M.O. 626 AIR MINISTRY

METEOROLOGICAL OFFICE

THE METEOROLOGICAL MAGAZINE

VOL. 86, No. 1,017, MARCH 1957

THE COLD WEATHER OF FEBRUARY 1956 WITH SPECIAL REFERENCE TO TEMPERATURES AT KEW DURING THE LAST 75 YEARS

By R. E. BOOTH

In England and Wales February 1956 was one of the coldest months of the present century, with mean temperature of the month, 32·6°F., little above freezing and 8°F.* below the 1921–50 average, the only colder months being January 1940 and February 1947 when mean temperatures were 31·7°F. and 30·4°F. respectively. During the last 75 years there is known to have been at least one other colder February—1895. The object of this paper is to investigate in what respect and to what extent February 1956 was really outstanding in southern England and to note at the same time any general trend in February temperatures. Kew, which has an unbroken record of temperature for at least 75 years is taken as a representative station. All temperatures considered in this note are screen temperatures.

On February 1, 1956 temperature at Kew rose to only 24°F. during the day, the lowest February maximum since 1895, and fell to 17°F. the following night, the lowest minimum temperature recorded during February since 1895 except for 1947 when it fell to 14·5°F. During the period February 19–24, 1956, temperature remained continuously below freezing. Belasco[1] examined Kew records over a long series of winters for days with mean temperature below freezing point. He termed a day whose mean temperature, based on the mean of 0–24 hr. hourly readings, was below 32·5°F. a "T-freezing day". As daily means at Kew are usually calculated in this manner they will be called simply "freezing days" in this paper, and remarks confined to February.

Table I gives the number of freezing days at Kew during the 78 Februaries from 1879–1956 inclusive. It will be seen that the number of freezing February days during 1956 was only exceeded in 1947, although equalled in 1895. The last column gives the number of freezing days during each decade and it will be observed that these reached a peak during the 1890's but that there was a higher number still during the 1940's, while the decade beginning 1950 has already had more freezing days up to 1956 than any other decade since 1880 except the two just mentioned, beginning in 1890 and 1940. Closer inspection

* February was by far the coldest month of the winter 1955–6 in England and Wales. December was a mild month with mean temperature 2·3°F. above the average and January mean temperature was only 0·6°F. below the average.

of the table indicates that there was a succession of cold Februaries, with mean temperature below freezing point on several days from 1886–1902 with a break of a year or two about 1897. Apart from the cold February of 1929 with 14 freezing days there were few very cold Februaries until the 1940's and even during this decade the middle years lacked freezing days. The last four Februaries have had a progressively increasing number of freezing days.

TABLE I—FREEZING DAYS AT KEW FOR FEBRUARY, 1879–1956

	0	1	2	3	4	5	6	7	8	9	Total
						Number of days					
1870	...	...	...	...	...	...	...	...	...	4	...
1880	1	1	1	0	0	0	11	2	9	5	30
90	2	3	4	1	4	*18*	2	0	...	4	38
1900	6	6	8	0	2	0	0	5	0	1	28
10	0	2	4	0	0	0	2	9	3	7	27
20	0	1	3	0	4	0	0	2	0	*14*	24
30	0	0	4	2	3	0	3	0	0	1	13
40	10	3	*13*	0	0	0	0	*21*	3	3	53
50	0	0	0	2	6	9	*18*	...	...	...	...

Table II gives the number of freezing days between certain temperature limits during the above mentioned 78 winters, and the annual frequency distribution of these days together with a similar analysis for each of the five years with the greatest number of freezing days shown in italics in Table I. The table shows that on 2 days in 1956 mean temperature was only 22°F.; this was on the 1st and 2nd. There have been no colder days during February since 1895 except for a spell of 3 days, 13th–15th, in 1929, when mean temperature each day was about 21°F. A spell of 4 very cold days in 1895 occurred on 6th–9th.

TABLE II—FREEZING DAYS AT KEW FOR FEBRUARY BETWEEN CERTAIN TEMPERATURE LIMITS FOR CERTAIN YEARS

	1879–1956	Annual frequency distribution	1956	1947	1942	1929	1895
°F.			*Number of days*				
31·5 to 32·4	74	0·97	3	3	4	2	1
30·5 to 31·4	42	0·55	1	3	4	1	2
29·5 to 30·4	41	0·53	2	1	1	2	2
28·5 to 29·4	25	0·33	2	5	2	1	1
27·5 to 28·4	21	0·27	5	3	0	1	2
26·5 to 27·4	19	0·25	1	4	2	3	0
25·5 to 26·4	10	0·13	2	1	0	0	3
24·5 to 25·4	7	0·09	0	1	0	0	2
23·5 to 24·4	2	0·03	0	0	0	0	1
22·5 to 23·4	1	0·01	0	0	0	1	0
21·5 to 22·4	2	0·03	2	0	0	0	0
20·5 to 21·4	3	0·04	0	0	0	3	0
19·5 to 20·4	1	0·01	0	0	0	0	1
18·5 to 19·4	1	0·01	0	0	0	0	1
17·5 to 18·4	2	0·03	0	0	0	0	2
16·5 to 17·4	1	0·01	0	0	0	0	0

Table III gives some idea of the cumulative effect of spells of freezing days. It comprises all years since 1879 with a spell of 9 freezing days or more during

February. The figure against each day is not a measure of the coldness of that day alone, but of that day combined with all the preceding days in that spell and represents the accumulated number of frost-degree days; the contribution of each day to this number being $33-t$, where t is the mean to the nearest whole degree Fahrenheit of 24 hourly temperature readings during the day. A spell of freezing days is not considered ended until the mean temperature of one or more consecutive days exceeds 32·4°F. It appears from the table that although the cold spell during 1947 was longer, the spell during 1895 was more severe. This can be attributed to the dull weather during February 1947 which was duller than any month since 1890; at Kew there was no sunshine February 2–22, the longest sunless period since records began. In 1895 there were 10 days with mean temperature below 27°F. whereas in 1947 there were only three. The table shows that February 1956 contained the third longest spell of freezing days of any February since 1895. The length of the 1956 spell was equalled in 1940 and the spell during 1929 was more severe, but during 1956 two other short freezing spells occured on the 1st–4th and 9th–12th; mean temperature fell below 27°F. on 3 of these days, but during the 10-day spell, 17th–26th, shown in Table III there was only one day with temperature below this value.

TABLE III—ACCUMULATED NUMBER OF FROST-DEGREE DAYS FOR FEBRUARY FOR SPELLS OF 9 OR MORE DAYS

days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
	Frost-degree days																				
1956	1	4	10	17	22	26	31	36	39	38											
1947	3	7	10	12	13	11	15	21	25	27	29	34	40	45	49	53	58	64	71	79	85
1940	1	4	6	12	15	19	21	21	22	23											
1929	6	16	28	40	52	57	61	67	70												
1917	1	6	9	12	16	19	27	35	38												
1895	5	7	10	11	18	32	47	60	75	83	88	95	104	112	116	119	126	129			

TABLE IV—FEBRUARY TEMPERATURES AT KEW FOR CERTAIN YEARS

Year	Greatest departure of mean temperature from average	Year	Lowest mean minimum temperature	Year	Greatest No. of freezing days
	°F.		°F.		
1895	−11·0	1895	23·8	1947	21
1947	−10·1	1947	27·1	1895	18
1956	− 8·2	1956	27·1	1956	18
1929	− 7·3	1929	27·5	1929	14
1942	− 7·1	1942	29·1	1942	13

Table IV shows the five years with the greatest departure of mean February temperature at Kew from the 1921–50 average, the five years with the lowest mean minimum temperatures and the five years with the greatest number of freezing days since 1879. Table III indicates that 1956 had the third longest spell of freezing days during this same period in spite of breaks. From the above considerations February 1956 could be regarded as the coldest February at Kew, and most probably in south-east England during at least the last 75 yr., apart only from 1947.

The cold weather during the three years 1895, 1947 and 1956 was not confined to south-east England, but affected the whole country. Figs. 1, 2 and 3 give the distribution of absolute minimum temperatures reported during

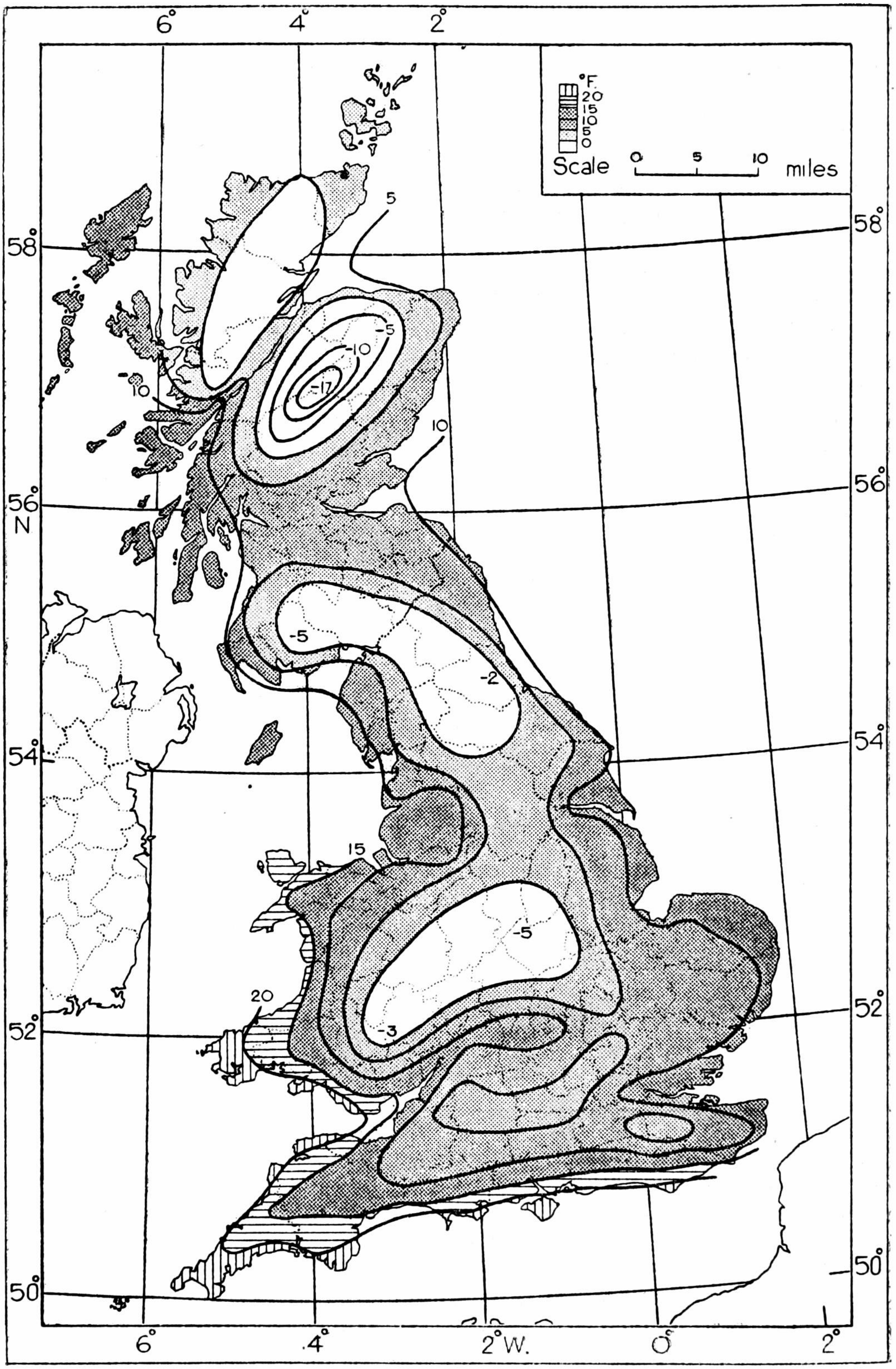


FIG. 1—DISTRIBUTION OF ABSOLUTE MINIMUM TEMPERATURES DURING FEBRUARY 1895

Temperatures are not corrected to sea level.

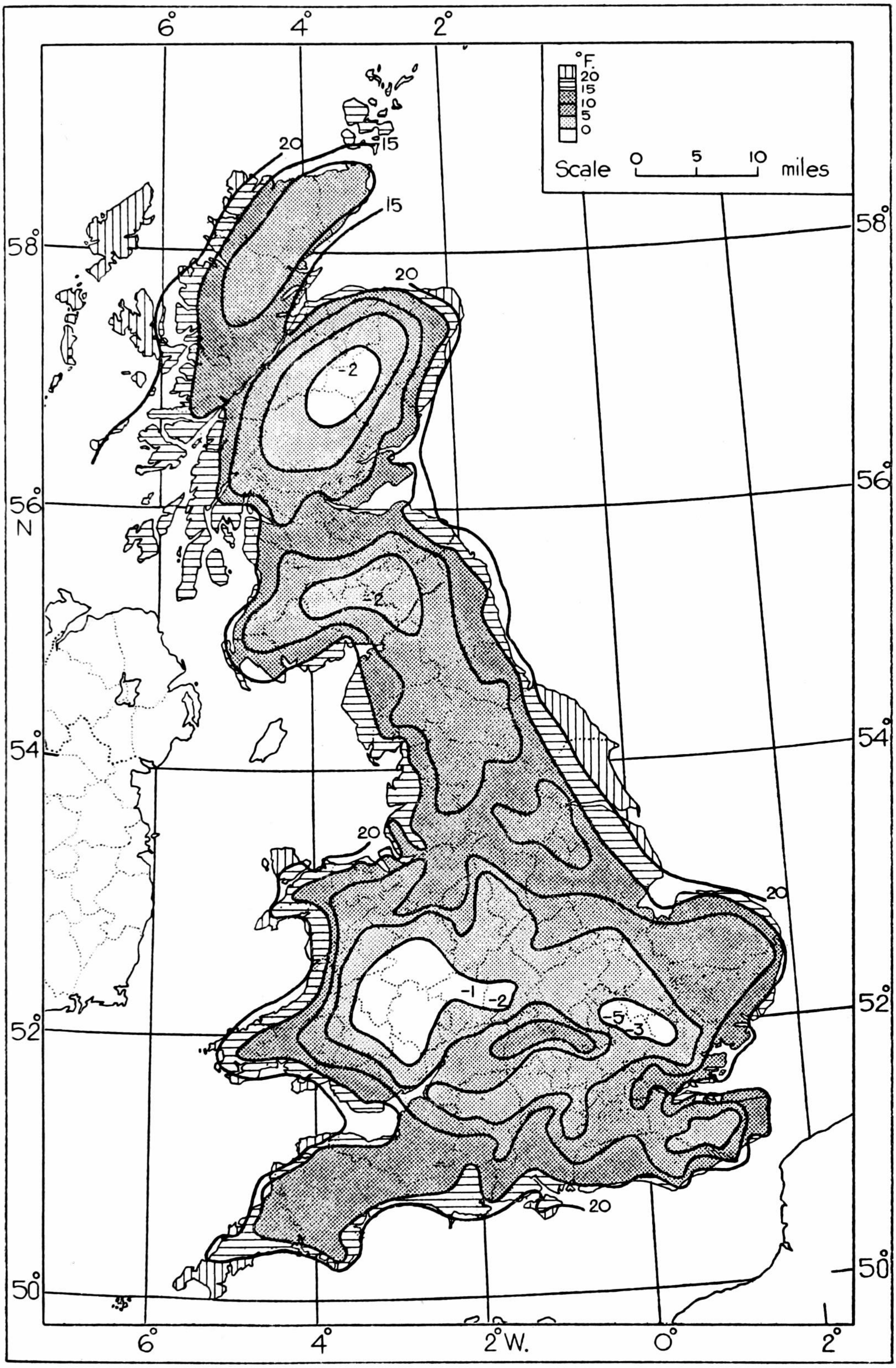


FIG. 2—DISTRIBUTION OF ABSOLUTE MINIMUM TEMPERATURES DURING FEBRUARY 1947

Temperatures are not corrected to sea level.

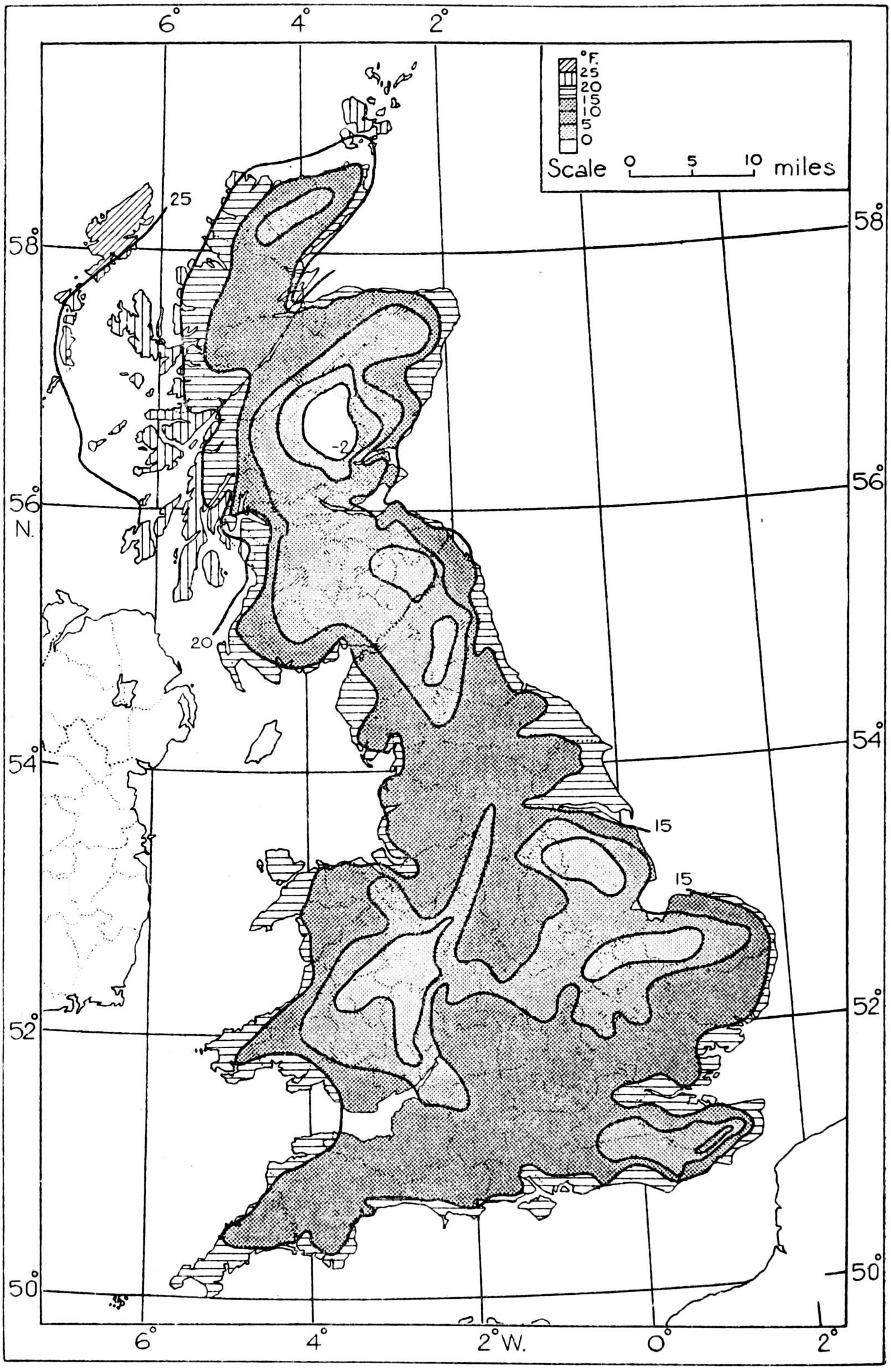


FIG. 3—DISTRIBUTION OF ABSOLUTE MINIMUM TEMPERATURES DURING FEBRUARY 1956

Temperatures are not corrected to sea level.

February of each of these three years and may be compared with the map of absolute minimum temperatures for the period 1901–1940[2] where a map of mean temperatures over the British Isles for February 1895 is also given.

In 1895 temperature fell below 0°F. over a wide area in the Midlands, northern England and Scotland; −17°F. was recorded at Braemar in Scotland. It fell below 10°F. at most places during the month except in coastal districts. During 1947 February temperature occasionally fell below 0°F. in a small area in central Wales and the west Midlands, locally around Bedfordshire and in the Cairngorms; −5°F. was recorded at Woburn, Bedfordshire. Except for coastal areas it fell extensively below 10°F. in Wales, the Midlands, East Anglia, Kent and Surrey and over most of the high ground in northern England and Scotland.

In 1956 temperature did not fall below 0°F. except locally in Scotland where −2°F. was recorded at Perth. Less than 10°F. was registered over much of the high ground north of 54½°N. and south of the Caledonian Canal, in central and southern Wales, over much of the Midlands, in Lincolnshire, Kent, Surrey and Sussex. Temperature fell below 5°F. locally in central Wales, Norfolk, Lincolnshire, the northern Pennines and in the Scottish Highlands.

Following the plan of Table IV, but this time taking England and Wales as a whole, tabulations show that the only February mean temperature since 1895 lower than that of 1956 was 1947. The same also applies to the mean minimum February temperature. It seems probable therefore that not only was February 1956 the coldest February at Kew since 1895 apart from 1947, but also in England and Wales as a whole.

The synoptic situation during the three coldest Februaries showed marked similarities. During February 1895 pressure was high over Scandinavia and decreased steadily during the first 10 days; pressure was generally low to the south-west of the British Isles. From the 12th the anticyclone over Scandinavia increased in intensity and moved steadily westward becoming centred over the North Sea on the 16th, and over the British Isles on the 18th; it then moved to the west of Ireland where it remained until the end of the month. With this pressure distribution easterly winds predominated during the first half of the month, but gradually backed to a northerly direction during the second half. From daily maps of minimum temperature it is seen that weather was most severe from February 6th to 13th[3]. The situation during February 1947 has been fully described by Douglas elsewhere in this Magazine[4], but it may be recalled that throughout most of February 1947 pressure was high over Scandinavia and was even higher around north and central Greenland and in a belt extending eastward to Siberia. The Greenland anticyclone helped to maintain easterly winds over the British Isles even after the Scandinavian anticyclone had given way. In 1956 February was dominated by easterly air streams from the continent. At times pressure was high to the west of Ireland, but twice during the month, on the 9th and 21st, anticyclones over or to the west of the British Isles, which had become detached from an extensive high pressure system over north-west Europe, formed a ridge across England as they rejoined the major continental system, bringing renewed bursts of direct continental air over the country. The lowest temperatures occurred during the first three days when air from the northern coasts of Russia was reaching this country, but temperatures were also very low from the 9th to 27th.

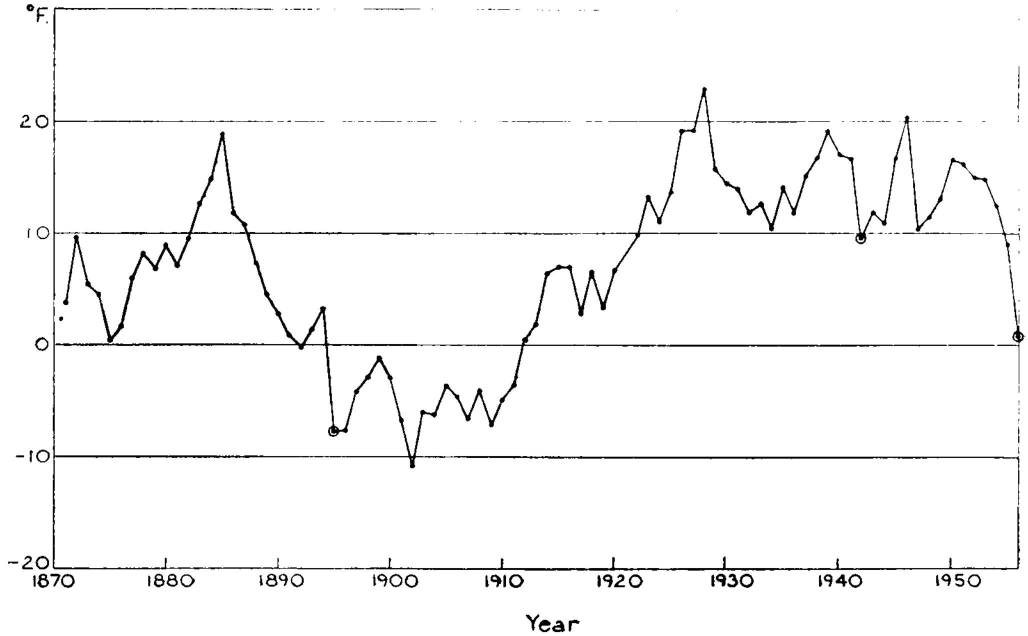


FIG. 4—ACCUMULATED DEPARTURE FROM 1871–1956 AVERAGE TEMPERATURE (40·1°F.) OF MONTHLY MEAN TEMPERATURE AT KEW DURING FEBRUARY

The values encircled show the five years with the lowest mean minimim temperatures. The five cold years include also 1929 and 1947.

The three cold Februaries were dominated by easterly winds. It was thought that as cold Februaries are associated with easterly winds, then if cold Februaries are becoming more frequent so should easterly winds. Mean February temperatures for Kew were extracted for the period 1871 to 1956, and wind directions were tabulated over as long a period as readily available, in this case 1908–1956.

Fig. 4 gives the accumulated departure of mean February temperatures at Kew from 1871 to 1956 from the mean February temperature over the whole period of 85 years. The curve, which slopes upward from left to right during a year when mean temperature was greater than the average, and downward when less, descends somewhat unevenly from a maximum value at 1885 to a minimum at 1902, ascending eventually to a second major maximum at 1928, after which, in spite of two or three secondary maxima there is a general over-all fall to 1956. This fall is very pronounced from 1953 to 1956. The five cold years referred to earlier in the text are marked in circles on the curve and it is noticeable that four of these occurred during the last 30 years. There is a striking series of cold Februaries, shown by the downward slope of the curve, from 1886 to 1895 broken only by the years 1893–4. This cold series of years is also shown by the large number of freezing days during this period in Table I; the mean minimum February temperature over these 10 years was only 32·9°F. A series of mainly warm Februaries is shown by the upward trend of the curve from 1910–28; the mean minimum temperature for these 19 Februaries was 36·6°F. and there were only 37 freezing days during this period, 16 of which occurred during the cold years 1917 and 1919. There was no very long series of warm or cold Februaries from 1928–50 but a few shorter period variations. Mean temperatures for February during the last five years have been below average and the difference from average has tended to increase progressively.

The wind tabulations consisted of listing the number of occasions when wind was observed to be blowing from each direction on an eight-point compass at 0700, 1300 and 2100 G.M.T. daily for every February from 1908 to 1956. The monthly total of winds from all directions therefore consists of 84 observations during an ordinary year and 87 during a leap year. For present purposes a general value only is required, so no correction has been made for leap years. The number of occasions winds were reported from a NE., E. or SE. direction were combined to arrive at an "index" of winds with an easterly component for each year.

For the period 1910–1928, when as previously noted the majority of Februaries had a mean temperature above the normal, the "easterly index" per annum was 17. Although there were several warm Februaries during the period 1929–56, the majority were cold; the easterly index for these 28 years was 24 per annum. The mean easterly index for the whole period 1908–1956 was 22 per annum. The difference from the mean value is even more striking if shorter periods containing only warm or cold Februaries are considered. During the periods 1910–1915 and 1920–28 each year had a February warmer than the average; the easterly index for these periods per annum was 11 and 18 respectively. On the other hand all Februaries during the periods 1929–32 and 1951–56 were colder than the average; the easterly index for these periods were 39 and 27 per annum respectively.

To sum up, it seems that since records began at Kew February 1956 was the third coldest February from nearly every point of view and also probably in England and Wales as a whole. During the last 75 years there have been an increasing number of cold Februaries since 1928 and this tendency has gone hand-in-hand with an increased frequency of winds from an easterly direction.

REFERENCES

1. BELASCO, J. E.; Freezing days in Great Britain. *Met. Mag., London,* **80,** 1951, p. 213.
2. GLASSPOOLE, J.; Variations of temperature over the British Isles. Unpublished. Copy available in Meteorological Office Library.
3. BAYARD, F. C., and MARRIOTT, W.; The frost of January and February 1895 over the British Isles. *Quart. J. R. met. Soc., London,* **21,** 1895, p. 141.
4. DOUGLAS, C. K. M.; The severe winter of 1946 to 1947. *Met. Mag., London,* **76,** 1947, p. 51.

SOME SPECIAL FEATURES OF THE CLIMATE OF ST. HELENA AND THE TRADE-WIND ZONE IN THE SOUTH ATLANTIC

By H. H. LAMB, M.A.

The Supervisor of meteorological observations on St. Helena, 16°S., 6°W. approximately, Mr. Gordon Lunn, has drawn attention to the rainfall and low temperatures registered in the twelve-month period from November 1954 to October 1955, which many local residents have described as the worst and wettest in living memory. Most of these months had below average temperatures.

The monthly totals in inches for the six rainfall stations on the island are given in the table below and the positions of these stations in relation to the island's topography are shown in Fig. 1. It will be seen in Table I that the wettest periods were February to April and June to August 1955 at most stations. February was everywhere the wettest month, closely followed by March at the high-level stations on all sides of the main ridge; July was the second wettest month at two stations at medium levels on the northern side,

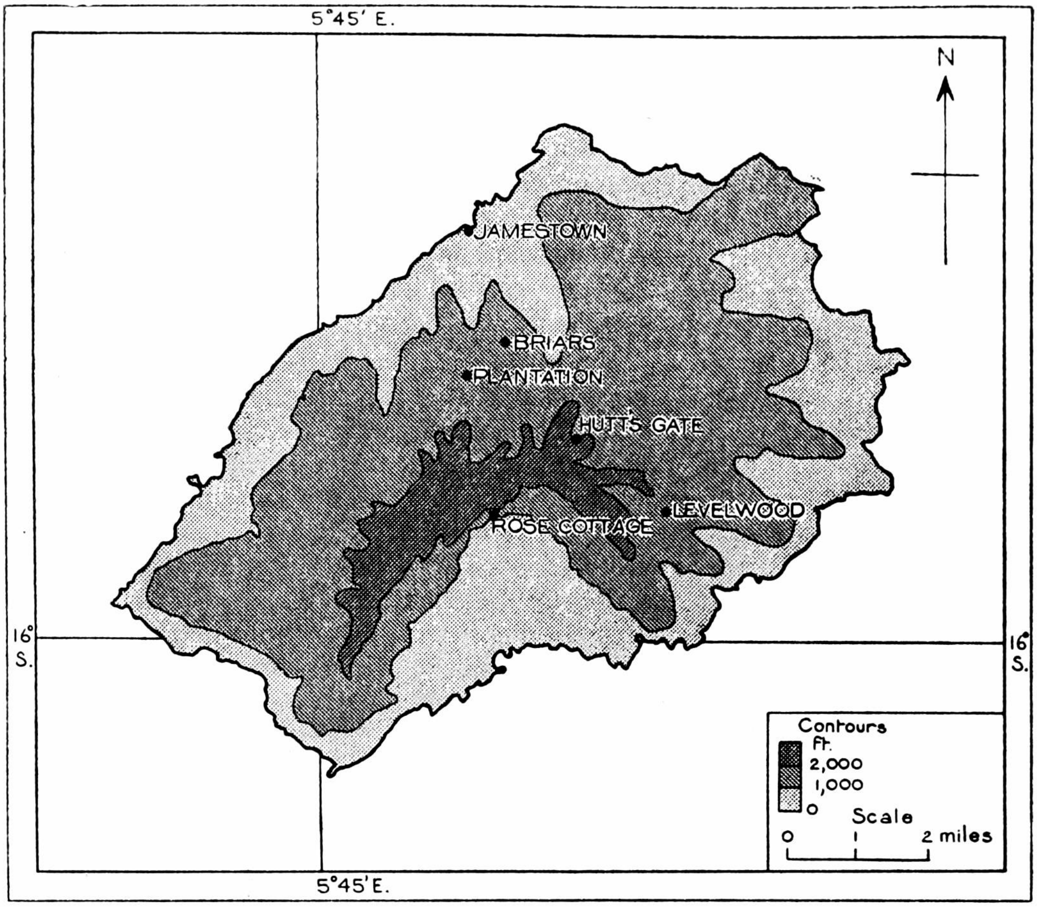


FIG. 1—ST. HELENA ISLAND SHOWING POSITION OF RAINFALL STATIONS IN RELATION TO TOPOGRAPHY

Plantation and Briars, whilst the August rainfall was outstanding only at the two stations with an eastern or north-eastern aspect, especially Levelwood.

TABLE I—RAINFALL IN INCHES AT ST. HELENA

Position and height above sea level	Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Rose Cottage 2,030 ft.	1954											1·5	1·7	
	1955	0·8	9·4	7·0	6·0	3·8	5·7	6·2	5·3	2·4	3·5			53·3
Hutt's Gate 2,060 ft.	1954											1·1	1·8	
	1955	0·5	6·4	5·2	4·0	3·1	3·7	4·0	4·0	2·4	2·2			38·4
Plantation 1,800 ft.	1954											0·8	1·5	
	1955	0·6	5·7	4·6	4·5	3·1	3·9	5·1	4·3	1·4	2·2			37·7
Levelwood 1,400 ft.	1954											0·9	1·3	
	1955	0·6	4·9	4·0	3·1	2·0	2·7	3·2	3·8	1·8	2·5			30·8
Briars 900 ft.	1954											0·5	0·6	
	1955	0·1	4·3	2·6	3·1	1·3	3·4	3·7	3·0	0·8	1·1			24·5
Jamestown 40 ft.	1954											0·2	0·1	
	1955	0·0	2·5	0·7	1·6	1·1	1·6	1·4	0·6	0·1	0·2			10·1

St. Helena is usually described as being in the heart of the SE. trade-wind, which blows so steadily that in the normal year Jamestown, the capital, has 71 per cent. SE., 18 per cent. S. and 8 per cent. E. winds at the midday observation. Actually the climate of the island and, to some extent, that of the trade-wind belt of the South Atlantic in general, have remarkable peculiarities, which have so far received little notice in meteorological literature.

Jamestown itself has very much a leeside, sheltered situation and enjoys an average rainfall of only five to six inches a year. The other stations for which we have records over several years all show average yearly totals ranging from 32 to 44 in. Examination of the records shows that in reality a good many years have been about as wet as, or wetter than, 1954. (Mr. Lunn, the present Supervisor, has only been three years in the island, and 1952 and 1953 were relatively dry.) Hutt's Gate flax mill at about 2,000 ft., for which records are available for 31 yr. since 1925, with an average rainfall of 32·1 in., has four times measured over 40 in. in the year (cf. 1954, 36·8 in.): the wettest year was 1950 with 43·65 in.; in 1939 the total was 39·6 in., followed by 41·2 in. in 1940. The driest years, 1933 and 1946, had 22·4 and 22·8 in. respectively.

The moist, equable climate of St. Helena may explain an entry on the climatic return for October 1902 by Mr. J. Homagee, observer and police magistrate: "A splendid climate for consumptives . . . two gentlemen here . . . in a critical condition when they arrived—one 22 years ago and the other three years since—are now quite recovered . . . no sign of their former illness. . . ."

More remarkable than the rainfall amounts are the average numbers of days with over 0·1 mm. rain—234 a year at Hutt's Gate. The same station has an average of only two "clear days" a year and 290 "cloudy (overcast) days". Even Jamestown gets 128 cloudy (overcast) days in the average year. The figures for Hutt's Gate are comparable with the dullest skies of the sub-Antarctic ocean and those for Jamestown compare with the Atlantic coast of Nova Scotia.

Even more surprising, for a position in the main trade-wind stream in 16°S., is the fact, which partly explains the cloudiness figures, that there is a good deal of altostratus. Over a sample period from November 1946 to April 1947 33 per cent. of the observations from St. Helena included altostratus, 39 per cent. cumulus or cumulonimbus and 36 per cent. stratocumulus. Sometimes combinations of these cloud types occurred in the same report. Two ships with trained meteorologists on board, passing between St. Helena and the African coast during this period, had a similar experience and confirmed the existence of fairly extensive altostratus; the surface wind directions were more variable than at St. Helena.

The conclusion, supported by southern-hemisphere weather analysis, that the trade-wind zone of the South Atlantic is troubled by a good deal of frontal activity, represented by the trailing cold fronts of cold outbreaks from the Weddell Sea and elsewhere in the Southern Ocean is inescapable. In this connexion reference may usefully be made to some interesting work, partly unpublished, by Instructor Commander G. P. Britton, R.N., formerly in charge of investigational work at the Royal Naval Weather Centre, Simonstown, South Africa. Britton found correlations which appear to be significant:

(i) between pressure at Tristan da Cunha and pressure at Cape Town two and a half days later;

(ii) between cold-front passages northwards over South Georgia and Tristan da Cunha and outbursts of rainfall in the rainy season on the Gold Coast, about 5°N., approximately six days later.

The penetration northwards right into the equatorial zone of the cold fronts of the South Atlantic is doubtless a complementary phenomenon to the position of the intertropical convergence always north of the equator in this sector and the occurrence of no tropical storms in the South Atlantic. Similar analyses of the general weather situation over the South Atlantic and eastern South America, with cold fronts from the south ultimately crossing the equator, were published some years ago by the Pan American Airways system, Rio de Janeiro. In the northern winter cold fronts from the north were similarly shown crossing the equator over Brazil.

Dr. W. Schmitt of the South African Weather Bureau, whose experience over six years of the Southern Hemisphere Analysis Project is of the greatest value in this field, has kindly read over these pages. He comments that St. Helena, and with it a wide area to the east and south-east, seems frequently affected by frontal weather from former cold fronts moving up to the Cape of Good Hope and passing inland over South Africa as far as a line south-eastwards from about 25°S. on the west coast. On passing farther inland over the continent beyond this line these fronts become less distinct, being involved in thundery convection in the southern summer, but evidently retain their identity and frontal slope in the trades over the ocean. In some cases, with a cold wave of greater amplitude than usual, a cut-off cold low develops near St. Helena or the region south of it: the island is then likely to receive rains of extended duration from dense medium cloud. It may be of interest therefore to add that at Hutt's Gate, St. Helena July and August 1955 were the coldest July and August in 21 years of record, 1935–55: the minimum temperature of 50°F. on August 20, 1955 at Hutt's Gate was the absolute lowest value so far reported from the island.

FRONTS IN THE INTERTROPICAL CONVERGENCE ZONE: AN OBSERVER'S LOG AND SOME REFLECTIONS THEREUPON

By H. H. LAMB, M.A.

Publication of the following extracts from the weather diary of the whaling ship *Balaena's* southward voyage to Antarctic waters in 1946 may serve as a contribution to our understanding of the intermittent frontal activity in the intertropical convergence. The writer's attention has been turned again to these observations, following the recent realization that similar phenomena identifiable in the South Atlantic are common enough to make altostratus cloud a prominent characteristic of the extraordinary climate of St. Helena[1] and of much of the zone of SE. trade winds.

By pure chance the *Balaena's* southward voyage direct to the Canary Islands and on towards Cape Town was so timed as to keep more or less continuously in view the cloud system (see photographs in the centre of this magazine) associated with a cold front which passed the ship off Finisterre, north-west Spain on October 17, 1946, until the ship apparently passed through it again in the intertropical convergence about 8½°N. on October 26. The front passed through a quiescent phase when it became for a while quasi-stationary in the belt of high pressure near the Canary Islands, but its activity and the depth of cloud development increased again as it moved on south.

The general synoptic situation over the given sector of the northern hemisphere is here illustrated in Figs. 1–4 by the analysis taken from the

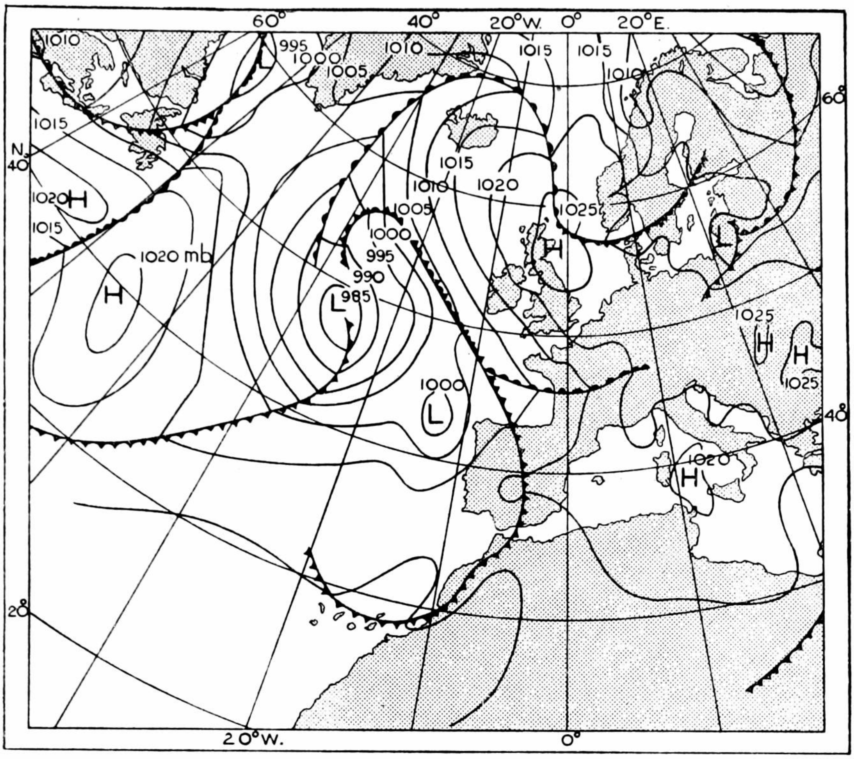


FIG. 1—SYNOPTIC CHART 1800 G.M.T. OCTOBER 17, 1946

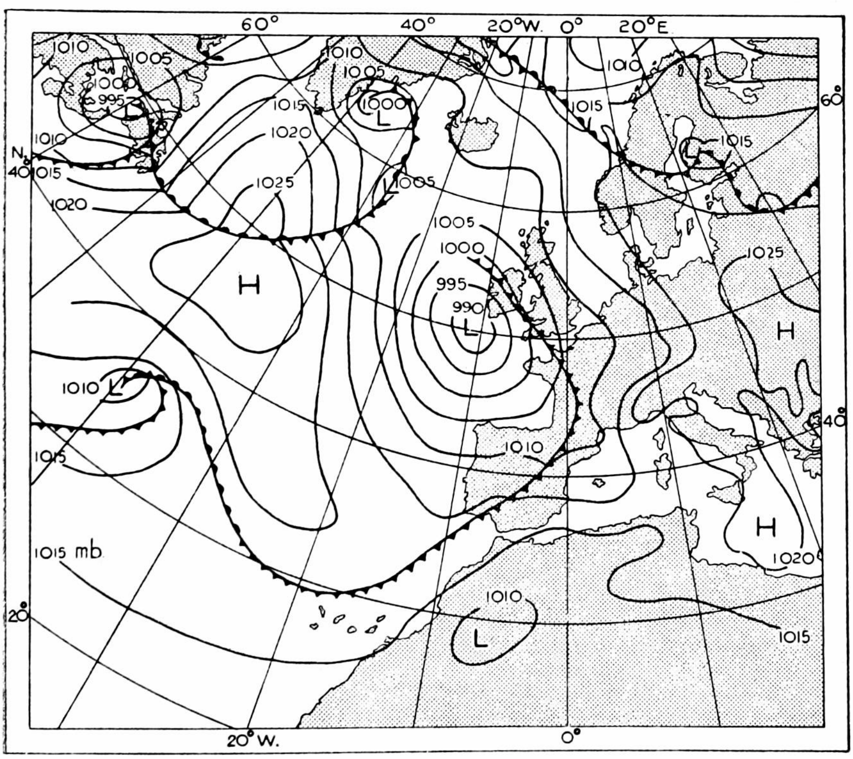


FIG. 2—SYNOPTIC CHART 1800 G.M.T. OCTOBER 19, 1946

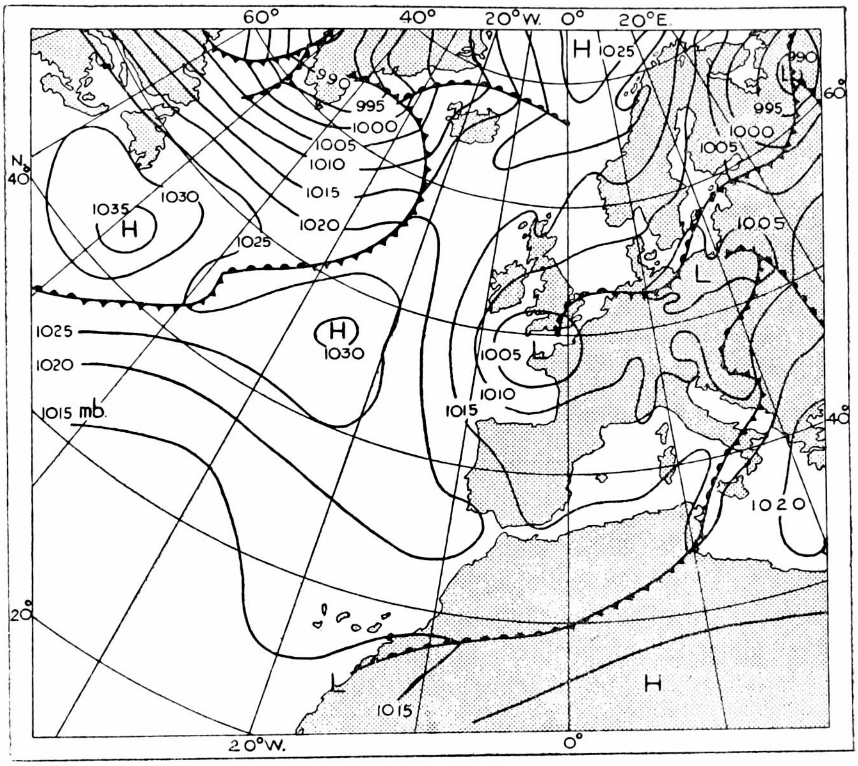


FIG. 3—SYNOPTIC CHART 1800 G.M.T. OCTOBER 21, 1946

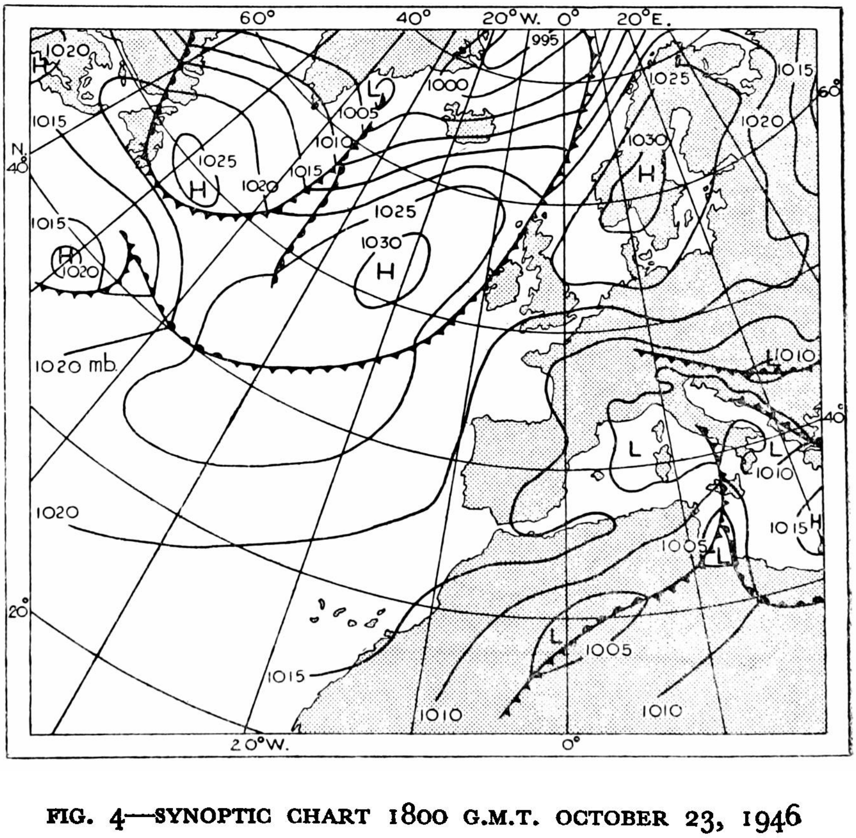


FIG. 4—SYNOPTIC CHART 1800 G.M.T. OCTOBER 23, 1946

north-west German daily weather reports, Hamburg for the evenings of October 17, 19, 21 and 23, 1946. A secondary cold front, shown on the German charts, gave drizzly rain as it overtook the *Balaena* on the night of October 18–19; but this was only a minor complication since the secondary front was again encountered by the *Balaena* approaching the Canary Islands on the morning of the 20th, just north of the now quasi-stationary main cold front with which it later substantially coalesced in the neighbourhood of the Islands.

The following are extracts from the original weather log, written on or about the days in question:—

17.10.46 0800 G.M.T., off Finisterre.

Sky clearing from the west after 4–5 hr. rain, which was sometimes moderate to heavy. Banded As Ac and Fc over land in Spain, the cloud systems orientated north–south approximately. Coastal mountains visible up to skyline . . . Wind SW. force 3.

17.10.46 Forenoon and early afternoon, Finisterre to 42°N. 97°W.

Sky clear most of forenoon apart from retreating frontal cloud-sheet and big Cu on eastern horizon and advancing As Ac and dense Ci coming up from western horizon. Wind backs to S. by E. and soon becomes force 7, later force 8–9.

17.10.46 1600–2000 G.M.T., 41·5°N. 9·7°W. at 1800 G.M.T.

Rain of slight intensity began about 1600 G.M.T. and lasted 3–4 hr. . . . much wind. By 1800 wind had veered and dropped to S. force 6 and from then onward continued gradually veering and dropping all through the following day. (Post-depressional trough).

18.10.46 0030 G.M.T., 40·5°N. 9·7°W. off Portugal.

Post-frontal sky, frontal cloud belt lying to the east: 9/10 As Ac . . . height judged about 9,000 ft. probably indicating the depth of the post-frontal cold air stream.

18.10.46 1200 G.M.T., 38·0°N. 10·5°W.

All day we seem to be skirting the frontal rain belt which lies not far to the east of the ship over the approaches to Gibraltar. Three distinct, though brief showers (10 min. duration) coming from the medium cloud-sheet fell on the ship and rain was in sight . . .till about 1600 . . .

18.10.46 1800 G.M.T., 36·7°N. 11·2°W.

Wind now SW. by W. force 3 to 4 . . . apparent that the frontal cloud sheet Ac Sc getting gradually lower and of more anticyclonic appearance. It remained 9/10 to 10/10 all day, orientation continuous with that observed with the frontal rainbelt on 17th . . .

19.10.46 0000 G.M.T., 35·7°N. 11·7°W.

Wind has veered much more rapidly during the night, and the sky, which became 10/10 at midnight with drizzly rain, now shows a clearing segment in the north-west. . . .

The Sc is still lower this morning (attributable to shallower cold air mass) . . . the ceiling slopes visibly upwards from about 1,600 ft. in the south-east (nearer the front, where it looks . . . thicker cloud and gloomy) to not lower than 3,000 ft. at the cloud edge some miles north-west of the ship. (Noted that the cloud sheet became very thin and anticyclonic looking for a time, though the north-west edge remained clear-cut.)

19.10.46 1800 G.M.T., 32°N. 13·7°W.

Renewed spreading of the Sc. from west and south-west suggests a wave or ripple on the weak, trailing front. By midnight the sky became almost 10/10 covered.

20.10.46 0700 G.M.T., 29·3°N. 15·0°W.

By morning the frontal Sc cloud sheet had narrowed again, and the edge moved away south, ahead of the ship, so that the sky is only about 4/10 covered. We overtook this cloud belt about 0700, and passed through a light shower. At this time the sky had decidedly the appearance of a weak front lying about east north-east to west south-west. . . . The wind veered more and more to NE. or ENE. force 2 to 3 as the front was approached. After passing south of the shower line the wind became very temporarily SE. force 1, then settled down to ENE. force 2 again. We entered a narrow belt of clear sky and saw ahead another belt of similar Sc base estimated 3,300 ft. tops 5,000–6,000 ft., orientated parallel with the previous cloud belt which lay only a few miles north of it. There was also big Cu, base 2,800 ft. penetrating right through the southern Sc system and with the peaks of the Canary Islands embedded. . . .

20.10.46 1200 G.M.T., Las Palmas, Gran Canaria (arrival).

The two Sc cloud belts with clear-cut edges continued westwards over the ocean as far as the eye could see. The height of the thin Sc appears to indicate more or less the depth of the post-frontal cold air stream hereabouts as 3,000–5,000 ft. as against 10,000–12,000 ft. off the Portuguese coast on the 17th–18th. (The cloud-sheet had gone through some variations of development and was at this stage relatively weak or quiescent but still thick enough to prevent the sun being visible, except in the middle of the day.)

The ship stayed in port at Las Palmas all day on the 21st. The cloud systems remained quasi-stationary over the islands and with little change of character, apart from slight drizzle in the night of the 20th–21st and a gradual lifting of the Sc cloud base on the morning of the 21st to perhaps 4,000 ft. The orientation of the cloud structure and edges gradually swung to east-south-east to west-north-west. A segment of clear sky was visible throughout along the northern horizon. About midday on the 21st the whole cloud system, still discernibly in two parallel belts though the separation was by this time quite small, began to move south again. The sky over the Canary Islands largely cleared from the north at sunset, first revealing the great mass of Teneriffe (12,100 ft.) in the guise of a great mountain apparently based on the stratocumulus. The surface wind picked up from NNE. to force 3.

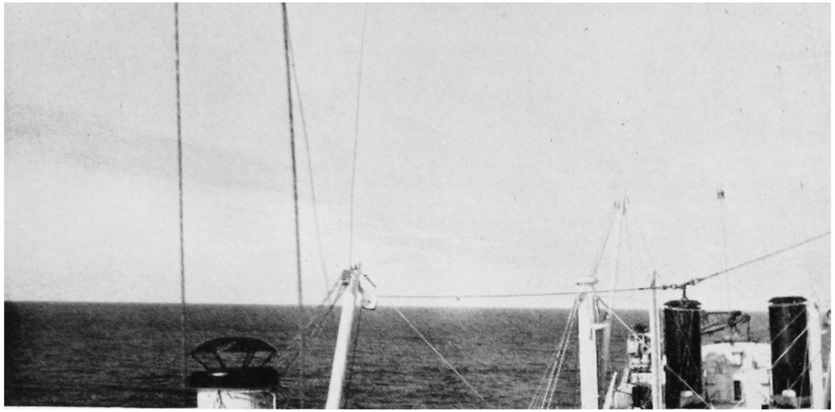
On the 22nd the WH. F. *Balaena* sailed from Las Palmas for the southward voyage at first light. The Sc. cloud sheet, its base now at 4,500–5,000 ft., was still in view and still lay about the hills of the western islands in the Canaries group. The orientation of the cloud edge had swung to about north-north-west to south-south-east (indicating greatest southward advance of the system in longitudes east of the ship near the coast of Africa and beyond).

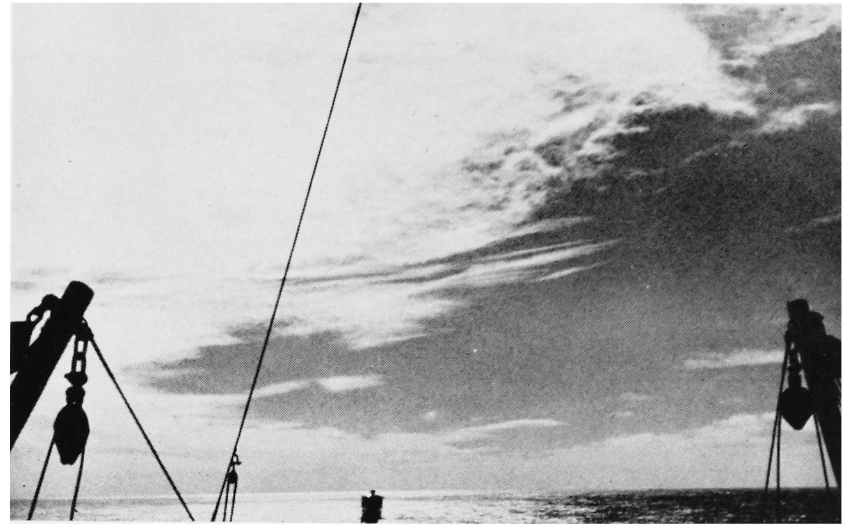
At 1800 G.M.T. on the 22nd the ship had reached 26·2°N. 15·8°W., the Sc cloud sheet was still in view as a north–south line near the western horizon and had lifted to perhaps 6,000–7,000 ft. The question of whether this cloud edge now represented the old frontal surface or some other effect parallel to the African coast line might now be open to argument, but could be gainsaid by historical continuity over the past 5–6 days and the fact that parallelism with the African coast was a phase of its history which had only just come about. Moreover, the cloud edge must have been over 200 miles from the coast.

During the 23rd, while the ship steamed south as far as 20°N. 18°W., the Sc system was for some time still visible on the western horizon, but becoming more remote. Later Ci and Cs came into view across the south-eastern, then the southern and western segments of the sky, and gradually became general and dense in places on the 24th. There was no other cloud to note all day, presumably because the relatively cold upwelling water near this part of the African coast inhibits convection. The water was coolest when the ship was nearest the African coast, and the breeze freshened to N. force 5.

At midday on the 25th the ship had reached 12·3°N. 17·6°W., the breeze had veered and dropped to NE. force 3 and the sky contained only abundant Ci and Cs along the south-eastern and western horizons and some more in the north. We had been out of the zone of cold water since midday on the 24th when the sea-surface temperature had risen rapidly to over 80°F. Still no convection cloud appeared, until a tremendous line-squall cloud belt of Cb and Ac stretching from horizon to horizon which was passed about 0500 G.M.T. on the 26th near 9°N. 15½°W. Lightning had been seen ahead of the ship from 2000 G.M.T. on the 25th.

The orientation of this Cb system, which was here south-east to north-west, was consistent with the theory that it represented maximum southward and south-westward advance of the same cloud system which had been in view from the *Balaena* for seven days, from the 17th to the 23rd inclusive, when it got too far ahead of the ship in 20–22°N. At that time the cloud edge consisted of stratocumulus and altocumulus, which had been getting steadily higher since its advance south from the Canary Islands. It is reasonable to suppose that a conversion of the cloud system to cumulus and cumulonimbus forms, though still associated with altocumulus, would take place as it advanced over much warmer waters: additionally, the advance out of the subtropical region of relatively high pressure would also favour increasing vertical motion, as long as the convergent system of surface breezes associated with the front persisted. Extrapolation of the front still shown on the German charts over the western Sahara, and active over Algeria and the western Mediterranean on the 24th–26th, also suggests that its continuation should lie very close to the intertropical convergence off the west coast of Africa near 10°N. on the 26th.





Top left—EDGE OF WEAK FRONTAL CLOUD-SHEET STRATOCUMULUS IN 32–33°N. ABOUT 13°W.

Some 200 miles east of Madeira on October 19, 1946. Photograph looking north, showing clearance, seen as pale clear sky in the picture, approaching from the north-west. The cloud-sheet overhead appears dark in this picture.

Top right—WEAK FRONTAL CLOUD-SHEET IN 32–33°N., ABOUT 13°W.

The afternoon of October 19, 1946: photograph looking south-west. The segment of clear sky appears dark and the thin edge of the cloud system brilliantly sunlit in this picture. The clearing edge has reached the zenith over the ship and the continuous, weak frontal cloud system is seen ahead of the ship along an arc from the eastern to the southern horizon.

Bottom left—QUIESCENT FRONTAL CLOUD-SHEET OVER THE CANARY ISLANDS

Northern edge of the main frontal cloud system chiefly stratocumulus but some cumulus over the islands, orientated east-north-east to west-south-west over the Canary Islands, October 20, 1946 about 0900 G.M.T. Photograph looking south, view approaching Gran Canaria, about 28° N. 15½° W. The dark area overhead is clear sky.

(see p. 76)

[*To face p. 80*

North-west

North-east

North-east South-east

FRONT IN THE INTERTROPICAL CONVERGENCE

Frontal cloud line largely cumulus and cumulonimbus but also much cirrostratus near $8\frac{1}{2}$°N. $15\frac{1}{2}$°W., 150 miles off Freetown, about 0900 G.M.T. October 26, 1946. Panoramic view between north-west and south-east, the right-hand side of the top picture and the left-hand side of the bottom picture facing about north-east: the ship's heading was by now south-east and the wake is seen to the north-west near the left-hand margin of the top picture. This is believed to be the same cloud system as that shown in the first three photographs, having acquired greater vertical development after passing from the latitude of subtropical high pressure into the intertropical convergence. The actual pressure fall was about 8–10 mb.

(see p. 76)

SECOND FRONT IN THE INTERTROPICAL CONVERGENCE

Photograph looking south-west about the same time as the previous panorama was taken, showing the base of a second cloud line, also largely cumulus and cumulonimbus, in the intertropical convergence near 8½°N., 15½°W. at 0900 G.M.T. on October 26, 1956. The ship was between these two cloud systems at this time. Both cloud systems were giving moderate rain at some points along their length. Perspective and foreshortening made it hard to judge the curvature of these roughly parallel lines of cloud, but they seemed to converge towards the west-north-west; in the other direction they separated towards north-east and south-east. The southern system appears therefore to have had the characteristic curvature of a front advancing north-eastwards in the southern hemisphere.

(see p. 76)

Examination of the charts for north-west Africa leads to the conclusion that this is actually a common situation. Such situations over north Africa were described as typical of the region by Petitjean in 1932[2].

Even more thought provoking is the observation in the *Balaena* weather log on October 26, 1946:—

At 0900 G.M.T. in approximately 8½°N. 15½°W. the ship lay between two well marked cloud lines, each orientated about south-east–north-west and probably some 10–15 miles apart, consisting of Cu and Cb base 1,500 ft., and occasionally 500–800 ft., tops of great height . . . associated Ci Cs plus altocumulus cumulogenitus in small amounts. One very interesting feature of these cloud lines was that their respective (slight) curvatures were in opposite senses: perspective suggested the two systems converging towards the west-north-west . . . but to the east, the eye could see them diverging more and more from each other, as if the northern cloud line led off into the interior of the Sahara somewhere east (and eventually north-east), whilst the southern system led off somewhere to the south-east and south.

In other words, the more southerly cloud system had the form and orientation of a frontal cloud system which might have advanced from the southern hemisphere[1].

After passing through the second cloud and thunder-shower system, the *Balaena* encountered southerly breezes force 2–3, which gradually strengthened over several days into the south-easterly trade wind of the South Atlantic. In this instance, there was, as a matter of fact, a good deal of altostratus in the South-Atlantic trade-wind zone and the observer had the impression again of skirting a quasi-stationary frontal system to the eastward.

It seems likely that continuity of the cloud systems advancing towards the intertropical convergence from higher latitudes in the northern and southern hemispheres would be best preserved over the oceans, though the cloud development necessarily passes through various vicissitudes on the way, as recorded in this case where observation was almost continuous. Such observations are therefore easiest made over the oceans and especially over the eastern sides of the oceans; they may nevertheless have some relevance in other sectors—for altostratus–altocumulus cloud sheets associated with cold fronts from the Mediterranean have been traced at least as far as Kufra oasis (24°N., 23°E.) in winter. The line of convergence in the surface winds sometimes survives after all frontal clouds have disappeared over the Sahara, to give line squalls and dust storms, haboobs, in the northern Sudan. Abyssinia and the eastern Sudan experience similar sand storms[3] in the northern summer with line squalls coming from the south and south-east.

The writer has examined the logs of two British private expeditions under F. Rodd to the Sahara for further evidence bearing upon the type of phenomena observed over the ocean.

These expeditions went from Kano and Katsina about 13°N. in the northern part of British Nigeria crossing the intertropical convergence zone to Agadez and Auderas (17 to 18°N.), operating northwards between longitudes 7 and 9°E., in the summers of 1922 and 1927. The parties set out in May, reached Agadez between mid July and early August and stayed north of 17°N. until after the end of the rainy season, working as far north as Iferuan (19°N.) by October or November before returning on different routes south to Nigeria or west across the desert and bush to the Niger river.

During the rainy season pretty regular daily convection cloud rains were experienced both north and south of the intertropical convergence, these cloud systems invariably travelling from approximately east to west and accompanied by gusty or squally easterly winds at the surface, though often preceded by westerly breezes in the morning. The regular movement of the convection clouds from east is no doubt explained by the easterly thermal wind south of the Sahara. Care is needed in interpreting these weather diaries, since the traveller has not always distinguished between the direction of movement of clouds and the direction of advance of cloud systems. On a certain number of days however systems of a different kind from the purely convection cloud development can be confidently identified: these systems generally covered the sky for periods ranging from some hours to a couple of days with altostratus and sometimes also altocumulus often described as high stratus and stratocumulus; sometimes the sky became covered with cirrocumulus. These cloud belts, which were commonly but not in all cases, accompanied by rain, appear to have passed over from south to south-west or from north according as the expeditions were south or north of the intertropical convergence. The behaviour of the surface wind in relation to the latter type of system was very much like a frontal change as we know it in other latitudes: thus after variable breezes on May 7–9, 1922 near 14°N., when the sky was overcast for a prolonged period, a fresh SW. breeze set in and the sky soon began to clear from south and south-west. The humidity rose, as it commonly does in Africa with the arrival of air that has had a shorter track from the sea. Similarly at Auderas (17½°N.) on August 8, 12, 19, 22 and 31, 1922, cloud systems passing over from north to south were preceded by light, mainly W'ly to NW'ly breezes which shifted to NE. and strengthened as the system passed. The identification with a tongue of cold air from the northern temperate zone is particularly clear, from the North Atlantic and Mediterranean analysis on the sequence of United States Weather Bureau Historical Weather Maps, in the case at the end of August; and the expedition's observer in 17½°N. was struck by the fact that the cirrocumulus was moving from the west on August 31 and September 2, 1922, a very rare occurrence, although on one or two other occasions the usual easterly current at medium and high cloud levels was absent and the cirrocumulus reported to be stationary.

The experiences of the 1927 expedition were quite similar. In some cases the systems of continuous layer cloud were mentioned as coming up on an arc across the whole southern or northern horizon.

The expeditions were travelling north during the period of northward advance of the intertropical convergence in May–July, but seem to have passed finally north of it about June 1, 1922 near 14°N. and about June 18, 1927 near 15°N. Before these dates all but one or two of the occasional systems of high stratiform cloud came up from the south; afterwards all the systems of this type which actually passed right over the expeditions came from the north. Once, near 17°N. on July 9, 1927, a cirrocumulus system approached from the south and withdrew again, and on one other occasion, August 30, 1927, near 17½°N. a rain belt approached from the south-west and slowly withdrew again. Diurnal convection rains became a regular occurrence in late July, August and early September in the mountain country near Agadez and Auderas. From late September until mid-November there were mostly clear skies, with surface winds from between E. and N. heavily predominant; in this period the only rainfall was with continuous cloud belts which passed from north to south over the region.

The possibility suggests itself that, over the oceans at least, the phases of full frontal activity in the so-called permanent intertropical front may occur when still organized frontal systems from higher latitudes have freshly come into the intertropical convergence zone. Cold fronts advancing northwards right across the equator have also been suggested by Forsdyke[4] near the east coast of Africa and a recent note[5] records similar events in Ceylon. Very slight air-mass differences, if any, can survive to this point and the frontal activity probably dies down at some stage when vertical convection has achieved sufficient mixing; though, if, independently a temporary weakening of the trade-wind streams and of the resulting convergence in the intertropical zone between the circulations of the two hemispheres should occur, this would also be expected to result in a decline or cessation of activity. Such a weakening would normally precede the advance of each further frontal disturbance line from higher latitudes.

On the return voyage in April–May 1947, the *Balaena* encountered quite a different phase of developments in the intertropical zone.

At several points in the trade winds of the South Atlantic the ship overtook several belts of light showers, orientated west-north-west to east-south-east across her course north-north-west from Cape Town, though typical trade-wind cumulus (growing bigger towards the equator) was the more prevalent condition. The last shower belt was passed i.e. overtaken, near 3°S. on April 30, followed by a typical frontal wind shift to WNW. force 2 which lasted for several miles north of the cloud line. Farther north the light S'ly breeze was gradually resumed. Over the ensuing two days WH. F. *Balaena* passed through the doldrums in fair weather with no front detectable; the light breeze gradually and continuously veered through SW., W. and NW. to become NNE. by midday May 2, 1947 near 7°N. 14°W. under skies that were quite cloudless apart from a thin veil of cirrostratus. The weather remained fine until a 60–80 miles wide belt of dense cirrus–cirrostratus orientated north-north-east to south-south-west was passed near 21°N. 18°W. on the 5th. Another more fully developed cloud system orientated east-north-east to west-south-west was encountered near the Canary Islands with appearance of light orographic rain on the islands.

The return voyage thus afforded an illustration of the case in which no frontal activity exists in the intertropical convergence zone. At such times the name intertropical front is really inapplicable and seems best avoided, since the lack of activity appears to be accompanied by a uniform air mass: in a word, there is nothing there.

There seems no difficulty in adapting our understanding of the trade winds[6] to take account of the observations presented in this article. As long ago as the early 1890's, Meinardus[7] had noticed from minute analysis of the sailing ships' observations in the Indian Ocean for the years 1885–1890 the essentially frontal character of the weather in the intertropical convergence, even distinguishing cases in which there were two, one and no frontal lines in the equatorial zone; he also stressed the occurrence of light variable or westerly wind components immediately beyond the front (*sic*) of the main trade-wind stream, these light westerlies occurring regardless of whether the front had crossed the equator or not. The only element which may be new in the observations here presented is the suggestion of historical continuity and movement of fronts of middle latitudes into the convergence zone from either side and towards one another, so that the precise latitude in which Meinardus's and Flohn's equatorial westerlies occur must be subject to continual variation. Flohn[6] actually presents the observations of a Japanese whaler crossing the intertropical convergence near 153°E. i.e. in Melanesia, in November 1947, in which apparently four fronts with wind shifts, cumulonimbus activity and sometimes altostratus were passed between 5°N. and 9°S. Two of these frontal lines were picked out as the northern and southern intertropical convergences, presumably because these two marked off the division of winds reasonably called part of the trade-wind streams from winds with pronounced westerly components on the equatorward side. Flohn identifies the control of the equatorial westerlies, which appear to be quasi-geostrophic at least with $\phi > 5°$, with events which produce cyclonic vorticity in the required zone. He also points to the prevalence of uplift weather phenomena in the westerly air, particularly at the front, rather than in the equator-ward moving trade-wind stream itself. This weather distribution doubtless involves a latitude effect of the Coriolis parameter. We may write the gradient wind equation, considering for simplicity straight meridional flow, with velocity constant,

$$\frac{1}{\rho}\frac{dp}{dx} = 2v\omega \sin\phi + A ,$$

where ρ is air density, dp/dx the pressure gradient, v the wind velocity, ω the angular velocity of the rotating earth, ϕ the latitude and A represents the accelerations due to other forces. Other things being equal, the gradient wind should increase as $\sin\phi$ decreases. The rate of change of $\sin\phi$ with latitude increases towards the equator. Air streams moving at a steady speed towards the equator will be too slow for the pressure gradient and there must be a general tendency for lateral spreading and subsidence in them, whereas air which moves away from the equator tends to move too fast for the pressure gradient with general horizontal convergence and vertical expansion.

The implied explanations of the equatorial rains are far removed from the older theoretical conception of direct association with the zone of maximum solar heating; Flohn believes that the trade winds are in fact driven towards the intertropical convergence by the subtropical anticyclones. The intertropical convergence is then an indirect result of the organized general circulation which produces subtropical anticyclones. From this viewpoint it seems inevitable that much of the activity in the intertropical convergence should be related to systems driven into it from outside and that, in particular, each time a subtropical anticyclone cell is rejuvenated by the arrival of a former polar anticyclone from middle or higher latitudes a cold front will be pushed towards the equator with a fresh impulse in the trade-wind stream.

REFERENCES

1. LAMB, H. H.; Some special features of the climate of St. Helena and the trade-wind zone in the South Atlantic. *Met. Mag., London*, **86**, 1957, p. 73.
2. PETITJEAN, L.; La frontologie en Afrique du Nord. *Beitr. Phys. frei. Atmos., Leipzig*, **19**, 1932, p. 163.
3. FLEMING, J.; Sandstorms in the Sudan. *Met. Mag., London*, **82**, 1953, p. 26.
4. FORSDYKE, A. G.; Synoptic analysis in the western Indian Ocean. *Mem. Brit. E. Afr. met. Serv., Nairobi*, **2**, No. 3, 1944.
5. JAYAMAHA, G. S.; A synoptic analysis of Ceylon weather. *Weather, London*, **11**, 1956, p. 10.
6. FLOHN, H.; Wilhelm Meinardus und die Revision unserer Vorstellungen von der atmosphärischen Zirkulation. *Z. Met., Berlin*, **7**, 1953, p. 97.
7. MEINARDUS, W.; Beitrage zur Kenntnis der klimatischen Verhältnisse des nordöstlichen Theils des Indischen Ozeans. *Aus d. Arch. dtsch. Seew., Hamburg*, **16**, No. 7, 1893.

METEOROLOGICAL OFFICE DISCUSSION

Slant visibility

The discussion held on Monday, November 19, 1956, at the Royal Society of Arts was opened by Mr. R. P. W. Lewis and Dr. R. Frith.

Mr. Lewis began by defining slant visibility or slant visual range, as the distance from the pilot's eye to the farthest point on the ground, ground marker, or approach or runway light, that he could see. Slant visual range was, however, only useful in so far as it defined the amount of ground or ground lighting which was visible, and this extended from the farthest visible point to the nearest visible point determined by the cockpit cut-off of the aircraft. This amount of ground could be measured either by its length or by the angle it subtended at the pilot's eye: it was not certain whether a pilot during his final approach to land needed to see a constant length of ground or a varying length of ground subtending a constant angle; there was evidence that a pilot kept his eyeballs fixed during the final approach in which case he could presumably only appreciate ground subtending a constant angle. When the aircraft touched down the slant visual range became the runway visual range.

The important cases to consider were those of critical landing conditions with bad visibility where the runway visual range gave a misleading idea of slant visual range. These conditions might be due to low cloud, fog, smoke or industrial haze, and heavy precipitation, especially snow. The case of heavy precipitation was not considered, and that of low cloud briefly dismissed as being essentially a problem of the accurate determination of cloud base, not visibility. The third case of fog was then considered in some detail.

The differences between day and night visibility were first discussed, the latter being possibly easier to deal with because effects of contrast, diffused sun and sky light, reflected sunlight, and so on were either absent or more standardized in form. The speaker then showed how, for a layer of homogeneous fog lying on the ground with perfect visibility above it, the length of ground lighting visible to a pilot varied with the height of the aircraft and the runway visual range[1]. The effect of a vertical variation of fog density was to alter the slope of the full lines in the figure: if density increased upwards, the lines would bend back (with increasing height) more sharply so that visual guidance became poorer; if the density decreased upwards, the lines would curve the other way. There were reasons[2] for supposing that a radiation fog should be thicker on top, and observations of slant visual range made using balloon-borne lights showed that this type of structure did occur and that slant visual range could decrease with height. It thus appeared that there were reasons why the amount of ground visible to a pilot should decrease down to the fog top and then increase again down to ground level whether the fog were homogeneous or not. However, the angular field of vision must for simple geometrical reasons remain constant above fog top, and below it must either remain constant or increase. There might thus be danger if the fog top were below the critical height, i.e. the height below which the aircraft must not descend without the pilot having adequate visual guidance, for, if the runway visual range were adequate and the slant visual range seemed adequate at the critical height, the pilot would decide to complete the landing but might then lose visual guidance on the way down. The same thing might happen even if the fog top were above the critical height and there was a marked vertical gradient of fog density with a maximum between the critical height and the ground, but this was not physically a likely contingency. However, no authenticated reports of such dangerous conditions during landings by civil aircraft had been received by the Meteorological Office despite repeated requests, and one had to assume that these conditions were very rare. This meant that the collection of reliable statistics would take many years. There was additional evidence[2] that fogs passed through the stage of critical visibility rapidly, tending to be thin or dense.

The speaker then pointed out that so far he had been treating fogs as horizontally stratified; however, real fogs were far from uniform in the horizontal, nor was their density constant in time, and the drifting patchiness of such a real fog probably caused much greater difficulties in the way of changing visibility during the aircraft's final approach to land than did any systematic variation in the vertical. This was illustrated by simultaneous visibility measurements at London Airport and Northolt, and by records from photo-electric visibility meters.

The fourth case when bad visibility was due to smoke or industrial haze was then dealt with. It appeared from an analysis of observations made at

Renfrew that in this case slant visual range was always greater than runway visual range. This was presumably because smoke was thickest near the ground where it was produced, and where an inversion would form at night.

The speaker then considered the practical utility of possible observations of slant visual range, distinguishing two cases:—

(i) when the aircraft was at its operating height

(ii) when the aircraft was at or near its critical height and the pilot intended to land.

In (i) the pilot wished to know whether he would have a reasonable chance of landing if he descended to the critical height. This descent would take about half an hour for a modern jet aircraft so that a forecast of conditions for about half an hour ahead was necessary. At present this involved a forecast of runway visual range. Knowledge of slant visual range was only likely to be useful in marginal conditions when it presumably needed to be known very accurately, and it was very doubtful if such an accurate forecast of slant visual range was possible. This meant in practice that, if the decision to descend to critical height was made dependent on slant visual range forecasts a number of unnecessary diversions would be made which would have to be set against the occasions when aircraft were spared abortive descents. Probably, if the report and forecast of runway visual range were satisfactory, a pilot would always wish to come down and see for himself. In (ii) if it were possible to make rapid measurements of slant visual range and transmit them to the pilot immediately, useful guidance could probably be given for the final approach to land; warning of deterioration of visibility below critical height for example, would have a valuable psychological effect. However, the patchiness of fog previously discussed made the value of any slant visual range measurements most dubious. However, even if good actual measurements of slant visual range could not be made, further study of fog might make it possible to give general advice to pilots on the basis of ground measurements, especially if a good way of estimating fog top could be found. At present it seemed that the best advice was that, if conditions were marginal on the ground and the aircraft were still above the fog at the critical height, then conditions would worsen as the descent continued. There seemed indeed to be very little reason for assuming that direct measurements of slant visual range could in any way help us to improve on this advice.

Mr. Lewis concluded by reminding the audience that there were great difficulties in the way of translating observations of visibility made on the ground by eye or instrument into what the pilot sees: one had to consider the effect of differing cockpit cut-off angles, the condition of the wind-screen, the fatigue and degree of dark adaptation of the pilot, as well as the strength and pattern of the approach and runway lighting (including their relative intensities) and the contrast with background illumination.

Dr. Frith began by repeating the previous speaker's warning that visual range is not determined by the density of the fog alone; and although a good deal is now known about the visibility of lights of different candle power, the visibility of objects of various shapes, sizes and colour, and about the effect on visibility of background brightness, very little is known about the variation in visual acuity from person to person or the effect on vision of weariness or strain. It was emphasized also that if the requirement was to measure what a pilot would see all the way down from the critical height, then a measurement from one point alone would not be enough. On the other hand detailed and accurate measurements of slant visual range would only be justified if the information was needed for an aircraft just about to land.

The audience were reminded that the effect of cockpit cut-off is such that, in a uniform fog, the visual guidance will increase as the aircraft descends. For example, in a uniform fog with a visual range of 2,000 ft. and a cockpit cut-off of 12°, then the guidance available to a pilot would increase from about 1,000 ft. at 200 ft. to 2,000 ft. at touch-down. This should be set against any deterioration of visibility due to fog patchiness or horizontal stratification.

The speaker then described various techniques for the measurement of slant visibility. The only one which has actually been used to any extent relies upon the observation of a light, or a number of lights, carried by a tethered balloon. This is a simple and practical method; but for use on airfields something which does not involve balloons is called for. A measure of slant visibility can be obtained using two intersecting searchlight beams, one directed vertically and the other at an angle, and varying the intensity of the vertical beam until the two beams are matched at the point of intersection. Errors arise if the beams are passing through fog of different densities. It is not known how serious this may be because we do not know what sort of variations of mean fog density to expect between two paths, intersecting at 200 ft., and 600 ft. apart at the ground.

Slant visibility may also be measured using an instrument similar to the pulsed-light cloud-base meter[3]. This instrument, suitable modified, could be used to measure the amount of back scattered light from the fog. In a clean fog the amount of back scattered light is a measure of the visibility but this is not true in a fog in which there is appreciable absorption. It seems probable that there will be significant absorption in smog and, if this is so, the pulsed-light technique may not provide an accurate measure of visual range.

A technique using flares was proposed by H. N. Green of the Royal Aircraft Establishment, Farnborough, and an elaboration has been suggested by J. W. Sparks, also of Farnborough. Sparks proposed that a flare be fired upwards to, say, 300 ft. and whilst falling from that height to the ground produced a uniform intensity of, say, 1 million candle power. This flare is "seen" from a point on the ground some distance away by a photo-electric device which, by a cunning arrangement involving a rotating toothed shutter, amplifies the signal from the flare but not the signal from any background. Thus the technique could be used both by day and by night. Like the balloon method it is simple and direct and it appears to be the one most likely to provide reliable and accurate results for routine use on airfields.

The Director opened the general discussion by welcoming visitors from outside organizations including the Ministries of Supply and of Transport and Civil Aviation.

Mr. Holland asked whether balloon observations could be usefully made half a mile off the runway.

Dr. Frith replied that the variation in visibility would be too great.

Mr. Cumming emphasized the danger of flying balloons anywhere on an airfield, and spoke of the difficulties of estimating visual range accurately and allowing for the great variability of physical conditions, intensity of lighting, and background illumination. He questioned the value of slant visual range reports to pilots; he thought they would be useful only when slant visual range decreased below the critical height, but this condition had never been found.

Capt. Woodman (British Overseas Airways Corporation) spoke of the difficulties facing the pilot. Patchiness of fog could cause him great trouble, perhaps more than poor general visibility. Pilots' experience of really bad conditions near the ground was limited, and if they suddenly lost visual guidance they at once went up again and diverted. He emphasized the need for more knowledge of fog and its structure; he thought that relatively small patches of bad visibility existed.

Mr. Worthington asked whether air-to-ground visibility was the same as ground-to-air visibility.

Dr. Frith replied that it was, provided that the background illumination was the same.

Mr. Burgess (Ministry of Supply) described experiments carried out by the Blind Landing Experimental Unit from October 1950 to March 1953 at Woodbridge Airfield. An observer was positioned opposite the threshold of the runway, and a balloon-borne light was moved according to his instructions so that both its height and range along a line parallel to the runway centre line were altered. From his observations the observer could build up a diagram of the fog structure and use it to calculate the heights at which a pilot would see the different bars of the Calvert Approach Lighting System assuming that his aircraft was on the glide path. This information was passed to the pilot of an actual aircraft who then made an approach and landing. The total time taken for the measurements and the approach and landing was about 15 to 20 min. Good agreement was obtained between the measurements and what the pilot actually saw; he normally saw lights from about 25 ft. above the forecast height. Eighty sets of measurements (both night and day) were made and the results were summarized. In nearly 30 per cent. of the conclusive measurements, the runway visual range bore little or no relation to the slant visual range. In one particular case the results were

runway visual range = 1,200 ft.
slant visual range at 50 ft. = 900 ft.
slant visual range at 100 ft. = 900 ft.
slant visual range at 150 ft. = 1,800 ft.

The results were obtained at one airfield only and so might not be representative. B.L.E.U. felt strongly that further work on slant visibility was necessary, especially since approach and landings speeds of new aircraft were increasing.

Dr. Stewart said that the scarcity of direct observations of slant visibility made it worthwhile to use all available indirect information. He showed a diagram in which vertical visibility observations from London Airport were plotted against horizontal visibility at the same time. The vertical visibility was almost always less than the horizontal, indicating that the fogs were usually thicker aloft than at the surface. The observations could be explained semi-quantitatively on the assumption that condensation in up-currents made the fog droplets larger near the top of the fog.

With this assumption, an idealized model of fog structure could be made, in which the visibility conditions were characterized by two quantities, the height of the fog top and the slant visibility from the fog top. Using these quantities as co-ordinates any fog could be represented by a point on a diagram, and points falling within certain areas on the diagram would represent conditions dangerous to aircraft. Dr. Stewart showed that if observations made at Cardington were plotted in this way very few of the representative points fell within the danger area. He deduced that dangerous conditions were certainly possible but seemed to be rare, occurring for only a few hours per year; he emphasized, however, that the choice as to what area on the diagram represented dangerous conditions was not really a matter of meteorology at all and that his choice of area, and hence his conclusions on frequency, were open to question. It was at least as important to decide what conditions really were dangerous as it was to find out how frequently different types of conditions occurred.

Mr. Holgate wondered whether observations from the top of the control-tower would be useful.

Dr. Frith thought they would show the general nature of the fog but not what it was like at another particular spot on the runway; the local heating due to the tower itself would be a disturbing factor.

Mr. Russell (Ministry of Supply) expressed alarm at the lack of knowledge of the vertical structure of fog and emphasized the need for further research.

Mr. Davies recalled a case where aircraft experienced difficulty in landing, and a powerful crimson searchlight revealed several distinct haze layers.

Mr. Gold emphasized that each fog was unique and thought that general rules would be of little value. It was unfortunately impossible to do a laboratory experiment on fog because local conditions, e.g. the type of surface over which the fog existed, made such a difference.

The Director, in conclusion, said that his only professional contact with the subject had been in connection with the calculation of the screening effect of a smoke screen, but that ordinary experience in a motor car was enough to demonstrate its difficulties and the psychological aspects of sudden recognition. He thanked the openers and the visitors for their contributions, and said the discussion had shown the importance of the subject and also how heavy was the responsibility of the meteorologist, not only for human safety, but also for the cost of diversions to the airlines.

REFERENCES

1. "SYSTEMIZER"; Examining the runway visual range system. *Aeroplane, London,* **84**, 1953, p. 21.
2. STEWART, K. H.; Radiation fog. Investigations at Cardington, 1951–54. *Met. Res. Pap., London,* No. 912, 1955.
3. ALMOND, R. E.; Electronics applied to meteorological instrumentation. *Met. Mag., London,* **84**, 1955, p. 115.

REVIEWS

Climate of central Canada. By W. G. Kendrew and B. W. Currie. $9\frac{1}{2}$ in. × $6\frac{1}{2}$ in., pp. 194, *Illus.*, Meteorological Division, Department of Transport, Toronto, 1955. Price: $1.

The arrangement of the book is the conventional, but satisfactory, one of an opening chapter on the general climatology of the area as a whole, followed by chapters on each of five separate regions.

Chapter 1 gives a good description of the general climate. Although, to the meteorologist, there are some rather elementary descriptions of meteorological processes, and to the commercial user, the tables in later chapters are the main interest, the general level of the discussion in Chapter 1 is a fair compromise. The standard of the descriptive writing is good, particularly in the sections on blizzards and "physiological" or "sensible" temperature.

It is a great pity that no detailed map of the geography is included in the book. Place names are often used which, many readers will find, require reference to an atlas. There are a few minor misprints including two cases where the reader is referred to the wrong diagram. On several occasions the diagrams are inconveniently placed; maps showing the mean cloud amount occur in the middle of the chapter on visibility, more than twenty pages away from the appropriate text. Chapter 1 includes a map of the main frontal zones. It would have been interesting to know how this was obtained, but we are not informed.

Chapters 2–6 deal individually with the various regions. There is not a great deal of text here, and there are a few repetitions of points made in Chapter 1. The main interest is in the tables of which there are a great number. These chapters are well planned, each having the same arrangement and numbering of paragraphs dealing with individual meteorological elements. There are many small tables in the text, and the type and arrangement of these are consistent from chapter to chapter.

Particularly useful statistics are contained in the sections on temperature, rainfall and snowfall. These include probabilities of different departures from normal monthly mean temperature, probabilities of a day with rain having rainfall within specified limits and frequencies of certain ranges of aggregate snowfalls at the end of each of the four winter months. General climatological tables are given at the end of each chapter. The observation hours used in computing mean pressure and temperature are not stated. Otherwise all necessary definitions are given.

The book may be summarized as one which contains a large amount of useful material in tabular form and a readable and informative text in Chapter 1. The book deserves a more permanent cover than the one of soft card used in the present edition.

H. D. HOYLE

A Mariner's Meteorology. By C. G. Halpine and H. H. Taylor. 9¼ in. × 6 in., pp. xi + 371, *Illus.*, D. Van Nostrand Co. Inc., 1956. Price: 42*s*.

This book is written by two American naval officers and, as stated in the Preface, it was "prepared primarily as a textbook for Midshipmen at the United States Naval Academy", but the authors go on to say that "all the material contained herein is applicable in its broad sense to everyone who goes to sea, whether professional or amateur".

The book is no doubt of value to the naval officer, particularly if he wishes to study the rudiments of the application of meteorology to aviation. As an informative treatise on meteorology for merchant seamen or for yachtsmen it seems to have a rather limited value. Its chief fault seems to lie in the fact that it attempts to cover so many varied aspects of meteorology without any attempt at specialization, and for some unknown reason it devotes almost as much attention to the meteorology of the United States mainland as it does to that of the oceans. For example, the question of tropical storms is dealt with in 12 pages, in which are included seven diagrams, whereas "Weather reports" takes up 35 pages. The specimen synoptic maps in the appendices are entirely related to the United States mainland and the relative text, discussing a particular forecast, blandly says: "On account of the lack of observations over the Atlantic Ocean the size of the area of bad weather cannot be determined accurately. . . ." Such a statement is scarcely encouraging to the large number of voluntary observing ships which regularly provide quite a reasonable network of observations in the relevant portion of the Atlantic Ocean.

Nevertheless, the book has some very good points. For example, there is an admirable graphic drawing showing the characteristics of the earth's atmosphere, in which the authors have included a wealth of information about heights up to 1,000 miles from the earth's surface. There is an excellent composite drawing of cloud formation from stratus to cirrus and some fine cloud photographs, alongside each of which is shown the appropriate symbol and a little drawing bringing out their characteristics, and a "thumb nail" description of the salient features. There is an admirable diagrammatic sketch showing the general circulation of the earth's atmosphere, on a globe, extending from the surface to the tropopause. There are also some good drawings and a simple and straightforward text describing the Coriolis force. The sections through frontal surfaces are also graphic (the best are taken from *Life* magazine). Some photographs are included to illustrate the Beaufort scale; a good idea, but some of them are badly chosen as they fail to give a realistic impression of the actual sea state to which they are meant to refer.

There is an extremely brief chapter on climatology, in which is included ocean currents, and another brief chapter on oceanography; all three subjects seem to be rather inadequately dealt with. There is a very interesting and well written chapter entitled "Weather at war" which includes a well illustrated section concerning the dangers of radio-active "fall-out". At the end of the book is a reasonably comprehensive glossary.

It is rather surprising that in the introduction to a book on maritime meteorology no mention is made of Maury (1854), although Leverrier's activities for collecting meteorological data for Europe in 1855 are quoted. When discussing the aneroid barometer, the authors refer to "certain types of minor errors". They make no reference to the necessity of frequently comparing it with a mercurial instrument. When talking about pressure tendency, the complication of the ship's progressive movement is not taken into account. A serious omission for the mariner occurs in a description of the signs indicating the approach or development of a tropical cyclone, where no mention is made of the large diurnal variation of pressure found in the tropics, and the mariner is not shown how the magnitude of a pressure fall due to an approaching and developing tropical cyclone can be distinguished from a normal pressure fall due to diurnal variation of pressure in the region. The description of the creation of a tropical cyclone is rather over simplified. When discussing upper air observations, although radio-sonde is mentioned, a description of radio wind technique is surprisingly omitted. On the subject of arctic smoke, no mention is made of the large temperature difference between air and sea which is essential for its formation. The authors claim that "it rarely presents a hazard to shipping".

In extreme cases arctic smoke can reduce visibility to less than ¼ mile and can extend to a considerable height. There is also the icing danger on the ship's structure to be associated with it.

The Beaufort scale as shown in this book is complicated somewhat by showing some equivalent wave heights for a United States Navy "Sea State Code" and the World Meteorological Organization's "International State of Sea Code". On the other hand, the height equivalents officially approved by the W.M.O. for association with the Beaufort scale are not shown. The visual storm warning signals shown in this book only refer to the United States waters and no reference is made to the existence of an "international" visual warning system which is used to some extent by most other countries.

Under the chapter entitled "Weather reports", a suggestion is made that "before departing for areas of the world unfamiliar to him, the mariner should obtain climatological information of these areas from the nearest weather central". An officer in a tramp ship would have a rather busy time if he carried out this procedure. Quite a lot of information of this nature is fairly readily available from Sailing Directions. When discussing weather maps, reference to observations from ships is omitted.

The chapters concerning the basic physics of the atmosphere are the best feature of this book. They are written in a very interesting and readable manner and are easily understandable by the student having only elementary scientific knowledge.

C. E. N. FRANKCOM and R. F. M. HAY

Between the planets. 2nd edn. By F. G. Watson. 9 in. × 6½ in., pp. x+188+40, *Illus.*, Harvard. University Press. London: Cumberlege, 1956. Price: 30*s.*

Astronomy and meteorology have both attracted increased public interest in recent years; to many, the two subjects are in fact closely akin. Most scientists would, of course, consider them poles apart, contrasting the largely immutable and orderly arrangements of the universe with the intangibility and complexity of the atmosphere. None the less there is perhaps one branch of astronomy whose problems approach, a little, those of meteorology, a branch—we might term it micro-astronomy—where the author finds "statistical procedures necessary to describe the many variations and the average over-all state".

This book deals with the myriads of small bodies, which, with the sun and the planets, comprise the solar system; it is clear that any interchange of material with outer space is on a small scale. After surveying briefly the solar system as a whole, the author deals first with its largest non-planetary members, the asteroids. Of comparatively recent discovery, these "flying mountains" are known to number many thousands, a few of them with orbits bringing them very close to the earth. Next the comets, the most spectacular of celestial phenomena and still not without an element of mystery, are described both from a point of view of their orbital motions and internal structure.

Of most direct interest to meteorologists are meteors, the very name indicating an early confusion with atmospheric phenomena, yielding as they do valuable information about the atmosphere around the 100-Km. level. These are discussed in detail in three chapters, including one on meteor showers, recently the subject of an attempted correlation with rainfall abnormalities, and one on radio observation of meteors and their ionized trails. There follow chapters on meteorites, including detailed analyses of their composition, together with descriptions of several craters known or suspected to be of meteoritic origin. Finally we come down to interplanetary dust, the author adhering to the theory that therein lies the explanation of the zodiacal light.

The author has given, in racy style, a comprehensive survey of his subject. The illustrations, closely related to the text, are excellent, the comet photographs being particularly striking, while of especial interest is one showing seven successive photographs of a meteor trail, its movement relative to stars and its gradual distortion being apparent.

P. GRAYSTONE

ERRATA

DECEMBER 1956, PAGE 372, line 27: *for* "At the 31st meeting" *read* "At the 39th meeting".

JANUARY 1957, PAGE 31; Column headed Difference from average daily mean; *for* "+0·6" *read* "−0·6".

AWARDS

Civil-airline personnel

An award of books was recently made to captains and navigators who have provided the best series of weather reports, in flight, post-flight, or on debriefing, during the twelve months ending April 15, 1956.

The recipients were:

Captain R. H. Payne, B.E.A.C.
1st Officer D. E. Goldsworthy, Britavia
Captain G. M. Allcock, B.O.A.C.
Captain S. A. Calder, Britavia.
Captain G. R. Buxton, B.O.A.C.
Navigator H. L. Chandor, B.O.A.C.
Captain W. J. Wakelin, B.E.A.C.
Captain R. A. J. Hanson, B.O.A.C.
Navigator G. F. Andrews, B.O.A.C.
Captain K. E. Buxton, B.O.A.C.
Navigator H. Fogg, B.O.A.C.
Navigator J. S. Blain, B.O.A.C.
Captain K. W. Fordham, B.O.A.C.
Navigator F. S. Tanner, B.O.A.C.
Navigator J. Broadley, B.O.A.C.
Captain C. M. Longden, B.O.A.C.
Captain R. H. Rose, B.E.A.C.

CORRIGENDUM

The first two recipients of Meteorological-Office awards to civil-airline pilots were not the two officers whose awards were recorded on p. 349 in the November 1956 number of this Magazine.

The first recipients were Captain L. V. Messenger, O.B.E. and Captain J. T. Percy, both of British Overseas Airways Corporation, who were presented by the Director with brief cases on October 24, 1955, for long and meritorious service in providing weather reports over the North Atlantic.

METEOROLOGICAL OFFICE NEWS

Retirement.—Mr. R. L. Sims, Senior Experimental Officer, retired on January 12, 1957. He was first engaged as a computer at the Royal Observatory, Greenwich, and after service with the Royal Field Artillery and the Meteorological Section, Royal Engineers in the First World War, he joined the

Office in February 1920 as a Technical Assistant. Apart from a period in 1937–38 in the Forecast Division at Headquarters, his 37 years' service was spent at aviation outstations including a tour of duty overseas. From 1951 until his retirement he served at Upavon.

Academic successes.—Information has reached us that the following staff have been successful in recent examinations; we offer them our congratulations.

General Certificate of Education (Advanced Level): J. M. Bayliss, D. E. Bradbury, F. E. Harrold, C. J. Heather, J. C. Howe, P. N. Mann, H. M. Race, C. G. Richer and L. P. Steele.

Higher National Certificate in Mechanical Engineering: K. E. Cowlard.

The International Geophysical Year Expedition.—The Royal Society Expedition's main party of 20 under the leadership of Col. R. A. Smart, R.A.M.C., reached Halley Bay on January 4, 1957.

WEATHER OF JANUARY 1957

As in December 1956, the great cold trough over eastern Canada and the Iceland depression were the dominating features of the circulation over the northern hemisphere. By January the depth and extent of the low-pressure region had so far increased that westerlies spread across Siberia north of 55°N. as far as 120°E. Temperatures were 8° to 10°C. above their usual winter minimum in north-east Siberia, and the Asiatic winter anticyclone was below normal intensity and displaced south-east. Temperatures over most of the polar basins and Alaska (greatest anomaly +10°C.) were also above normal.

The lowest mean pressure for the month was 980 mb. or slightly below near 62½°N., 37½°W. between Iceland and south Greenland, approximately equal to the lowest monthly mean pressure in any January since 1873 and 17 mb. below the 1900–1939 normal. The anomaly is to be attributed to intensity of the individual depressions and constancy of position, not to any displacement.

Pressures were above normal everywhere in a broad arc from Alaska (maximum anomaly +18 to 20 mb. over the Canadian Rockies), central and south-eastern United States of America (anomalies +3 to +4 mb.) and the Azores (anomalies +1 to +2 mb.) to central Europe (anomalies up to +6 mb.).

The month was mild, up to 3°C. above normal, all over north-western, central and northern Europe (anomalies +4°C. in Finland), but rather cold over the Mediterranean and southern Europe and also in part of north-west Siberia.

Mean temperatures were 3° to 6°C. below normal over most of Canada and locally 8° to 11°C. below normal over the Canadian Rockies. Mexico and the Mexican Gulf was 1° to 3°C. warmer than normal, but low temperatures from Canada and the northern United States spread over the Atlantic as far as the Azores and the West Indies (about 1°C. below normal).

Precipitation totals were much above normal, locally over five times the normal, in eastern and northern Greenland, also in northern Alaska. There was another region with over five times the normal rainfall across more or less all the north of India.

In the British Isles a period of rather cold anticyclonic weather from the 10th to the 19th came between periods of almost equal duration of milder but more disturbed cyclonic weather at the beginning and end of the month.

During the first three days fronts, associated with a complex low-pressure area near Iceland, crossed the country, bringing occasional rain with mild, rather dull weather generally. Rain was widespread on the 4th and 5th as secondary depressions accompanied by gales and heavy rain moved north-eastwards near or across north-western districts of the British Isles. Temperature reached 57°F. in places on both days and remained above 50°F. over most of England and Wales throughout the intervening night. Fog formed around dawn at many places in southern England on the 7th and persisted all day locally. Colder air spread south-east on the 9th and 10th as an anticyclone became established off southern Ireland, and on the 12th the north-westerly winds over the British Isles freshened temporarily and showers became more general as a depression moved south-east to southern Scandinavia. As the anticyclone intensified and moved northward, winds over the country veered to north-east on the 14th bringing sleet showers to many eastern coastal districts. Pressure rose to the unusually high value of 1050·9 mb. at Benbecula and Belmullet, Co. Mayo on the 16th before the anticyclone began to decline and move south-eastwards across England to the continent. After a quiet period which lasted nearly a week in most parts of the country, winds rose to gale force again in Scotland on the 19th. During the next four days a major frontal belt lay over the British Isles giving fairly widespread rain and although temperatures were generally higher than of late there was occasional snow in the north. Mild polar maritime air spread over the country from the Atlantic on the 24th to give showers in most areas, scattered thunderstorms and some sleet or snow in the western and northern districts. Weather from the 25th to the end of the month was dull, wet and mild as vigorous Atlantic depressions moved north or north-east towards Iceland and associated fronts crossed the British Isles. There were severe gales over the Atlantic throughout this period and occasionally off our north-western coasts when gusts exceeded 90 kt. at times on the 31st.

Mean temperatures generally were about two degrees above the normal, the cold spell in the middle of the month being easily outweighed by the two mild spells. Rainfall was below the average over most of England and more than 150 per cent. of the average in the neighbourhood of the Brecon Beacons, Snowdonia and over most of Scotland south and west of a line from Perth to Cape Wrath.

The mild weather has brought on most outside crops; greens and spring cabbage particularly have a very forward appearance. Most growers fear that a spell of severe weather will cause a great deal of damage. In many areas the ground is soaked, sometimes even waterlogged; the dampness has encouraged the spread of diseases, both among growing crops and those in store.

The general character of the weather is shown by the following provisional figures:—

	AIR TEMPERATURE			RAINFALL		SUNSHINE
	Highest	Lowest	Difference from average daily mean	Percentage of average	No. of days difference from average	Percentage of average
	°F.	°F.	°F.	%		%
England and Wales ...	60	19	+2·5	97	+2	102
Scotland ...	59	15	+1·9	147	+2	120
Northern Ireland ...	58	22	+0·9	159	+1	139

RAINFALL OF JANUARY 1957

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.	Per cent of Av.
London	Camden Square ...	1·59	85	*Glam.*	Cardiff, Penylan ...	4·90	133
Kent	Dover	2·07	97	*Pemb.*	Tenby	3·62	97
,,	Edenbridge, Falconhurst	2·43	99	*Radnor*	Tyrmynydd	6·85	109
Sussex	Compton, Compton Ho.	3·72	117	*Mont.*	Lake Vyrnwy	9·16	158
,,	Worthing, Beach Ho. Pk.	1·87	80	*Mer.*	Blaenau Festiniog ...	17·45	171
Hants.	St. Catherine's L'thouse	2·35	95	,,	Aberdovey	4·45	115
,,	Southampton (East Pk.)	2·93	110	*Carn.*	Llandudno	2·51	104
,,	South Farnborough ...	1·43	68	*Angl.*	Llanerchymedd ...	4·42	140
Herts.	Harpenden, Rothamsted	1·33	64	*I. Man*	Douglas, Borough Cem.	3·70	110
Bucks.	Slough, Upton	1·44	77	*Wigtown*	Newton Stewart ...	4·46	108
Oxford	Oxford, Radcliffe ...	1·61	89	*Dumf.*	Dumfries, Crichton R.I.	5·21	162
N'hants.	Wellingboro' Swanspool	1·32	71	,,	Eskdalemuir Obsy. ...	10·21	189
Essex	Southend, W. W. ...	·94	64	*Roxb.*	Crailing...	3·40	176
Suffolk	Felixstowe	1·04	68	*Peebles*	Stobo Castle	4·91	164
,,	Lowestoft Sec. School...	1·27	76	*Berwick*	Marchmont House ...	3·20	142
,,	Bury St. Ed., Westley H.	1·39	78	*E. Loth.*	North Berwick Gas Wks.	2·29	134
Norfolk	Sandringham Ho. Gdns.	2·22	114	*Midl'n.*	Edinburgh, Blackf'd. H.	2·97	169
Wilts.	Aldbourne	2·44	98	*Lanark*	Hamilton W. W., T'nhill	5·60	170
Dorset	Creech Grange... ...	3·19	98	*Ayr*	Prestwick	4·24	149
,,	Beaminster, East St. ...	3·97	114	,,	Glen Afton, Ayr San. ...	7·03	138
Devon	Teignmouth, Den Gdns.	2·90	99	*Renfrew*	Greenock, Prospect Hill	9·25	143
,,	Ilfracombe	3·76	114	*Bute*	Rothesay, Ardencraig ...	6·94	154
,,	Princetown	11·68	146	*Argyll*	Morven, Drimnin ...	10·58	167
Cornwall	Bude	2·55	84	,,	Poltalloch	8·29	164
,,	Penzance	3·33	88	,,	Inveraray Castle ...	13·81	168
,,	St. Austell	3·82	89	,,	Islay, Eallabus... ...	8·05	172
,,	Scilly, Tresco Abbey ...	...	...	,,	Tiree	5·83	137
Somerset	Taunton	1·78	75	*Kinross*	Loch Leven Sluice ...	5·37	170
Glos.	Cirencester	3·75	144	*Fife*	Leuchars Airfield ...	2·76	152
Salop	Church Stretton ...	2·14	82	*Perth*	Loch Dhu	13·85	152
,,	Shrewsbury, Monkmore	1·06	54	,,	Crieff, Strathearn Hyd.	6·89	171
Worcs.	Malvern, Free Library...	1·46	66	,,	Pitlochry, Fincastle ...	4·77	136
Warwick	Birmingham, Edgbaston	1·30	58	*Angus*	Montrose Hospital ...	2·40	121
Leics.	Thornton Reservoir ...	1·66	84	*Aberd.*	Braemar	3·30	103
Lincs.	Boston, Skirbeck ...	1·68	104	,,	Dyce, Craibstone ...	...	...
,,	Skegness, Marine Gdns.	1·80	104	,,	New Deer School House	2·24	96
Notts.	Mansfield, Carr Bank ...	1·66	77	*Moray*	Gordon Castle	2·17	107
Derby	Buxton, Terrace Slopes	3·81	85	*Nairn*	Nairn, Achareidh ...	2·28	126
Ches.	Bidston Observatory ...	1·09	52	*Inverness*	Loch Ness, Garthbeg ...	6·51	148
,,	Manchester, Ringway...	1·45	61	,,	Loch Hourn, Kinl'hourn	20·63	164
Lancs.	Stonyhurst College ...	4·27	100	,,	Fort William, Teviot ...	16·09	166
,,	Squires Gate	2·77	105	,,	Skye, Broadford ...	...	...
Yorks.	Wakefield, Clarence Pk.	·99	52	,,	Skye, Duntulm... ...	8·89	168
,,	Hull, Pearson Park ...	1·64	91	*R. & C.*	Tain, Mayfield... ...	3·31	136
,,	Felixkirk, Mt. St. John...	1·56	78	,,	Inverbroom, Glackour...	8·01	149
,,	York Museum	1·03	58	,,	Achnashellach	13·73	151
,,	Scarborough	1·52	76	*Suth.*	Lochinver, Bank Ho. ...	6·71	158
,,	Middlesbrough... ...	1·38	86	*Caith.*	Wick Airfield	3·07	125
,,	Baldersdale, Hury Res.	4·65	139	*Shetland*	Lerwick Observatory ...	5·25	123
Norl'd.	Newcastle, Leazes Pk....	1·03	52	*Ferm.*	Crom Castle	5·75	173
,,	Bellingham, High Green	4·77	167	*Armagh*	Armagh Observatory ...	4·56	181
,,	Lilburn Tower Gdns. ...	2·85	138	*Down*	Seaforde	5·65	179
Cumb.	Geltsdale	3·95	141	*Antrim*	Aldergrove Airfield ...	3·68	135
,,	Keswick, High Hill ...	8·99	178	,,	Ballymena, Harryville...	4·74	128
,,	Ravenglass, The Grove	3·47	104	*L'derry*	Garvagh, Moneydig ...	5·66	165
Mon.	A'gavenny, Plâs Derwen	3·71	100	,,	Londonderry, Creggan	5·16	143
Glam.	Ystalyfera, Wern House	9·88	156	*Tyrone*	Omagh, Edenfel ...	6·07	172

Printed in Great Britain under the authority of Her Majesty's Stationery Office
By Geo. Gibbons Ltd., Leicester

Wt-37. K16.