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GASSIOT FELLOWSHIPS IN GEOPHYSICS

By the DIRECTOR-GENERAL

The functions of the Meteorological Office, as set out in the preamble to the *Annual Report*, include "research in meteorology and geophysics". In the long history of the Office, the word "geophysics" has come to mean geomagnetism and seismology. In the reorganization which followed the Report of the Brabazon Committee, research was given full status in the Meteorological Office, but with the emphasis almost entirely on meteorology.

The position of geophysics in the Office can be understood only when viewed against the historical background. In 1840, about 15 years before the Meteorological Office was created, three assistants were added to the staff of the Astronomer Royal at Greenwich Observatory to take "regular observations with meteorological apparatus and the two principal magnetic instruments". About 1910, the Meteorological Office took over from the National Physical Laboratory responsibility for "the whole of the work which it is proposed should remain at Kew and which includes terrestrial magnetism and other subjects not strictly meteorological; and also the work of the Observatory at Eskdalemuir, which is mainly magnetic". The Director was given control of the Observatories "with the scientific advice of a committee appointed by the Royal Society to administer the Gassiot Trust".

The Trust referred to above arose from the bequest in 1871, by John P. Gassiot, F.R.S., of a large sum of money to the Royal Society "to assist in carrying out and maintaining magnetical and meteorological observations with self-recording instruments, and any other physical investigations that may be practicable and desirable at Kew Observatory". The income from the Trust is paid to the Air Ministry for the benefit of the Meteorological Office and is absorbed in the general account, but in the post-war period the Air Ministry has made grants to the Royal Society which far exceed the now modest income of the Gassiot Fund. These grants have been distributed by the Gassiot Committee to further investigations, mainly in the universities, which cover a wide range of atmospheric physics.

In the first half of this century much valuable work was done at Kew and Eskdalemuir in atmospheric electricity, radiation, upper air soundings, geomagnetism and seismology, but it became increasingly difficult, as the original members of the staff retired, to provide adequate careers for scientists specializing in geomagnetism or seismology. Even before the outbreak of the Second World War, Sir Nelson Johnson, faced by the ever-growing demands of meteorological research and staff shortages, decided to reduce considerably the volume of seismological activity at Kew. Records, however, continued to be taken in both terrestrial magnetism and seismology, but although they were kept going through the war, their publication inevitably fell into arrears.

The last decade thus saw research activity in geomagnetism and seismology sink to a low level within the Office simply because of lack of man-power. The measurements and records continued, and geomagnetic data from Lerwick and Eskdalemuir and the Kew seismograms are highly regarded by workers in these fields. But a major scientific institution cannot rest content with the making and publication of observations, valuable though these may be. There must be opportunities for creative interpretation as well, which in realistic terms means freeing scientific staff of adequate capabilities for long uninterrupted periods of study devoted entirely to these subjects. The difficulty has been to find a way of doing this with, at the same time, provision of adequate career prospects.

The problem has been studied by the Meteorological Committee. Lord Hurcomb and his colleagues, following a line of thought suggested by the Director-General, recommended that the Secretary of State for Air should set up within the Office two fellowships (to be known, with the agreement of the Royal Society, as Gassiot Fellowships) for research in geomagnetism and seismology, respectively. This recommendation was accepted and the scheme is now in being.

The Gassiot Fellowships should not be confused with the ordinary Junior and Senior Fellowships offered regularly for work in government scientific establishments. The salary range is higher and the period of tenure, it is hoped, will be longer (normally seven years, with a possible extension to ten years). The scheme is primarily designed to attract university men in mid-career who could reasonably look forward, at the end of their fellowship periods, to becoming readers or professors.

The International Geophysical Year, and the development of large rockets and satellites, have given a great impetus to the study of the earth sciences in many countries. At one time Britain undoubtedly led in this field, but of late we have been overtaken by both Russia and the United States of America. In the present scheme, the Fellows will be allowed complete freedom to choose and pursue any investigations which fall within the recognized scope of their disciplines, publication will be encouraged and they will be free from administrative duties connected with the running of the Observatories or with the routine work of the Office in connexion with geomagnetism and seismology. Contact with universities is regarded as an essential part of the contract. Such opportunities, it is hoped, will stimulate interest in geophysics in this country, and in this way the Gassiot Fellowships may well create not only focal points of study in both disciplines but also lasting and worthwhile memorials to the International Geophysical Year.

THE FORECASTING OF DRY SPELLS OF THREE DAYS OR MORE AT LONDON AND IN SOUTH-EAST ENGLAND IN MAY TO OCTOBER

By C. A. S. LOWNDES

Introduction.—Most of the dry spells occurring in the months May to October are associated with a spread of high pressure from the south-west or west of the British Isles, that is, with synoptic Types V and VI as defined by Lowndes.[1] The initial attack on the problem of forecasting dry spells has been devoted to those originating in this way.

Data extracted.—A study of upper air charts revealed that pronounced thermal troughs in the western Atlantic often preceded the dry-spell periods. It was decided to study all thermal troughs occurring between 60°W and 30°W and to measure their intensity in terms of 1000–500-millibar thickness anomaly. For this purpose graphs of mean thickness values were prepared for longitudes 60°, 50°, 40° and 30°W and latitudes 60°, 55°, 50°, 45° and 40°N, based on five-year monthly mean values. The graphs enabled the mean thickness to be read off for any particular day at any of the grid points.

Experience in assessing the troughs suggested that the most useful measurement was the thickness anomaly on the trough axis at 45°N. The following details of each trough were therefore recorded:

(i) The thickness anomaly on the trough axis at 45°N when the trough was nearest to the longitudes 60°, 50°, 40° and 30°W, together with the appropriate dates.

(ii) The maximum negative thickness anomaly reached on the trough axis at 45°N together with the date and longitude.

(iii) The maximum negative thickness anomaly reached on the trough axis at any latitude, together with the date and the latitude and longitude.

A measure of the pressure level to the south-west of the British Isles seemed likely to be of interest. The pressure at Horta (38°32′N, 28°38′W) in the Azores at 1200 G.M.T. on the days when the troughs most nearly approached 60°, 50°, 40° and 30°W was therefore recorded. The pressure anomaly was obtained using a graph based on a 38-year record at Horta, from which the mean could be read off for any particular day. The graphs of mean thickness at longitudes 60°W and 50°W (latitude 45°N) and of mean pressure at Horta are shown in Figure 1. The data were extracted for the years 1951 to 1958.

Thickness troughs associated with dry spells at London.—It was evident from a study of the data that troughs which attained a negative thickness anomaly of the order of 10 decametres or more between 60°W and 50°W were often associated with dry spells at London which started within four days of the trough reaching 50°W. However, troughs which satisfied this condition and which became stationary near 60°W or became very weak by the time they had reached 50°W were not associated with dry spells. A further requirement, that the negative thickness anomaly should not be less than five decametres when the trough reached 50°W, was found to eliminate such occasions.

At this stage, further data were extracted as follows:

(iv) The maximum negative thickness anomaly reached between 60°W and 50°W.

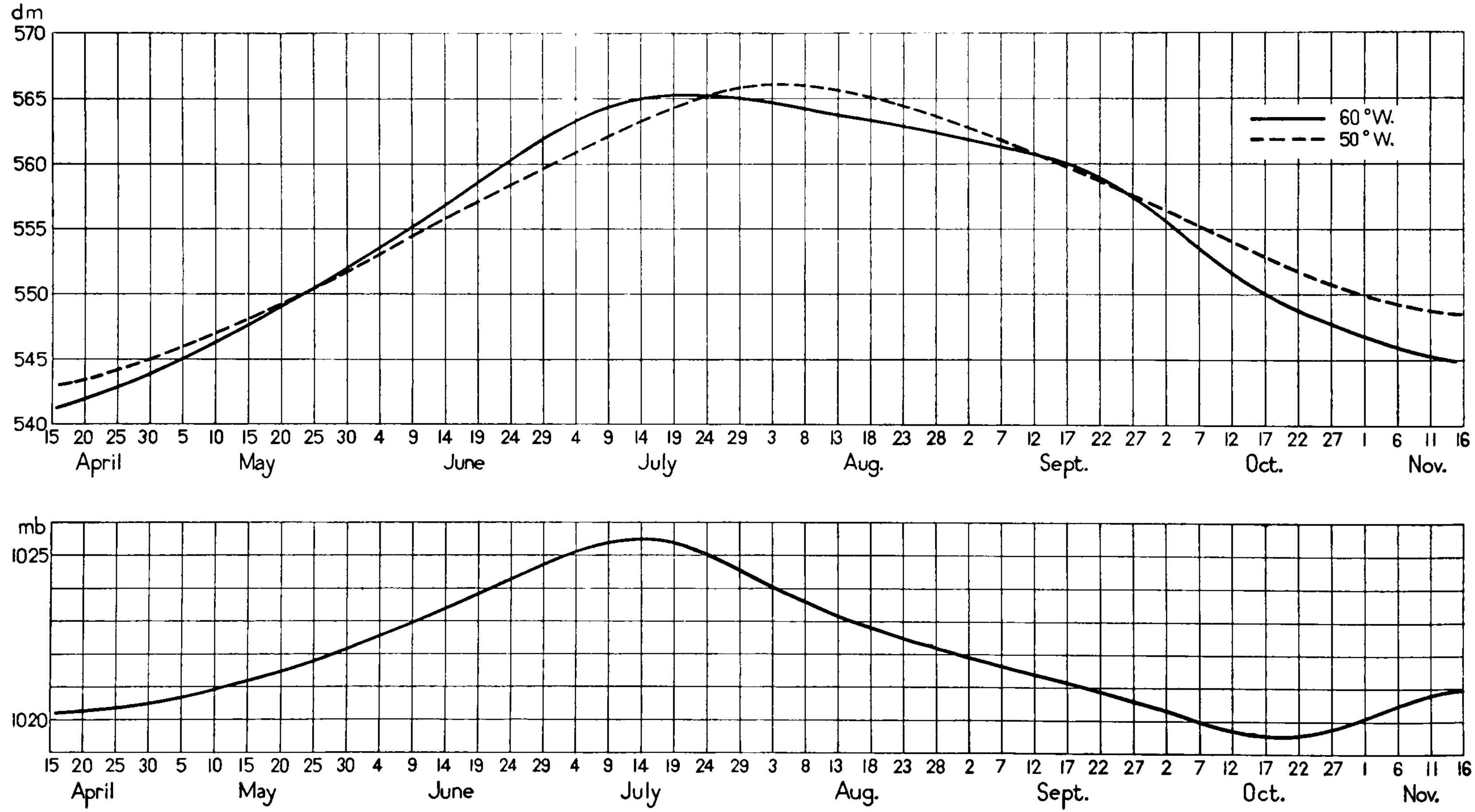


FIGURE 1—MEAN 1000–500-MILLIBAR THICKNESS CURVES FOR LONGITUDES 60°W AND 50°W (LATITUDE 45°N) AND THE MEAN PRESSURE AT HORTA

The thickness curves are based on five-year monthly means obtained for the period 1949–53 for the months June to November and for 1950–54 for April and May. The mean surface pressure curve for Horta is based on 38-year monthly means for the period 1902–39.

(v) The pressure anomaly at Horta at 1200 G.M.T. on the day of maximum negative thickness anomaly.

For all troughs between 60°W and 50°W which attained a negative thickness anomaly at 45°N of eight decametres or more and which were associated with a negative thickness anomaly of not less than five decametres on reaching 50°W, a diagram was plotted (Figure 2) of the maximum negative thickness anomaly at 45°N (between 60°W and 50°W) against the pressure anomaly at Horta at 1200 G.M.T. on the day of maximum negative thickness anomaly. If the trough was associated with a dry spell of three days or more a dot was

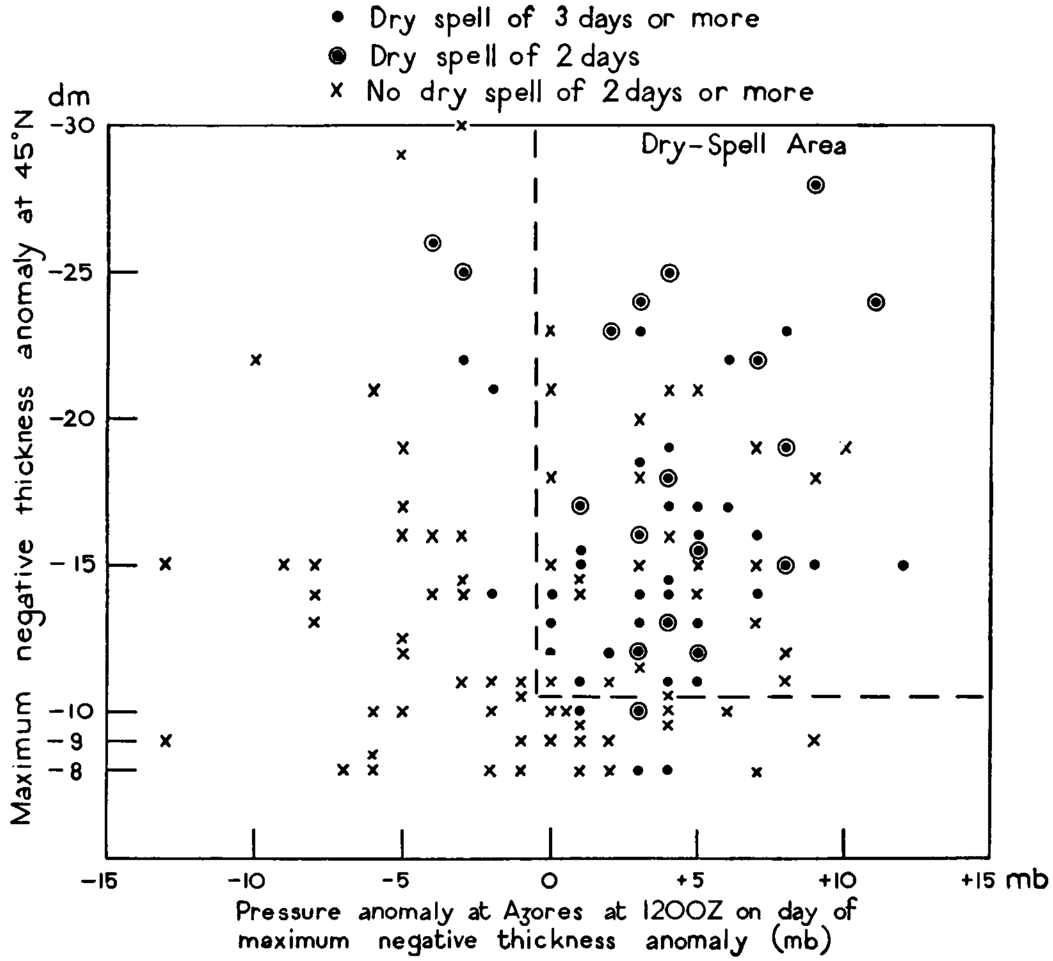


FIGURE 2—DRY SPELLS AT KEW, LONDON, MAY TO OCTOBER (EIGHT YEARS)

For troughs which attained a negative thickness anomaly at 45°N of at least eight decametres between 60°W and 50°W and which were associated with a negative thickness anomally of at least five decametres on reaching 50°W.

plotted. A spell of only two days was indicated by a dot within a circle. It is evident from the graph that no spells of three days or more were associated with a negative pressure anomaly of more than three millibars. Most of the dry-spell plots are enclosed within the area indicated. This suggests that, in the main, for a trough to be associated with a dry spell, the thickness anomaly must reach 11 decametres and at the same time the pressure at the Azores must be normal or above.

Most of the forecast failures indicated by crosses in the "dry-spell area" occurred in September and October. A study of the upper air charts for these two months showed that in a number of these cases the belt of maximum 500-millibar flow to the south of the trough was in relatively high latitudes.

TABLE I—LATITUDE OF 500-MILLIBAR FLOW TO SOUTH OF TROUGH (MAY TO OCTOBER)

Latitude °*N*	Troughs associated with dry spells	Troughs not associated with dry spells
	number of cases	
57	0	1
54	0	1
52	0	1
50	0	2
49	0	6
48	0	3
47	0	3
46	3	0
45	4	2
44	4	0
43	5	2
42	4	5
41	5	3
40	2	4
39	1	4
38	0	2

Table I shows the latitude at which the flow at 500 millibars to the south of the trough was centred when the thickness trough was at 50°W for the cases which were associated with dry spells of three days or more and also for those which were not associated with dry spells.

The latitude of the 500-millibar flow varied from 39°N to 46°N for the troughs which were associated with dry spells, whilst in 17 cases not associated with dry spells the flow was centred north of 46°N.

TABLE II—NUMBER OF CASES OF FLOW NORTH OF 46°N IN EACH MONTH

May	June	July	Aug.	Sept.	Oct.	Total
			number of cases			
0	1	1	1	9	5	17

The number of cases of flow north of 46°N for each month is shown in Table II; nearly all occurred in September and October.

It was further noted that in a number of cases when troughs were not associated with dry spells there was a well defined westerly 500-millibar flow in high latitudes to the north of the trough. In all but two of the 14 cases where the high-latitude flow was not considered negligible compared with the flow to the south of the trough, either no surge of pressure occurred in the region of the British Isles ahead of the trough, or it was insufficient to produce a dry spell of three days or more at Kew. In the other two cases, dry spells occurred at Kew, but not in south-east England. In one case a dry spell did occur, but not because of a surge of pressure ahead of the trough. The trough moved from 60°W to 50°W from 11–12 September 1956 and a surge of pressure occurred to the south of the British Isles without providing a dry spell. However, a large high which had followed the trough from America moved across the British Isles from the west to give a dry spell at Kew and in south-east England.

A high-latitude flow represented by one or two 500-millibar contours at 60-metre intervals can always be considered negligible. A flow represented by three contours can be considered negligible if the contours cover more than about eight degrees of latitude on average. Flows represented by four contours or more are always significant. There is some evidence that flows north of 75°N can be ignored.

TABLE III—NUMBER OF CASES OF SIGNIFICANT WESTERLY FLOW IN HIGH LATITUDES IN EACH MONTH

May	June	July	Aug.	Sept.	Oct.	Total
			number of cases			
4	0	0	1	7	2	14

The number of cases for each month when the 500-millibar flow in high latitudes was not considered negligible is shown in Table III. Most occurred in May and September. (Two of these cases were also listed in Table II, that is, the flow to the south of the trough was north of 46°N.)

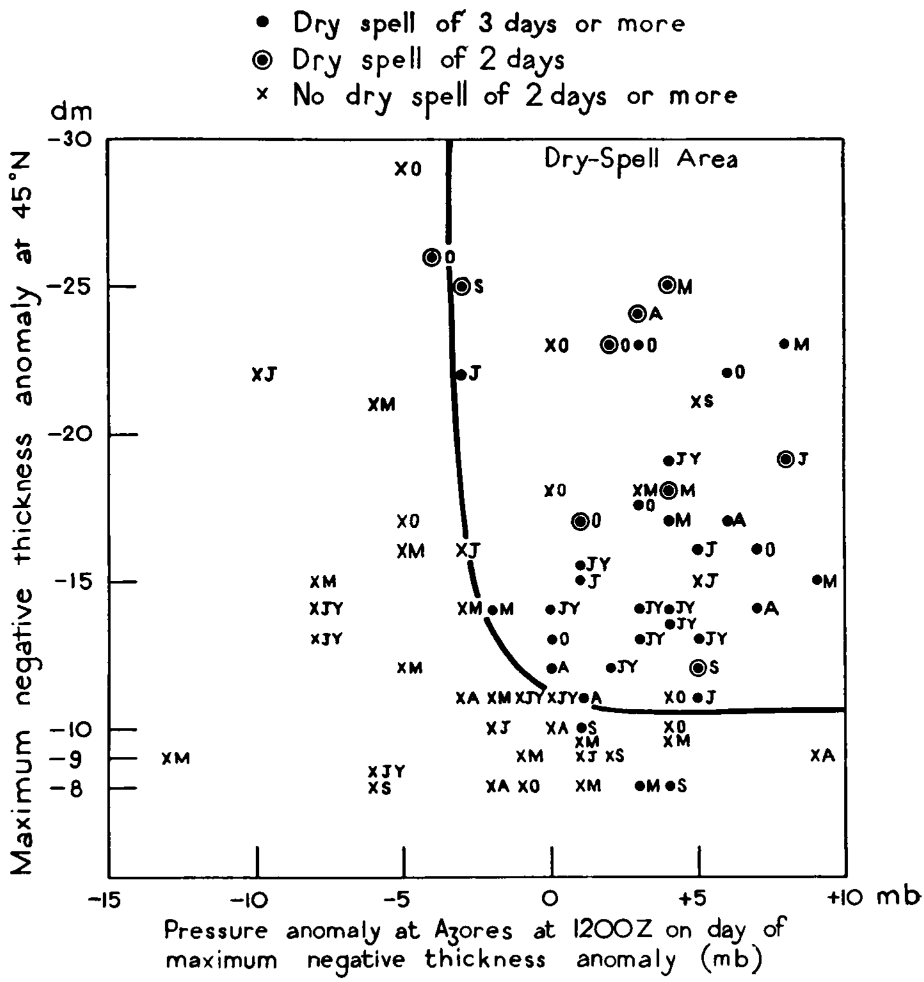


FIGURE 3—DRY SPELLS AT KEW, LONDON, MAY TO OCTOBER (EIGHT YEARS)

For troughs which attained a negative thickness anomaly at 45°N of at least eight decametres between 60°W and 50°W and which were associated with a negative thickness anomaly of at least five decametres on reaching 50°W; 500 mb flow to south of trough centred south of 47°N; flow in high latitudes negligible.

Figure 2 was then replotted, excluding cases where the 500-millibar flow to the south of the trough was north of 46°N and where the westerly 500-millibar flow in high latitudes was not considered negligible, resulting in Figure 3. The month in which each case occurred is indicated by an initial letter next to the plotted symbol. The graph can be divided into two areas as indicated. Of the 40 cases in the "dry-spell area" 26 were associated with dry spells of three days or more and seven with spells of two days.

TABLE IV—DRY SPELLS AT LONDON: THE CASES WITHIN THE "DRY-SPELL AREA" CLASSIFIED ACCORDING TO THE MONTH IN WHICH THEY OCCURRED

	May	June	July	Aug.	Sept.	Oct.	Total
				number of cases			
3 days ...	4	4	9	4	0	5	26
2 days ...	1	1	0	1	2	2	7
No spell ...	2	1	0	0	1	3	7

Table IV shows the 40 cases classified according to the month in which they occurred. The figures show that of the 20 cases in June, July and August within the "dry-spell area" only three were not dry spells of at least three days' duration.

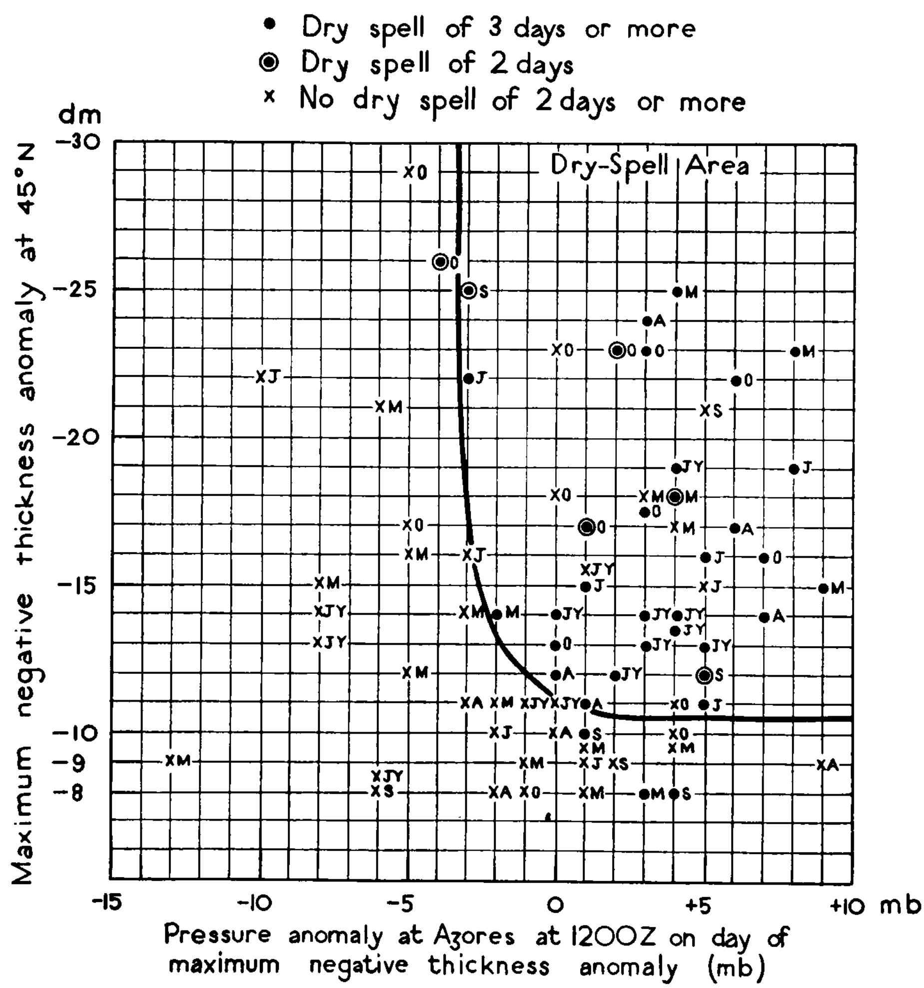


FIGURE 4—DRY SPELLS IN SOUTH-EAST ENGLAND, MAY TO OCTOBER (EIGHT YEARS)

For troughs which attained a negative thickness anomaly at 45°N of at least eight decametres between 60°W and 50°W and which were associated with a negative thickness anomaly of at least five decametres on reaching 50°W; 500 mb flow to south of trough centred south of 47°N; flow in high latitudes negligible.

Thickness troughs associated with dry spells in south-east England.—The spells at Kew were examined to determine how far they represented dry spells in south-east England. The Beaufort letters in the *Daily Weather Report* were examined for the stations London Airport, Tangmere, Hurn, Felixstowe, Gorleston, Mildenhall and Boscombe Down. A dry day was allowed if pr_0, id_0, or ir_0 occurred at only one station, or during the night, or if precipitation occurred very early or very late in the day at the beginning or end of the spell. A graph similar to Figure 3 was produced for south-east England (Figure 4). The graph can be divided into the same areas as in Figure 3. Of the 40 cases in the "dry-spell area" 27 were associated with dry spells of three days or more and five with spells of two days.

TABLE V—DRY SPELLS IN SOUTH-EAST ENGLAND: THE CASES WITHIN THE "DRY-SPELL AREA" CLASSIFIED ACCORDING TO THE MONTH IN WHICH THEY OCCURRED

	May	June	July	Aug.	Sept.	Oct.	Total
				number of cases			
3 days ...	4	5	8	5	0	5	27
2 days ...	1	0	0	0	2	2	5
No spell ...	2	1	1	0	1	3	8

Table V shows the 40 cases classified according to the month in which they occurred. The figures show that of the 20 cases in June, July and August within the "dry-spell area" only two were not dry spells of at least three days' duration. In 21 cases the dry spells were associated with surges of pressure from the south-west (Type V), in four cases from the west (Type VI) and in

TABLE VI—FORECASTING FOR SOUTH-EAST ENGLAND: TROUGHS ASSOCIATED WITH DRY SPELLS OF THREE DAYS OR MORE

Trough number	Year	Date trough at 60°W	Date trough reached 50°W (d)	Date of start of dry spell	Length of dry spell in days
1	1951	27 June	28 June	$d+2$	3
2	1952	21 June	22 June	$d+3$	7
3	1952	27 June	29 June	$d-4$	7
4	1952	21 July	22 July	$d+2$	3
5	1953	31 May	5 June	$d+1$	5
6	1953	2 August	3 August	$d-1$	3
7	1953	6 August	7 August	d	5
8	1953	24 August	26 August	d	3
9	1953	29 September	30 September	$d+1$	3
10	1953	2 October	3 October	$d+2$	7
11	1954	23 August	24 August	$d+1$	3
12	1954	29 August	29 August	$d+1$	3
13	1955	22 July	23 July	$d+2$	8
14	1955	6 October	7 October	$d+2$	3
15	1956	9 May	10 May	$d+2$	5
16	1956	19 June	21 June	$d+4$	3
17	1956	9 July	10 July	d	3
18	1956	20 July	22 July	$d+3$	3
19	1956	19 October	20 October	$d+1$	3
20	1957	17 May	20 May	$d+1$	3
21	1957	22 May	23 May	$d+2$	9
22	1957	9 June	10 June	$d+2$	6
23	1957	26 July	28 July	$d+1$	7
24	1957	28 September	30 September	$d+2$	8
25	1958	27 April	29 April	d	6
26	1958	10 June	11 June	$d+2$	4
27	1958	5 July	6 July	$d+1$	5

one from the north-west (Type VII). In all these cases the surge of pressure occurred ahead of the trough. In the remaining case, the trough moved from 60°W to 50°W from 9–10 May 1956. No surge of pressure occurred ahead of the trough, but a large high which had followed the trough from America moved to south-west of the British Isles to give a dry spell. In this instance the trough was followed closely by another.

Table VI shows the dates of the dry-spell periods of three days or more which were associated with the 27 troughs. The date of the beginning of each spell is shown with reference to the date *d* on which the trough reached 50°W.

TABLE VII—FORECASTING FOR SOUTH-EAST ENGLAND: DATE OF BEGINNING OF SPELL WITH REFERENCE TO DATE *d* ON WHICH TROUGH REACHED 50°W

Date	Number of cases
$d-4$	1
$d-1$	1
d	4
$d+1$	8
$d+2$	10
$d+3$	2
$d+4$	1
Total	27

Table VII shows that most of the spells began one or two days after the troughs reached 50°W.

If the spells had been forecast to begin within 24 hours of the trough reaching 50°W, the beginning of 18 spells and the continuation of two spells for a further four days would have been forecast.

TABLE VIII—FORECASTING FOR SOUTH-EAST ENGLAND: THE NUMBER OF SPELLS OF THREE DAYS OR MORE INDICATED IN EACH YEAR (MAY TO OCTOBER)

Year	Total number of spells of Types V, VI and VII	Number of spells indicated by troughs
1951	5	1
1952	7	2
1953	9	6
1954	2	2
1955	8	2
1956	7	5
1957	5	5
1958	6	3
Total	49	26*

* One of the two spells in 1952 was partly indicated by one trough and partly by another.

The number of spells indicated in each year is shown in Table VIII. All of the spells in 1954 and 1957 were indicated. Few were indicated in 1951, 1952 and 1955.

Table IX shows the number of spells indicated in each year for the months June, July and August for which the most successful indications were obtained. All of the spells in 1953, 1954, 1956 and 1957 were indicated and all but one in 1951 and 1958. Few were indicated in 1952 and 1955. Of the nine spells not indicated, six were part of prolonged settled periods which occurred in the summers of 1951, 1952 and 1955.

TABLE IX—FORECASTING FOR SOUTH-EAST ENGLAND: THE NUMBER OF SPELLS OF THREE DAYS OR MORE INDICATED IN EACH YEAR (JUNE TO AUGUST)

Year	Total number of spells of Types V and VI	Number of spells indicated by troughs
1951	2	1
1952	6	2
1953	4	4
1954	2	2
1955	4	1
1956	3	3
1957	2	2
1958	3	2
Total	26	17

Note: There were no Type VII spells.

Table X shows the pressure change at London from the day when the trough was at 60°W to the beginning of the dry spell in south-east England. In all but one case there was some rise in pressure. In two cases the pressure had risen and then fallen to a lower value than the original by the time the dry spell had begun. For all cases when the pressure was originally 1016 millibars or less, the mean rise was 12 millibars.

TABLE X—FORECASTING FOR SOUTH-EAST ENGLAND: TROUGHS ASSOCIATED WITH DRY SPELLS OF THREE DAYS OR MORE, AND PRESSURE CHANGE AT LONDON

Trough number	Pressure change at London from date trough at 60°W to start of dry spell in S.E. England	Pressure difference	Length of spell
	mb	*mb*	*days*
1	1017–1029	+12	3
2	1022–1024–1021	−1	7
3	1021–1025	+4	7
4	1022–1025	+3	3
5	1011–1021	+10	5
6	1018–1023	+5*	3
7	1024–1025	+1	5
8	1006–1016	+10	3
9	1023–1029	+6	3
10	1025–1034	+9	7
11	1010–1016	+6	3
12	1025–1024	−1	3
13	1021–1025–1018	−3	8
14	1006–1026	+20	3
15	1019–1025	+6	5
16	1020–1022	+2	3
17	1016–1021	+5	3
18	1008–1028	+20	3
19	1024–1030	+6	3
20	1016–1025	+9	3
21	1022–1024	+2	9
22	1005–1033	+28	6
23	1008–1018	+10	7
24	1024–1029	+5	8
25	1015–1027	+12	6
26	1016–1025	+9	4
27	1016–1026	+10	5

* To second day of spell; spell began on the day the trough reached 60°W.

The "dry-spell area" of Figure 4 contains eight crosses which indicate troughs which were not associated with dry spells of two days or more. The dates on which these troughs moved from 60°W to 50°W are as follows: (i) 21–22 October 1952, (ii) 13–15 May 1954, (iii) 13–14 June 1954, (iv) 1–2 May 1956, (v) 4–5 July 1956, (vi) 26–27 September 1956, (vii) 4–5 October 1956, (viii) 16 October 1958. Three of the cases occurred in October, two in May and one in June, July and September.

Rule for forecasting dry spells in south-east England in May to October (Type V, VI and VII spells).

(1) Follow all 1000–500-millibar thickness troughs which move east of 60°W from chart to chart *until they reach 50° W.*

(2) On each chart, estimate the thickness value at 45°N on the trough axis to the nearest decametre and calculate the thickness anomaly using the appropriate normal curve. Note the surface pressure at Horta to the nearest millibar and calculate the pressure anomaly using the normal curve.

(3) If the negative thickness anomaly reaches 11 decametres and with the trough at 50°W is not less than five decametres, plot the maximum negative thickness anomaly against the pressure anomaly (at the time of maximum negative thickness anomaly) on the graph. If the plot falls within the "dry-spell area", a spell of at least three days is likely to begin within 48 hours of the trough reaching 50°W. Occasionally the spell may begin after three or four days. On other occasions, the dry spell may have begun already and a continuation of at least three days is likely.

This procedure applies *provided that*, with the thickness trough at 50°W, (*a*) the 500-millibar flow to the south of the trough is centred south of 47°N and (*b*) that any westerly 500-millibar flow to the north of the trough is negligible compared with that to the south.

Notes:

(i) It will not be practicable to measure the troughs exactly between 60°W and 50°W. The first and final measurements should be made as near as possible to 60°W and 50°W.

(ii) In most cases the troughs will move through 60°W to 50°W but the rule does not exclude troughs which form between 60°W and 50°W or at 50°W.

Conclusion.—The rule would have forecast 23 of the 49 dry spells of three days or more (Types V, VI and VII) which occurred in the months of May to October in south-east England. It would also have forecast eight spells of two days and on eight occasions would have failed to forecast a spell of two days or more. The rule would have forecast 14 of the 26 dry spells of three days or more (Types V and VI) which occurred in the months June, July and August in south-east England. It would also have forecast three spells of two days and on two occasions would have failed to forecast a spell of two days or more.

REFERENCE

1. LOWNDES, C. A. S.; Dry spells of three days or more at London from May to October. *Met. Mag., London,* **89**, 1960, p. 105.

[*To face p. 140*

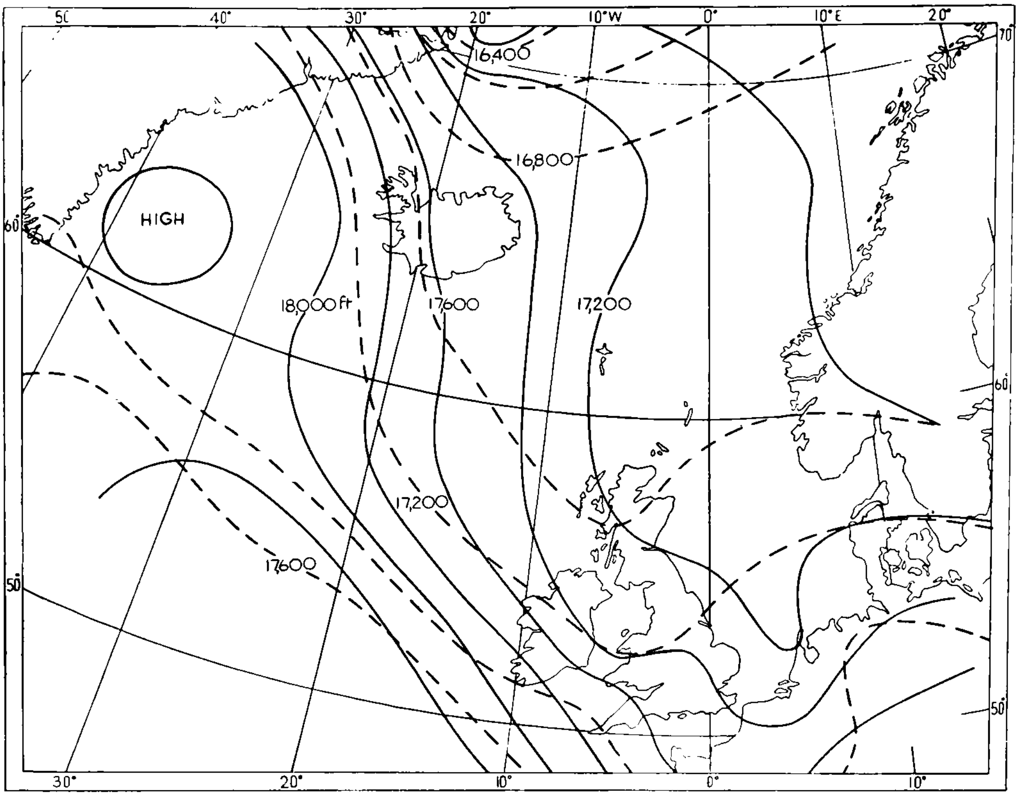


FIGURE 1(*a*)—1200 G.M.T., 7 JANUARY 1959

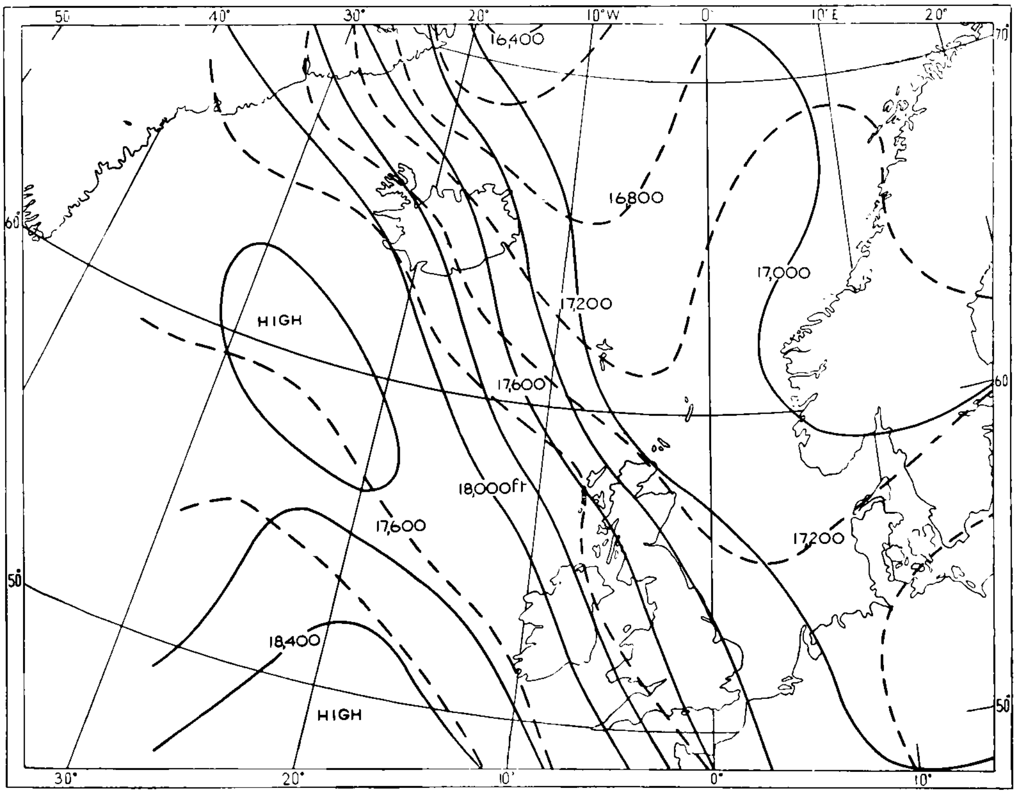


FIGURE 1(*b*)—1200 G.M.T., 8 JANUARY 1959

500-MILLIBAR CONTOURS (FULL LINES) AND 1000–500-MILLIBAR THICKNESS LINES (BROKEN LINES)

(see p. 146)

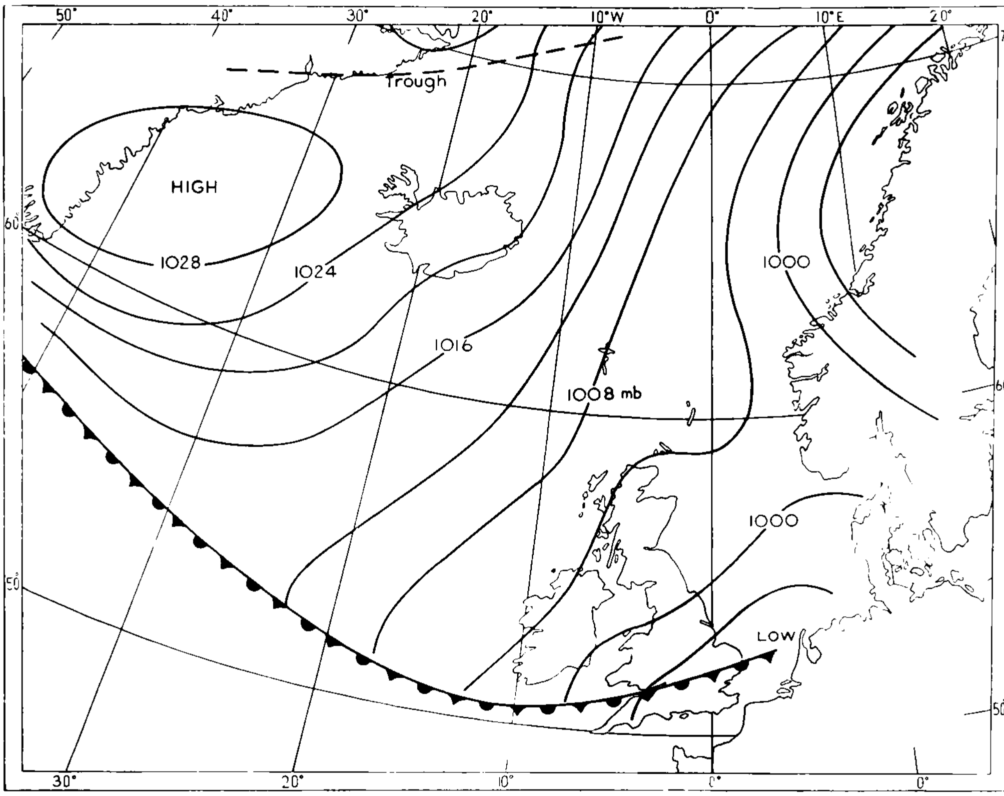


FIGURE 2(*a*)—0600 G.M.T., 7 JANUARY 1959

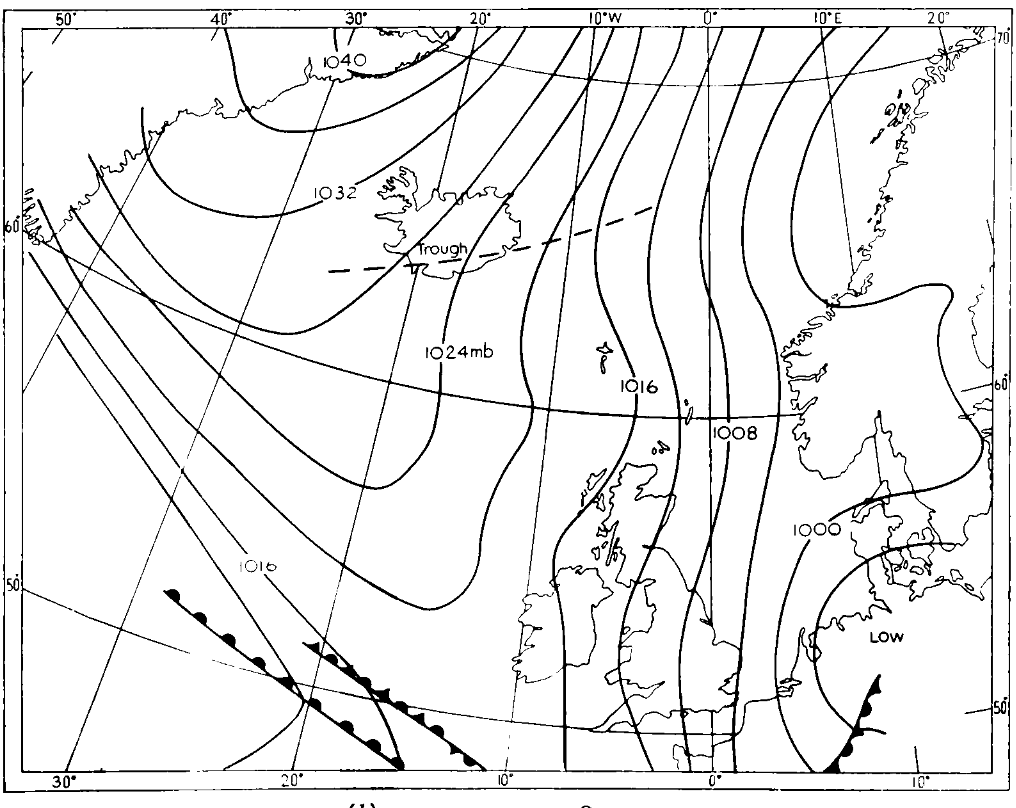


FIGURE 2(*b*)— 0000 G.M.T., 8 JANUARY 1959

MEAN-SEA-LEVEL CHARTS

(see p. 146)

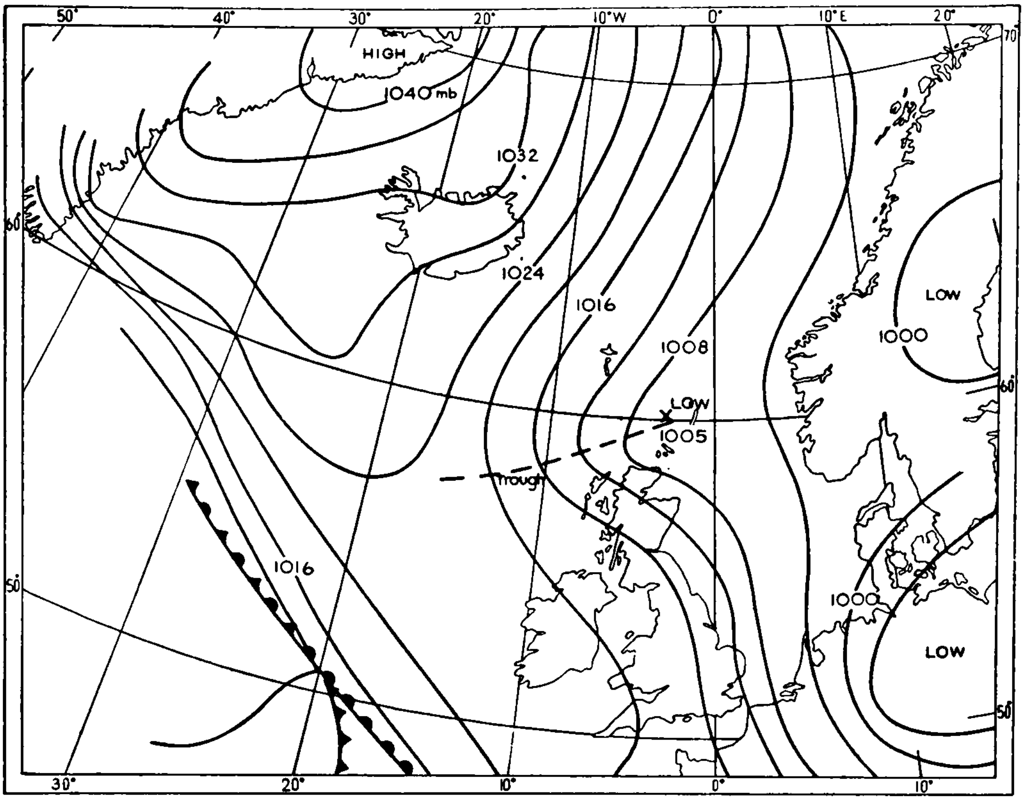


FIGURE 2(*c*)—1200 G.M.T., 8 JANUARY 1959

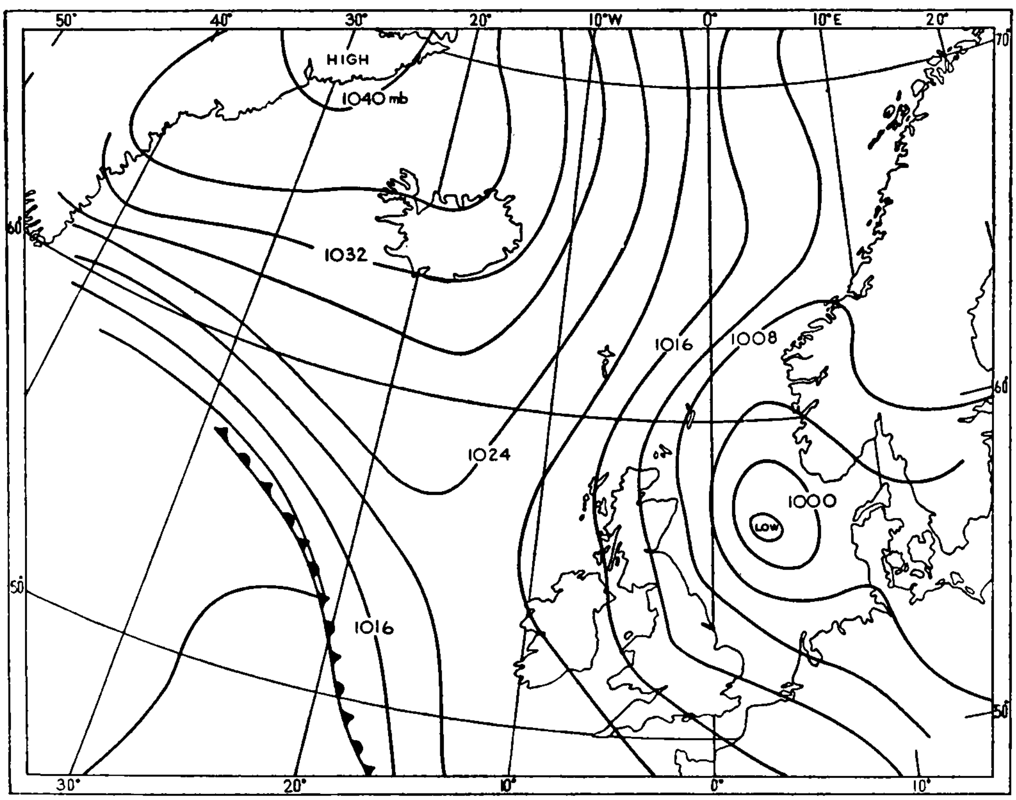


FIGURE 2(*d*)—0000 G.M.T., 9 JANUARY 1959

MEAN-SEA-LEVEL CHARTS

(see p. 146)

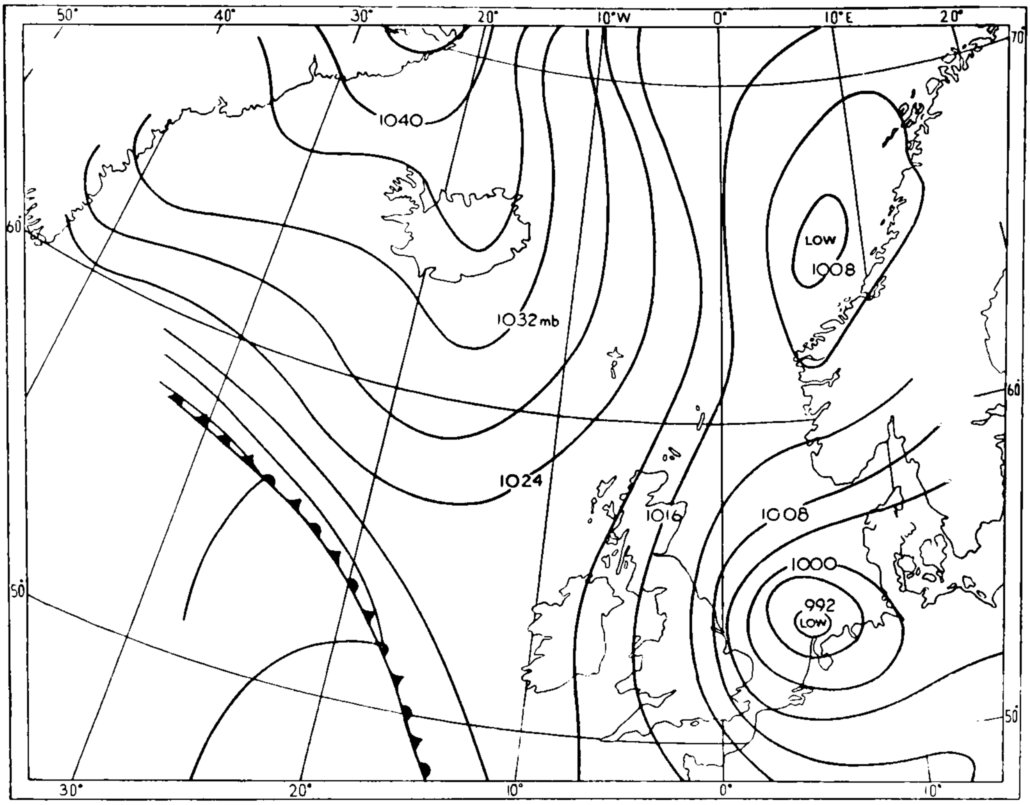


FIGURE 2(*e*)—1200 G.M.T., 9 JANUARY 1959, MEAN-SEA-LEVEL CHART

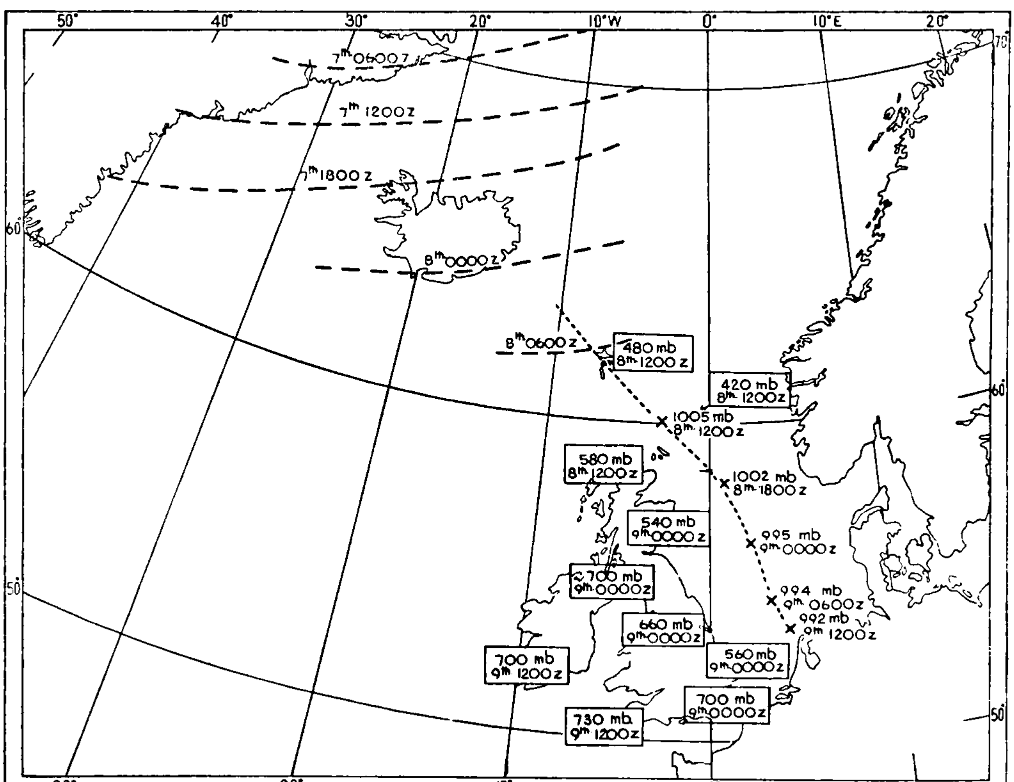


FIGURE 3—MOVEMENT OF SURFACE TROUGH AND LOW CENTRE, 7–9 JANUARY 1959

The boxed values give the height and time for the lowest level reached by the warm air at the radio-sonde stations. (see p. 146)

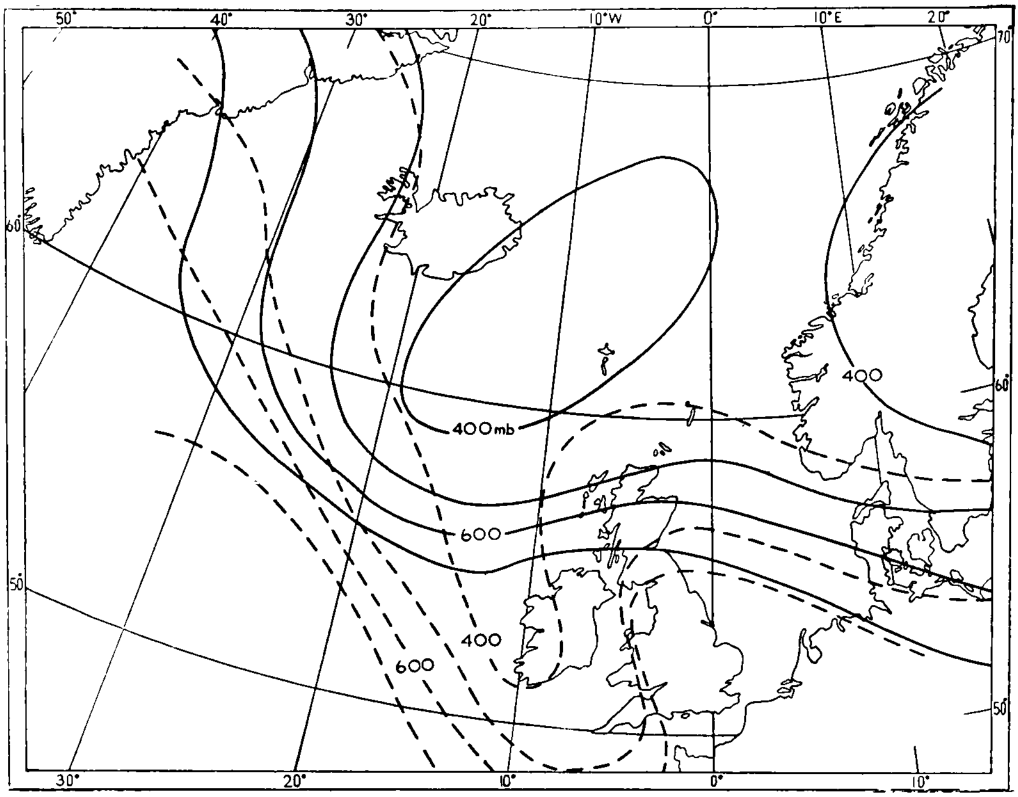


FIGURE 4(*a*)—0000 G.M.T., 7 JANUARY 1959

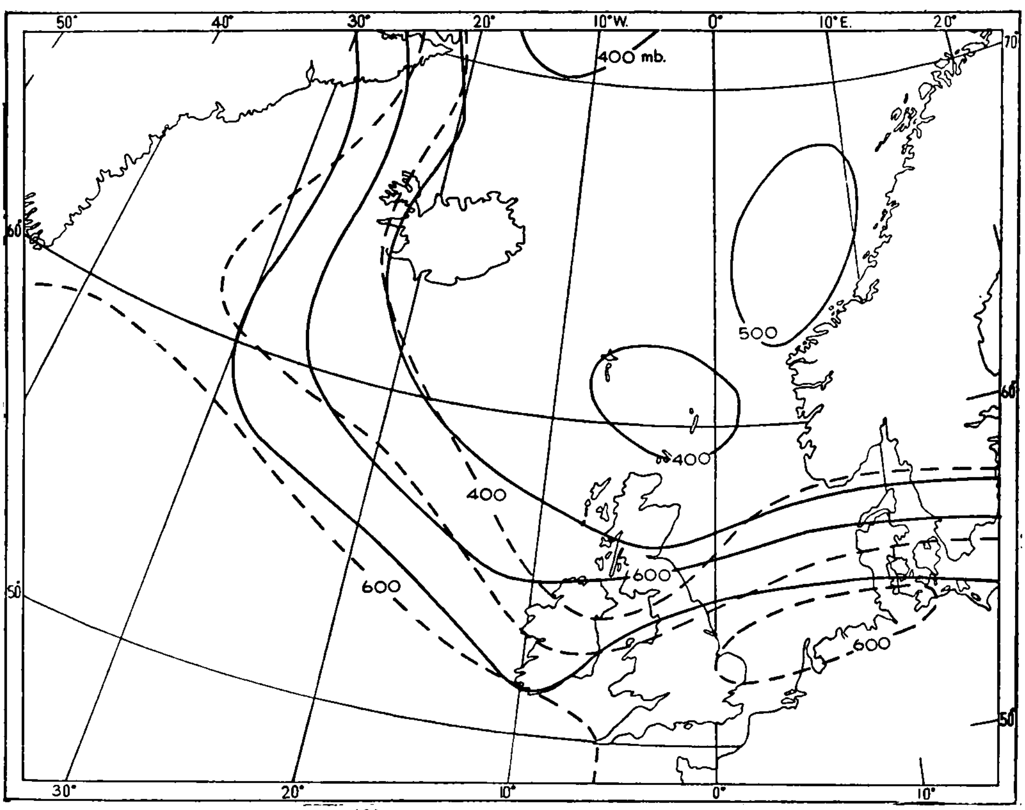


FIGURE 4(*b*)—1200 G.M.T., 7 JANUARY 1959

CONTOURS OF THE BASES OF POTENTIAL PSEUDO-WET-BULB TEMPERATURES OF 5°C (FULL LINES) AND 10°C (BROKEN LINES)

(see p. 147)

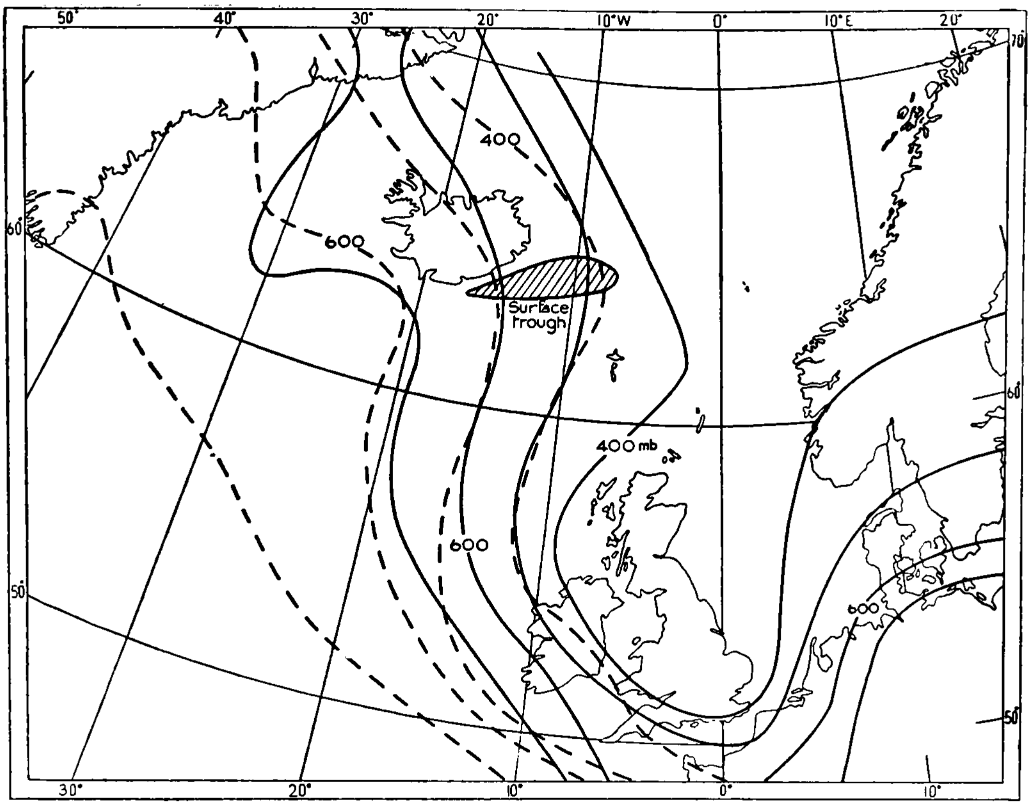


FIGURE 4(*c*)—0000 G.M.T., 8 JANUARY 1959

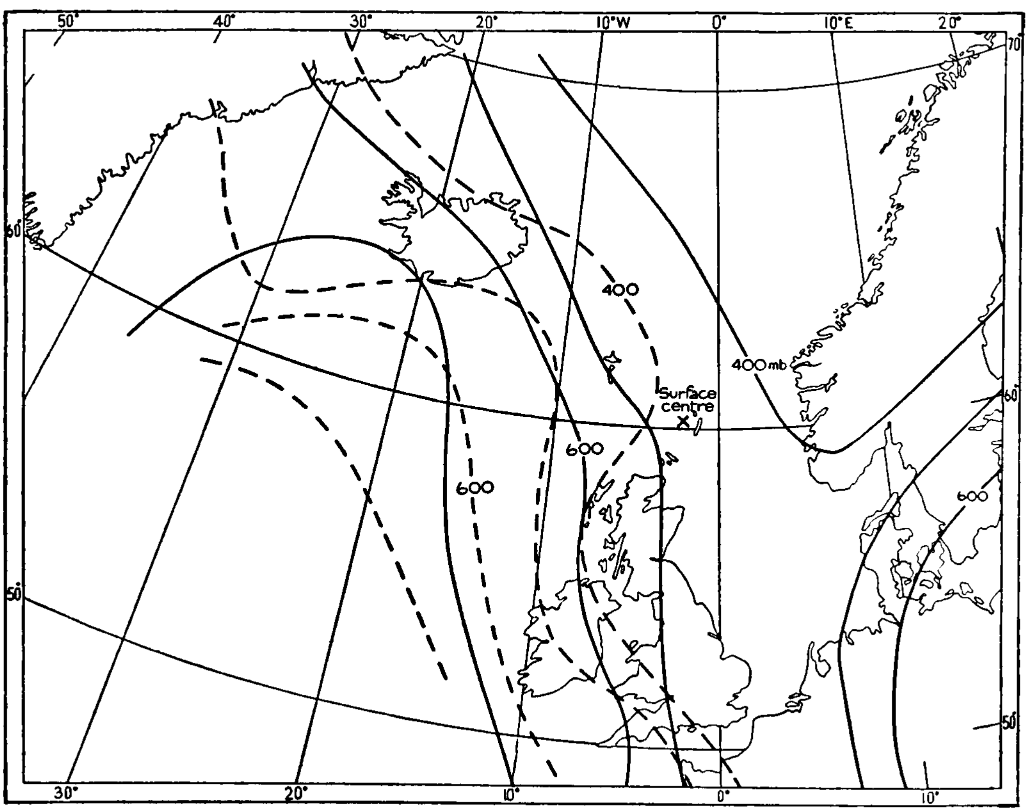


FIGURE 4(*d*)—1200 G.M.T., 8 JANUARY 1959

CONTOURS OF THE BASES OF POTENTIAL PSEUDO-WET-BULB TEMPERATURES OF 5°C (FULL LINES) AND 10°C (BROKEN LINES)

(see p. 147)

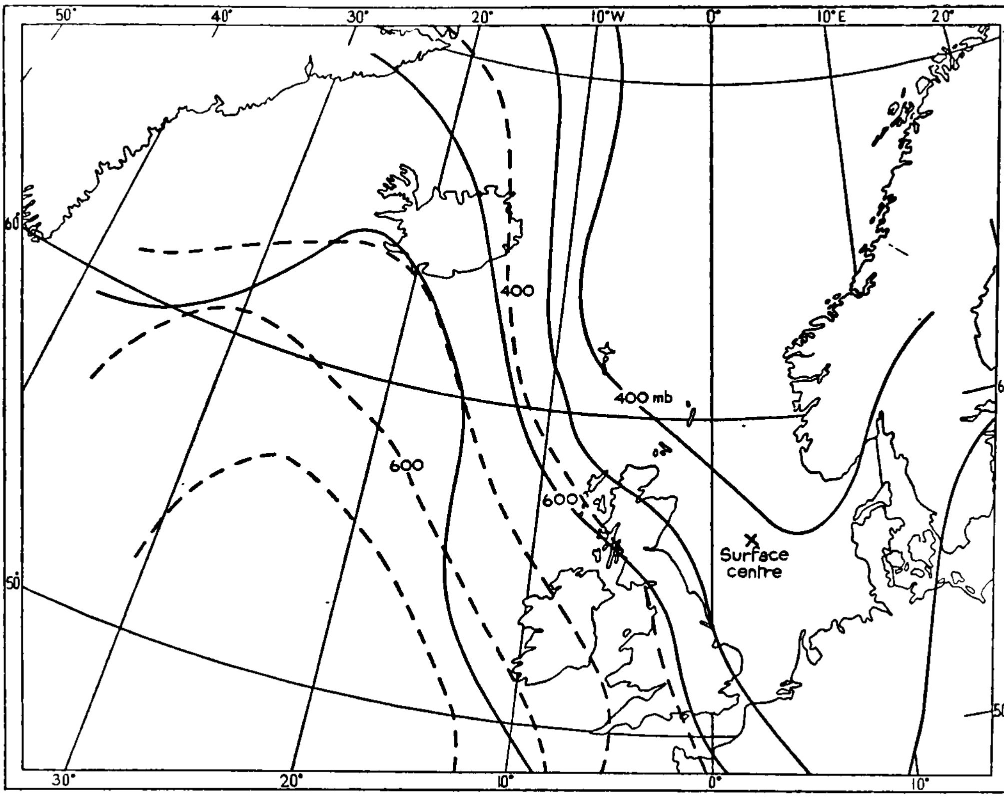


FIGURE 4(*e*)—0000 G.M.T., 9 JANUARY 1959

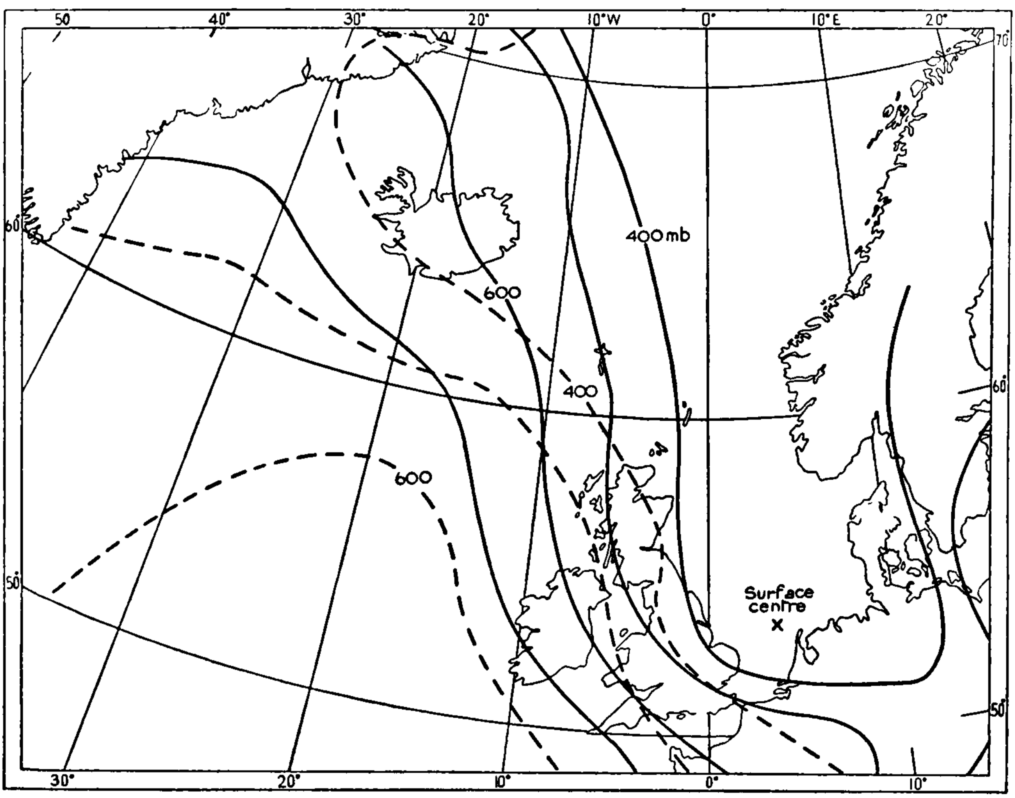


FIGURE 4(*f*)—1200 G.M.T., 9 JANUARY 1959

CONTOURS OF THE BASES OF POTENTIAL PSEUDO-WET-BULB TEMPERATURE OF 5°C (FULL LINES) AND 10°C (BROKEN LINES)

(see p. 147)

FRONTAL CONTOUR ANALYSIS OF A "POLAR" LOW

By D. G. HARLEY, B.Sc.

In the Canadian winter, when Arctic air covers the plains east of the Rockies, depressions, which originate west of the Rockies and have the form of frontal waves in the westerlies overlying the cold air, frequently move eastwards. The frontal surfaces remain well above the ground so that conventional surface frontal analysis fails. The Canadian Meteorological Service has developed frontal contour analysis to deal with this situation,[1] and uses the term TROWAL to describe the trough of warm air aloft which corresponds to the warm sector of ground-level systems.

Such overhead systems are not often prominent near the British Isles, but as Greenland forms a long high barrier to the airflow like the Rockies, it may be expected to produce similar effects on occasion. One apparent case is examined below.

In the period 7–9 January 1959 a strong north-westerly flow at 500 millibars lay across central Greenland, Iceland and the British Isles (Figures 1(*a*), 1(*b*)), while at the same time the low-level airflow over the whole area east of Greenland was Arctic air from between north and north-east (see Figures 2(*a*)–2(*e*)). The north-westerly upper flow contained air with potential pseudo-wet-bulb temperatures as high as +10°C, such as are associated in winter with maritime air masses from much further south. The nearest air like this at sea level was never nearer than about 700 nautical miles away in the middle Atlantic. The lowest level at which this air appeared on the east coast of Greenland was about 7000 feet, near the general level of the land mass of Greenland.

A weak surface pressure trough travelled down the east Greenland coast during the 7th. There were some indications earlier of a disturbance in the Norwegian Sea north of Jan Mayen but, significantly, this pressure trough also affected the coast west of the surface pressure ridge. Tendencies were as much as three millibars in three hours, down and up. The trough was aligned roughly west-south-west to east-north-east, across the upper wind, and for a time it could be detected over a length of about 700 nautical miles. It crossed Iceland with a period of snow between 1800 G.M.T. on the 7th and 0600 G.M.T. on the 8th. The speed of movement was about 24 knots. West of Iceland the trough then faded out, but east of Iceland it intensified in the cyclogenetic thickness pattern. Surface heating in this area tends anyway to have a cyclogenetic effect on a cold northerly flow.

By 1200 G.M.T. on the 8th a low centre of 1005 millibars had appeared just west of Shetland. This low moved south-east at 23 knots and continued to deepen but a little less rapidly (about five millibars in six hours). After 0600 G.M.T. on the 9th the low moved more slowly and then filled up. No surface fronts were apparent near the centre until deepening was complete. The lowest layers of air all around were of Arctic origin, with potential pseudo-wet-bulb temperatures (p.w.b.) of less than +2°C. The nearest surface front lay 750–900 miles away, south-west of ship "Juliet", parallel to the track of the low. The British tephigrams, however, showed much warmer air (not just subsided Arctic air) with p.w.b. of +5° to +10°C, moving south-south-east over the British Isles parallel with the low. The lowest levels reached by the warm air are shown in Figure 3 together with the track of the low; with the twelve-hour interval between soundings the true minima were probably lower. The base of the warm air rose rapidly after the minimum except at Valentia and Camborne. There was very little upper cloud associated with the trough while it was over the British Isles.

Frontal contour analysis suggested itself as an aid to finding the history of this warm superior air. The frontal contour charts were constructed using potential pseudo-wet-bulb temperature change and wind shear as criteria. The use of p.w.b. made it clear that the warmer air was of different origin, not merely subsided Arctic air. There appeared to be two stages of warmer air with p.w.b. of about +5°C and +10°C respectively. Figures 4(*a*)–4(*f*) show the results. There was, of course, some uncertainty about much of the detail because of the time and space intervals between observations, but the uncertainty in the detail of the disturbance on the 500-millibar chart was much greater. Nevertheless, the changes in the waves on the frontal surface are easily seen and have a similarity to warm-sector behaviour at sea level. On the 9th the warm wave first moved ahead of the surface low and then disappeared, like an occluding warm sector.

The detail on the upper air charts was too sparse to define with certainty small perturbations in the upper flow crossing Greenland but there were indications of one on the 7th. The boundaries of the strong upper flow over the east Greenland coast were about Kap Tobin (70°25′N, 21°58′W) and Angmagssalik (65°37′N, 37°39′W). Backwards extrapolation of the depression track led to this area.

Conclusion.—A perturbation like a frontal wave in the north-westerly upper flow arrived east of the high ground of Greenland and caused a pressure wave in the Arctic air there which lay below the upper stream. As the wave travelled south-east in the cyclogenetic region between east Greenland and north Scotland the surface pressure wave deepened into a depression. There may well have been a small disturbance moving in the Arctic air from north of Jan Mayen which contributed to the development, but although on the surface chart the depression looked like a "polar" low, its speed and direction and the simultaneous movement of warm superior air over the British Isles, showed that the upper frontal wave played a vital part.

How many "polar" lows have similar histories?

REFERENCE

1. BOVILLE, B. W.; Meteorological Office discussion—The three-front model. *Met. Mag., London*, **85**, 1956, p. 83.

RECORDING EQUIPMENT FOR THE BRITISH RADIO-SONDE

By A. H. HOOPER

The British radio-sonde represents the changes in atmospheric pressure, temperature and relative humidity that it experiences as variations in the frequency of a sustained electrical oscillation. As the instrument ascends, the oscillation is used to modulate a radio transmitter which can be listened to by the ground station. This modulation can represent only one variable at a time and so is switched, in turn, between pressure, temperature and relative humidity. The first step in ascertaining the values of pressure, temperature and humidity experienced is to measure and record the various frequencies of the oscillation as they are being heard. The method adopted for this task has changed but little through the twenty years the radio-sonde has been in existence and has always involved a considerable element of human skill. Equipment is now being introduced at stations to carry out the task automatically, with several advantages such as improvement in accuracy and the obtaining of more information.

It has been standard practice to compare the successive frequencies as they are received at the ground station with the output of a variable audio-frequency oscillator. The latter is adjusted until it is judged to be at the same frequency as that received from the radio-sonde and the frequency is then read from a scale and noted down. At first, equality of the radio-sonde and oscillation frequencies was sought by listening to the beat note between them and adjusting the oscillation to make this note as low as possible. This process was found to be insufficiently accurate and to be slow in relation to the time available for the observation. A change was then made to a visual display (in the form of the "magic eye" sometimes found in domestic radio receivers) in which a shadow on a fluorescent screen is caused to flutter by the beat note between the two audio-frequencies. It was found that the adjustment for equal frequency could be quickly made, as recognition of nil flutter is nearly instantaneous. The measured frequencies were recorded together with their times of observation by writing them on paper tape, unreeling from a drum at a known rate. Subsequently, as a separate step, a graph was plotted of observed frequency with time so that the computer could make a visual selection of those observations necessary adequately to represent the sounding. At a later date the display was further improved by the use of a cathode ray oscilloscope, the two frequencies being used to generate Lissajous' patterns. With this method the correct adjustment for equal frequency is indicated by a stationary closed loop and can be attained by a skilled operator with more accuracy than necessary in about half the time available for the observation. The residual time is then used in reading both audio-frequency and time and plotting the corresponding points directly on graph paper, thereby cutting out a time-consuming intermediate stage. This procedure has continued unchanged through subsequent years to the present day. Development of the skill required to observe and plot the signals occupies a substantial proportion of the radio-sonde training course and it is only after a further period at an upper air station that the ability to work accurately in all receiving conditions is acquired.

It is probably a universal aim of users of radio-sondes to have equipment capable of producing a permanent record of the received signals. In fact such equipment has been available for some foreign radio-sondes for over fifteen years. However, it was not until recently that the continued improvement in electronic techniques allowed a system to be developed for the British radio-sonde which afforded the necessary accuracy in the time available for observations. The equipment is now being introduced progressively at our stations and will both improve the accuracy of upper air reports and provide fine-structure information for research and special purposes.

The basic steps undertaken by the equipment are first a measurement of the periodic time of a received signal, then a conversion of this time measurement to a representative voltage and finally an indication of the voltage on the moving chart of a pen recorder. For routine radio-sonde work the measured time is of 100 cycles of the received audio-frequency and takes about 1/10

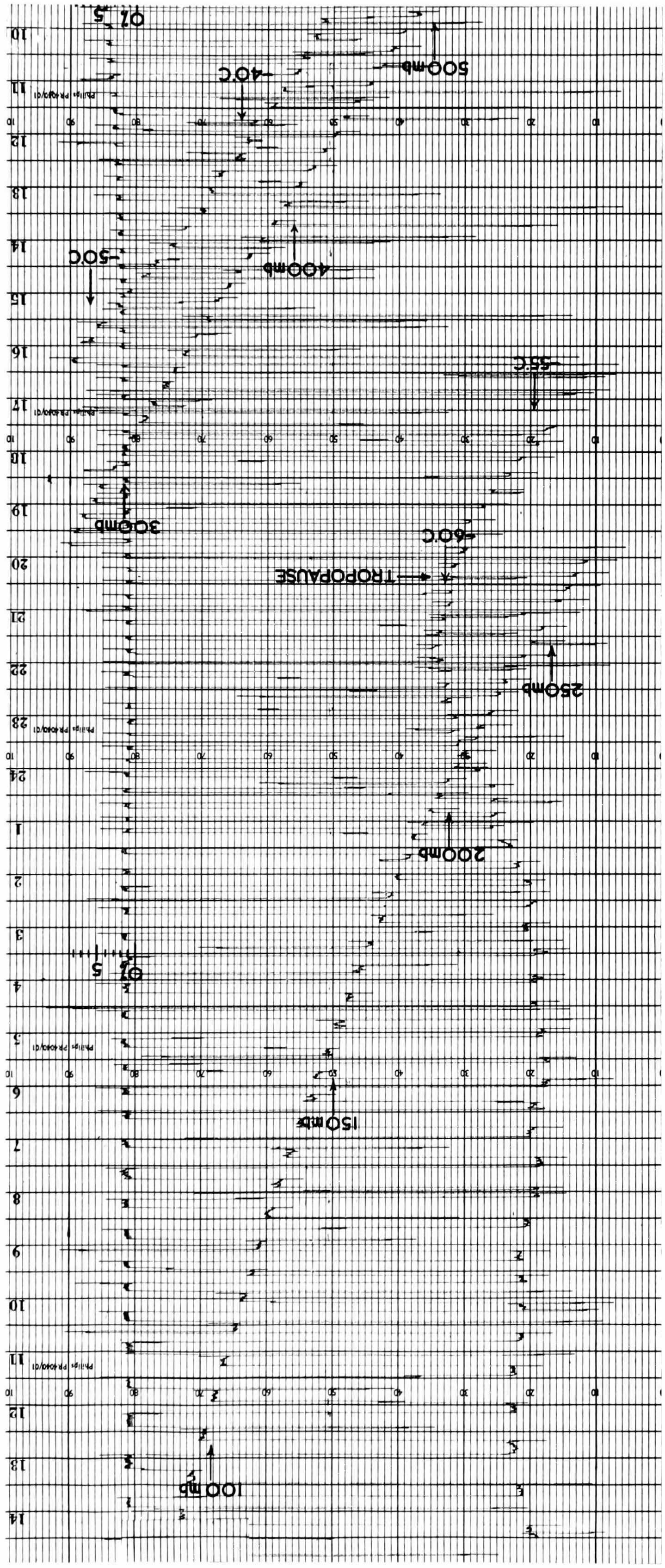
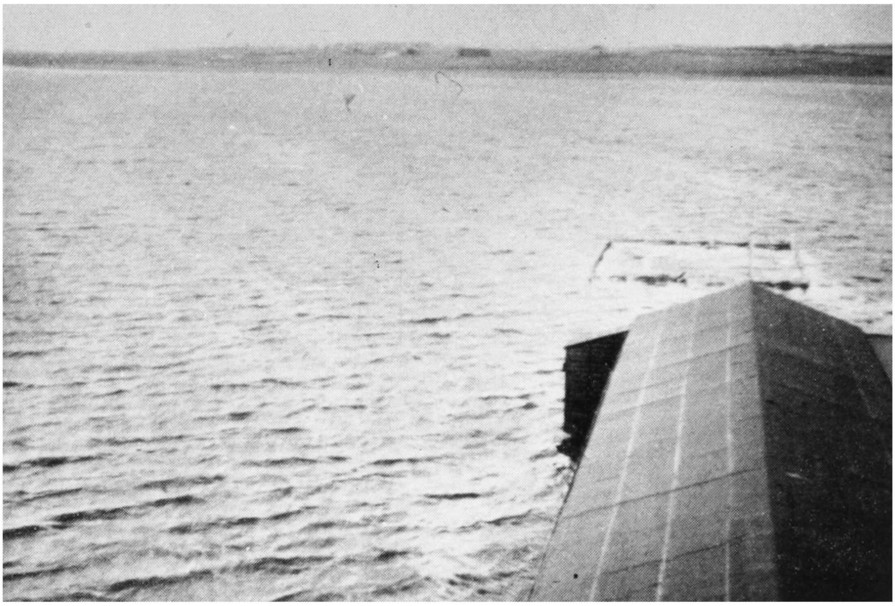


FIGURE 1—PART OF A TRACE PRODUCED BY THE NEW RADIO-SONDE RECORDING EQUIPMENT (CINTEL)



Photograph by W. B. Young

THE METEOROLOGICAL OFFICE AND FLOODED INSTRUMENT ENCLOSURE AT STORNOWAY AIRPORT, 2 DECEMBER 1959

(see p. 157)

second to complete. The re-setting time of the whole system is about ¾ second and as each radio-sonde signal lasts about five seconds, four measurements or more can be taken in place of the single measurement made by the human operator. With this additional information it has been found possible to record lapse rates of temperature and humidity in much finer detail than hitherto. The full range of frequency variation is displayed on four spans of the chart so that in passing progressively through the range of frequencies the recorder pen travels across the chart four times, its return to the origin each time being automatic and without any possibility of zero shift. The position taken up by the pen for a given measurement of periodic time is held until the next measurement is taken. The equipment as described here is arranged for routine use with the present radio-sonde system. Simple modifications can be made to alter the accuracy, resolution and number of recording spans. Modification for use with other telemetering frequencies and systems is also quite easy. Thus although developed for use with the present radio-sonde the equipment need not inhibit changes to the sonde nor prevent the adoption of an entirely different telemetering system.

Figure 1 shows part of a record which includes the tropopause. The groups of measurements made on each received signal can be seen, and in the original record which uses red ink on a green chart they stand out clearly. The complex structure of the tropopause zone can be seen and it is interesting to note that the level assigned to the tropopause depends considerably upon the tropopause definition used.

In routine use the equipment is able to resolve the total range of variation of the radio-sonde signals into about 3200 parts. This is considerably better than the resolution of 1200 parts which can just be achieved by a first rate operator. In the course of comparisons it was found that in general the accuracy of a single measurement by the equipment is significantly better than that by an average operator even though the machine takes very much less time. Exceptionally with the weak signals received from a radio-sonde at great distances, the human operator using his intelligence to discriminate between such weak signals and a background of noise is able to produce a more accurate result. However, in such circumstances the high repetition rate of the equipment enables its performance to be improved by averaging the several measurements taken over the period required by a human operator for a single measurement.

Each radio-sonde ascent provides about 150 signals each of temperature and humidity. Of these, only a few, at the turning points between major changes of lapse rate, are directly reported (although the remainder contribute to the reported pressure–height relation). It is noteworthy that it is precisely when significant changes of lapse rate occur, as at the tropopause and other inversions, that the average human operator is most likely to make errors. During comparison with a radio-sonde station several large operator errors of this kind occurred but were excluded from the statistical comparison. It is perhaps in avoiding errors of this kind, with their effect upon the interpretation of a tephigram and upon the construction of contour charts, that the equipment will most help in the routine use of radio-sonde data.

The system can obviously be modified to provide data of particular value for research. For example, a complete ascent could be made measuring temperature alone, with heights derived from synchronized radar readings. In this way a very fine temperature structure could be made available with readings at height intervals of less than five metres.

The present recording apparatus is being produced by Messrs. Rank-Cintel Ltd. who designed the current system to meet the requirement for upper air recording specified by the Meteorological Office.

RATE OF VISIBILITY DETERIORATION IN FOG AT MERRYFIELD, AND THE TIME OF FOG DISPERSAL

By E. B. TINNEY, B.Sc.

Summary.—The features of the variation of visibility in fog at Exeter Airport, and the time of fog dispersal have been examined by W. E. Saunders.[1] The investigation reported here has been carried out on precisely parallel lines to find out whether similar results would be forthcoming for a rural area more removed from the sea than is Exeter Airport. The results and tables are laid out in similar form to those of Saunders' paper in order to facilitate comparison. The results obtained show a close similarity to those for Exeter Airport.

The site.—The airfield at Merryfield lies about 150 feet above mean sea level and is on a small plateau with small depressions around it on most sides. Some of these depressions contain small streams, and fog patches usually form in these hollows before fog forms on the airfield. These fog patches tend to form while the screen temperature on the airfield is still some 3–5°F above the temperature at which the fog ultimately forms on the airfield.

Further afield the edge of the Blackdown Hills lies to the south-west with heights between 900 and 1,000 feet within four to six miles of the airfield, while the foothills of the Blackdowns lie some six to seven miles to the south of the airfield and provide a barrier to air from the English Channel, which is about 16 miles away. The airfield is cut off from the fenland of Sedgemoor by a ridge about 300 feet high lying some four miles to the north-east. The Quantocks lie about 12 miles to the north.

The observations and the scope of the investigations.—Hourly observations were considered over the periods 21 March 1952 to 23 December 1954 and from 1 June 1955 to 31 March 1956. The observations were examined to ascertain the time taken, after the formation of fog, for the visibility to fall below set limits. The limits chosen being (i) 550 yards or less, and (ii) 220 yards or less. The limit for fog is here taken as being a visibility of 1,000 yards or less.

The type of fog considered was water fog, as defined by Corby and Saunders,[2] and in none of the cases was the relative humidity less than 95 per cent at the time of fog formation.

The investigation was further pursued to ascertain whether any relationship existed between:

(i) the fog-point temperature and the time taken for the above visibility limits to be reached;

(ii) the fall of temperature below the fog-point temperature and the attainment of the visibility limits;

(iii) the visibility three hours before the fog formation and the time taken to reach the visibility limits after fog formation;

(iv) the wind direction three hours before fog formation and the time taken to reach the visibility limits after fog formation.

For most of the periods stated the observational routine commenced at midnight and continued until 1600 or 1700 G.M.T. so it was not possible to include cases where fog was already present at midnight. Where fog formed soon after midnight details of wind and visibility three hours before fog formation could not be included in the relevant tables, hence the smaller number of totals in those tables. The cases considered throughout were those where the fog formed after midnight.

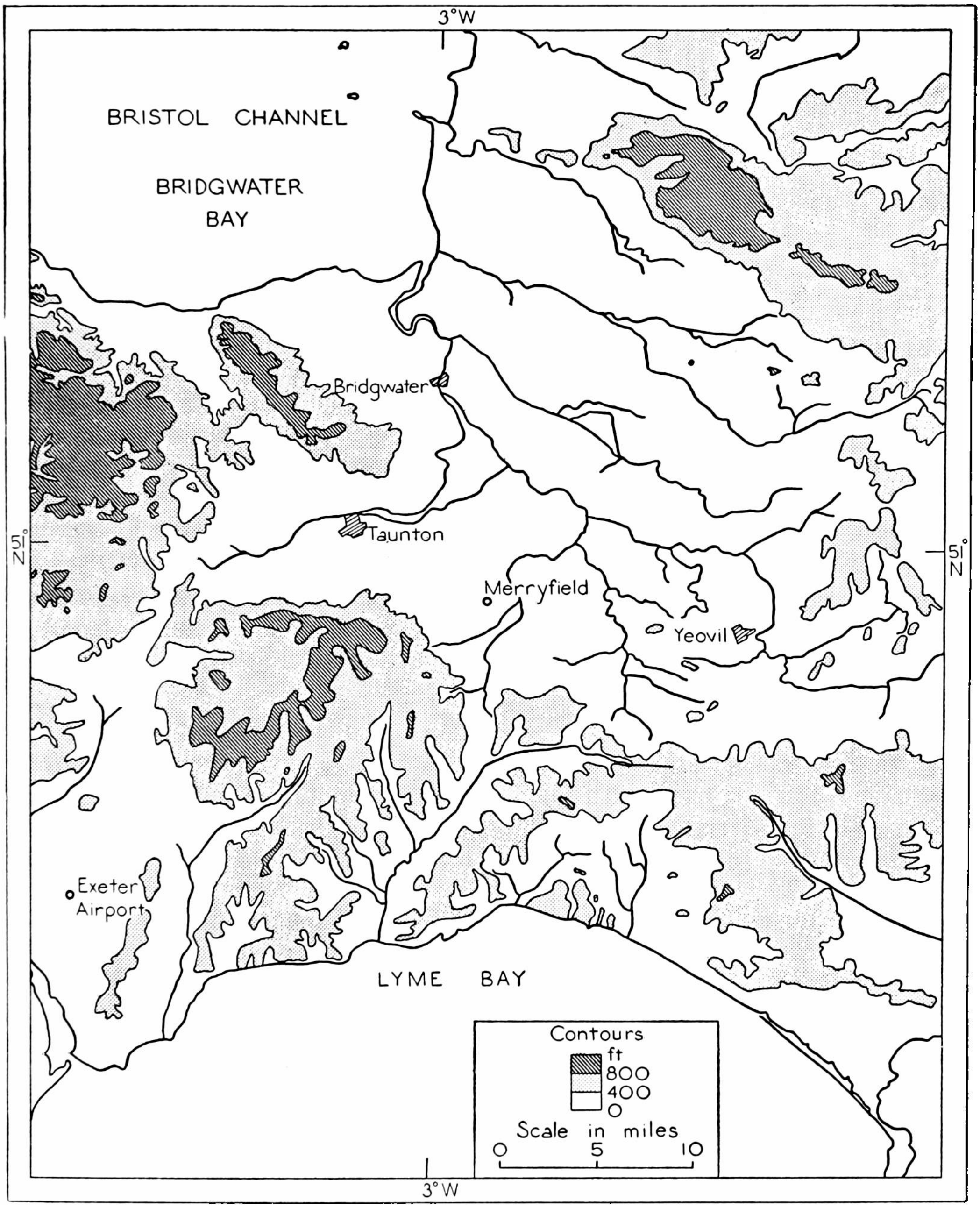


FIGURE I—TOPOGRAPHY AROUND MERRYFIELD

The variation of visibility in relation to the state of ground was not examined as there were no observations of this element over much of the period. Finally, the time of fog clearance was examined on those occasions where fog was present or occurred after 0600 G.M.T.

Time taken for the visibility to fall to certain limits.—The variation in visibility following the initial fog report was tabulated against the time interval from the time of formation. As in the Exeter investigations, cases where fog-clearing factors were in operation were excluded, for example, freshening wind, cloud cover, frontal passage, or those which occurred at the end of the night. In some cases these factors came into operation after the 550-yard limit had been reached and thus prevented such cases from being included in the 220-yard limit table. The distribution of the time taken for the visibility to fall from the formation of fog (visibility 1,000 yards or less) to 550 yards or below, and to 220 yards or below is given in Table I. In the majority of cases visibility

TABLE I—FREQUENCY OF THE TIME TAKEN FOR VISIBILITY IN FOG TO FALL BELOW 550 YD. OR 220 YD.

Visibility	Hours, from the initial report of fog: 0–1	1–2	2–3	3–4	Limit not reached	Total
	number of occasions					
550 yd. or below	52	8	0	0	7	67
220 yd. or below	36	12	4	2	9	63

fell very rapidly. Visibility fell to 550 yards or less within one hour on 78 per cent of occasions, and within two hours on 90 per cent of occasions; the corresponding figures for the visibility to fall to 220 yards or less are, within one hour, 57 per cent and within two hours 76 per cent. The comparable figures for Exeter are 86, 95, 51 and 74 per cent and they show very close agreement.

Further, if the visibility is likely to fall to 550 yards it is practically certain to fall to 220 yards or less provided no fog-clearing factors intervene, there being only two more cases of failure to reach the 220-yard limit than to reach the 550-yard limit.

The rate of change of visibility was examined in conjunction with the fog point and the results are given in Table II. In the case of Exeter all occasions of failure to reach the 550-yard limit occurred when the initial fog point was below 40°F. At Merryfield there is no sign of such a limit, as failures were scattered from fog points of 55–59°F. (with three cases) down to 20–24°F. (with

TABLE II—DISTRIBUTION OF THE TIME TAKEN FOR VISIBILITY IN FOG TO FALL BELOW CERTAIN LIMITS WITH VARIATION OF FOG-POINT TEMPERATURE

Fog point °F.	Hours from initial report of fog for visibility to reach 550 yd. or less				Hours from initial report of fog, for visibility to reach 220 yd. or less				
	0–1	1–2	2–3	Limit not reached	0–1	1–2	2–3	3–4	Limit not reached
	number of occasions								
60–64	1	—	—	—	1	—	—	—	—
55–59	1	2	—	3	1	2	—	—	3
50–54	6	—	—	1	4	—	1	—	1
45–49	13	1	—	1	10	2	1	—	1
40–44	7	1	—	—	4	1	1	—	1
35–39	6	1	—	1	5	1	—	1	1
30–34	9	1	—	—	5	4	—	—	—
25–29	7	2	—	—	5	2	—	1	1
20–24	1	—	—	1	1	—	—	—	—
15–19	1	—	—	—	—	—	1	—	—
Total	52	8	—	7	36	12	4	2	9

one case in the latter range). Thus, from the initial fog-point temperature there seems to be no indication as to whether the 550-yard or the 220-yard limit will, or will not, be reached. Again, in agreement with the findings for Exeter, dense fog can still be expected with the fog point several degrees below freezing, and it even occurred with the lowest fog-point temperature, that is, in the 15–19°F. range.

TABLE III—DISTRIBUTION OF FALL OF TEMPERATURE BELOW FOG POINT FOR VISIBILITY TO REACH CERTAIN LIMITS

Fog point °F.	Fall of temperature, °F. from fog point, for visibility to reach 550 yd. or less				Fall of temperature, °F, from fog point, for visibility to reach 220 yd. or less			
	0–1	1–2	2–3	3–4	0–1	1–2	2–3	3–4
	number of occasions							
60–64 ...	1	—	—	—	1	—	—	—
55–59 ...	1	1	—	1	1	1	—	1
50–54 ...	5	—	1	—	3	—	—	1
45–49 ...	13	—	—	—	8	1	1	—
40–44 ...	7	—	1	—	4	1	—	—
35–39 ...	7	—	—	—	7	—	—	—
30–34 ...	8	—	—	—	7	1	—	—
25–29 ...	7	1	—	—	5	1	—	—
20–24 ...	1	—	—	—	1	—	—	—
15–19 ...	1	—	—	—	1	—	—	—
Total ...	51	2	2	1	38	5	1	2

Table III gives details of the further fall of temperature below the fog point necessary for the visibility to reach the limits of 550 yards or less, and 220 yards or less. This demonstrates most markedly how practically no further fall in temperature is required for the great majority of cases with 550 yards or less visibility and also with 220 yards or less. For a fall of up to 1°F. visibility becomes 550 yards or less on 91 per cent of occasions and 220 yards or less on 82 per cent of occasions. In no case was the fall of temperature as much as 4°F. Where a fall of more than 1°F. was necessary to achieve either limit there was no grouping around any particular fog-point temperature, these cases being fairly well scattered over the whole range of fog points.

Relation to visibility before fog formation.—The distribution of the time taken for the visibility in fog to fall below the selected limits in relation to the visibility three hours before fog formation is shown in Table IV. The time taken to reach either the 550-yard or the 220-yard limit is not affected by the earlier visibility; if anything, the visibilities where mist was previously present gave rather slower thickening of the fog. The suggestion in the case of Exeter that there is a tendency for hazy initial conditions to be followed by a rather slower deterioration than when fog forms in clear air is not borne out.

TABLE IV—DISTRIBUTION OF THE TIME TAKEN FOR VISIBILITY IN FOG TO FALL BELOW CERTAIN LIMITS WITH DIFFERENT VISIBILITIES THREE HOURS BEFORE FOG FORMATION

Visibility 3 hours before fog formation	Hours, from initial report of fog, for visibility to reach 550 yd or less				Hours, from initial report of fog, for visibility to reach 220 yd or less			
	0–1	1–2	2–3	Limit not reached	0–1	1–2	2–3	Limit not reached
	number of occasions							
Over 6¼ mi.	10	–	–	–	6	1	1	2
2½–6¼ mi.	17	–	–	1	14	–	–	3
2,200 yd–2½ mi.	4	–	–	–	3	1	–	–
1,100–2,200 yd	9	3	–	2	8	2	–	2
Total	40	3	–	3	31	4	1	7

Relation to wind direction before fog formation.—The time taken from fog formation for visibility to fall below the selected limits was analysed in relation to the wind direction three hours before fog formation. This comparison is set out in Table V. The striking feature here is the large number of cases of calm three hours before fog formation, to wit, 78 per cent of the cases where visibility fell to 550 yards or less, and 80 per cent of the cases where visibility fell to 200 yards or less. The corresponding figures in the case of Exeter were 42 and 43 per cent. There are insufficient cases where wind was present three hours before the fog for any deductions to be drawn regarding wind direction.

TABLE V—DISTRIBUTION OF THE TIME TAKEN FOR THE VISIBILITY IN FOG TO FALL BELOW CERTAIN LIMITS WITH VARIATION OF WIND DIRECTION THREE HOURS BEFORE FOG FORMATION

Wind direction before fog formation	Hours from initial report of fog, for visibility to reach 550 yd. or less			Limit not reached	Hours from initial report of fog, for visibility to reach 220 yd. or less				Limit not reached
	0–1	1–2	2–3		0–1	1–2	2–3	3–4	
degrees				*number of occasions*					
001–030 ...	—	—	—	—	—	—	—	—	—
031–060 ...	—	—	—	—	—	—	—	—	—
061–090 ...	2	—	—	—	2	—	—	—	—
091–120 ...	—	—	—	—	—	—	—	—	—
121–150 ...	—	—	—	—	—	—	—	—	—
151–180 ...	1	—	—	—	1	—	—	—	—
181–210 ...	1	1	—	—	1	—	—	—	—
211–240 ...	1	—	—	—	1	—	—	—	—
241–270 ...	—	—	—	—	—	—	—	—	—
271–300 ...	—	—	—	—	—	—	—	—	—
301–330 ...	1	—	—	—	1	—	—	—	—
331–360 ...	3	—	—	—	3	—	—	—	—
Calm ...	32	2	—	4	26	4	2	—	5
Total ...	41	3	—	4	35	4	2	—	5

The time of clearance of fog.—Attention was then turned to the reverse process, namely the dispersal of fog, and here it is obviously natural that the actual time of fog dispersal should vary with the time of year in sympathy with the seasonal changes of insolation. The time of fog dispersal will also be dependent on the vertical extent of the fog on any one day. The times of fog dispersal were therefore examined to ascertain how they varied throughout the year. Before this could be done it was necessary to eliminate various other factors which, by interfering with the insolation, etc., were capable of accelerating or delaying the time of fog dispersal after the time at which the dispersal would occur by insolation alone. The criteria adopted for these factors was as follows and the cases affected by them were excluded:

(i) precipitation occurring during the fog;

(ii) where four-eights or more of any cloud existed, excepting broken cirrus. In cases where the sky was initially obscured, this limit was applied when the sky became visible. Cases where the cloud was formed as low stratus as a consequence of fog dispersal, and thus was not a cause of the dispersal were however included.

(iii) increasing wind, which is also a fog-clearing factor, but in all cases, except two, the wind was calm at the time of clearance. In these two cases, the wind varied between calm and four or five knots during the clearance and these cases were included.

The occasions of fog considered were those where fog existed at 0600 G.M.T. or where it formed after that time. This time was originally chosen as being the end of the cooling period taken over the year as a whole and also as a very convenient time in respect of short-term forecasts for day-time activity. In none of the cases where fog formed after 0600 G.M.T. did the sky become obscured. With the absence of any precise information as to the vertical thickness of the fog, the occasions considered were divided into two categories: those where the sky was initially visible and those where the sky was initially obscured, thus giving a rough classification of the fog thickness.

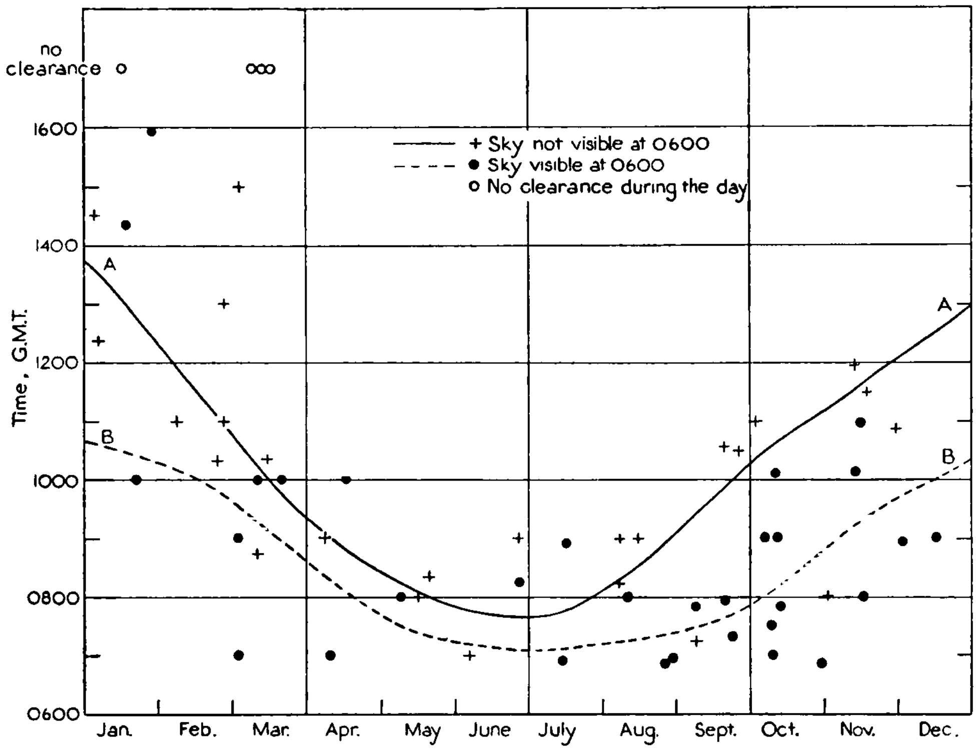


FIGURE 2—TIME OF FOG CLEARANCE (RADIATION CONDITIONS) AT MERRYFIELD WITH FOG AT 0600 G.M.T., 1 FEBRUARY 1952 TO 23 DECEMBER 1954 AND 1 JULY 1955 TO 31 MARCH 1956

After applying the above criteria the remaining cases have been plotted in Figure 2. The curves AA and BB show the mean times of clearance according to whether the sky was obscured at 0600 G.M.T. or not, and indicate a marked separation of the times of clearance, especially in the autumn. The scantiness of the observations in parts of the curve must, of course, lead to the curves being only approximate at those times of the year. The results show that clearance in 72 per cent. of the cases of "sky obscured" and 64 per cent of the cases of "sky visible" were within plus or minus one hour of their respective mean curve times.

Curves were originally drawn for Exeter using the same time of 0600 G.M.T. and the same criteria, and a comparison between those and the curves now obtained for Merryfield revealed that in the autumn there was very little difference in the time of clearance of fog at the two stations. However, in the spring months the clearance at Merryfield was shown to lag behind that of Exeter by about ¾ hour regardless as to whether the sky was or was not visible at 0600 G.M.T.

REFERENCES

1. SAUNDERS, W. E.; Variation of visibility in fog at Exeter Airport and the time of fog dispersal. *Met. Mag., London*, **86**, 1957, p. 362.
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MEAN 200-MILLIBAR WINDS AT ADEN IN JANUARY 1958

By R. MURRAY, M.A.

The wind at Aden at 200 millibars (and other high levels) was unusually strong throughout most of the month of January 1958 as can be seen from Table I.

TABLE I—STATISTICS OF WIND AT 200 MILLIBARS AT ADEN IN JANUARY

January	No. of observations	$\mathbf{V}_R$		V_S	σ	σ_N	σ_E
		deg	*kt*	*kt*	*kt*	*kt*	*kt*
1949	26	284	21	31	28	24·1	14·5
1950	58	281	15	23	21	14·0	15·9
1951	62	204	7	20	21	11·9	16·9
1952	62	290	33	37	29	14·3	24·8
1953	55	232	13	26	27	17·0	20·3
1954	62	221	5	20	22	16·7	14·5
1955	60	280	32	36	24	14·4	19·6
1956	62	246	18	27	24	17·7	16·0
1957	61	240	18	24	20	15·4	12·1
1958	61	271	47	56	33	23·6	23·4
1949–57	508	265	16	27	27	17·4	20·4
1949–58	569	267	19	30	29	18·1	22·8

$\mathbf{V}_R$, vector mean wind; V_S, scalar mean wind; σ, standard vector deviation; σ_N and σ_E, standard deviations of northerly and easterly components respectively.

In view of the values of standard vector deviation winds stronger than 50 knots must be expected on a few individual days in January, but a monthly mean wind equal to 271 degrees 47 knots or a mean wind speed equal to 56 knots would be very unlikely on the basis of the data from the nine Januarys before 1958.

The zonal component of the monthly mean wind was the dominant one in all the Januarys excepting 1951 and 1954 when the monthly mean winds were very light. The frequency of occurrence of the zonal components of the individual winds for the nine Januarys from 1949–57 and for January 1958 are shown in Table II.

TABLE II—FREQUENCY OF ZONAL COMPONENTS OF WIND AT 200 MILLIBARS AT ADEN IN JANUARY 1958

	Westerly component (kt)								Easterly component (kt)				
	80	70	60	50	40	30	20	10	0	10	20	30	40
	number of occasions												
1949–57	2	1	12	16	37	62	77	90	109	59	29	13	1
1958		8	17	6	11	10	1	2	3	0	2	1	

Note: The components within the range 84·5 to 74·5 kt are grouped as 80 kt and so on for other groupings.

It will be seen from Table II that westerly wind components greater than or equal to 45 knots occurred on slightly more than 50 per cent of occasions in January 1958 and only on about 6 per cent of occasions in the entire nine previous Januarys. The two samples of data given in Table II are quite different in character and appear to be drawn from a different population. It is also noteworthy that the frequency distribution for the 1949–57 data is quite skew.

For the nine Januarys 1949–57 the average monthly zonal wind is 16·1 knots and the standard deviation of the monthly means is about 9 knots. On the assumption that mean monthly zonal winds for the period 1949–57 constitute an adequate sample of monthly means which follow a normal frequency distribution, the chance that the mean zonal component of January 1958 (that is, 47·1 knots) will occur is less than one in 1,000. Thus the assumption made is highly unlikely.

Synoptically it is not unreasonable to expect the frequency distribution of the zonal component to have the skewness indicated by the data in Table II. In January the main feature of the long-period monthly mean chart at 200 millibars in the Middle East is the westerly subtropical jet stream (mean speed about 100 knots) across northern Arabia. In the mean there is a strong horizontal wind shear northwards from Aden up to the axis of the jet stream. The latitudinal wind shear is about 25 knots per five degrees to the north of Aden and only about 12 knots per five degrees to the south of Aden. It is clear that in individual Januarys the position and intensity of the subtropical jet stream is rather critical as far as the winds at Aden are concerned. A displacement of the subtropical jet stream a few degrees northwards of its average position will result in the mean wind at Aden being some 10 knots weaker than average, whereas the same displacement southwards of the subtropical jet stream (assuming the intensity is the same) will result in the monthly mean wind at Aden being 20–30 knots stronger than average. The skewness of the frequency distribution of zonal components of wind at 200 millibars is thus accounted for.

It is probable that zonal wind frequency distributions will be skew at other places near the edge of pronounced climatological jet streams (for example, the high-level easterly jet stream of the tropics). In such cases strong winds may occur over a period of the order of a month more frequently than would be expected with a normal circular frequency distribution, the statistical characteristics of which are described by a knowledge of average monthly wind and standard vector deviation.

NOTES AND NEWS

Sea flooding at Stornoway on 2 December 1959

On the morning of 2 December 1959, the combination of spring tides and a south-south-easterly gale at Stornoway brought the sea over the shingle banks at Melbost Beach and across the main road to the airport which assumed the appearance of a sea loch. The whole southern end of the aerodrome was covered to a depth of between six and eight feet.

The meteorological office building was not flooded although the water was lapping at the steps of the porch leading to the rear door and waves were breaking against the wall at the south end of the office with sufficient force to cause vibration of the building.

The flooding occurred rapidly between 0800 and 0830 G.M.T. on 2 December and covered the instrument enclosure to a depth of about three feet (see photograph facing p. 149). By wading through one foot of water it was possible to reach the enclosure by 1500 G.M.T. on 4 December to take stock of the damage. The only instrument to suffer was the clock of the tilting-siphon rain-gauge, but cables supplying power to two of the visibility lights and to the air sampling equipment were also affected.

METEOROLOGICAL OFFICE NEWS

Retirements.—The Director-General records his appreciation of the services of:

Mr. W. L. Lineham, Senior Experimental Officer, who retired on 31 March 1960. He joined the Meteorological Office as a Technical Assistant in August 1920. The whole of his service in the Office has been spent at aviation outstations. From 1952 until his retirement he served at Ternhill.

Mr. G. A. Livett, Senior Experimental Officer, who retired on 21 March 1960. He joined the Office as a Technical Assistant in June 1922. After spending twelve months at an aviation outstation he was transferred to the Instruments Division at Headquarters and a year later to the Forecasting Division where he remained for twelve years. Since 1937 he has served continuously at aviation outstations and at the time of his retirement he was at Upavon. During the First World War he served in the Royal Air Force. Mr. Livett has accepted a temporary appointment in the Meteorological Office.

Mr. C. W. Hollis, Senior Assistant (Scientific), who retired on 8 April 1960. He joined the Office in 1928 as a locally appointed Clerk in the Middle East after earlier service as a Royal Air Force meteorologist. He returned to the United Kingdom in 1937 and apart from a short spell at Headquarters in 1945 in the Security Section his subsequent service has been spent at aviation outstations. At the time of his retirement he was serving at Thorney Island. Mr. Hollis has accepted a temporary appointment in the Meteorological Office.

METEOROLOGICAL OFFICE DISCUSSION

Forecasting for public services

The captions to Figures 4 and 5 on pages 116 and 117 of the April 1960 *Meteorological Magazine* should be interchanged.

REVIEWS

The theory of homogeneous turbulence. (Students edition.) By G. K. Batchelor. 8½ in. × 5½ in., pp. xi + 197, *illus.*, Cambridge University Press, Bentley House, 200 Euston Road, London, N.W.1., 1959. Price: 18*s* 6*d*.

This excellent monograph has been in existence since 1953, and the demand for it is obviously reflected in the reprinting, first in 1956, and now again in the form of this student's edition with thin cardboard covers. The work was reviewed in the November 1953 issue of this Magazine, and as the text appears to be quite unchanged it is unnecessary to do more than welcome the less expensive format. It is, however, appropriate to observe with satisfaction that many of the fundamental concepts of turbulence expounded therein are being used more and more in the researches on the structure and effect of atmospheric turbulence which have developed over the last ten years.

F. PASQUILL

Weather. By R. S. Scorer. 9 in. × 5½ in., pp. 63, *illus.* Phoenix House Ltd., 38 William IV Street, Charing Cross, London, 1959. Price: 9*s.* 6*d.*

This little book, written in light easy vein, is one of a series called *Progress of science* which have been written specially for young people of 12 upwards. The books in this series are designed to explain as simply as possible the latest developments in the different branches of science and also to suggest careers for the young scientist of tomorrow. Other titles in the series already published include "Life in the deep", "Robots", "Radio astronomy" and "Transport".

Dr. Scorer presents the subject in a new style and approaches it from a contemporary point of view that will be found very different from so many other books on elementary meteorology. His effort to appeal to the young will not be lost. The chapters are short, ranging from two to six pages. Some of the rather novel chapter headings are: Thermals and clouds, Ice and thunderstorms, The bath plug experiment and your barometer, Wind-making circulations, The energy of wind and storms, Storms of violence.

In writing for or teaching the young it is sometimes difficult to decide to what extent simple explanations of physical processes and phenomena should be given when they only tell half the story. A compromise must obviously be made since a glimmer of understanding is better than none at all if the interest of the pupil is to be captured and retained. Nevertheless, teachers must be careful not to plant half-truths which may stick in young minds and be hard to eradicate in later years. An example of this kind is to be found on p. 15 when Dr. Scorer tries to explain the age-old question of why it gets colder as we go higher. Adiabatic heating and cooling due to vertical motion is only half of the answer, which is a highly complex question of radiational balance.

Again, on p. 18 there is some very confused argument about the lapse rate of air surrounding rising thermals. This again appears to be a case of half a truth is better than the whole truth if it can be absorbed by the young reader. We can hardly believe that Dr. Scorer seriously means that the measured temperature in the atmosphere decreases always at the dry adiabatic or at the saturated adiabatic lapse rate—but this is what it seems to mean.

The short chapter on careers consisting of a page and a half is too curt. A great deal more could be made of this opportunity to make meteorology exciting to the young. The facts are not altogether accurate. Dr. Scorer states that research is being carried out in meteorology mainly in the universities of Britain and other countries. This may be true in other countries, particularly in the United States, although there commercial consulting firms have recently been awarded substantial contracts by the Government to do research. But in Great Britain surely the programme of research undertaken by the Meteorological Office compares in quality and quantity with that done by the universities. The impression might be gained from p. 56 that the Meteorological Branch of the Royal Air Force is a separate service. It is of course solely a Reserve and has only a training function in peacetime.

A most condescending attitude is adopted towards forecasting and forecasters. Forecasting will for a long time remain a practical application of meteorology about which the world at large sets an economic value in terms of pounds, shillings and pence. This should not be lost sight of by the research worker. The term forecaster is a bad one which came into being very largely during the War when there was a shortage of professional meteorologists with degrees in mathematics and physics. The term synoptic meteorologist is better and lifts the exacting science of synoptic chart analysis from that of a lesser profession, worthy of minds less gifted academically, implied by Dr. Scorer, to its proper place.

The book, which contains 35 excellent photographs, is well produced and good value for 9*s*. 6*d*. to all young people who are interested in the weather.

A. H. GORDON