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COLD SPELLS AT LONDON

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Introduction.—This work was undertaken to provide a background to the problem of forecasting the ending of cold spells at London. A cold spell was defined as a period of four or more consecutive days at Kew with the maximum temperature on each day below normal and with the average anomaly of the maximum temperature over the period not less than 3°F (1.7°C). The limiting value of 3°F was chosen because the descriptive terms for cold weather used by the Central Forecasting Office associate anomalies of less than 3°F with average temperatures and only include the words 'cold' or 'cool' in association with anomalies of 3°F or more. (At the time of writing, the use of the Fahrenheit scale is being discontinued in favour of the Celsius scale and the new definition requires a limiting value of 2°C .) The last day of a spell was defined as the day preceding that on which the maximum temperature first rose to normal or above. The graphs published in the *Monthly Summary of the Daily Weather Report* which show maximum temperatures and normal values* for Kew were used to extract the dates of the beginning and end of the spells, and to measure the anomaly of the maximum temperature on each day during the spells. The spells were extracted for the 25-year period 1935 to 1959. Where a spell extended from one month to another it was included in the month which contained the greater part of it. References to anomalies of maximum temperature throughout this paper refer to negative anomalies.

The frequency of cold spells of four days or more.—There were 356 spells during the whole period, giving an average of 1.2 spells per month. Figure 1 shows the average number of spells for each individual month, ranging from 1.0 in February, September and November to 1.6 in May and July. The average monthly range of daily maximum temperature, for the same period, is also shown for comparison. The general similarity of the two curves suggests that for most months the number of spells is related to the range of maximum temperature. The main difference between the curves is associated with July in which the number of spells appears to be higher than the range of tempera-

*Note—For the years 1935 to 1936 the normal values were based on the period 1901 to 1930, for the years 1937 to 1952 on the period 1906 to 1935, and for the years 1953 to 1959 on the period 1921 to 1950.

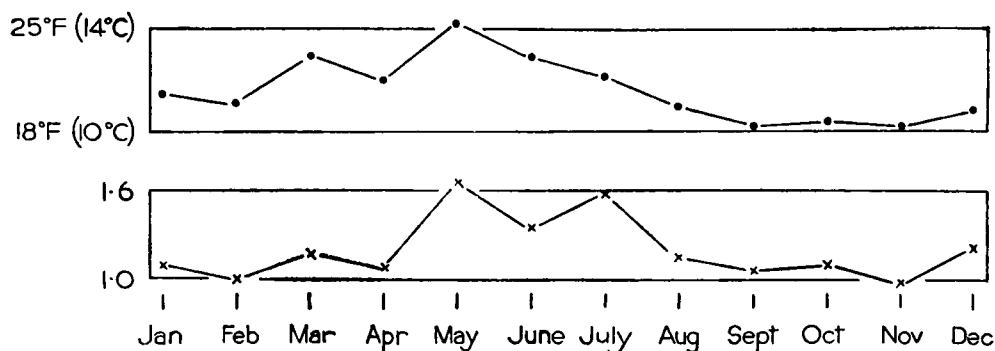


FIGURE 1—THE RELATION BETWEEN THE RANGE OF MAXIMUM TEMPERATURE AND THE NUMBER OF SPELLS FOR EACH MONTH

— average monthly range of maximum temperature
 x—x—x average number of spells

ture might suggest. This could be explained by a high proportion of spells in July with small anomalies, but in fact August had more of such spells than July.

Table I shows the number of months unaffected by cold spells, that is months with less than four consecutive cold-spell days.

TABLE I—NUMBER OF MONTHS UNAFFECTED BY COLD SPELLS (IN 25 YEARS)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
4	4	6	9	4	1	2	4	5	8	9	6

Roughly one in three Aprils, Octobers and Novembers were unaffected by cold spells. On the other hand a cold spell affected nearly every June and July. The number of months unaffected by cold spells in individual years averaged 2.5 and ranged from nil in 1941 and 1956 to five in 1937 and 1949 and seven in 1959.

The frequency of each length of spell is shown in Figure 2. The upper figures at the top of the columns refer to the whole year and those in brackets refer to the six winter months November to April. Of the total spells, 22 per cent were of 4 days, 14 per cent of 5 days and 12 per cent of 6 days, so that nearly half the spells were of 4 to 6 days duration. Spells of 4 to 10 days made up 76 per cent of the total. Of the remainder, 20 per cent were of 11 to 21 days and 4 per cent were 22 days or more in length; the longest spell lasted 56 days. Of the total spells, 55 per cent occurred in the six summer months and 45 per cent in the winter months. The difference was mainly associated with an excess of spells of 6 to 8 days in the summer months. There were 51 spells of 2 weeks or more of which 29 occurred in the winter months. Spells of 3 weeks or more totalled 17 of which 9 occurred in the winter months.

The probability of a cold spell continuing.—The frequency of each length of spell was plotted against the spell-length, a best fitting curve drawn through the points and the frequency corresponding to each length of spell read off from the curve. This procedure was carried out for the six winter and the six summer months. Table II shows the probability values calculated from the frequencies obtained in this way. In the winter months the probability of a cold spell continuing for a further day increases from 0.77 after 4 days to 0.83 after 6 days. After spells of from 7 to 16 days, the probability is roughly

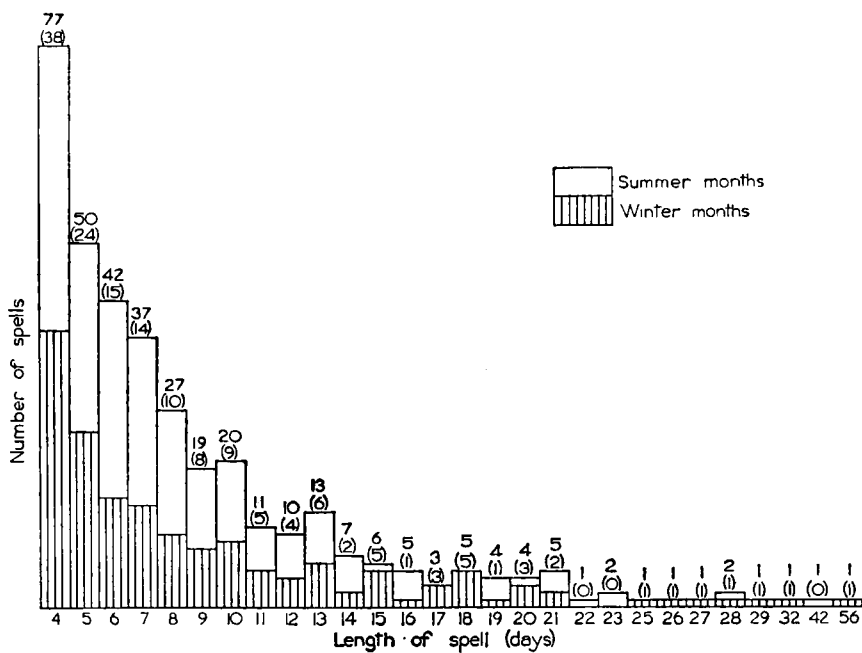


FIGURE 2—FREQUENCY OF EACH LENGTH OF SPELL

Total number of spells — 356, summer months — 194, winter months — 162.

Upper figures at the top of the columns refer to the whole year, figures in brackets to the winter months November to April.

constant at about 0.85. In the summer months, after spells of from 4 to 16 days the probability is roughly constant at about 0.80. There is an even chance that a spell of 4 days will last a further 3 days but in the winter months a spell of 6 days or more has an even chance of lasting a further 4 days.

TABLE II—THE PROBABILITY OF COLD SPELLS OF VARIOUS LENGTHS CONTINUING FOR A FURTHER ONE, TWO, THREE OR FOUR DAYS

(a) Six winter months

	Length of cold spell in days							
	4	5	6	7	8	9	10	11
Further day	0.77	0.81	0.83	0.84	0.84	0.85	0.85	0.86
Further 2 days	0.62	0.67	0.70	0.71	0.71	0.72	0.73	0.74
Further 3 days	0.52	0.56	0.59	0.60	0.61	0.62	0.63	0.64
Further 4 days	0.43	0.47	0.50	0.51	0.52	0.53	0.54	0.54

	Length of cold spell in days						
	12	13	14	15	16	17	18
Further day	0.86	0.86	0.85	0.85	0.84	0.83	0.82
Further 2 days	0.74	0.73	0.72	0.71	0.70	0.68	
Further 3 days	0.63	0.62	0.61	0.59	0.57		
Further 4 days	0.53	0.52	0.50	0.49			

(b) Six summer months

	Length of cold spell in days							
	4	5	6	7	8	9	10	11
Further day	0.80	0.79	0.79	0.79	0.79	0.80	0.80	0.80
Further 2 days	0.63	0.62	0.62	0.62	0.63	0.64	0.64	0.65
Further 3 days	0.50	0.49	0.49	0.50	0.51	0.51	0.52	0.52
Further 4 days	0.39	0.39	0.39	0.40	0.40	0.41	0.41	0.41

	Length of cold spell in days						
	12	13	14	15	16	17	18
Further day	0.81	0.80	0.80	0.80	0.79	0.78	0.75
Further 2 days	0.65	0.64	0.64	0.63	0.62	0.59	
Further 3 days	0.52	0.51	0.51	0.49	0.46		
Further 4 days	0.41	0.40	0.39	0.37			

It is likely that the relatively high probabilities for the longer spells in the winter months are mainly associated with January and February for which months the average length of spell is much greater than for the other months of the year (see Table X).

The synoptic types associated with cold spells at London.—The classification of the daily weather of the British Isles by Lamb¹ was used to define the synoptic types associated with the cold spells. The classification was made according to the following definitions:

Cyclonic type (C).—Depressions stagnating over, or frequently passing across, the British Isles.

Westerly type (W).—High pressure to south (also sometimes south-west and south-east) and low pressure to the north of the British Isles. Sequences of depressions and ridges travelling east across the Atlantic.

North-westerly type (NW).—Azores anticyclone displaced north-east towards the British Isles or north over the Atlantic west of our coasts, or with extensions in these directions. Depressions (often forming near Iceland) travel south-east or east-south-east into the North Sea and reach their greatest intensity over Scandinavia or the Baltic.

Northerly type (N).—High pressure to the west and north-west of the British Isles, particularly over Greenland and sometimes extending as a continuous belt south over the Atlantic Ocean towards the Azores. Low pressure over the Baltic, Scandinavia and the North Sea. Depressions move south or south-east from the Norwegian Sea (sometimes having formed in the Iceland–Jan Mayen region, sometimes having come through from farther north and sometimes having entered the Iceland–Jan Mayen region by way of a col near south Greenland).

Easterly type (E).—Anticyclones over, or extending over, Scandinavia and towards Iceland. Depressions circulating over the western North Atlantic and in the Azores–Spain–Biscay region.

Southerly type (S).—High pressure covering central and north Europe. Atlantic depressions blocked west of British Isles or travelling north and north-east off our western coasts.

Anticyclonic type (AC).—Anticyclones centred over, near, or extending over the British Isles, also cols situated over the country between two anticyclones.

The synoptic type which predominated during each cold spell was noted. The predominant type was taken to be that which occurred on the greatest number of days. If more than one type was equally predominant in this respect, the type which was associated with the greatest anomalies of maximum temperature was taken. Table III shows the number of spells which were predominantly associated with each synoptic type expressed as a percentage of the total number of spells.

TABLE III—THE PERCENTAGE OF COLD SPELLS PREDOMINANTLY ASSOCIATED WITH EACH SYNOPTIC TYPE

	C	W	NW	Synoptic type			S	AC	Total
				N	E	percentage of spells			
Six winter months	3	5	1	11	11		4	10	45
Six summer months	13	14	3	12	7		1	5	55
Year	16	19	4	23	18		5	15	100

Over the whole year the highest proportion, some 23 per cent, were northerly-type spells which occurred with about equal frequency in the summer and winter months. Some 19 per cent were westerly-type spells, three-quarters of which occurred in the summer months. A further 18 per cent were easterly-type spells of which two-thirds occurred in the winter months. Of the 16 per cent which were cyclonic-type spells, three-quarters occurred in the summer months. Of the 15 per cent which were anticyclonic-type spells, two-thirds occurred in the winter months. Only about 5 per cent were southerly or north-westerly-type spells.

It is clear that in the winter months the cold spells were mainly associated with the northerly, easterly and anticyclonic types and in the summer months with the westerly, cyclonic and northerly types. Table IV shows the number of cold spells which were predominantly associated with each synoptic type, for each month.

TABLE IV—THE NUMBER OF COLD SPELLS PREDOMINANTLY ASSOCIATED WITH EACH SYNOPTIC TYPE, FOR EACH MONTH (IN 25 YEARS)

Synoptic type	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	<i>number of spells</i>											
<i>C</i>	0	4	2	4	11	9	7	10	5	3	2	1
<i>W</i>	1	2	0	3	1	9	17	13	8	2	5	7
<i>NW</i>	1	0	0	2	2	2	4	1	1	0	0	1
<i>N</i>	9	5	6	9	13	8	6	4	5	7	4	6
<i>E</i>	5	5	15	5	7	3	4	0	1	9	4	5
<i>S</i>	3	3	2	0	1	1	0	0	0	1	4	3
<i>AC</i>	8	6	4	4	6	1	1	0	6	5	5	7

Cyclonic-type cold spells occurred mainly in the summer months May to August. Westerly-type cold spells were mainly restricted to the months June to September. The number fell sharply from September to October when there was a sharp rise in the number of easterly-type cold spells. May had the highest number of northerly-type cold spells and March the highest number of easterly-type spells. Anticyclonic-type cold spells occurred mainly in the winter months, the number falling sharply from May to June and rising again sharply from August to September.

Table V shows the proportion of days associated with each synoptic type which were part of a cold spell, based on the period 1938 to 1961. The figures represent the probability of a day associated with a particular type being part of a cold spell. The probability is nearly 0.9 for the easterly type in January and February and is about 0.8 for the northerly type in May, August and September and the anticyclonic type in January.

TABLE V—THE PROBABILITY OF A DAY ASSOCIATED WITH A PARTICULAR SYNOPTIC TYPE BEING PART OF A COLD SPELL, 1938–1961

Synoptic type	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
	<i>probability</i>											
<i>C</i>	0.26	0.45	0.34	0.32	0.62	0.54	0.57	0.61	0.42	0.16	0.14	0.32
<i>W</i>	0.16	0.10	0.07	0.13	0.25	0.29	0.40	0.41	0.28	0.06	0.12	0.13
<i>NW</i>	0.35	0.32	0.33	0.26	0.55	0.49	0.50	0.62	0.49	0.50	0.22	0.20
<i>N</i>	0.72	0.73	0.62	0.64	0.78	0.65	0.68	0.81	0.80	0.75	0.52	0.59
<i>E</i>	0.86	0.89	0.60	0.57	0.43	0.29	0.44	0.13	0.29	0.51	0.53	0.66
<i>S</i>	0.50	0.25	0.20	0.08	0.14	0.14	0.07	0.12	0.03	0.16	0.13	0.26
<i>AC</i>	0.77	0.63	0.28	0.25	0.28	0.18	0.15	0.17	0.30	0.31	0.50	0.67

The anomalies of daily maximum temperature associated with cold spells at London.—Tables VI to VIII describe the anomalies of daily maximum temperature for cold spells associated with each synoptic type, for each month, to the nearest degree Fahrenheit. Averages based on less than three spells are not included and those based on only three or four spells are shown in brackets.

TABLE VI—THE AVERAGE ANOMALY OF DAILY MAXIMUM TEMPERATURE

ASSOCIATED WITH THE COLD SPELLS											
Synoptic type	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov. Dec.
						<i>degrees Fahrenheit</i>					
<i>C</i>	—	(5)	—	(5)	5	5	4	4	4	(4)	—
<i>W</i>	—	—	—	(4)	—	4	5	4	4	—	4
<i>NW</i>	—	—	—	—	—	—	(4)	—	—	—	—
<i>N</i>	7	6	6	6	7	6	5	(5)	5	5	(6)
<i>E</i>	7	11	7	5	5	(5)	(5)	—	—	5	(5)
<i>S</i>	(8)	(4)	—	—	—	—	—	—	—	—	(5)
<i>AC</i>	6	6	(5)	(4)	5	—	—	—	4	5	4

Dashes represent occasions on which averages were based on less than three spells and figures in brackets are averages based on only three or four spells.

TABLE VII—THE AVERAGE EXTREME ANOMALY OF DAILY MAXIMUM TEMPERATURE

ASSOCIATED WITH THE COLD SPELLS											
Synoptic type	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov. Dec.
						<i>degrees Fahrenheit</i>					
<i>C</i>	—	(9)	—	(9)	8	9	8	8	6	(7)	—
<i>W</i>	—	—	—	(7)	—	7	9	7	7	—	7
<i>NW</i>	—	—	—	—	—	—	(6)	—	—	—	—
<i>N</i>	10	12	10	10	11	12	9	(10)	9	8	(11)
<i>E</i>	12	16	11	9	9	(9)	(11)	—	—	8	(8)
<i>S</i>	(15)	(9)	—	—	—	—	—	—	—	—	(8)
<i>AC</i>	11	10	(8)	(8)	9	—	—	—	8	7	7

Dashes represent occasions on which averages were based on less than three spells and figures in brackets are averages based on only three or four spells.

TABLE VIII—THE ABSOLUTE EXTREME ANOMALY OF DAILY MAXIMUM

TEMPERATURE ASSOCIATED WITH THE COLD SPELLS											
Synoptic type	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov. Dec.
						<i>degrees Fahrenheit</i>					
<i>C</i>	—	(15)	—	(11)	12	15	13	13	9	(10)	—
<i>W</i>	—	—	—	(9)	—	9	12	10	10	—	9
<i>NW</i>	—	—	—	—	—	—	(7)	—	—	—	—
<i>N</i>	17	15	13	13	14	16	13	(14)	14	10	(13)
<i>E</i>	18	21	18	13	13	(12)	(13)	(5)	—	11	(14)
<i>S</i>	(18)	(12)	—	—	—	—	—	—	—	—	(11)
<i>AC</i>	16	16	(11)	(9)	13	—	—	—	10	9	10

Dashes represent occasions on which averages were based on less than three spells and figures in brackets are averages based on only three or four spells.

Table IX shows the number of spells in each month with the average anomaly of the daily maximum temperature within certain limits, expressed as a percentage of the total number of spells in each month.

TABLE IX—THE PERCENTAGE OF SPELLS IN EACH MONTH (IN 25 YEARS) WITH THE AVERAGE ANOMALY OF THE DAILY MAXIMUM TEMPERATURE WITHIN CERTAIN

LIMITS											
Average anomaly	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov. Dec.
						<i>percentage of spells</i>					
3°–6°F (1.4°–3.6°C)	63	56	62	89	71	88	90	96	88	93	83
7°–10°F (3.7°–5.8°C)	30	32	38	11	29	12	10	4	12	7	17
> 10°F (5.8°C)	7	12	—	—	—	—	—	—	—	—	—
Total number of spells	27	25	29	27	41	33	39	28	26	27	24

The length of the cold spells.—The average length of the cold spells and the duration of the longest spell which occurred in each month are shown in Table X.

TABLE X—THE AVERAGE AND MAXIMUM LENGTH OF SPELLS FOR EACH MONTH
(IN 25 YEARS)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Average length	12	13	7	8	7	8	9	9	9	8	7	8
Maximum length	27	56	20	18	16	23	22	42	28	23	29	26

The average length was 13 days in February and 12 in January. Over the rest of the year it varied from 7 to 9 days. The maximum length of spell varied from 56 days for February to 16 days for May. The two longest spells of 56 and 42 days were centred on February and August respectively. The former extended over the period 19 January to 15 March 1947, the latter over the period 28 July to 7 September 1956, but the end of the spell was temporary and further cold spells occurred over the periods 9–12 and 15–18 September so that the spell could be said to have lasted a further 11 days, totalling 53 days.

The relation between the extreme anomaly and the length of spell.—Figure 3 shows the relation between the extreme anomaly and the average length of spell for the six winter and six summer months. For anomalies of up to 11°F (6°C) the length of spell was greater in the summer months, particularly for anomalies of 6° to 7°F (3° to 4°C). For anomalies above 11°F (6°C) the length of spell was greater in the winter months.

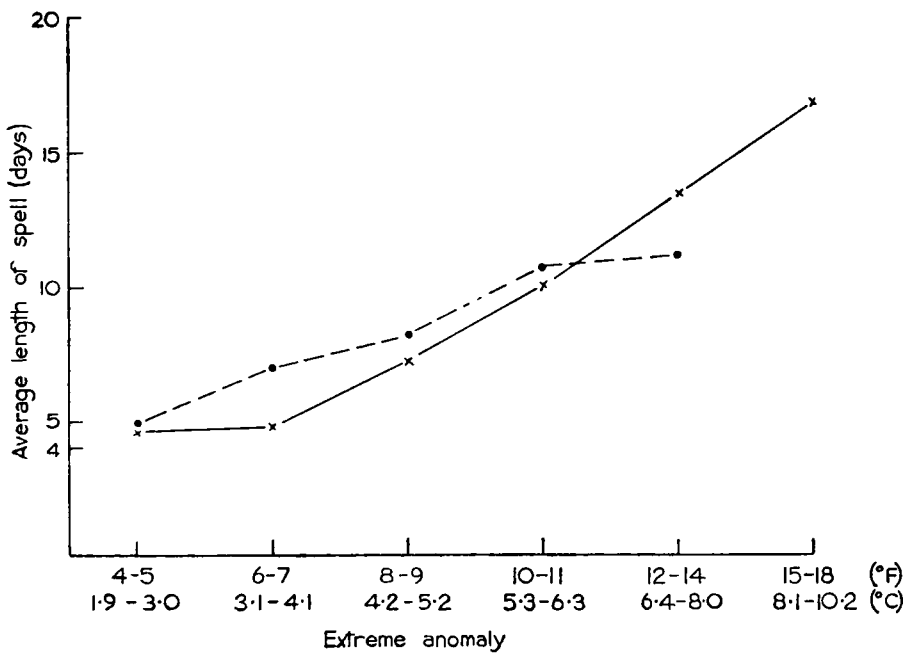


FIGURE 3—THE RELATION BETWEEN THE EXTREME ANOMALY AND THE AVERAGE LENGTH OF SPELL FOR THE SIX SUMMER AND SIX WINTER MONTHS
- - - - - summer months x—x—x winter months

The same graph for the winter months only is shown in Figure 4, with the upper and lower tenpercentile limits of the length of spell indicated by pecked lines. On 90 per cent of occasions in the winter months, a spell with an anomaly

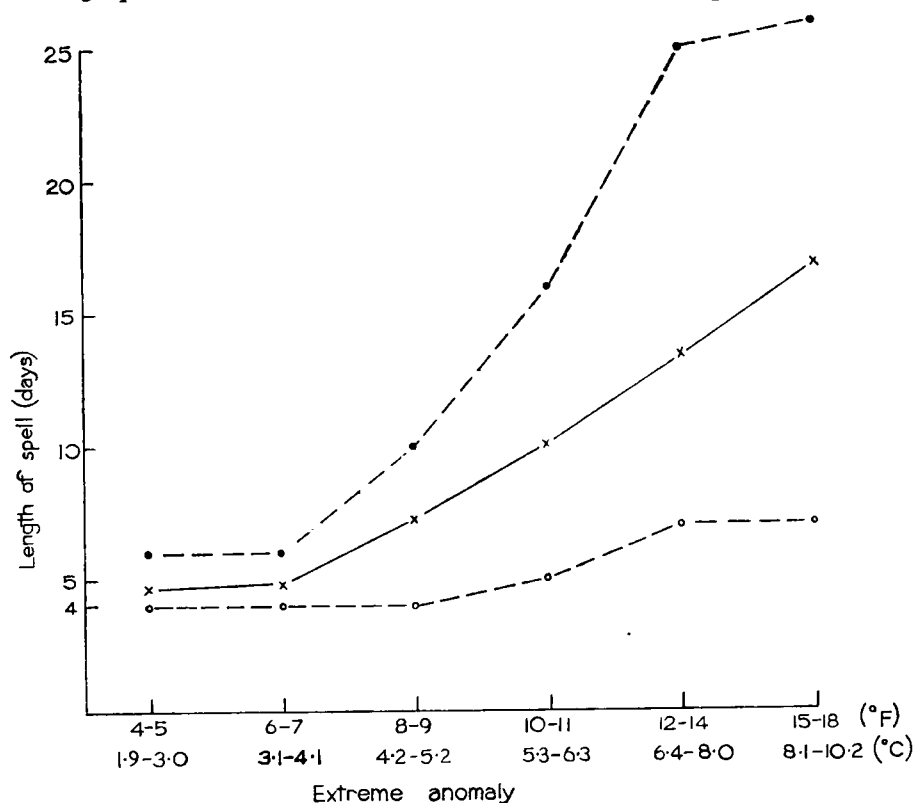


FIGURE 4—THE RELATION BETWEEN THE EXTREME ANOMALY AND THE LENGTH OF SPELL FOR THE SIX WINTER MONTHS

--- upper tenpercentile limit x—x—x average length
o—o—o lower tenpercentile limit

of 10°F (6°C) or more lasted for at least 5 days and a spell with an anomaly of 12°F (7°C) or more for at least 7 days. A similar graph for the summer months is shown in Figure 5. On 90 per cent of occasions in the summer months, a spell with an anomaly of 10°F (6°C) or more lasted for at least 6 days.

The incidence of cold-spell days.—Table XI shows the number of cold-spell days expressed as a percentage of the total days for each month and also the average number of cold-spell days for each month.

TABLE XI—THE PERCENTAGE AND AVERAGE NUMBER OF COLD-SPELL DAYS FOR EACH MONTH (IN 25 YEARS)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Percentage	42	41	30	29	38	37	40	35	31	24	24	32
Average number	13	12	9	9	12	11	12	11	9	7	7	10

January, February and July each had about 40 per cent of cold-spell days whilst May, June and August had between 35 and 38 per cent. October and November had the lowest proportion of 24 per cent. The average number of cold-spell days ranged from 7 in October and November to 11-13 in January, February, May, June, July and August.

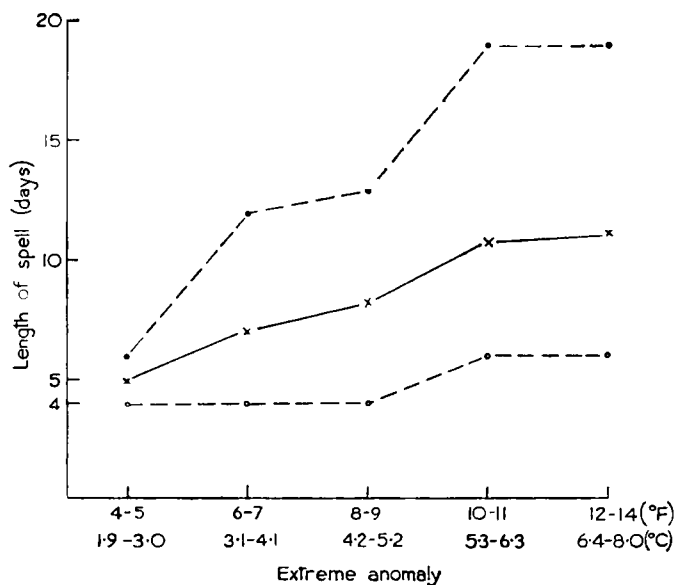


FIGURE 5—THE RELATION BETWEEN THE EXTREME ANOMALY AND THE LENGTH OF SPELL FOR THE SIX SUMMER MONTHS

--- upper tenpercentile limit x—x—x average length
 o—o—o lower tenpercentile limit

Figure 6 shows the percentage of cold-spell days for each month and the average monthly range of daily maximum temperature for comparison. The curves show some similarity from March to December but the maximum percentage in these months occurred in July whilst the maximum range occurred in May. The curves are quite dissimilar for January and February in which months the range was relatively small but the percentage of cold-spell days was at a maximum. The high percentage of cold-spell days in January and February is clearly associated with the much higher average length of spell in these two months compared with the rest of the year.

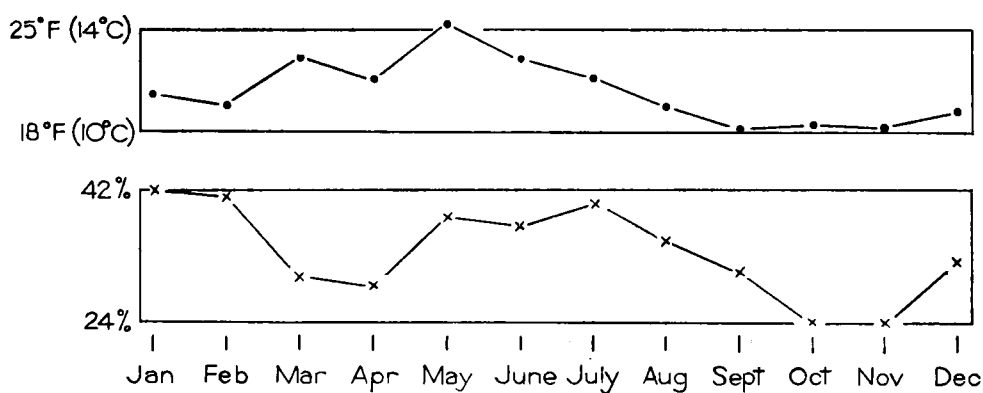


FIGURE 6—THE RELATION BETWEEN THE RANGE OF MAXIMUM TEMPERATURE AND THE PERCENTAGE OF COLD-SPELL DAYS FOR EACH MONTH

--- average monthly range of maximum temperature
 x—x—x percentage of cold-spell days

The ending of the cold spells.—Table XII shows the number of occasions on which the day after the end of the spell was associated with each synoptic type, expressed as a percentage of the total number of spells during the periods described.

TABLE XII—THE SYNOPTIC TYPE ON THE DAY AFTER THE END OF THE COLD SPELL

	<i>C</i>	<i>W</i>	<i>NW</i>	Synoptic type <i>N</i> <i>E</i> <i>S</i>			<i>AC</i>	<i>U</i>	Total spells
				<i>percentage of spells</i>					
Six winter months	12	36	7	4	7	19	6	9	162
Six summer months	13	36	4	3	5	17	15	7	194
Year	12	36	6	3	6	18	11	8	356

U indicates occasions when the weather over the British Isles was not classifiable according to any of the seven types.

Over the whole year, 36 per cent of the spells ended with the westerly type and 18 per cent with the southerly type. About 10 per cent ended with the cyclonic and anticyclonic types. There was little difference between the winter and summer halves of the year, but most of the anticyclonic-type endings occurred in the summer months. The ending of 24 per cent of the spells was temporary, that is a further cold spell began during the 4 days following the last day of the spell. Of these spells 61 per cent occurred in the summer half of the year.

Table XIII shows the number of cold spells associated with each synoptic type which had a temporary ending, for the six winter and six summer months.

TABLE XIII—THE NUMBER OF COLD SPELLS WITH A TEMPORARY ENDING

(a) Six winter months

	<i>C</i>	<i>W</i>	Predominant synoptic type <i>NW</i> <i>N</i> <i>E</i> <i>S</i>				<i>AC</i>
			<i>number of spells</i>				
With temporary ending	3	2	1	4	13	2	10
Total spells	13	18	4	39	39	15	34

(b) Six summer months

	<i>C</i>	<i>W</i>	Predominant synoptic type <i>NW</i> <i>N</i> <i>E</i> <i>S</i>				<i>AC</i>
			<i>number of spells</i>				
With temporary ending	12	17	2	12	6	0	3
Total spells	45	50	10	43	24	3	19

In the winter months only 10 per cent of northerly-type spells, 11 per cent of westerly-type spells and 13 per cent of southerly-type spells had a temporary ending. In the summer months, only 16 per cent of anticyclonic-type spells had a temporary ending.

Table XIV is in two parts (a) and (b) according to season. The main figures demonstrate the number of occasions when the ending of the spell was permanent and are classified according to the synoptic type during the spell and the type just after the spell. The figures in brackets show how often the ending was temporary.

There is a suggestion that spells with certain characteristics are unlikely to have a temporary ending; e.g. in the winter months westerly- and northerly-type spells with a westerly-type ending, and in the summer months northerly-type spells with a southerly-type ending.

TABLE XIV—THE ASSOCIATION BETWEEN THE SYNOPTIC TYPE ON THE DAY AFTER THE END OF THE COLD SPELL AND THE PERMANENCE OF THE ENDING

(a) Six winter months

Predominant synoptic type during spell	Synoptic type on day after end of spell number of occasions							
	<i>C</i>	<i>W</i>	<i>NW</i>	<i>N</i>	<i>E</i>	<i>S</i>	<i>AC</i>	<i>U</i>
<i>C</i>	1 (1)	4 (1)	0 (1)	—	—	3 (0)	1 (0)	1 (0)
<i>W</i>	1 (0)	11 (1)	—	1 (0)	1 (0)	2 (0)	—	0 (1)
<i>NW</i>	—	0 (1)	2 (0)	—	—	—	—	1 (0)
<i>N</i>	7 (1)	15 (0)	2 (1)	1 (1)	0 (1)	6 (0)	1 (0)	3 (0)
<i>E</i>	3 (2)	9 (3)	2 (1)	1 (0)	3 (3)	6 (1)	—	2 (2)
<i>S</i>	1 (1)	2 (1)	—	—	2 (0)	6 (0)	—	2 (0)
<i>AC</i>	1 (0)	8 (3)	2 (1)	1 (1)	1 (0)	3 (4)	6 (1)	2 (0)

(b) Six summer months

Predominant synoptic type during spell	Synoptic type on day after end of spell number of occasions							
	<i>C</i>	<i>W</i>	<i>NW</i>	<i>N</i>	<i>E</i>	<i>S</i>	<i>AC</i>	<i>U</i>
<i>C</i>	10 (3)	11 (3)	1 (0)	—	1 (1)	5 (3)	3 (0)	2 (2)
<i>W</i>	2 (3)	18 (12)	1 (0)	1 (0)	—	2 (0)	6 (1)	3 (1)
<i>NW</i>	1 (1)	3 (0)	2 (0)	—	—	1 (0)	1 (1)	—
<i>N</i>	2 (1)	7 (2)	2 (0)	0 (2)	2 (1)	10 (0)	6 (5)	2 (1)
<i>E</i>	1 (0)	7 (1)	—	0 (2)	3 (1)	6 (1)	1 (0)	0 (1)
<i>S</i>	—	3 (0)	—	—	—	—	—	—
<i>AC</i>	1 (0)	3 (1)	1 (1)	—	1 (0)	4 (1)	5 (0)	1 (0)

U—occasions when the weather on the day after the end of a spell was not classifiable according to any of the seven types. The first figure represents the number of occasions when the ending of a spell was permanent, and the figure in brackets the occasions when the ending was temporary.

The period between the end of a cold spell and the beginning of the next.—Figure 7 shows the average period between cold spells and also the upper and lower tenpercentile limits of the period, for each month. The average period ranged from a minimum of 10 days in May to a maximum of



FIGURE 7—THE PERIOD BETWEEN THE END OF A COLD SPELL AND THE BEGINNING OF THE NEXT

--- upper tenpercentile limit x—x—x average
 -o-o-o lower tenpercentile limit

24 days in August. On 90 per cent of occasions in April the period was of at least 4 days and in November and December of at least 3 days. The longest period of 156 days occurred after a spell which ended in August.

Conclusions.—In the 25-year period 1935 to 1959, cold spells of 4 days or more, as defined in this paper, averaged just over one per month. Roughly one in three Aprils, Octobers and Novembers were unaffected by cold spells but a cold spell affected nearly every June and July. The number of months unaffected by cold spells in individual years ranged from nil in 1941 and 1956 to seven in 1959. Some 76 per cent of the spells were of 4 to 10 days in length and the longest spell lasted 56 days. The probability of a cold spell continuing for a further day is roughly constant at about 0.8 for spells of up to 18 days duration.

The highest proportion of cold spells, some 23 per cent, were predominantly associated with the northerly synoptic type. In the winter months the spells were mainly associated with the northerly, easterly and anticyclonic types and in the summer months with the westerly, cyclonic and northerly types. About half the spells in March were predominantly associated with the easterly type and just under half the spells in July and August with the westerly type.

The probability of a cold spell is particularly high with the easterly type in January and February, the northerly type in May, August and September and the anticyclonic type in January.

The largest average anomaly of daily maximum temperature of 11°F (6°C) was associated with easterly-type cold spells in February. Westerly-type cold spells were the least cold with an average anomaly of 4°F (2°C) or less in most months. The largest average extreme anomaly of 15° to 16°F (8° to 9°C) was associated with easterly-type cold spells in February and southerly-type cold spells in January. The largest absolute extreme anomaly of 21°F (12°C) was associated with an easterly-type cold spell in February. The month which was least affected by very cold days was October with an absolute extreme anomaly of 11°F (6°C).

The average length of spell for January and February was 12 to 13 days, much higher than for the rest of the year when it varied from 7 to 9 days. On 90 per cent of occasions, in the winter months, a cold spell with an extreme anomaly of 10°F (6°C) or more lasted for at least 5 days, and with an anomaly of 12°F (7°C) or more for at least 7 days. In the summer months a spell with an anomaly of 10°F (6°C) or more lasted for at least 6 days.

The average number of cold-spell days for each month ranged from 7 in October and November to 11 to 13 in January, February, May, June, July and August.

Some 24 per cent of the cold spells had a temporary ending, but in the winter months only about 10 per cent of northerly- and westerly-type cold spells had a temporary ending. There is a suggestion that cold spells with certain characteristics are unlikely to have a temporary ending, in particular, westerly- and northerly-type cold spells with a westerly-type ending in the winter months and northerly-type cold spells with a southerly-type ending in the summer months.

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A STUDY OF PERSISTENT AND SEMI-PERSISTENT THICK AND DENSE FOG IN THE LONDON AREA DURING THE DECADE 1947-56

By T. KELLY, B.Sc.

Introduction.—The three stations used in this study were London (Heathrow) Airport, Croydon Airport and Kingsway. The information required for Heathrow had already been extracted for the period 1949-56 and was supplied by the Meteorological Office, Bracknell. The Chief Meteorological Officer, London (Heathrow) Airport, provided that for the two years 1947 and 1948. The information for Croydon and Kingsway was extracted from the original daily registers.

Following normal Meteorological Office practice, persistent fog is taken to mean fog which lasts for 24 hours or more. For the purpose of this study, semi-persistent fog is defined as fog which lasts for 12 hours or more and therefore includes all occasions of persistent fog. Dense fog is defined as visibility less than 55 yards (as is customary in connexion with the public), and thick fog less than 220 yards, and therefore, all occasions of dense fog will be included in the statistics for thick fog.

All cases of persistent and semi-persistent thick and dense fog during the period are given for the three stations in Table I and Table II. For Heathrow and Croydon, hourly observations were used to estimate the lengths of the foggy periods, each hourly observation being assumed to represent one hour of fog. In the Heathrow and Croydon data a sequence of hourly observations of fog was regarded as being unbroken if the visibility had risen above the prescribed limits at a single hourly observation only, in an otherwise continuous sequence. There was, in fact, a break of one single hour in seven cases at Heathrow and six at Croydon. At Kingsway, observations were available only at 3-hourly intervals and the assumption was made that each observation of fog represented 3 hours of fog, as assumed by Shellard.¹ Objection may be made to this but, in order to determine the validity of the assumption, estimates of persistent and semi-persistent thick and dense fog at Croydon were derived from 3-hourly observations and these were compared with those based on hourly observations. Inspection of columns 5, 6, 7 and 8 in Table I shows that the agreement between the two sets of information is good. There were three instances when the 3-hourly observations gave semi-persistent thick fog not given by the hourly observations and one instance when the hourly observations gave semi-persistent thick fog not given by the 3-hourly observations, the periods which lasted for less than 12 hours being given in brackets. The outstanding discrepancies between columns 5 and 7 of Table I took place on 25-26 November 1950, when the visibility was 300 yards at midnight, thus breaking the sequence of 3-hourly observations but not that of the hourly observations, and on 19-20 January 1953, when the visibility was not less than 220 yards at 1300 and 1400 GMT on the 19th, thus breaking the hourly sequence but not the 3-hourly sequence. In Table I the number of occasions of persistent and semi-persistent thick fog at Croydon based on hourly observations was 24 compared with 26 based on 3-hourly observations, and the total number of hours was 414 based on hourly observations compared with 432 based on 3-

TABLE I—PERIODS OF PERSISTENT AND SEMI-PERSISTENT THICK FOG IN THE LONDON AREA

Year	Month	Heathrow (hourly)		Croydon (hourly)		Croydon (3-hourly)		Kingsway (3-hourly)	
		Period observed date/time (GMT)	Estimated duration hours	Period observed date/time (GMT)	Estimated duration hours	Period observed date/time (GMT)	Estimated duration hours	Period observed date/time (GMT)	Estimated duration hours
1947	Jan.	07/2300 – 08/1000	12						
	Feb.								
	Nov.	05/2300 – 06/1200	14	06/0100 – 06/1600	16	06/0300 – 06/1500	15	09/1800 – 10/0900	18
	Nov.	06/1600 – 07/0800	17					06/0600 – 07/0600	27
	Nov.	30/2100 – 01/1800	22						
	Mar.	02/2100 – 03/1100	15	(02/2100 – 03/0600 05/2000 – 06/1000	10) 15	02/2100 – 03/0600 05/2100 – 06/0900	12 15		
1948	Mar.								
	Mar.			30/2000 – 31/0700	12	30/2100 – 31/0600	12	06/1500 – 06/2400	12
	Oct.	11/0900 – 12/1000	14						
	Nov.	27/0900 – 29/1000	50	23/2000 – 24/0900 27/2100 – 29/0600	14 34	23/2100 – 24/0900 27/2100 – 29/0600	15 36		
	Nov.	30/0100		29/1400		29/1500			
	Dec.		38		44		45		24
1949	Dec.	25/1900 – 01/1400	29	26/0700 – 01/0900	13	26/0900 – 01/0900	12	27/1800 – 28/0900	18
	Jan.	28/0200 – 28/1500	14	26/0700 – 26/1900		26/0900 – 26/1800		28/1500 – 29/0900	21
	Jan.	29/0900 – 30/0300	19					30/1500	
	Jan.			30/1300 – 30/2400	12	(30/1800 – 30/2400	9)	– 01/1200	
	Nov.	15/0200 – 15/1800	15						
	Nov.	18/2000 – 19/1700	22						
1950	Jan.	26/2000 – 28/1300	30						
	Nov.	25/0700 – 25/1900	13	25/1500 – 26/0900	19	25/1200 – 25/2100	12		
	Nov.	26/0700 – 27/0900	27	26/1600 – 27/0800	17	26/1800 – 27/0600	15		
	Jan.	29/2000 – 30/1100	16	29/0700 – 30/0500	23	29/0900 – 30/0300	21	26/1200 – 27/0600	21
1951	Oct.			15/0000 – 15/1100	12	15/0000 – 15/0900	12		
	Oct.	15/2200 – 16/1100	14	15/2200 – 16/0900	12	16/0000 – 16/0900	12		
	Dec.	13/1800 – 14/1100	18					13/2100 – 14/0900	15

TABLE I—PERIODS OF PERSISTENT AND SEMI-PERSISTENT THICK FOG IN THE LONDON AREA—continued

1 Year	2 Month	Heathrow (hourly)		Croydon (hourly)		Croydon (3-hourly)		Kingsway (3-hourly)	
		3 Period observed <i>date/time</i> (GMT)	4 Estimated duration <i>hours</i>	5 Period observed <i>date/time</i> (GMT)	6 Estimated duration <i>hours</i>	7 Period observed <i>date/time</i> (GMT)	8 Estimated duration <i>hours</i>	9 Period observed <i>date/time</i> (GMT)	10 Estimated duration <i>hours</i>
1952	Feb.	05/1600 – 08/1200	69	(28/0000 – 28/1000 07/0300 – 07/1300)	11 11	28/0000 – 28/0900 07/0300 – 07/1200	12 12	06/0900 – 08/0900 08/1800 – 09/0300	51 12
	Dec.								
	Dec.								
1953	Dec.			27/0400 – 27/1600	13	27/0600 – 27/1500	12		
	Jan.	19/0600 – 20/1100	30	19/1500 – 20/0300	13	19/0900 – 20/0300	21		
	Mar.	02/2100 – 03/0900	13	02/2000 – 03/1000	15	02/2100 – 03/0900	15		
	Mar.			03/2100 – 04/0900	13	03/2100 – 04/0900	15		
1954	Nov.	17/0000 – 17/1200	13						
	Nov.	25/1600 – 26/0400	13						
	Dec.	17/2200 – 18/1800	21	17/2300 – 18/1300	15	18/0000 – 18/1200	15	18/0300 – 18/1500	15
	Dec.	20/2100 – 21/0900	13	17/2200 – 18/1100	14	18/0000 – 18/0900	12		
1955	Nov.	17/2200 – 18/1200	15						
	Nov.	19/2000 – 20/0900	14						
	Jan.	21/1600 – 22/0900	18						
	Oct.	11/2000 – 12/1100	16						
1956	Nov.			30/0400 – 30/1600	13	30/0600 – 30/1500	12		
	Dec.	01/1800 – 02/1100	18						
	Jan.	04/0800 – 06/1100	52	05/0500 – 06/0900	29	05/0600 – 06/0900	30	05/0600 – 06/0900	30
	Nov.			22/2200 – 23/0900	12	23/0000 – 23/0900	12		
	Dec.	08/2300 – 09/2200	24	19/0400 – 19/1700	14	19/0600 – 19/1500	12	19/0300 – 20/0300	27
	Dec.	20/0100 – 20/2400	24	20/0100 – 20/2000	20	20/0300 – 20/1800	18		

TABLE II—PERIODS OF PERSISTENT AND SEMI-PERSISTENT DENSE FOG IN THE LONDON AREA

1 Year	2 Month	Heathrow (hourly)			Croydon (hourly)			Croydon (3-hourly)			Kingsway (3-hourly)		
		3 Period observed	4 Estimated duration	5 Period observed	6 Estimated duration	7 Period observed	8 Estimated duration	9 Period observed	10 Estimated duration	11 Period observed	12 Estimated duration	13 Period observed	14 Estimated duration
		<i>date/time (GMT)</i>	<i>hours</i>	<i>date/time (GMT)</i>	<i>hours</i>	<i>date/time (GMT)</i>	<i>hours</i>	<i>date/time (GMT)</i>	<i>hours</i>	<i>date/time (GMT)</i>	<i>hours</i>	<i>date/time (GMT)</i>	<i>hours</i>
1947	Nov.	06/1600 – 07/0400	13	27/2100 – 29/0500	32	27/2100 – 28/0600	12	06/1200 – 07/0600	21				
1948	Nov.	27/1400 – 28/0400	15			28/1200 – 29/0300	18						
	Nov.			30/0800		30/0900		30/1500					
	Dec.			– 01/0900	26	– 01/0300	21	– 01/1200	24				
1949	Jan.	29/1300 – 29/2400	12										
1950	Nov.	26/1600 – 27/0400	13										
1951	Nov.	Nil											
1952	Dec.	06/0100 – 07/1300	37										
1953	Mar.												
1954		Nil		02/2200 – 03/0900	12	03/0000 – 03/0900	12	06/0900 – 08/0300	45				
1955		Nil											
1956	Jan.	04/1400 – 05/0200	13										
	Jan.	05/0500 – 06/0300	23	05/1800 – 06/0500	12	05/1800 – 06/0300	12	19/0600 – 19/1500	12				
	Dec.												

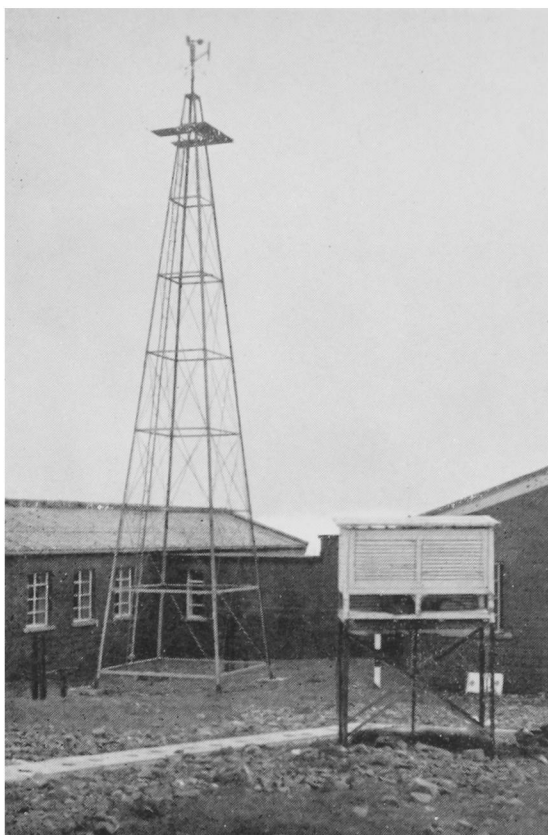


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Photograph by Mr P. W. Hewitt

**PLATE I—'BOAT DRILL', WINNING PHOTOGRAPH IN THE 1961 SEAFARERS'
EDUCATION SERVICE COMPETITION**

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Crown copyright

**PLATE II—THERMOMETER SCREEN AND ELECTRICAL ANEMOMETER MAST AT
LOWTHER HILL**

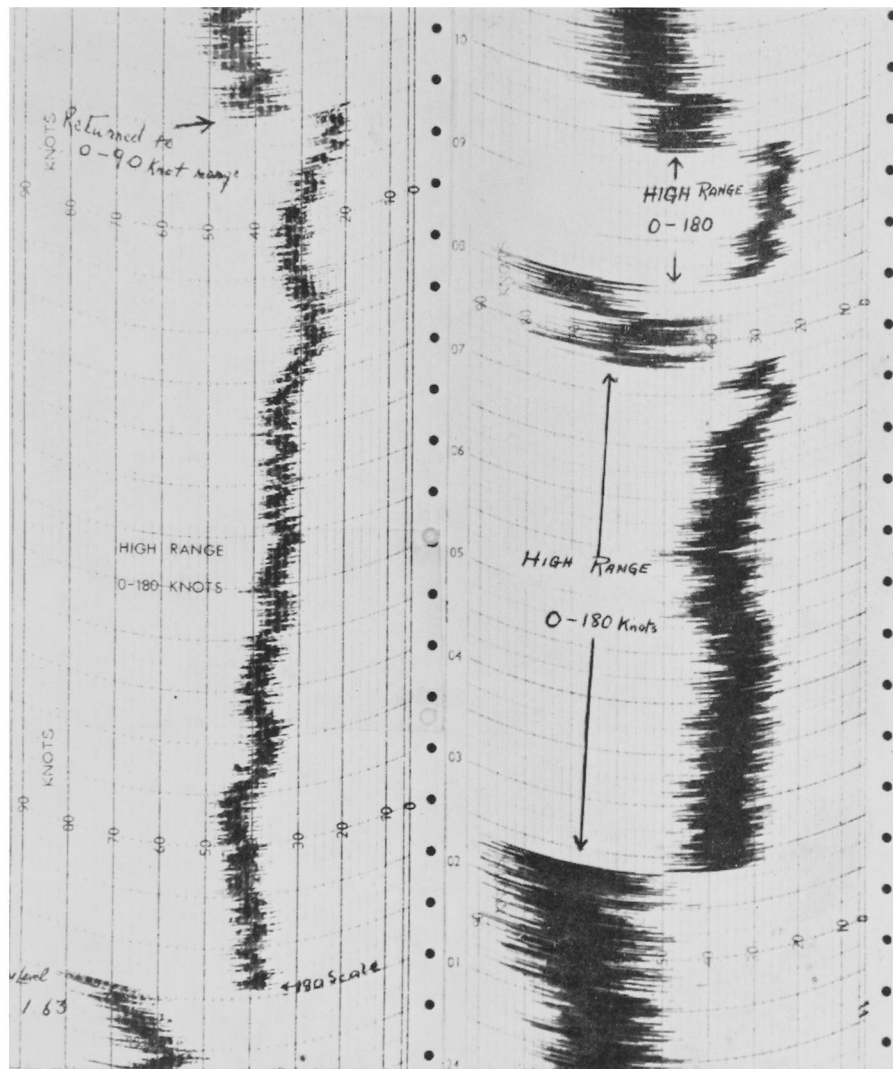
The electrical anemometer, which has a 'standard' exposure, was brought into use in July 1961.



Crown copyright

PLATE III—SUNSHINE RECORDER AT LOWTHER HILL

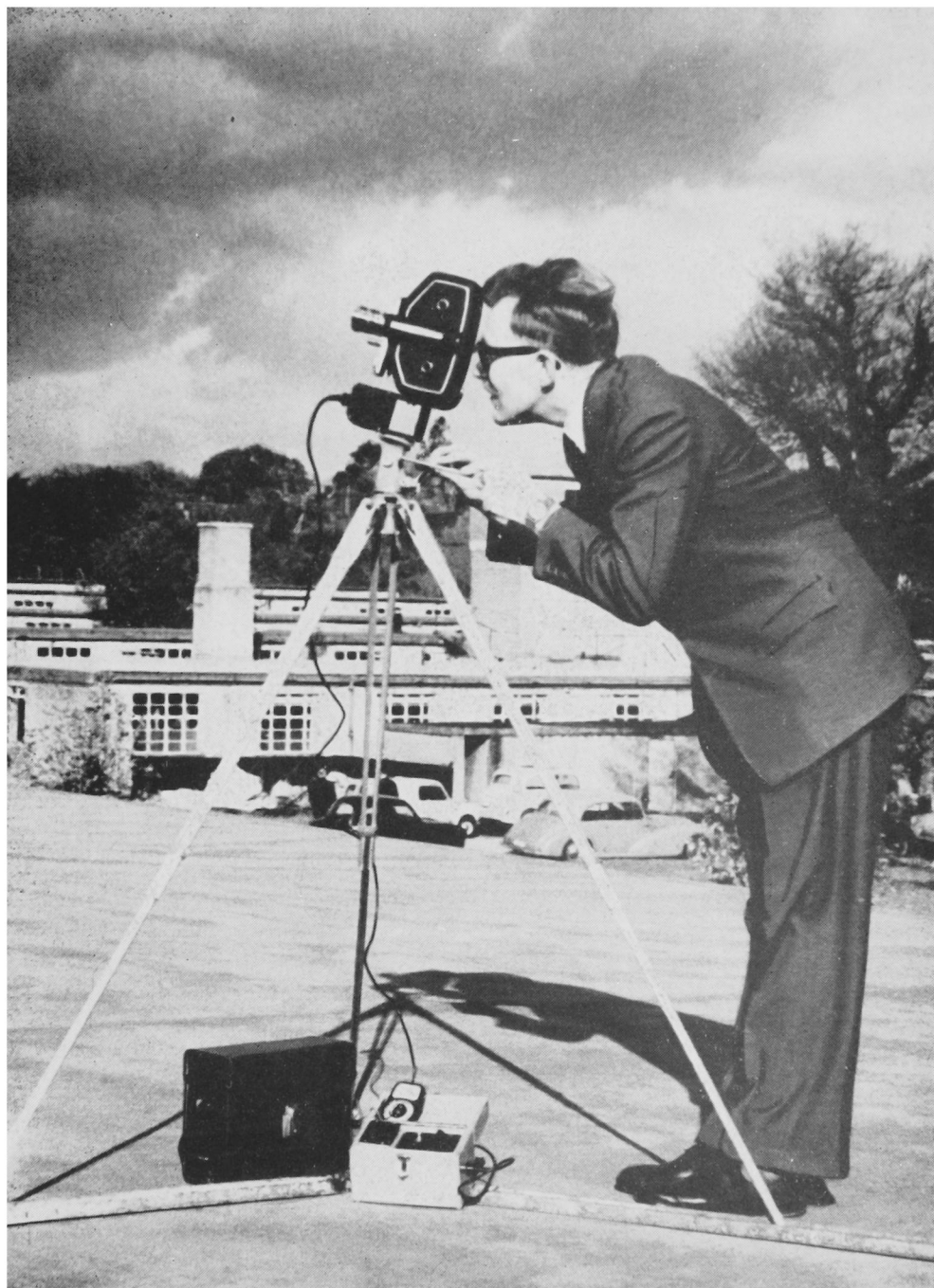
This view looking E'S indicates the nature of the site which is 2377 feet above sea level.



Given copyright

PLATE IV—ANEMOGRAMS FROM THE ELECTRICAL ANEMOMETER AT LOWTHER HILL, LANARKSHIRE SHOWING THE HIGHEST MEAN HOURLY WIND AND THE HIGHEST GUST EVER RECORDED ON AN ANEMOMETER WITH 'STANDARD' EXPOSURE

The upper chart shows the highest mean hourly wind of 86 knots recorded on 20 January 1963, the lower chart the highest gust of 106 knots on 12 February 1962. Note the change from one scale to another when the wind reaches a certain speed.



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PLATE V—TIME-LAPSE CINE-CAMERA IN USE AT THE METEOROLOGICAL OFFICE
TRAINING SCHOOL

See page 192

hourly observations. Thus the error introduced by using the 3-hourly observations seems to be of the order of an over-estimation of about 8 per cent in the number of occasions of semi-persistent thick fog and about 4 per cent in the total number of hours. In Table II columns 5 and 7 would have been almost identical but for the fact that the visibility was not less than 55 yards at 0900 GMT on 28 November 1948, and again on 1 December 1948, thus breaking the 3-hourly sequence but not the hourly sequence each time. It is, therefore, reasonable to assume that the information based on 3-hourly observations at Kingsway can be compared directly with that derived from hourly observations at Heathrow and Croydon.

Discussion.

(a) *Thick fog*.—Tables III, IV and V are extracted from Table I and show the number of occasions and the total duration, month by month, of semi-persistent thick fog at Heathrow, Croydon and Kingsway respectively. A comparison of these tables shows that the frequency of semi-persistent thick fog is highest at Heathrow and lowest at Kingsway. In fact, over the period considered, semi-persistent thick fog occurred in the ratios: Heathrow : Croydon : Kingsway = 34 : 24 : 13 = 3 : 2 : 1 (approximately). At Heathrow and Croydon semi-persistent thick fog was observed during the months October to January inclusive, and also in March. It was most frequent in November and did not occur at all in February. At Kingsway October was free from semi-persistent thick fog but there were five cases in both November and December and one in each of the months January, February and March. Of the 13 occurrences of semi-persistent thick fog at Kingsway only three

TABLE III—NUMBER OF OCCASIONS AND TOTAL NUMBER OF HOURS OF PERSISTENT AND SEMI-PERSISTENT THICK FOG AT HEATHROW

Year	Jan.	Feb.	Mar.	Oct.	Nov.	Dec.	Yearly total
1947	1 (12)				3 (53)		6 (65)
1948			1 (15)		3 (105)	1 (29)	5 (149)
1949	2 (33)				2 (37)		4 (70)
1950	1 (30)				2 (40)		3 (70)
1951	1 (16)			1 (14)		1 (18)	3 (48)
1952						1 (69)	1 (69)
1953	1 (30)		1 (13)		2 (26)	2 (34)	6 (103)
1954					2 (29)		2 (29)
1955	1 (18)			1 (16)		1 (18)	3 (52)
1956	1 (52)					2 (48)	3 (100)
Total	8 (191)		2 (28)	2 (30)	14 (290)	8 (216)	34 (755)

First figure is number of occasions, figures in brackets are total number of hours.

TABLE IV—NUMBER OF OCCASIONS AND TOTAL NUMBER OF HOURS OF PERSISTENT AND SEMI-PERSISTENT THICK FOG AT CROYDON

Year	Jan.	Feb.	Mar.	Oct.	Nov.	Dec.	Yearly total
1947					1 (16)		1 (16)
1948			1 (15)	1 (12)	2 (48)	2 (57)	6 (132)
1949	1 (12)						1 (12)
1950					2 (36)		2 (36)
1951	1 (23)			2 (24)			3 (47)
1952						1 (13)	1 (13)
1953	1 (13)		2 (28)			1 (15)	4 (56)
1954					1 (14)		1 (14)
1955					1 (13)		1 (13)
1956	1 (29)				1 (12)	2 (34)	4 (75)
Total	4 (77)		3 (43)	3 (36)	8 (139)	6 (119)	24 (414)

First figure is number of occasions, figures in brackets are total number of hours.

TABLE V—NUMBER OF OCCASIONS AND TOTAL NUMBER OF HOURS OF PERSISTENT AND SEMI-PERSISTENT THICK FOG AT KINGSWAY

Year	Jan.	Feb.	Mar.	Oct.	Nov.	Dec.	Yearly total
1947		1 (18)			1 (27)		2 (45)
1948			1 (12)		3 (63)		4 (75)
1949							
1950					1 (21)		1 (21)
1951						1 (15)	1 (15)
1952						2 (63)	2 (63)
1953						1 (15)	1 (15)
1954							
1955							
1956	1 (30)					1 (27)	2 (57)
Total	1 (30)	1 (18)	1 (12)		5 (111)	5 (120)	13 (291)

First figure is number of occasions, figures in brackets are total number of hours.

were not accompanied by semi-persistent thick fog at Heathrow and/or Croydon, although on these three occasions thick fog was observed at Heathrow and Croydon but it did not last for 12 hours. From this, it can be concluded that semi-persistent thick fog usually occurs at Kingsway only when thick fog is widespread in the London area. Over the 10-year period considered, the total number of hours of semi-persistent thick fog was: Heathrow : Croydon : Kingsway = 755 : 414 : 291 = 5 : 3 : 2 (approximately).

Table VI gives the dates of the earliest and latest reports of semi-persistent thick fog at each of the three stations. The number of occasions of persistent thick fog was: Heathrow : Croydon : Kingsway = 10 : 3 : 5, showing that the frequency of persistent thick fog was highest at Heathrow and lowest at Croydon.

TABLE VI—EARLIEST AND LATEST OCCURRENCES OF SEMI-PERSISTENT THICK FOG IN THE LONDON AREA

	Earliest occurrence	Duration	Latest occurrence	Duration
Heathrow	15 October 1955	16 hours	2 March 1948	15 hours
Croydon	15 October 1951	12 hours	5 March 1948	15 hours
Kingsway	*6 November 1947	27 hours	6 March 1948	12 hours

*This was also a persistent fog.

The total number of hours of persistent thick fog was: Heathrow : Croydon : Kingsway = 373 : 107 : 159 = 7 : 2 : 3 (approximately). The longest periods of persistent thick fog were 69 hours at Heathrow on 5 December 1952, 44 hours at Croydon on 29 November 1948 and 51 hours at Kingsway on 6 December 1952. The dates of the earliest and latest reports of persistent thick fog at each of the three stations are given in Table VII.

TABLE VII—EARLIEST AND LATEST OCCURRENCES OF PERSISTENT THICK FOG IN THE LONDON AREA

	Earliest occurrence	Duration	Latest occurrence	Duration
Heathrow	26 November 1950	27 hours	26 January 1950	30 hours
Croydon	27 November 1948	34 hours	5 January 1956	29 hours
Kingsway	6 November 1947	27 hours	5 January 1956	30 hours

(b) *Dense fog*.—All the cases of persistent and semi-persistent dense fog are listed in Table II. At Heathrow semi-persistent dense fog was reported in November, December and January, at Croydon it was recorded in November, December, January and March while at Kingsway it occurred only during the months of November and December. The number of occasions of semi-

persistent dense fog was: Heathrow : Croydon : Kingsway = 7 : 4 : 4. During the period considered, the total number of hours of semi-persistent dense fog was: Heathrow : Croydon : Kingsway = 126 : 82 : 102 = 6 : 4 : 5 (approximately).

During the decade 1947–56 there was only one case of persistent dense fog (37 hours on 6–7 December 1952) at Heathrow, although a dense fog lasted for 23 hours on 5–6 January 1956. Persistent dense fog occurred twice at Croydon (32 hours on 27–29 November 1948 and 26 hours on 30 November–1 December 1948) and twice at Kingsway (24 hours on 30 November–1 December 1948 and 45 hours on 6–8 December 1952). There was, therefore, little difference between the three stations. The longest period of dense fog (dealt with in detail by Douglas and Stewart²) was the 45 hours which occurred at Kingsway in December 1952.

Synoptic situation.—An examination was made of the synoptic situation on each occasion of persistent thick fog. In most cases an anticyclone moved slowly across, or in the vicinity of, the British Isles from the Atlantic, but in two instances new anticyclones formed over the British Isles in the slack pressure gradient behind a cold front. Persistent fog also formed in the southerly airstream associated with well-established anticyclones over the continent of Europe.

Conclusions.—Semi-persistent thick fog occurred most frequently at Heathrow and least frequently at Kingsway, while persistent thick fog was most frequent at Heathrow and least frequent at Croydon. Heathrow had almost twice as many semi-persistent dense fogs as Croydon and Kingsway but there was little difference between the three stations when persistent dense fog was considered.

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551.509.317

THE 100 MB CHART AND A CHANGE OF SURFACE WEATHER TYPE NEAR THE BRITISH ISLES

By N. E. DAVIS, M.A.

Investigation of the 100 mb synoptic contour chart has been proceeding at London (Heathrow) Airport for the past two years. The following note reports on a very successful example of the use of the 100 mb chart in forecasting the end of a long spell of cold weather in the United Kingdom. The note presents only a concise account of the chart sequences without attempting to justify them on mathematical or physical grounds.

March 1962 was characterized at Heathrow by a long, cold, mainly dry spell lasting until the 25th, followed by near-normal temperatures in a rather wet cyclonic spell for the last 6 days. Table I shows the mean maximum and minimum temperatures and total rainfall at Heathrow for the first 25 days, the last 6 days and the whole month, compared with the March average for 1947 to 1962.

TABLE I—CHANGE OF SURFACE WEATHER TYPE IN MARCH 1962

	1-25	March 1962 26-31	1-31 <i>degrees centigrade</i>	March average (1947-1962)
Mean maximum temperature	6.4	10.9	7.3	10.5
Mean minimum temperature	-0.9	2.1	-0.3	2.8
			<i>millimetres</i>	
Rainfall	14.8	20.0	34.8	37.7

This table shows that the temperature for the first 25 days was nearly 4°C below normal (an exceptional departure from the mean) whilst the last 6 days were near normal. The total rainfall was only slightly below the normal of about 38 millimetres but more than half the total precipitation fell during the last 6 days. Table I therefore shows that a very significant change of weather type took place in the vicinity of the British Isles on about 25 March. That such a change was imminent was foreshadowed by the 100 mb contour chart some 4 days earlier.

Figure 1 shows the 100 mb chart for 0001 GMT, 20 March 1962. This chart was typical of the first 20 days of the month. A closed cyclonic circulation was centred between Spitzbergen and Novaja Zemlja with another closed circulation over Canada. The looping track of the second centre is shown by the thick line joining the crosses which mark the position of the centre at 0001 GMT each day from 1 March to 20 March. Between these two centres a ridge persisted over the mid-Atlantic with a surface 'high' in the Greenland-Iceland area (near the top of the upper ridge). The British Isles were, as a consequence, mostly in a cold anticyclonic northerly flow at the surface.

Figure 2 shows the 100 mb chart for 0001 GMT, 21 March; a definite change is in progress. The closed circulation over Labrador has filled up leaving a trough extending southwards over Newfoundland, whilst the ridge over the mid-Atlantic shows definite signs of collapse. The process was even more marked on the 100 mb chart for 0001 GMT, 22 March (Figure 3) which shows quite a westerly flow existing from Greenland to Scotland, compared with the strong ridge of 20 March. It was confidently anticipated at Heathrow that the cold northerlies over the British Isles would be replaced by a cyclonic type of circulation within two or three days—the two or three days time lag being required for a suitable depression to move from the Cape Hatteras (North Carolina) area round the upper trough and thence eastwards to Scotland. Subsequently the trough at 100 mb off Labrador moved westwards, but the Atlantic remained under the influence of the west to west-north-west airstream.

Figure 4 shows the 0001 GMT surface chart for 22 March 1962. A deepening depression is moving eastwards near Cape Hatteras and a stationary 'high' is centred near ocean weather station Alpha (62°N, 33°W). Twenty-four hours later (Figure 5) the depression has moved eastwards to a position between Bermuda and Newfoundland whilst a warm-front wave is developing east of Newfoundland. Figure 6 shows the situation at 0001 GMT, 24 March. The warm-front wave has developed rapidly south-east of Greenland whence it moves eastwards towards northern Scotland on 25 March (Figure 7).

This change of type is a spectacular example of downward effects in the atmosphere; a change in the mid-stratosphere influences the subsequent tropospheric developments.

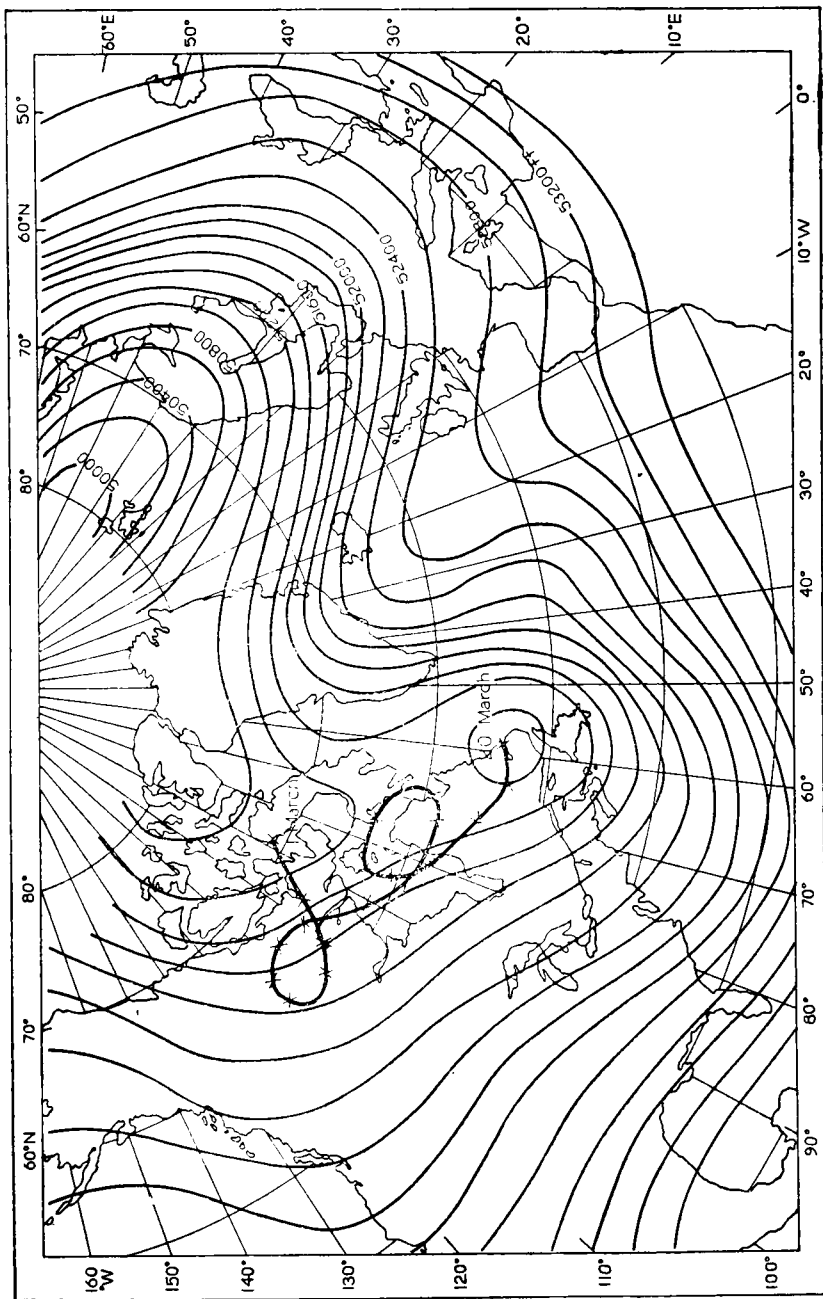
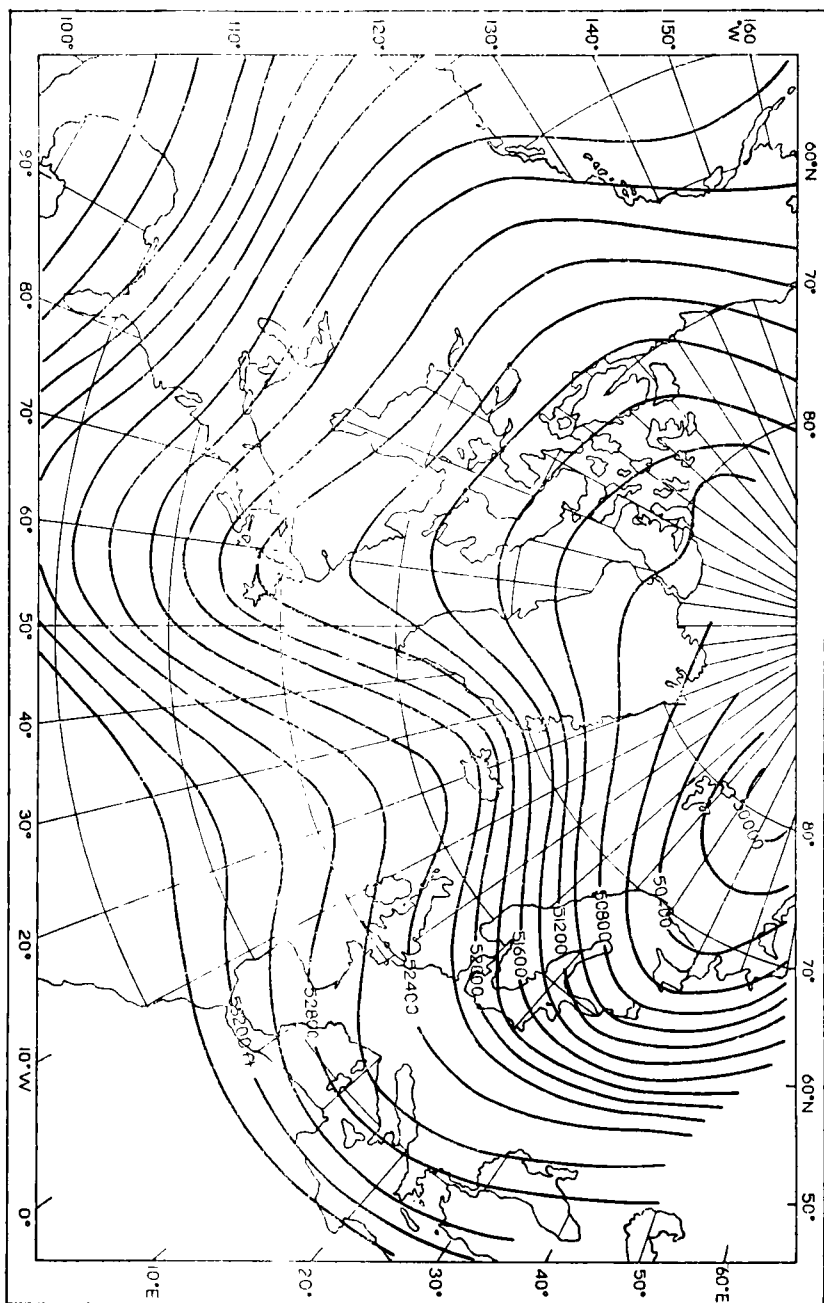
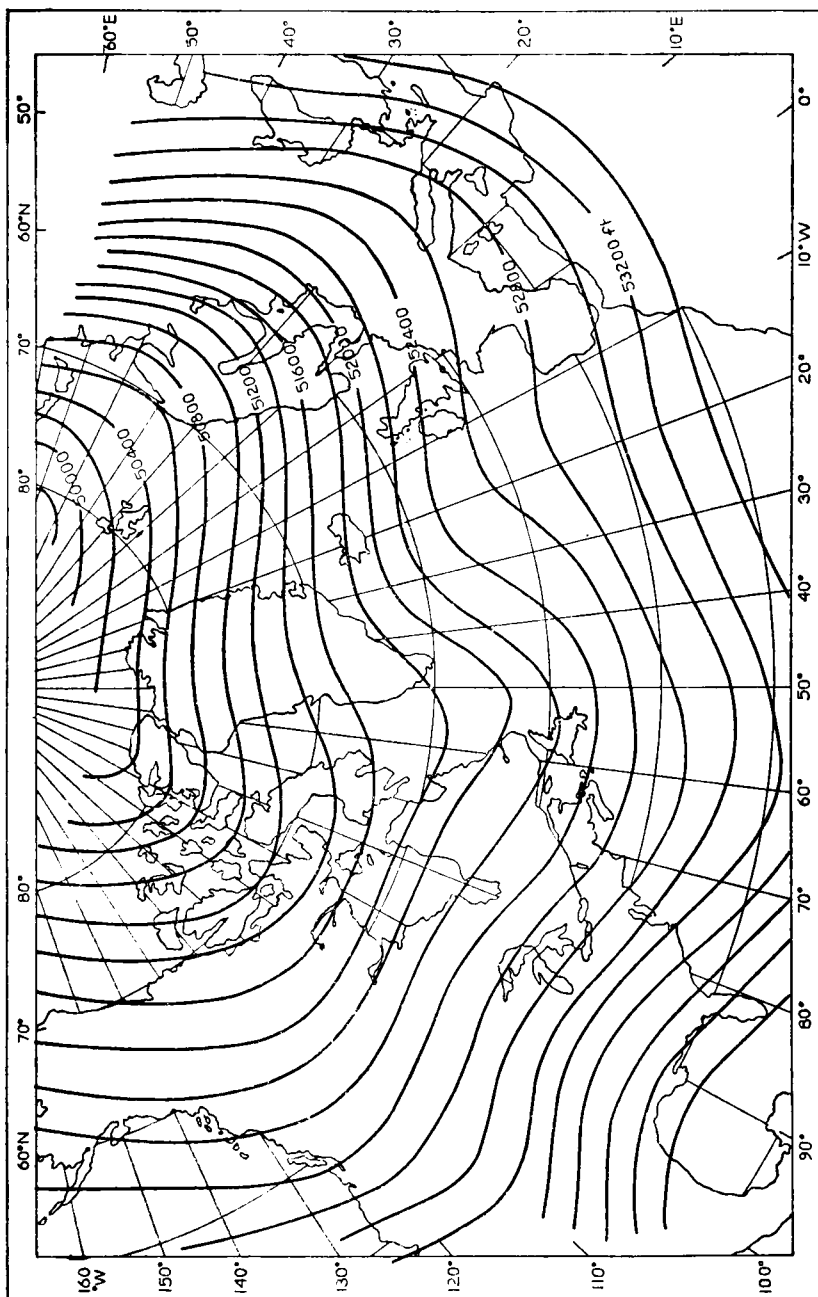


FIGURE 1—100 MB CONTOURS FOR 0001 GMT, 20 MARCH 1962
 x—x—x Track of closed circulation from 1–20 March

FIGURE 2—100 MB CONTOURS FOR 0001 GMT, 21 MARCH 1962





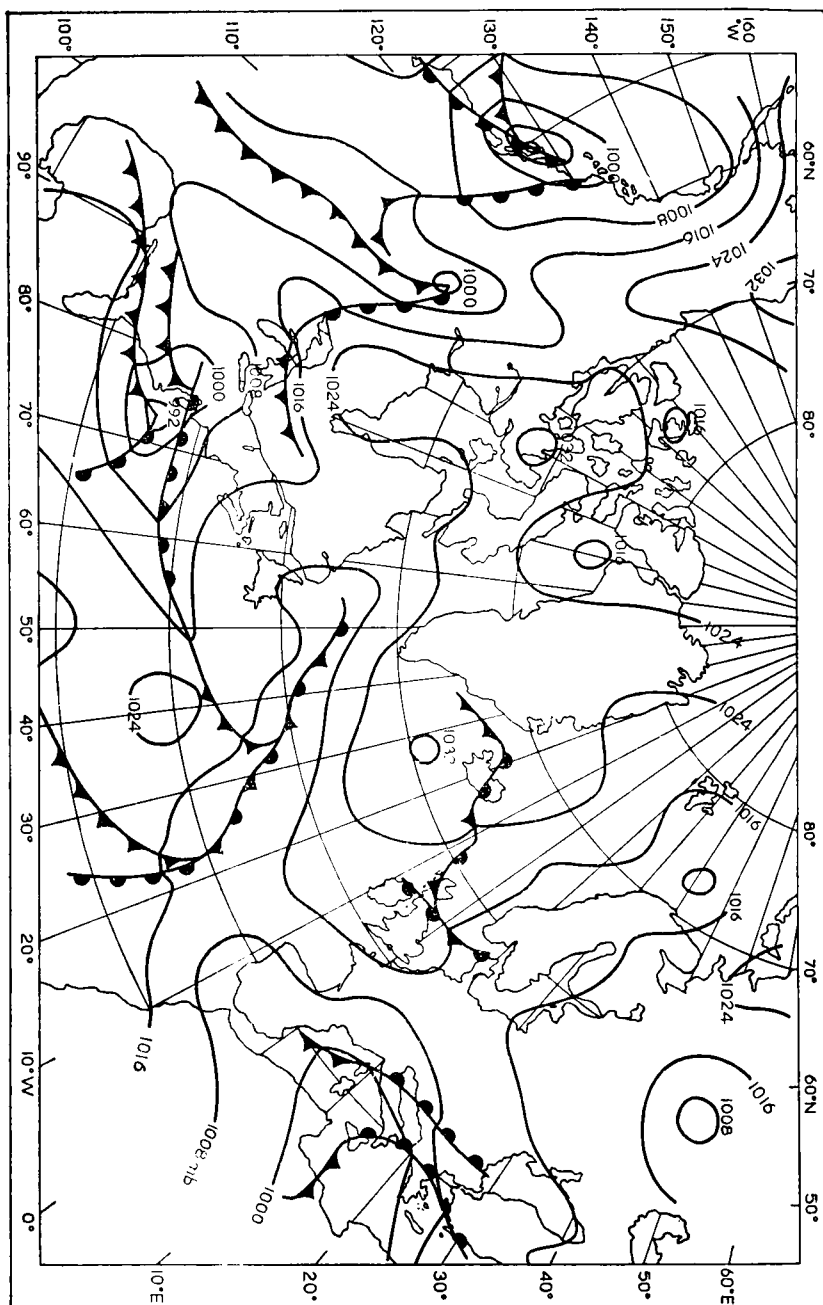


FIGURE 4—SURFACE CHART FOR 0001 GMT, 22 MARCH 1962
Isobars at 8 mb intervals

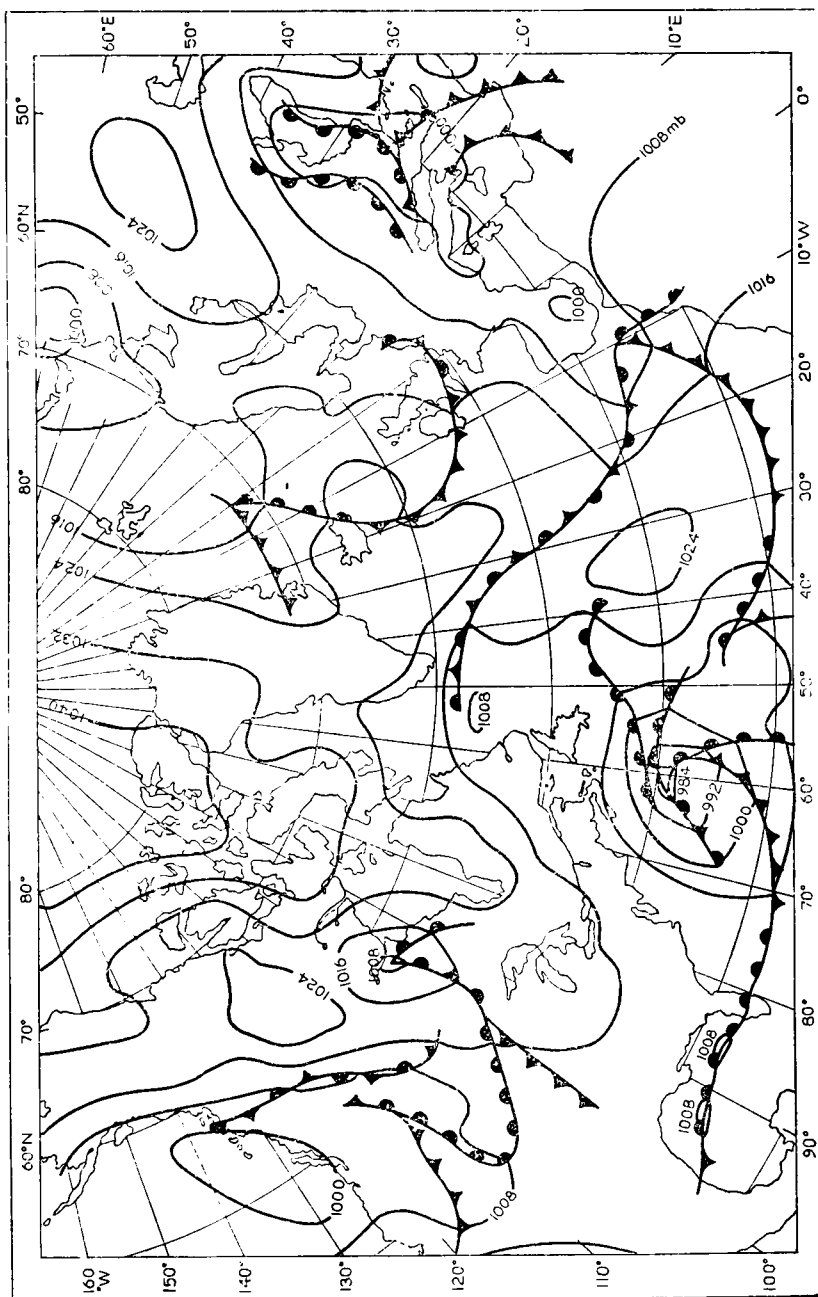


FIGURE 5—SURFACE CHART FOR 0001 GMT, 23 MARCH 1962
Isobars at 8 mb intervals

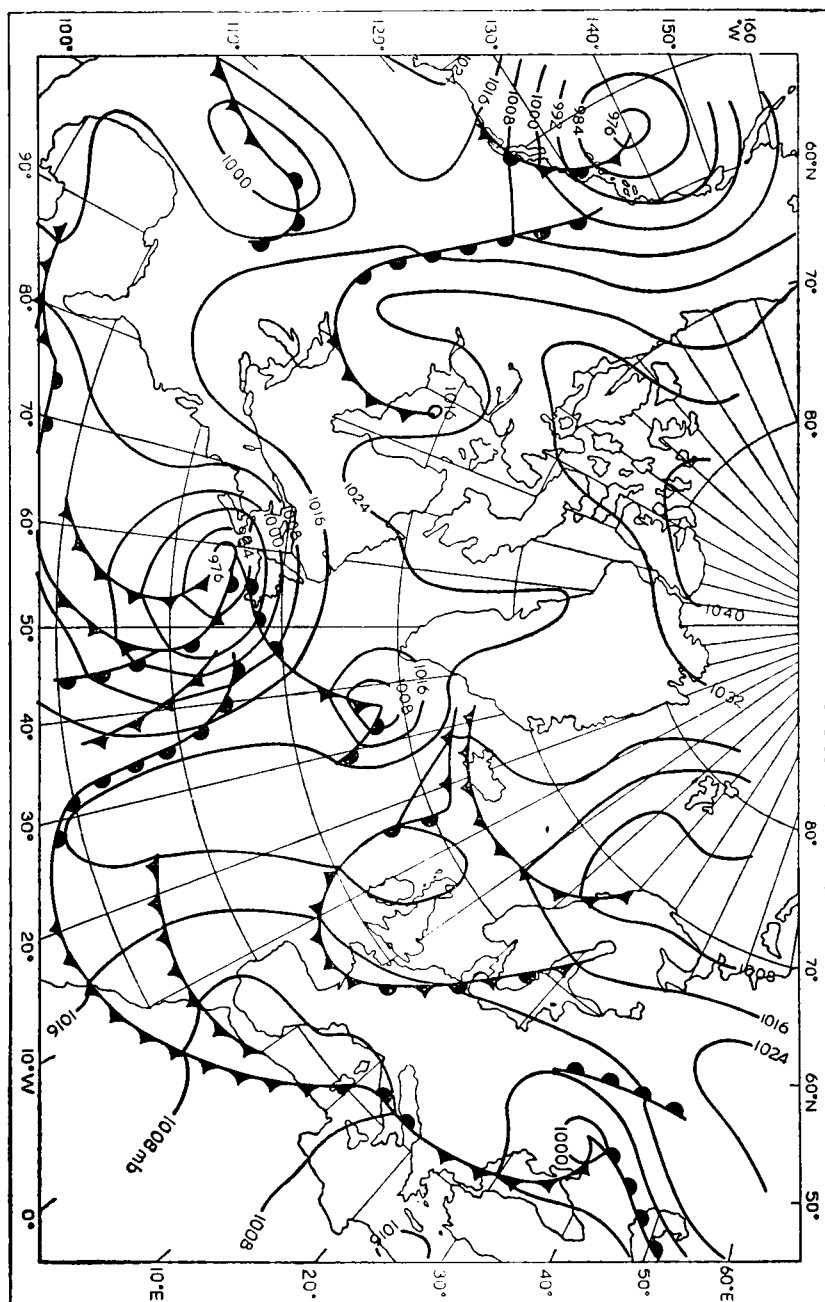


FIGURE 6—SURFACE CHART FOR 0001 GMT, 24 MARCH 1962
Isobars at 8 mb intervals

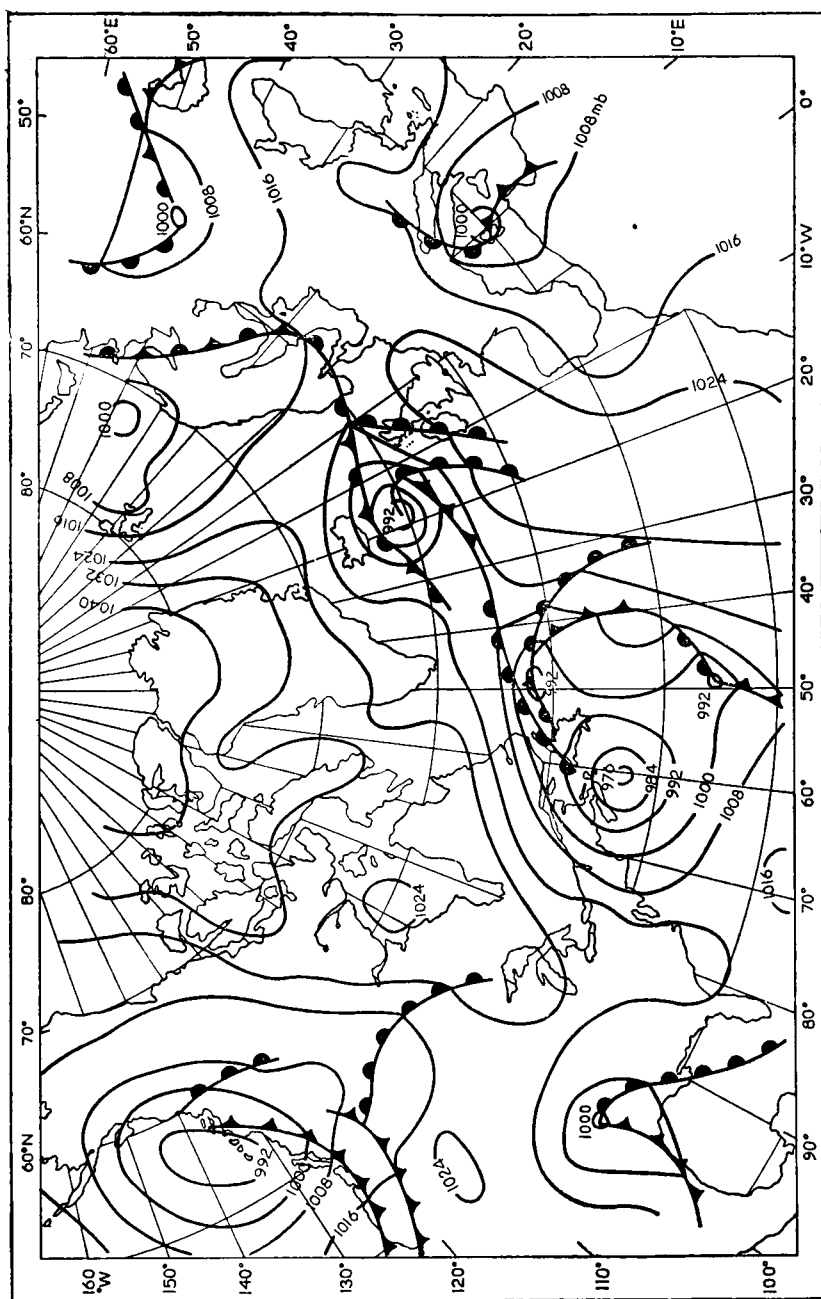


FIGURE 7—SURFACE CHART FOR 0001 GMT, 25 MARCH 1962
Isobars at 8 mb intervals

TIME-LAPSE PHOTOGRAPHY IN METEOROLOGY

By D. J. GEORGE

For many years the cine-camera has been used for scientific photography, one particular technique being the use of time-lapse photography to show movement or growth which occurs in nature on a time scale too slow to be noticeable to the human eye, for example growth of plants and cloud evolution. Cinematograph films are usually projected at a speed of 16 frames per second (silent films) or 24 frames per second (sound films) so if the subject is photographed at a slower rate, the projected picture will show a speed up of movement depending on the ratio of camera speed to projection speed.

Time-lapse photography has been used intermittently in meteorology since the beginning of the century. A survey by Farquharson¹ in 1939 mentions the use of the cine-camera by Sir Napier Shaw in 1911² to show cloud development ahead of a depression, and the use of the animated diagram technique to illustrate the evolution of a depression. Several workers used the time-lapse method for photographing clouds in the 1920's and 1930's, amongst others, Devaux,¹ Masanao Abe,³ Idrac,⁴ Kampé de Fériet⁵ and Linke.⁶ Professor Brunt⁷ used the method in this country to show the motion of stratocumulus cloud, whilst Mügge⁸ made a series of films in Germany, copies of which are in use in the Meteorological Office Training School.

Since the war, improved cameras and films have been available, and several workers have used time-lapse cameras for cloud investigations, in conjunction with still cameras, aircraft and a dense network of ground and upper air stations, (for example Schaefer,⁹ Larsson,¹⁰ Ludlam and Saunders,¹¹ Holmboe and Klieforth¹² and Conover¹³). A series of time-lapse films on clouds by Mügge and Wachter are available in the World Meteorological Organization (WMO) Film Loan Service.¹⁴ Several enthusiastic glider pilots and photographers have made time-lapse sequences of clouds using quite modest equipment.

A 16 mm cine-camera has been in use at the Meteorological Office Training School since late 1960, in order to make instructional colour films on clouds. The camera (Bell and Howell 627) has an Angenieux wide-angle fixed-focus 10 mm lens, and is connected to a battery operated intervalometer which takes single frames at intervals which can be varied from 1 second to 15 seconds. The camera is mounted on a strong tripod fitted with a pan and tilt head, whilst exposure is adjusted manually after checking the lighting with an exposure meter (see Plate V). Some experimenting was necessary to find the appropriate time interval to use, as too large an interval resulted in a jerky motion of the subject, whilst too short an interval resulted in little visible change in the cloud. Intervals used have varied from 1 second to 10 seconds, depending on the angular velocity of the cloud. The graph (Figure 1) shows the relationship between angular velocity of the cloud and time-lapse interval used. One difficulty is that high clouds, for example glaciating cumulonimbus tops, are quickly obscured by lower clouds which have a greater angular velocity. Also, the horizontal speed of the cloud may be such that the cloud is lost in the distance before a sufficient length of film is obtained.

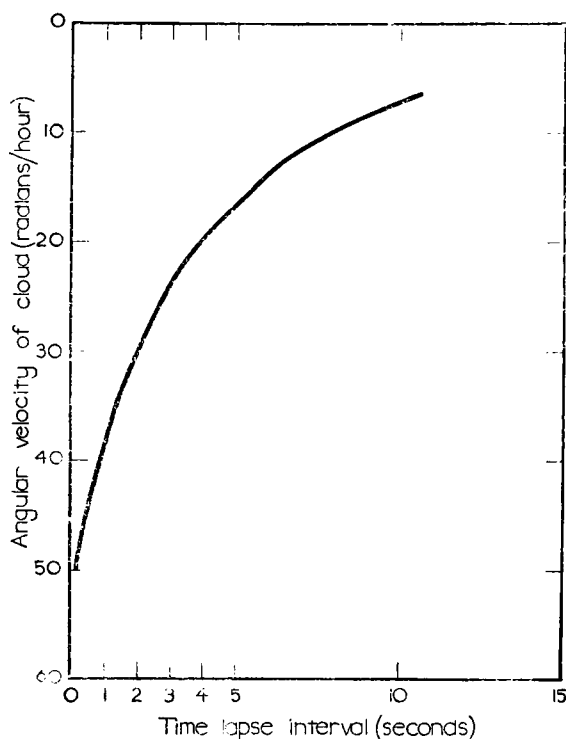


FIGURE 1—RELATIONSHIP BETWEEN ANGULAR VELOCITY OF CLOUD AND TIME-LAPSE INTERVAL USED

Subjects photographed have included growth and diurnal variation of cumulus, formation of stratocumulus cumulonimbus, orographic cumulus, cumulonimbus, effect of frontal cloud cover on convection, altocumulus castellanus and floccus, glaciation of an altocumulus sheet, passage of fronts, jet-stream cirrus, wave clouds and dispersal of fog. A 30-minute film has been prepared on convection cloud¹⁵ which includes the cloud scenes and relevant synoptic surface and upper air charts and diagrams, with written commentary. This film may be of interest to RAF flying schools and gliding clubs. A second film is to be prepared on layer cloud.

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METEOROLOGICAL OFFICE DISCUSSION

Some variations of temperature and wind in the lower stratosphere

The third Monday Discussion of the season was held at the Royal Society of Arts on 21 January 1963. The subject was 'Some variations of temperature and wind in the lower stratosphere'.

In opening the discussion Mr. R. A. Ebdon referred to the early ideas of the stratosphere as a region of comparative calm. However, since about 1950—due to improvements in the performance of the radiosonde, some very interesting variations have been observed in stratospheric winds and temperatures.

Dealing with high latitudes of the Northern Hemisphere he described the variations in wind and temperature which occur from winter to summer. He went on to describe the year-to-year variations which occur during the period of the 'final warming' and the break-down of the stratospheric circumpolar vortex in the late winter or early spring. It was pointed out that 'sudden' (or 'explosive') warmings and coolings of the stratosphere are also a common occurrence over the British Isles during late winter and early spring.

Attention was then focused on lower latitudes and the recently detected tropical stratospheric wind fluctuation. Using data for Canton Island ($02^{\circ}46'S$, $171^{\circ}43'W$) and other equatorial stations it was shown that, during the last nine years or so, equatorial stratospheric zonal wind components have displayed a fluctuation with a periodicity varying between about 22 and 29 months. The fluctuation consists of a change from easterly to westerly winds or vice versa, and is seen first at high levels, taking about 6 months to descend from 25 mb to 60 mb. The amplitude of the fluctuation decreases with height between 25 mb and 80 mb. Near the equator the stratospheric winds show little or no annual variation and the dominant feature of the wind pattern is the fluctuation of approximately 26 months; whereas away from the equator in the tropics there is a very marked annual variation, although the fluctuation is still present. The amplitude decreases with distance from the equator and is only just detectable at latitudes 25–30 degrees. The 12-monthly running means of equatorial stratospheric temperatures also show the approximately 26-month fluctuation.

Mr. Ebdon concluded by saying that such data as are available provide evidence for suggesting that the fluctuation was in existence during the early years of this century.

The discussion, opened by the Director-General, covered a variety of topics ranging from the possible effect of stratospheric fluctuations on surface weather

to the suggestion that the stratospheric wind fluctuation might extend to the ionosphere. Several speakers wondered why 'sudden warmings' did not occur at other times of the year in high latitudes and mention was made of a possible 2-year periodicity in the strength and behaviour of the stratospheric circumpolar vortex. Regarding low latitudes, the need for a mechanism to produce westerly winds at the equator was discussed.

METEOROLOGICAL OFFICE NEWS

Seafarers' Education Service 1961 competitions

We have heard with pleasure of the success of two members of the meteorological staff in the ocean weather service in the competitions run by the Seafarers' Education Service.

In the 1961 competitions Mr. P. W. Hewitt, Scientific Assistant aboard O.W.S. *Weather Reporter* gained first prize in the photographic competition. Mr. Hewitt's subject was 'Boat Drill' described by the judges as a "picture which combines dramatic interest with good photography, each face providing an interesting study and the whole conveying an authentic sense of the occasion". The picture was reproduced as the cover of the summer 1962 issue of *The Seafarer*, the Quarterly Journal of the Seafarers' Education Service. The photograph actually illustrates an air-sea rescue exercise at sea. One 'survivor' is lying on a stretcher covered with a blanket, others are sitting in the boat with blankets wrapped round them, while the one in the foreground is being hoisted on board with a canvas belt and line. (Note the man with the 'walkie-talkie' radio set near the officer in the stern of the boat.) See Plate I.

In the 1962 competitions Mr. J. Connolly, Experimental Officer aboard O.W.S. *Weather Monitor* gained second prize in the painting competition. Mr. Connolly submitted three paintings, all of Irish landscapes, described by the Director of the Service as "very pleasant and competent work". One of these paintings will have a place in the Services Exhibition which is annually circulated to various seamen's clubs and nautical colleges.

Successes have also been gained by men in other branches of the ocean weather service. In 1959 Mr. C. E. Birtchnell, Radio Officer aboard O.W.S. *Weather Monitor*, shared the third prize in the essay competition whilst Mr. J. Stuart-Welldon, Assistant Steward in O.W.S. *Weather Watcher* was commended for his poetry entry. In 1961 the same Mr. Birtchnell, who had then moved to the *Weather Reporter*, was highly commended for a painting which was subsequently displayed in an exhibition.

These annual competitions form an integral part of the work of the Seafarers' Education Service. Competitions are held for short stories, photographs, essays, articles, poems, models, paintings, handicraft and crosswords, with prizes ranging from £20 to 15s. They are open to all British seafarers, irrespective of branch, rank or rating, and also to the lighthouse service. As an example of the range of these competitions, this year the essays may be on (a) Ships and the Future, (b) Freedom from Hunger, (c) Christmas at Sea, (d) Character Study and (e) My Favourite Book. The painting competition may be of any subject; the handicraft, anything done by hand; the short story

competition, a short story on any theme, whilst the poetry competition is for a poem not exceeding 25 lines on any subject. The photographic competition is open for original photographs of ships and other nautical subjects of general rather than of personal interest.

In addition, the service will consider articles and crosswords for publication in their Quarterly Journal with payment. Mr. C. E. Birtchnell, mentioned above as a prize winner, also received payment for an article in 1960.

The Far East Air Force Command Sailing Championships

The Far East Air Force Command Sailing Championships were held in December 1962 at RAF Seletar Yacht Club, and the winning team was captained by Mr. P. F. McAllen, Senior Meteorological Officer 224 Group. Mr. McAllen, was posted to 224 Group shortly before the championships and was given special permission to sail for RAF Changi Yacht Club where he has held the post of Captain of Boats for the past two years. The other teams which entered the championships were from RAF Yacht Clubs at Hong Kong, Gan, Seletar and Tengah, and the team-racing was in International Snipes. The weather was good with showers bringing a gusty but welcome relief from the light northerly winds.