, i.e., the greatest visibility common to half the horizon circle was used for synoptic purposes. From January 1st, 1949, following the introduction of the new International Code and a new reporting routine, the visibility reported in synoptic and aeronautical codes was changed to the minimum visibility. The procedure remained in operation for the remainder of the period under review.

An analysis of differences in reporting arising out of the application of the two most recent definitions of synoptic visibility stated above was made in 1954 and it was found that, in the case of Shannon Airport, the vast majority of reports of horizontal visibility are the same when either definition is applied. In this paper differences arising out of changing definitions are not taken into account.

The definition of ceiling as used in this paper is based on a cumulative concept, being the lowest level at and below which the cloud amount as seen by an observer on the ground covers more than half the sky.

Topographical Features of Shannon Airport:

Shannon Airport is situated on the northern bank of the Shannon Estuary. At that point the estuary is about 2 miles wide. To the west and north-west of the Airport the mouth of the River Fergus joining the Shannon Estuary spreads over a width of 4 to 6 miles. The official elevation of the Airport is 15 feet above M.S.L. and it is protected from the tidal waters of the estuary by an embankment.

The land within 5 miles of the Airport is relatively flat, reaching heights in excess of 200 feet only in a few isolated points. Further to the east and east-north-east the ground rises sharply to over 1,000 feet, while in the sector between north-west and south-west on both sides of the Shannon Estuary the ground rises generally to a height of over 200 feet at a distance of 8 to 12 miles from the Airport. The nearest point of the Atlantic seaboard is about 25 miles to west-north-west of the Airport. Figure 1. shows the main topographical features of the enviroments of Shannon Airport.

General Geographical Influences affecting Weather at Shannon Airport:

Situated so close to the west coast of Ireland Shannon Airport has a predominantly oceanic climate and, being near the main tracks of depressions in the north Atlantic, conditions there are very variable but, in general, cloudless skies, very light surface winds or extremes of temperature are infrequent. The variability of weather at Shannon Airport tends to mask seasonal characteristics in respect of the occurrence of fog or low cloud and "normal" characteristics of a month may be entirely absent in a particular year. The prevailing wind over the year is between west and south-west, but in March and October south-east winds are most common while north-east winds are most common in May. With a low frequency of calm conditions and, in view of the absence of major smoke sources in the environments of Shannon Airport visibility is generally excellent.

Classification of Occasions of Poor Visibility and Low Ceiling:

In the six-year period under review there were 2,790 half-hourly reports of conditions worse than one mile visibility and/or 500 feet ceiling. This represents approximately 2.65% of the total observations. 1,932 of these reports were classified as due to radiation effects and 858 due to other air-mass effects and frontal influences. There were 1587 reports (1.51% of total) of visibility below 1100 yards and of these 1459 were due to radiation effects. The 128 other cases of visibility below fog limits were almost all in Winter time. Figures 2 and 3 give histograms of the frequency of occurrence of poor conditions at different times of the day due to any cause and Figures 4 and 5 give histograms of frequency of similar occurrence due to radiation effects. The poor conditions due to radiation were, in the majority of cases, below the fog limit while those due to other causes were usually not worse than one mile visibility and 300 to 400 feet ceiling.

Radiation Effects:

Synoptic situations favourable for the occurrence of radiation fog at Shannon Airport fall generally into three categories. The most favourable situation appears to be associated with an anti-cyclone centred to the north of Ireland maintaining a weak easterly gradient over Shannon Airport. An example of such a situation is given in Figure 6. Another relatively common fog situation is associated with a slack ridge building up over Shannon Airport and giving a weak northerly flow immediately in the wake of a cold front or a cold occlusion. An example of such a situation is given in Figure 7. Thirdly, a very slack area over the country and associated with a dying depression may provide suitable radiation conditions. Figure 8 gives an example of such a situation.

It is well-established by observation that, even in conditions favourable for radiation, fog does not usually form over the Airport but forms on the Fergus and Shannon Estuary and drifts over the airfield in light local winds. Radiation fog at Shannon Airport tends to be rather intermittent in character, a fog-free observation occasionally occurring long before the fog finally clears.

This intermittent character of the fog at Shannon Airport presents a special difficulty in forecasting the time of onset and clearance of poor conditions. While the histograms shown in Figures 4 and 5, give an indication of the average time of onset and clearance of radiation fog they include all cases where the clearance or onset was affected by change of gradient and cloud cover. We have attempted to establish the earliest probable time of onset and the latest probable time of clearance of radiation fog in any day each month, omitting those cases where the onset and clearance time appeared to be materially affected by increasing gradient or change in cloud cover. Table I gives the result based on the six years' observation.

Table I - Limiting times for radiation fog at Shannon Airport in different months when not complicated by other factors

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Earliest Onset	--	2000	1900	0000	2300	0100	0200	2300	0000	2300	2100	--
Latest Clearance	1200	1100	1300	0900	0900	0800	0900	1000	1000	1100	1400	--

It must be emphasized that these figures are largely subjective and are based on data over a relatively short period indicating marked variability. Thus in the first 6 months of 1948 there were 54 observations of poor landing weather due to radiation while in the corresponding period of 1953 there were 413 cases. Analysis over a longer period may indicate extensive amendments to some of the times. No times are suggested for December or for the onset of fog in January due to considerable irregularity in the times of occurrences of fog in those months. A rather striking example of this irregularity occurred in December, 1950, (see Figure 6). On that occasion fog which formed in conditions favourable for radiation drifted over the Airport at 1100 GMT. on 26th December and did not clear until 1800 GMT. on 27th. In the period under review it was found that, except in the months of March, November and December, radiation fog rarely persisted more than 4 hours after sunrise.

The frequency of occurrence of spells (either continuous or with clearances of not more than two hours' duration) of fog of specified durations are given in Table II. The figures for March are considerably influenced by a prolonged situation favourable for fog in March, 1953. Those for August are similarly influenced by the observation for August, 1947. The figures for each duration include those of greater duration.

Table II - Frequency of occurrence of spells of radiation fog in excess of specified duration at Shannon Airport in the period July, 1947-June, 1953, inclusive

	Number of cases of duration in excess of:			
	24 hours	18 hours	12 hours	6 hours
January	0	1	2	5
February	0	0	0	2
March	0	0	3	16
April	0	0	0	1
May	0	0	0	2
June	0	0	0	0
July	0	0	0	1
August	0	0	0	9
September	0	0	0	2
October	0	0	0	4
November	1	2	4	10
December	1	1	2	4

The long spell in November which figures in Column 1 of Table II lasted 27½ hours, while the longest spell in December lasted 31 hours. This long spell has already been referred to above.

In the six-year period no radiation fog was experienced in 17 individual months. There was no November free of poor conditions due to radiation but each of the other eleven months of the year was fog free at least once in the entire period.

<u>Relation between Wind Direction and the Occurrence of Radiation Fog:</u>

The surface and geostrophic winds were tabulated for each occasion on which poor conditions due to radiation occurred at the station. For the purposes of this tabulation surface winds under 5 knots and geostrophic winds under 10 knots were regarded as calm. Table III gives the percentage of cases which occurred with different surface and geostrophic wind directions in the period.

Table III - Percentage frequency of occurrence of poor weather with different surface and geostrophic wind directions at Shannon Airport in the period July, 1947-June, 1953, inclusive

Direction in degrees	Calm	000 to 030	030 to 060	060 to 090	090 to 120	120 to 150	150 to 180	180 to 210	210 to 240	240 to 270	270 to 300	300 to 330	330 to 360
Surface Wind;	39.3	5.3	4.9	5.9	15.7	8.9	2.6	0.9	1.2	2.5	2.1	1.7	9.0
Geostrophic Winds:	61.9	2.0	2.4	2.9	2.9	7.3	7.3	6.9	1.2	2.4	0.4	2.0	0.4

Apart from calm conditions, radiation fog is most frequent with surface wind directions east-south-east and north-north-west. Winds from those directions bring the fog from the flat marshy terrain to north and south-east. Fog is not common with surface winds from between south and north-west and poor conditions from these directions, which figure in TableIII, are most frequently lifted fog which, having formed on the south side of the Shannon near Foynes, is blown north-eastwards and arrives over the Airport as low stratus. This occurrence was noted most frequently in Summer months.

The most common gradients associated with poor radiation conditions are south-easterly to southerly. In only 2.2% of the cases did radiation fog exist with gradients of 20 knots or more and, in some of those cases, the gradient was tightening and fog had cleared at the next observation.

Other Air-mass Conditions:

Apart from radiation fog the most common occurrences of non-frontal poor conditions are associated with a westerly or west-north-westerly flow of maritime warm air.

Many frontal systems which pass eastwards over Shannon Airport are partly occluded at the time of passage. However, when recent warm moist air arrives over Shannon Airport from the west in an open warm sector, almost continuous low stratus accompanied by outbreaks of drizzle is frequently experienced. Horizontal visibility of one mile and ceiling of 300 to 400 feet are common in such situations. In exceptional cases, with moderate drizzle and very warm air, ceiling may be down to 100 feet and visibility less than ½ mile.

Our examination suggests that such warm sector conditions are almost invariably associated with surface wind directions between 240° and 290° and gradient wind directions between 240° and 300°. Conditions will remain poor while the surface and gradient wind directions are within the above limits and the warm air persists, but a change of wind direction outside these limits will normally bring marked improvement in landing weather. Warm sector low stratus at Shannon Airport seems to be largely independent of wind strength and was observed with surface winds over 20 knots and gradient winds of 50 knots.

Diurnal or seasonal variations of this phenomenon were not marked in the six-year period and the more notable cases occurred in the months of January, June, July, October and November.

Figure 9. shows the synoptic situation during a spell in June, 1948. The warm front passed East of Shannon Airport between 2300 on 23rd and 0000 on 24th but the poor conditions did not set in until 1400 G.M.T. on 24th when the gradient direction became favourable. The very low stratus persisted for 24 hours with ceiling frequently as low as 100 feet. Visibility was below fog limits for three observations. Cloud below 1,000 feet was observed almost continuously until 0600 G.M.T. on 26th June when the gradient backed to south-westerly.

Isolated cases of poor landing conditions with gradient strengths of under 25 knots from other directions were also noted in association with outbreaks of non-frontal rain but were not sufficiently numerous to be definitely associated with particular synoptic situations.

Sea Fog:

The high ground on both sides of the Shannon Estuary to west of the Airport seems to be sufficient to prevent sea fog penetrating so far inland, except on very rare occasions. In the six-year period it reached the Airport only on four occasions. These occasions were in different months (May, July, August and September). In each case sea fog drifted into the Airport in the late evening (1900-2200 G.M.T.) after a thermal low or trough had formed over the centre of Ireland during the day and the circulation of the low was sufficiently developed to bring the fog to Shannon Airport. On two occasions the surface heating during the day was followed by good radiation conditions at night and the fog did not clear until after 0900 G.M.T. on the next day. Of the other occasions the fog cleared after 3½ in one case and after 5 hours in the other. Figure 10 shows a thermal low over Ireland prior to the onset of sea fog at Shannon Airport. On that occasion the sea fog arrived at 2000 G.M.T.

Snow:

Snow is quite rare at Shannon Airport and usually does not last long on the ground. The Shannon Estuary does not freeze even in severe Winters. When snow does occur however, it is accompanied by a marked deterioration in ceiling and visibility and frequently it is reported with ceiling 200-400 feet and visibility as low as ½ mile.

Frontal Passages:

Shannon Airport, due to its geographical location, experiences very frequent frontal passages. The vast majority of frontal passages at the Airport are not accompanied by conditions of ceiling and/or visibility below 500 feet and one mile.

A quasi-stationary front at Shannon Airport and orientated in an east/west direction gives the worst frontal conditions at the Airport.

In such synoptic situations ceiling and visibility may drop below fog limits. An example of such a situation is given in Figure 11.

A cold front orientated NE/SW approaching Shannon Airport from the north-west is the most common situation for poor frontal weather at the Airport (see Figure 12). In such cases conditions at Shannon Airport usually deteriorate when the front reaches Blacksod Point. The clearance follows gradually on the frontal passage, but as fronts in this orientation frequently tend to trail, several hours of ceiling at 300 to 400 feet and visibility 1 to 2 miles may be experienced. If the front becomes stationary it may, as stated above, bring considerably worse conditions.

Conditions of ceiling below 500 feet and visibility less than a mile are not usually associated with warm front passages. When a vigorous S.E. circulation precedes a warm front, ceiling is usually above 800 feet before and at the frontal passage. The passage of a diffuse warm front with a slack pressure gradient may, on rare occasions however, be accompanied by ceiling below 300 feet. An example of such a situation is given in Figure 13.

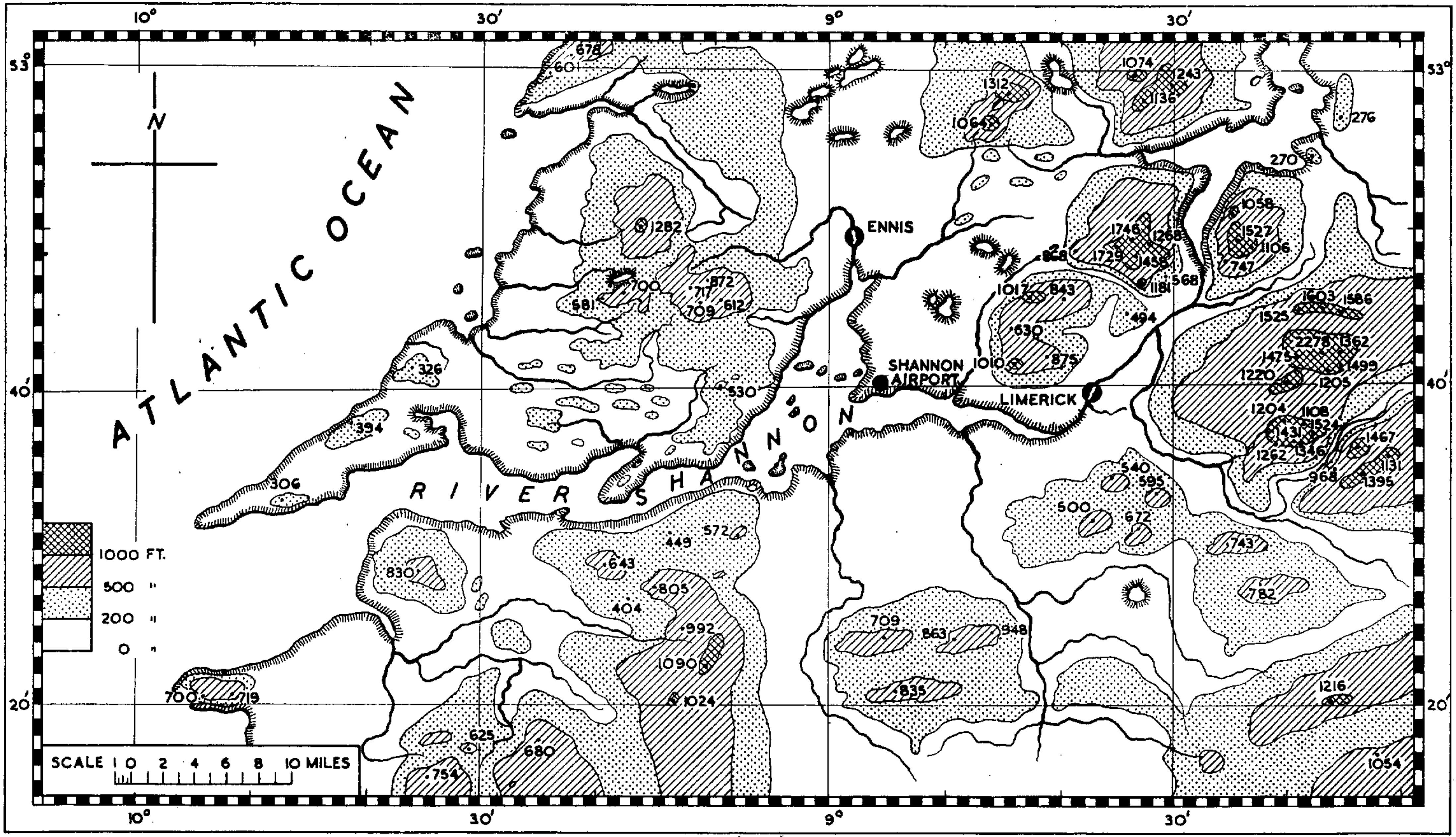

FIG. 1. Topography of Environments of Shannon Airport

HISTOGRAMS OF LANDING CONDITIONS WORSE THAN CEILING 500 FEET AND/OR VISIBILITY 1 MILE AT SHANNON AIRPORT

BASED ON DATA FOR JULY 1947 TO JUNE 1953 INCLUSIVE. THE INTERVAL OF TIME (GMT) IS 1 HOUR. EACH 5 PER CENT IS INDICATED BY A SHORT DASHED LINE.

APRIL – OCTOBER

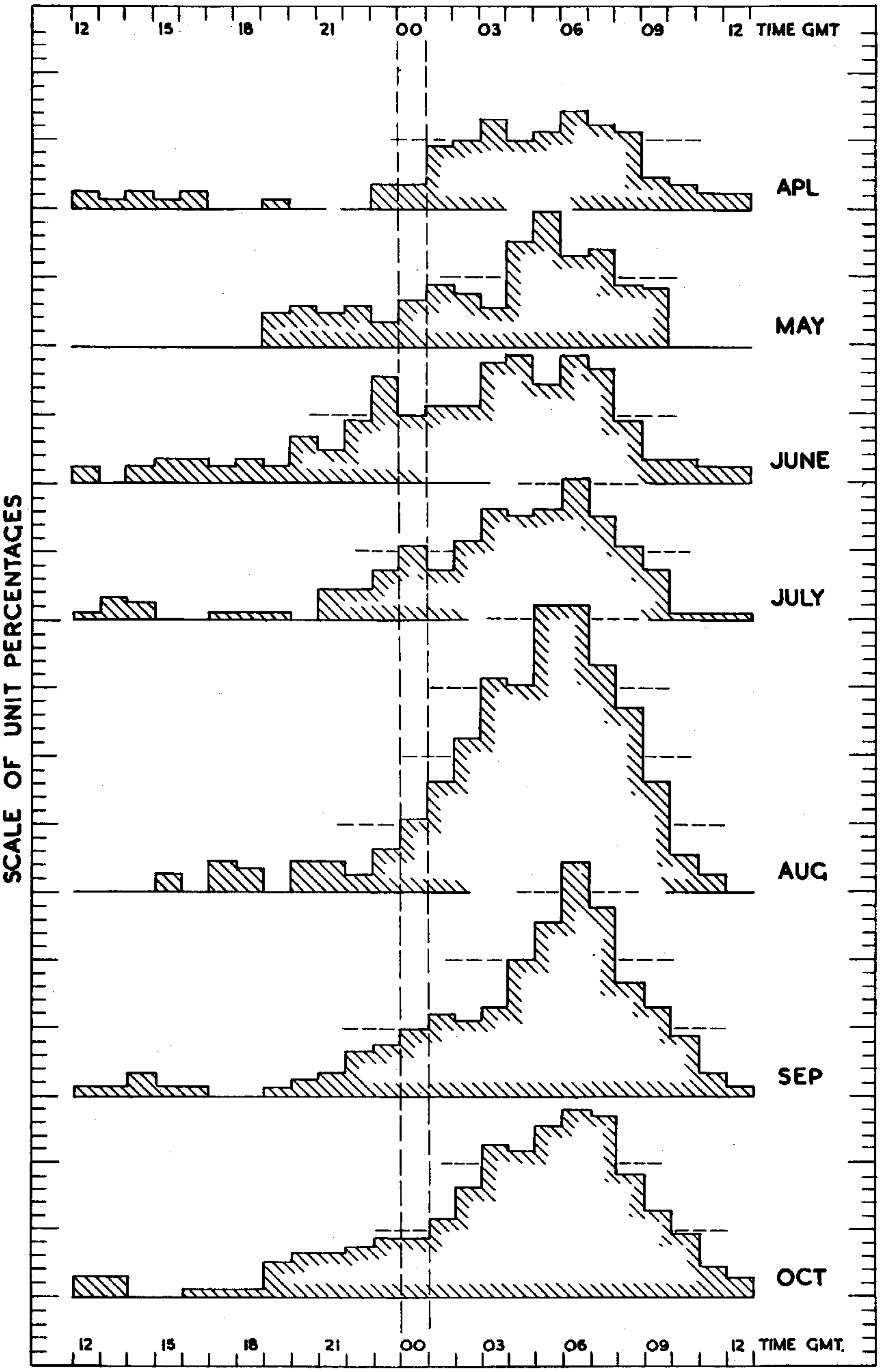

Fig. 2.

HISTOGRAMS OF LANDING CONDITIONS WORSE THAN CEILING 500 FEET AND/OR VISIBILITY 1 MILE AT SHANNON AIRPORT

BASED ON DATA FOR JULY 1947 TO JUNE 1953 INCLUSIVE. THE INTERVAL OF TIME (GMT) IS 1 HOUR. EACH 5 PER CENT IS INDICATED BY A SHORT DASHED LINE.

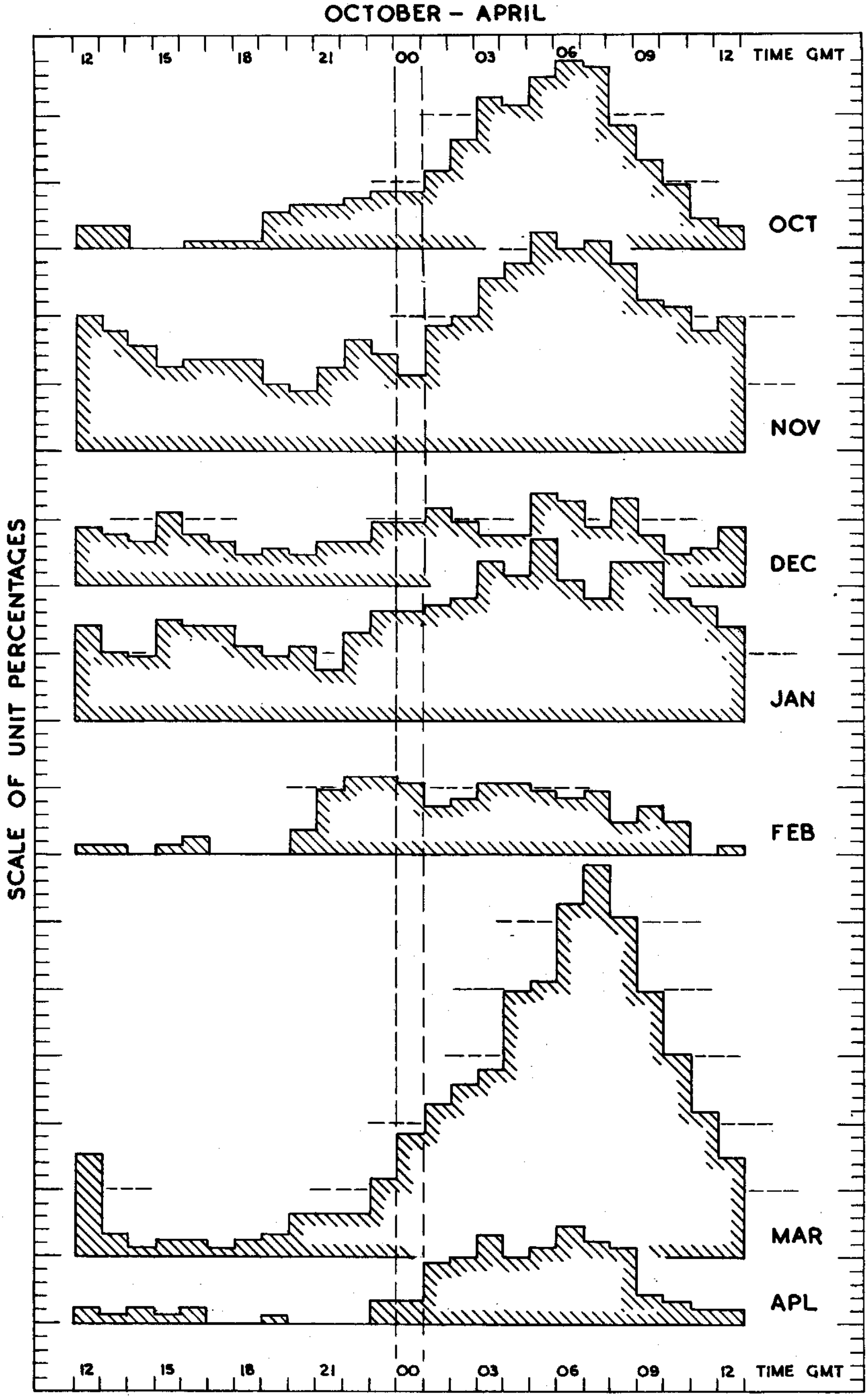

Fig. 3.

HISTOGRAMS OF LANDING CONDITIONS WORSE THAN CEILING 500 FEET AND/OR VISIBILITY 1 MILE DUE TO RADIATION EFFECTS AT SHANNON AIRPORT

BASED ON DATA FOR JULY 1947 TO JUNE 1953 INCLUSIVE. THE INTERVAL OF TIME (GMT) IS 1 HOUR. EACH 5 PER CENT IS INDICATED BY A SHORT DASHED LINE.

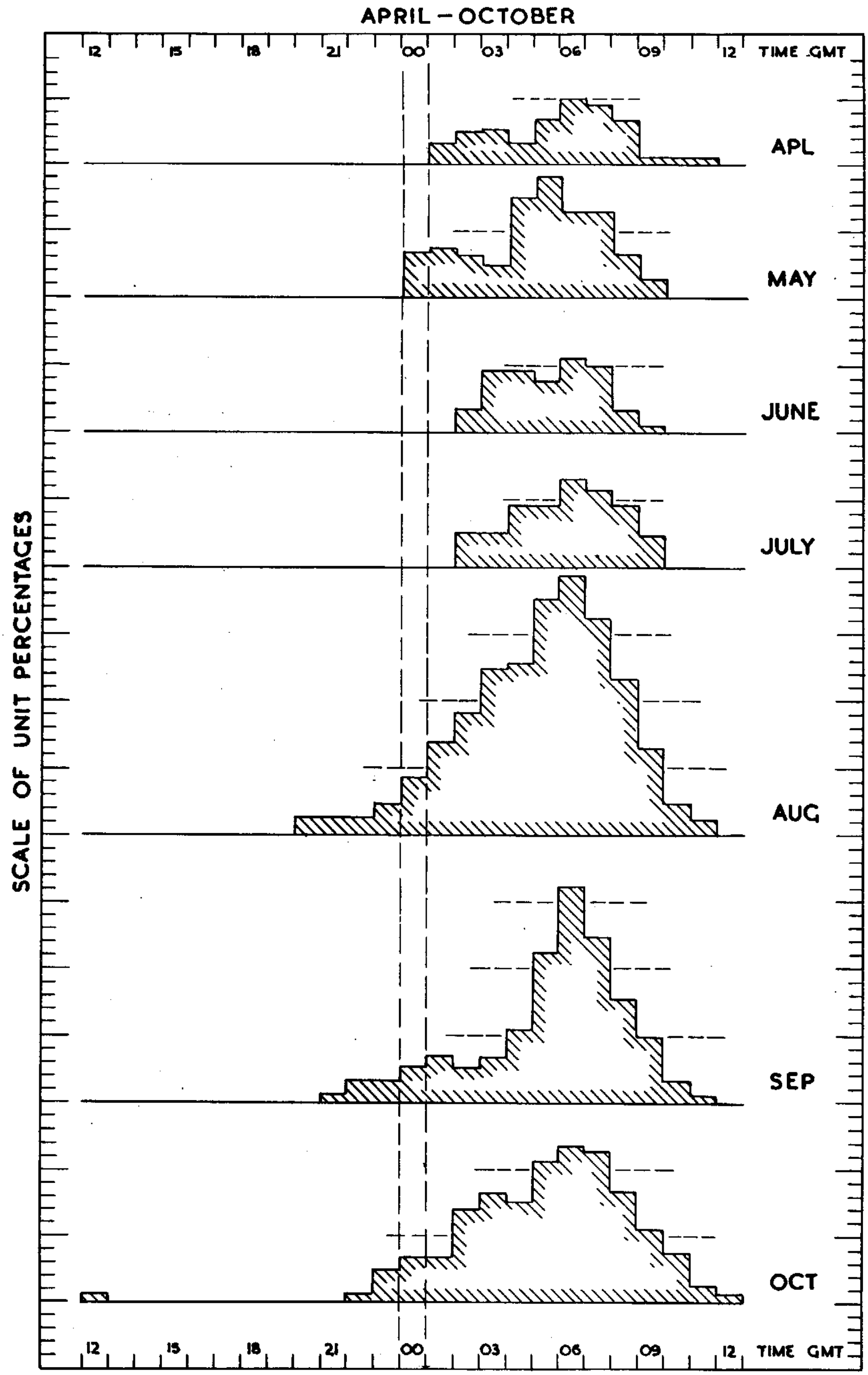

Fig. 4.

HISTOGRAMS OF LANDING CONDITIONS WORSE THAN CEILING 500 FEET AND/OR VISIBILITY 1 MILE DUE TO RADIATION EFFECTS AT SHANNON AIRPORT

BASED ON DATA FOR JULY 1947 TO JUNE 1953 INCLUSIVE. THE INTERVAL OF TIME (GMT) IS 1 HOUR. EACH 5 PER CENT IS INDICATED BY A SHORT DASHED LINE.

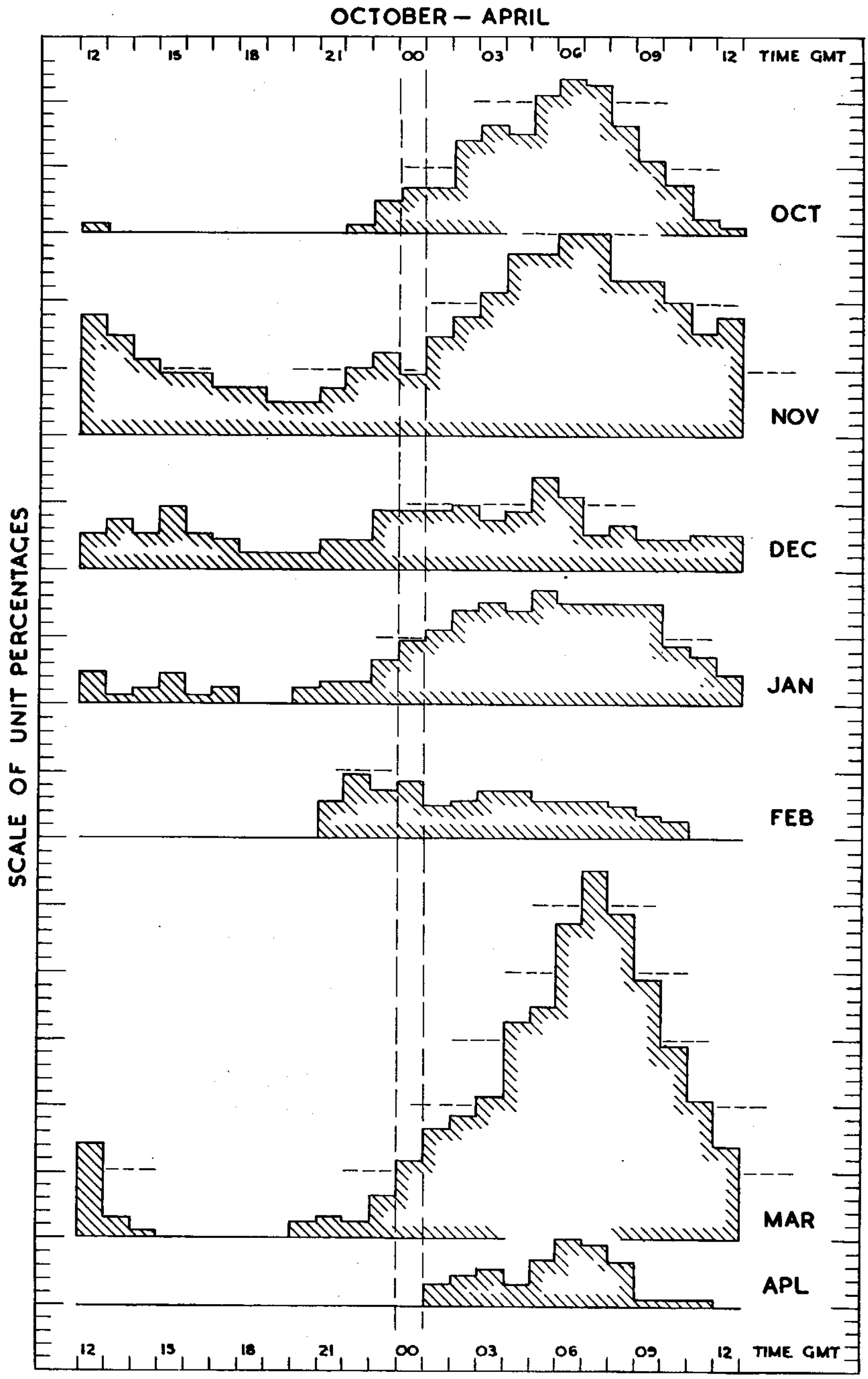

Fig. 5.

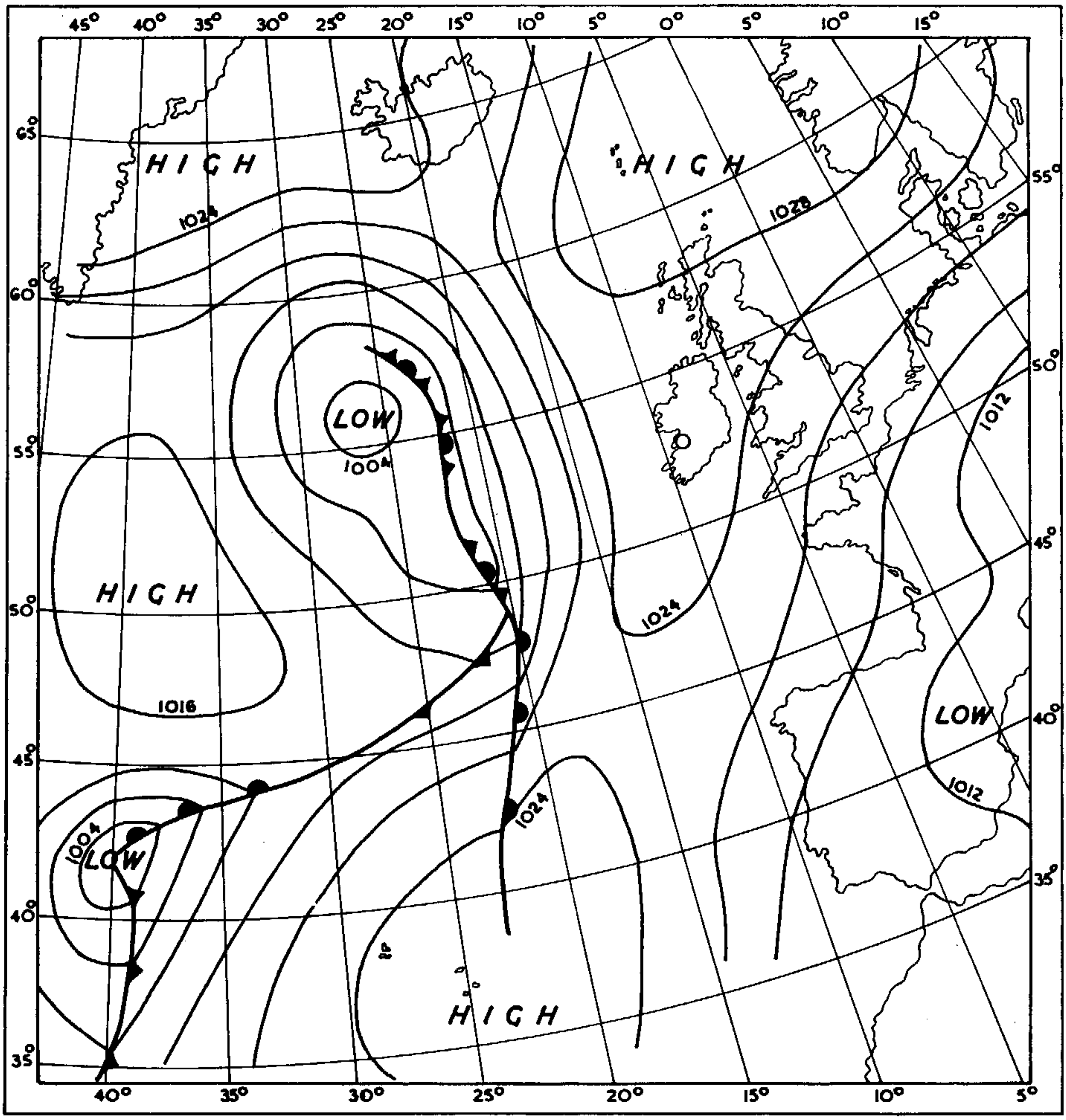

Fig. 6. Surface Chart, 1800 G.M.T. 26th December, 1950.

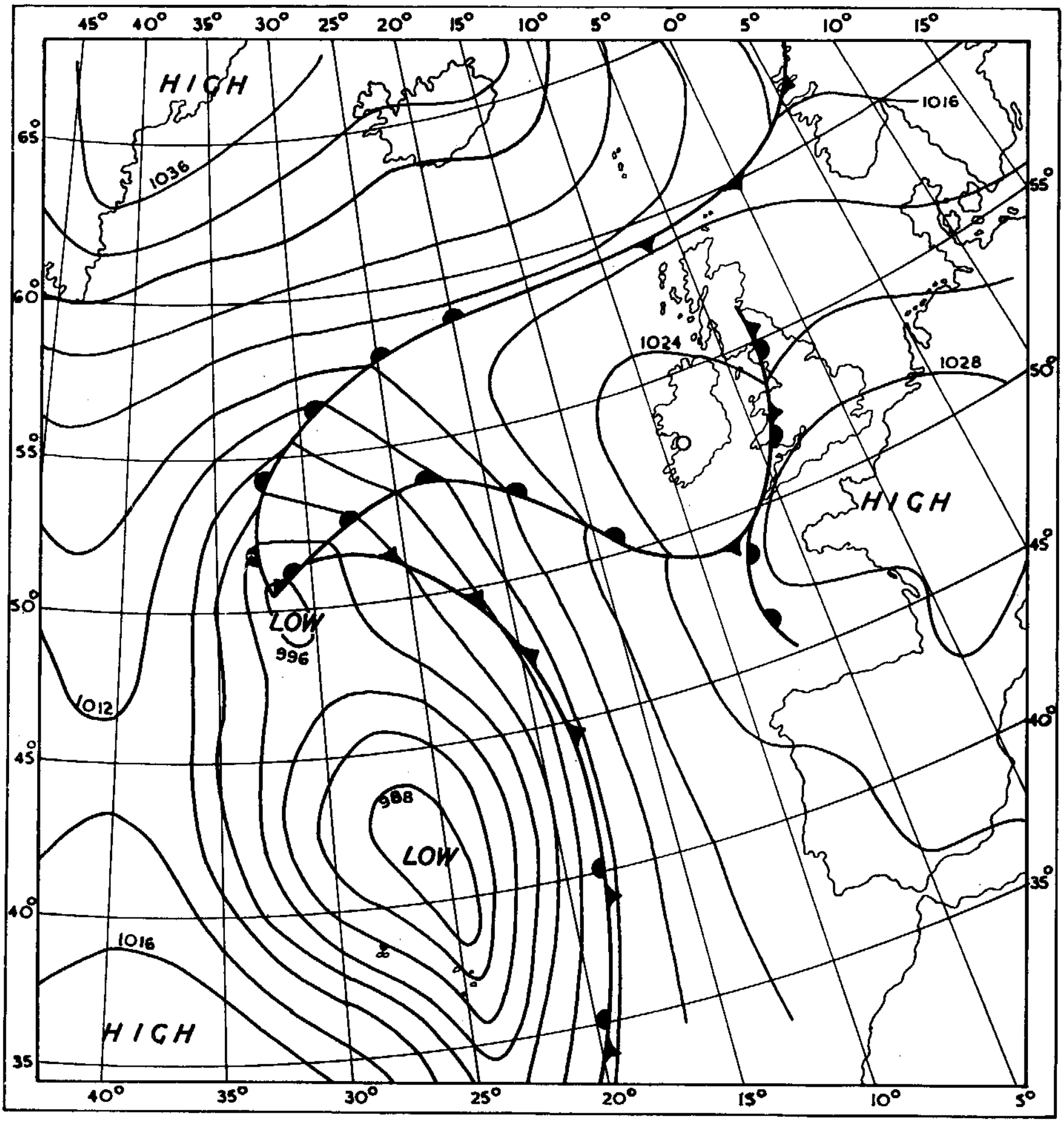

Fig. 7. Surface Chart, 0000 G.M.T. 29th February, 1952.

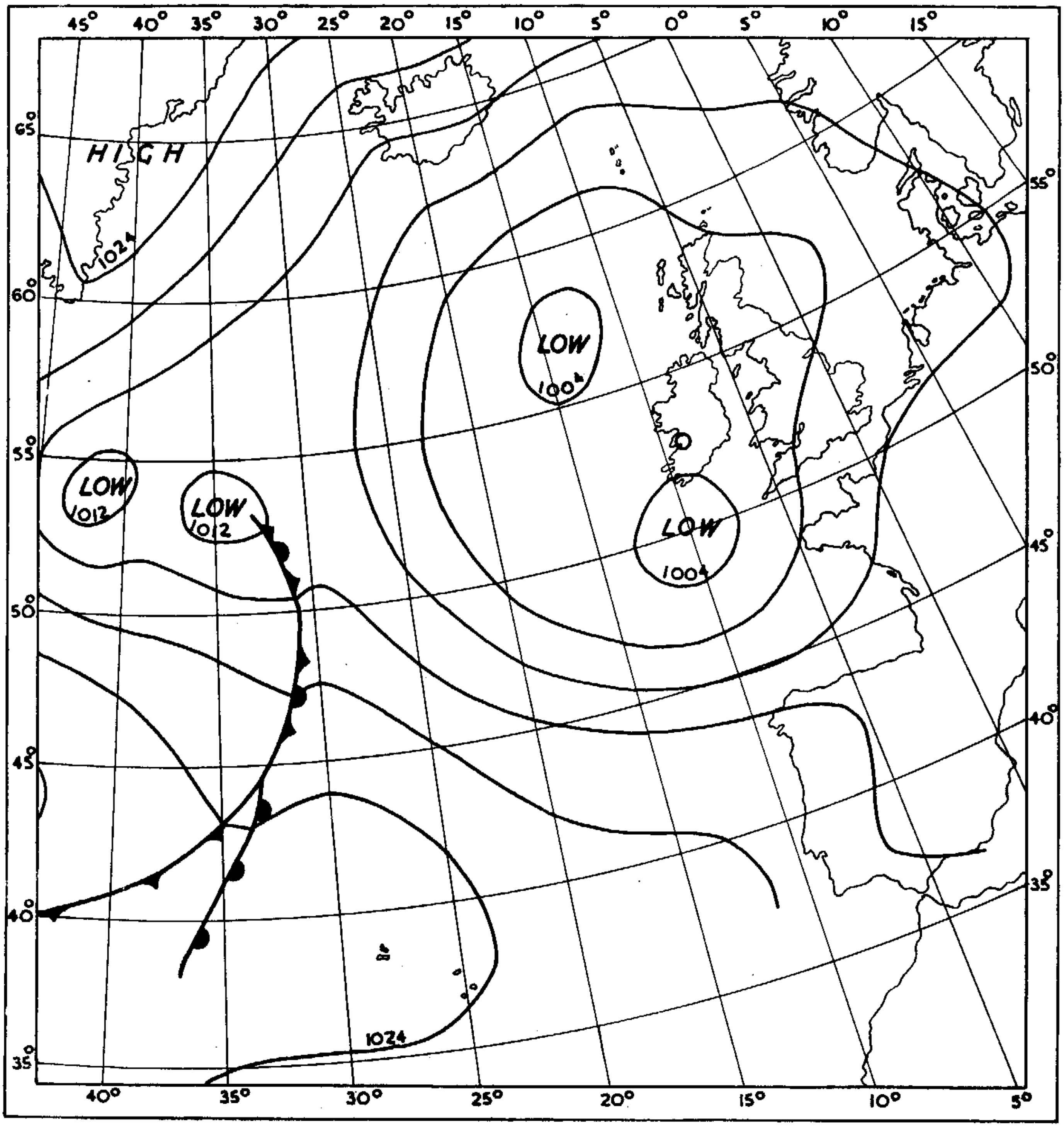

Fig. 8. Surface Chart, 0000 G.M.T. 24th August, 1950.

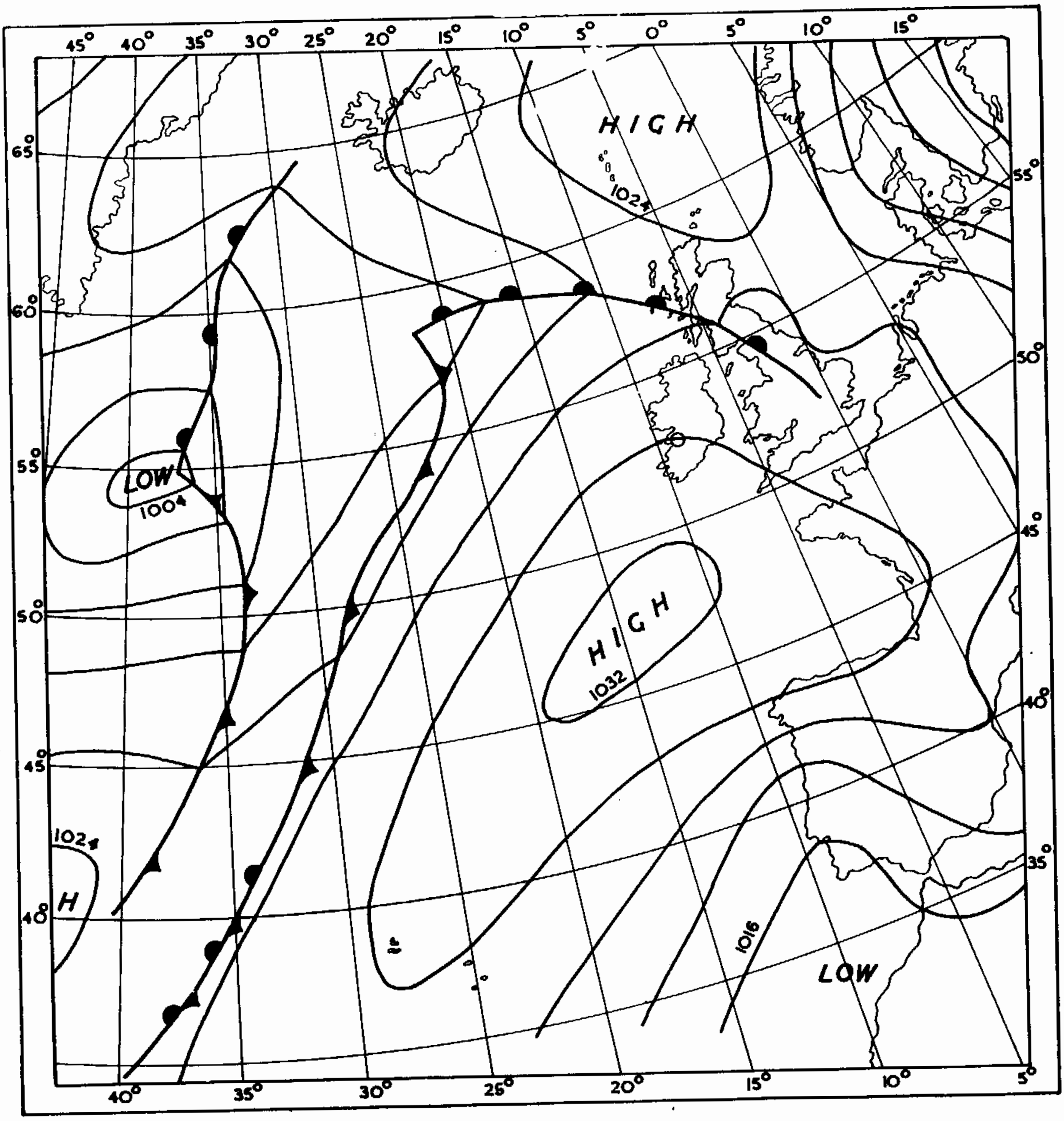

Fig. 9. Surface Chart, 0000 G.M.T. 25th June, 1948.

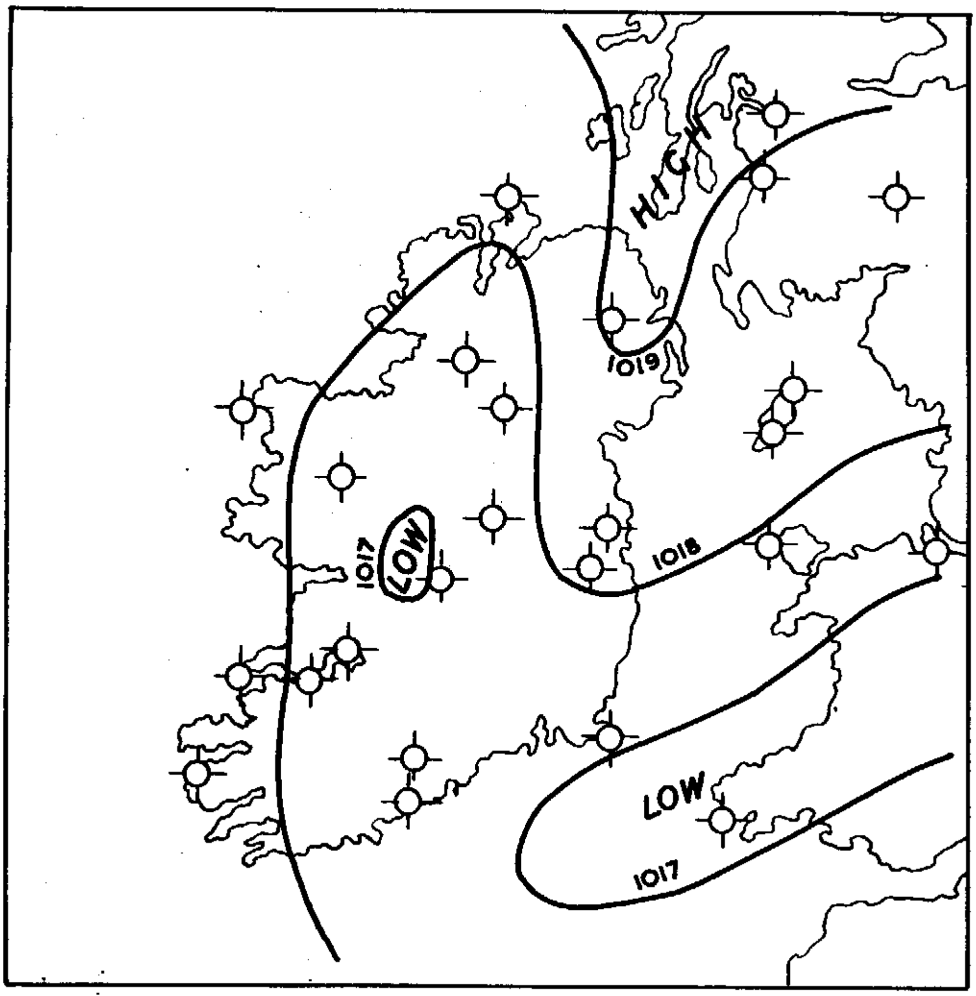

Fig. 10. Surface Chart, 1800 G.M.T. 19th August, 1947.

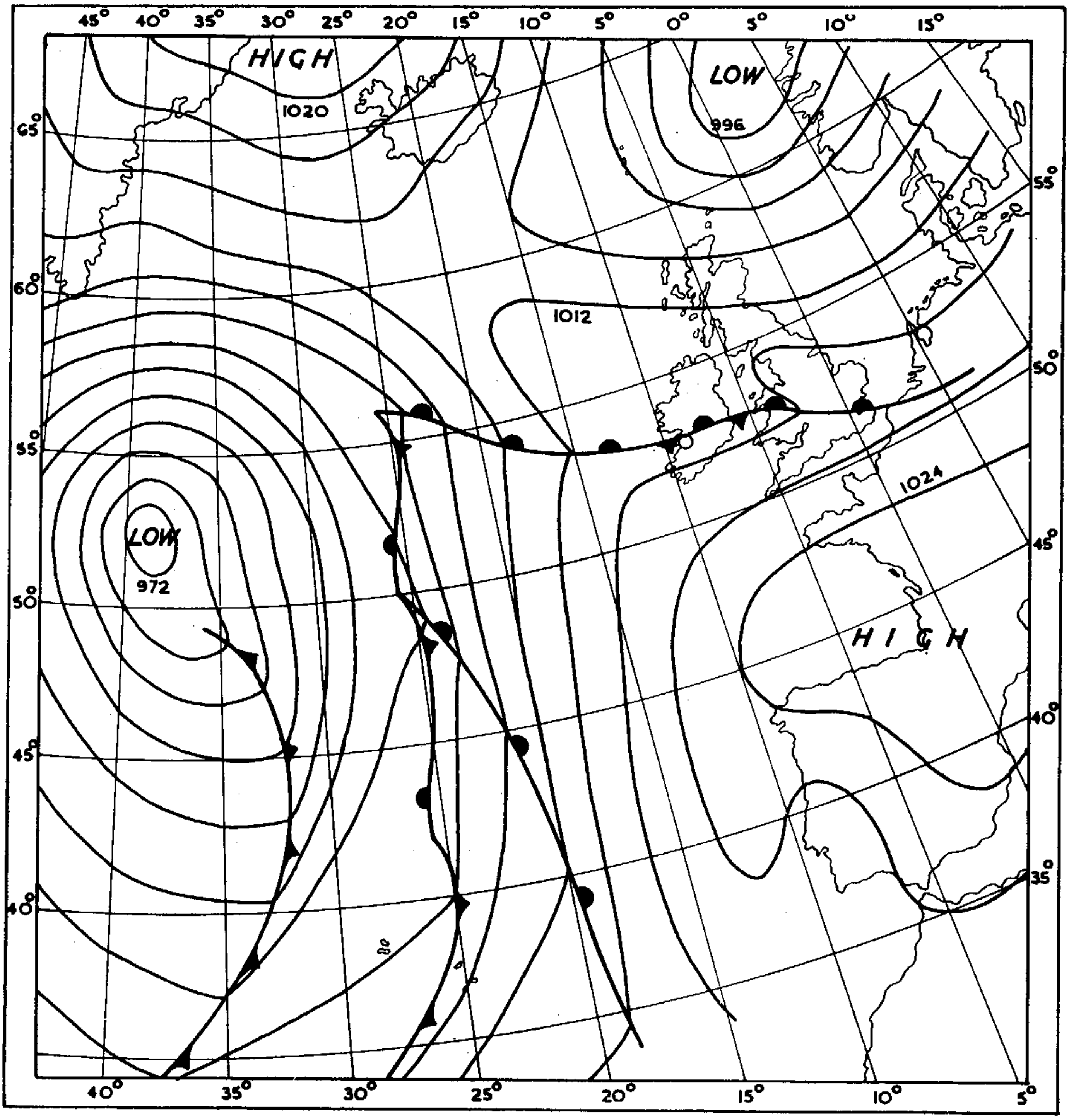

Fig. 11. Surface Chart, 1800 G.M.T. 4th November, 1947.

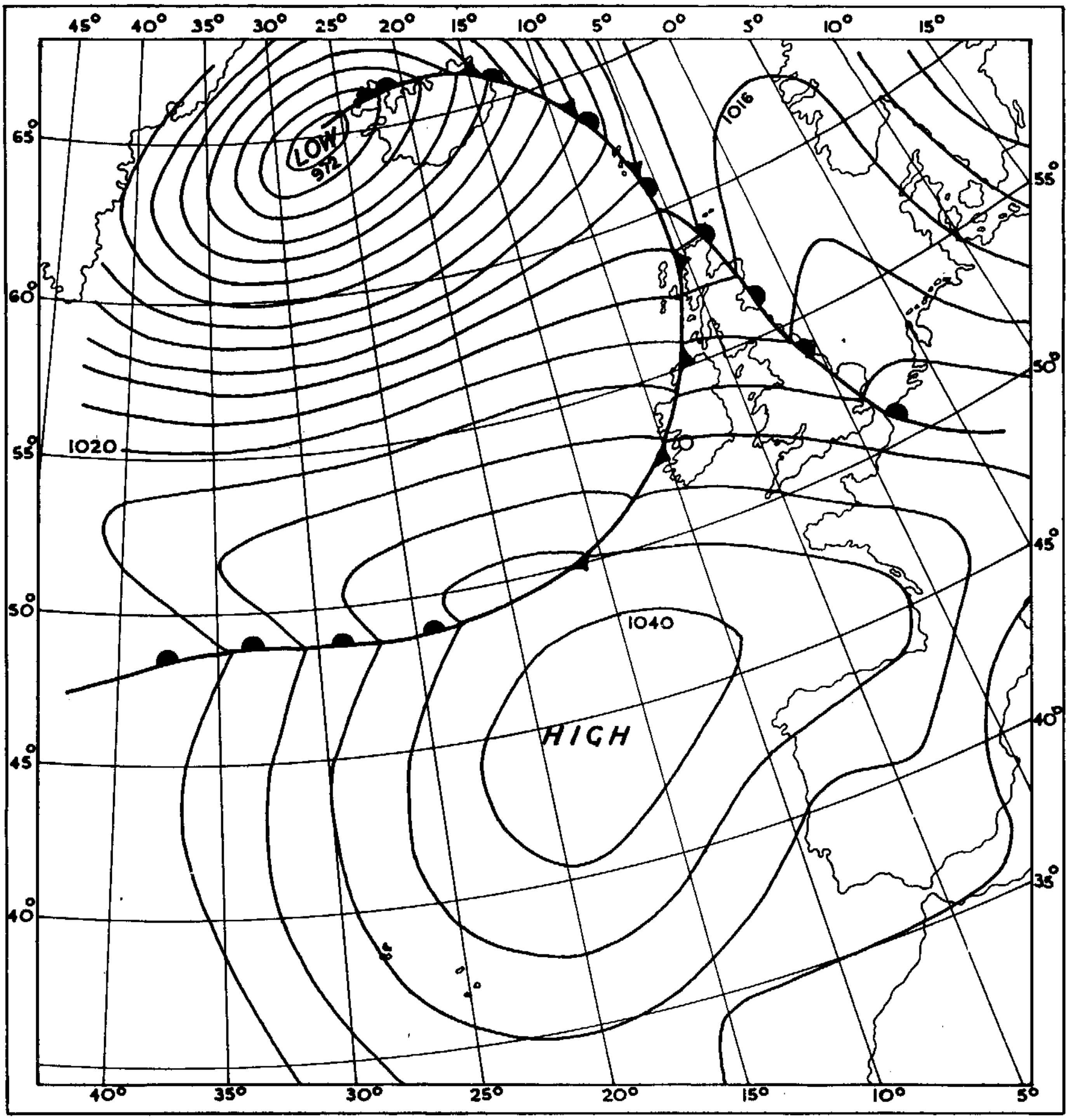

Fig. 12. Surface Chart, 1800 G.M.T. 15th January, 1949.

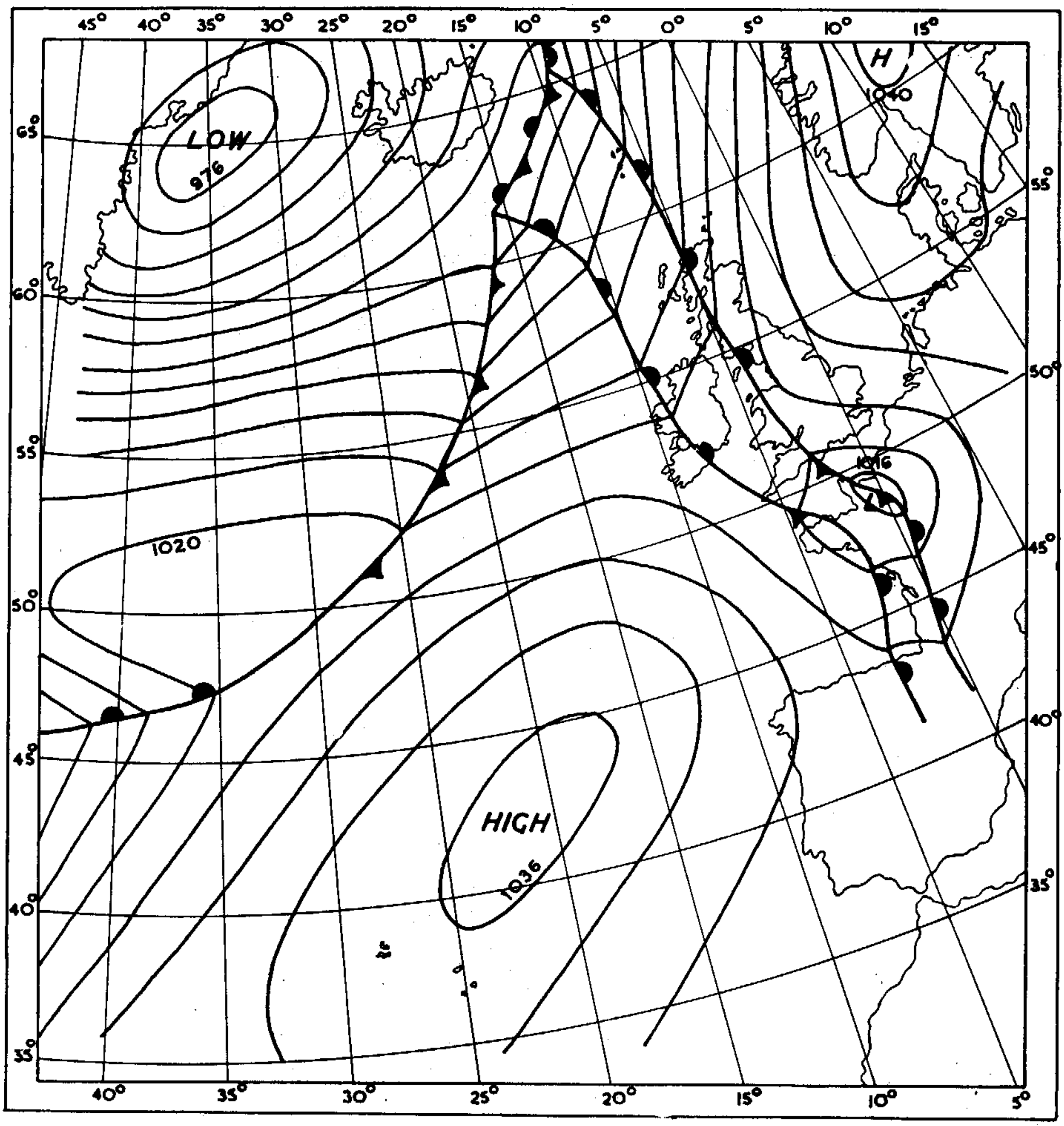

Fig. 13. Surface Chart, 0000 G.M.T. 5th March, 1949.