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BLUE SUN AND MOON

By G. A. BULL, B.Sc.

Over much of western Europe between September 26 and 30, 1950 the sun and moon were seen blue in colour.

The first reported observation of the "blue" sun in Europe was made from Bwlchgwyn, near Wrexham, Denbighshire, North Wales at 0615 G.M.T., very soon after sunrise, on the morning of September 26. Bwlchgwyn is 1,200 ft. above M.S.L. and commands a wide clear view of the eastern horizon. The sun was obscured by cloud at Bwlchgwyn soon after this observation was made and was not seen again during the day. Over the western and northern parts of the British Isles there was too much low cloud on the morning of the 26th for the sun to be seen.

After midday, the clouds began to break over Scotland, and the phenomenon was seen from most places in that country. Later in the afternoon it was seen from Wales and western England.

The colour assumed by the sun is variously described from steely grey to deep blue, royal blue or purple. An observer at Glasgow said the sun appeared as it does through the deep blue anti-glare glass used in motor-cars. The brightness of the sun was diminished to such an extent that it could be watched continuously without discomfort. In fact, some persons who telephoned the Meteorological Office in Edinburgh during the afternoon were uncertain whether they were looking at the sun or the moon.

The disc of the sun was quite sharp and there was no sign of corona or halo. The attention of some people was directed to the sun by noticing that the "rays" shining into rooms were blue.

On observing the phenomenon, Mr. F. Bothwell, of the Meteorological Office at Leuchars, Fife, arranged for an aircraft to ascend to report on the change in colour with height. The pilot of the aircraft, F/Lt. West Jones, reported as follows:—

1549 G.M.T.: 31,000 ft: [sun] still blue, entering cloud of brown haze colour.

1554 G.M.T.: 38,000 ft.: nearly through cloud which obscures land, sun normal, colour tinged with blue.

1558 G.M.T.: 43,000 ft.: above cloud, sun normal colour.

The pilot of an aircraft flying near Cambridge at 0715, September 27, reported encountering brown haze with a smell of burnt paper at 30,000–32,000 ft.

The pilots of some aircraft flying the Atlantic made similar observations. Thus, the pilot of aircraft CFTFM reported to Prestwick that he passed through thick smoke between 0500 and 0600 G.M.T. on September 26 at 17,000 ft. in lat. 59°N., long. 35° to 25°W., and had to use instruments because of the poor visibility. A pungent smell suggestive of forest fires came into the aircraft.

The observing officers of s.s. *Manchester Progress* report seeing the sun mauve in colour over the central North Atlantic (59°02′N., 46°13′W.) on September 25 from 1500 to 1515 G.M.T. After the latter time the sun was hidden by cloud.

On the following night, the moon had a green or blue tinge as seen from the British Isles, but the effect was less pronounced than with the sun. Mr. J. Paton writes that the moon as seen from Edinburgh was still bluish at 2330 on the 26th and normal at midnight.

Mr. R. J. Murgatroyd of the Meteorological Office at R.A.F. Headquarters in Germany reports that the sun was seen blue or mauve in colour over the British Occupation Zone in Western Germany from dawn on the 27th until the afternoon. At Gatow, near Berlin, the sun was first seen blue about noon and the moon appeared blue throughout the following night, 27th–28th. From Schwechat (near Vienna) neither sun nor moon appeared blue.

A detailed report on the observations of blue sun at Gibraltar and the Atlantic to westward has been received from Mr. E. A. Ward of the Meteorological Office, Gibraltar. He writes that it was seen at 39° 40′N., 12° 20′W. on the 27th by the pilot of the routine meteorological flight from Gibraltar, following descent to the 950-mb. level. From the 500-mb. level, an hour before, the sun had appeared normal. From Gibraltar itself the blue sun was first seen soon after dawn on September 28 and it retained its blue colour all that day. The colouration was most marked during the forenoon and evening and was faint in the afternoon. Blue sun was also seen on the morning and evening of the 29th and on the morning of the 30th. The sky at Gibraltar had a milky, or at times grey, appearance as though covered with a uniform sheet of high cloud which, owing to the absence of halo phenomena, was at first thought to be thin altostratus. This sheet persisted with occasional changes in density until the afternoon of the 30th when it disappeared and the sun's colour returned to normal.

Mr. D. W. Johnston, of the Meteorological Office, Malta, reports that the sun was visible there on the 27th and 28th but was not blue. On the 29th and 30th the sky was almost continuously overcast but when the sun partially broke through about 1600 G.M.T. on the 29th, the sunshine seemed to be of a faintly bluish tinge.

According to the Press the blue sun was also seen on the 27th from France, Switzerland, Portugal and Scandinavia.

Cause of the optical phenomena.—Canadian newspapers state that extensive forest fires broke out in Alberta some 340 miles north-west of Edmonton during Saturday, September 23. Smoke from these fires travelled eastwards reaching Ontario, some 2,000 miles from the scene of the fire, by the afternoon of Sunday, September 24. Over eastern Canada and the north-eastern United States the smoke clouds were thick enough to blot out the sun and to cause lights to be switched on in buildings and streets. Floodlights had to be turned on to allow baseball games to proceed. The base of the smoke cloud over eastern Canada was estimated at 7,000 ft.

There seems little doubt that the optical phenomena already described were produced by the same smoke.

The observations of a milky haze rather like altostratus as seen from the ground, which appeared as a brown haze to the pilot of the aircraft over Leuchars, and the reports of smoke and mauve sun over the Atlantic support this view.

The upper air charts for the relevant period show that the upper winds over the Atlantic were favourable for carrying the smoke to Europe. A trajectory computed from the charts of the *Daily Aerological Record* using winds at 750 mb. (approximately 8,000 ft.) over eastern Canada, 500 mb. (approx. 18,000 ft.) over the western half of the Atlantic and at 300 mb. (approx. 30,000 ft.) over the eastern half brings the smoke to Scotland by the afternoon of September 26. The heights in the computation were varied to allow for the apparent ascent of the smoke layer as it travelled eastwards.

An intense depression was centred over Labrador on the 24th and 25th and over Davis Strait on the 26th. A broad wedge of high pressure extended northwards from the Azores. Another depression was centred to the east of Greenland. A slow-moving depression which was over the British Isles on the 25th moved eastwards to the North Sea on the 26th. At 1500 on the 26th there was, at the 300-mb. level, a long trough extending from Scandinavia over the Low Countries and France to Spain. The strength of the high-level winds over the Atlantic is shown by the fact that o.w.s. *Weather Observer*, at 59°N., 18·8°W., and roughly on the trajectory of the smoke, measured winds of 299° 62 kt. at 300 mb. at 0300 G.M.T., 281° 66 kt. at 0900 and 291° 90 kt. at 1500 on the 26th. Aldergrove observed a wind of 357° 74 kt. at 1500 on the same day.

The upper air temperatures measured on the 26th over the Atlantic and Great Britain show very dry air at all levels between 900 mb. and 400 mb. as do those measured at Gibraltar from the 27th to the 30th.

As Mr. Ward of Gibraltar has pointed out in correspondence, the upper winds of the 27th and 28th were favourable for rapid movement southwards of the smoke from the British Isles. The wind at 500 mb. over the Bay of Biscay on the 27th was about 020° 50 kt., and at 300 mb. it was about 80 kt. The Gibraltar meteorological reconnaissance flight reported north-easterly winds of 65–80 kt. at 500 mb. to the westward of Portugal. Over Gibraltar itself the upper winds were from SSW. to WSW.

Precisely the same optical phenomena have been seen in the past, notably in the tropics after the explosion of Krakatoa in 1883. A large number of occasions before 1887 of blue or green sun and moon, usually definitely connected with volcanic smoke, are described in Kiessling's large work[1] on twilight and allied phenomena. More recently, reports of the sun being seen blue through duststorms in the United States[2] and Egypt[3] have been published.

A very vivid description by Whymper of a bright green sun seen through smoke from a sudden eruption of the volcano Cotopaxi in the Andes on July 3, 1880 is reported by Kiessling[1]. Kiessling made observations of the sun through various artificially produced smokes including the smokes from sal-ammoniac, burning magnesium, gunpowder and smouldering vegetation. He used an apparatus in which glass vessels were filled with the particular smoke until the sun was only just visible through it. The colour of the sun was at first a brownish red but gradually became first a strong violet and later a brilliant azure blue. Kiessling emphasized that the effect was the same with all the kinds of smoke which he used and says further that the same observation can be made with steam. Minnaert[4] describes seeing the sun blue and green through the steam cloud from a railway engine while Keen[5] describes the similar effect obtained when viewing a source of white light through colloidal sulphur particles.

The optical theory of the " blue " or " green " appearance of the sun is not as yet worked out. Lord Rayleigh showed over 70 years ago that particles small in comparison with the wave-length of the incident radiation give much more intense scattering on the shorter than the longer wave-lengths and so tend to make the sun more red in colour. On the other hand particles large in comparison with the wave-length give neutral scattering, but a cloud of such particles all of the same size produces a corona diffraction system. The angular radius of the brightest ring of the system is inversely proportional to the diameter of the particles and is nearly 3° for particles of radius 0·01 mm. No corona was reported as visible at the same time as the " blue " sun and some observers specifically mention the absence of corona. The optical effects produced by particles of radius between about the wave-length of visible light, which occupies the range of wave-lengths 0·0004 to 0·0007 mm., and 0·002 mm. are not yet thoroughly understood, because the mathematical formulæ given by Mie[6] for the scattering of radiation are unsuited to numerical computation for the scattering of light by such particles, and the simple diffraction theory based on Babinet's principle does not apply to such particles either. Minnaert in his discussion of the blue sun ascribes the phenomenon to particles of the order of magnitude just mentioned.

Note added later.—Dr. H. Wexler, of the United States Weather Bureau, in *Weatherwise*[7] gives much more information on the movement of the smoke and the occurrence of associated optical phenomena over North America.

The forest fires in Alberta were burning during the week commencing September 17 and reached their peak from September 22 to 24. The smoke covered all eastern Canada and the United States, and the sun or moon was seen coloured at Washington, D.C., from September 25 to 27. Detailed computations of the diffusion of the smoke are being made in the Weather Bureau.

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DISTANCE OVER WHICH AN AIRCRAFT FLYING ON A CONSTANT HEADING MAY EXPERIENCE SEVERE ICING IN CONVECTIVE CLOUD

By R. F. JONES, B.A., and J. G. D. BEIMERS

Introduction.—In considering aircraft-icing problems it has long been recognized that the cumulonimbus cloud is the cloud in which, owing to the large amount of free water available in the supercooled state, icing is likely to be most severe. Cumulonimbus clouds, however, are isolated and of varying sizes, and information has been lacking on the frequency with which such clouds and, therefore, potentially severe icing will be encountered on an aircraft flight at a constant heading, and on the length of time an aircraft might be exposed to the risk of continuous severe icing. Answers to both these problems would be of value in assessing the general icing risk to aircraft and would assist in the design of aircraft de-icing equipment.

Recent papers[1,2] have discussed the radar echoes received from precipitating cumulus and cumulonimbus clouds, using a 10-cm. radar equipment. The echoes received from levels above the freezing level have been interpreted as coming from that part of the cloud which contains a large enough concentration of supercooled water drops of raindrop size. Although 10-cm. radar equipment will not therefore define the whole volume of the cloud[3], it will indicate the part of the cloud in which the free water concentration is greatest and therefore the part of the cloud in which the icing may be expected to be most severe. The P.P.I. display of such an equipment gives a projection of the echoing volume of the cloud on a nearly horizontal plane. The horizontal dimensions of a cumulonimbus echo do not vary considerably with height[3] except near to the echo top, nor is the echo column at any time appreciably inclined to the vertical, so that the width of an echo on the P.P.I. display along a particular bearing can with reasonable accuracy be taken to represent the distance over which an aircraft, flying on this bearing above the freezing level and below the echo top, would be exposed to the risk of severe icing.

An analysis of P.P.I. display-tube photographs taken on showery days may therefore give useful data towards the solution of the problems set out in the first paragraph above and this paper gives the results of such an analysis.

Data available and method of analysis.—P.P.I. display-tube photographs, taken at East Hill (near Dunstable, Bedfordshire), are available for many different weather situations and those photographs relating to days with isolated showers were extracted. Days on which the showers appeared to be associated with well marked troughs or cold fronts, leading to a long line of almost continuous echo extending along one bearing only, were not considered.

On each photograph the largest aggregate length of echo intercepted on a straight line through the station (the centre of the photograph) was measured, so that this line gave the heading an aircraft, flying over the station, would take to experience the greatest icing risk at the time the photograph was taken. The line covered a total range of 120 miles with the station at its centre, but, to exclude errors due to permanent echoes and observations made at excessively short ranges, all echoes lying within 10 miles of the station were ignored, leaving a total length of 100 miles to be examined. In addition the longest distance continuously within echo on this bearing was also measured.

Facing p. 8 are typical examples of the photographs used and measurements made.

A total of 290 photographs taken on 39 days in the period May 13, 1947, to May 17, 1949, inclusive, was analysed in this way. The number of photographs taken on any one day was not the same, but, as the number of individual days was so small and the choice of a representative picture for a particular day impossible, all the available photographs, taken at intervals of not less than five minutes, have been used in the analysis. The maximum readings for each day have been extracted and are set out in Table I. It should be remembered that photographs may not have been taken at the most favourable time on every day, so that the value of the information in Table I is limited.

TABLE I—FREQUENCY OF VARIOUS MAXIMUM ECHO DISTANCES

	Maximum extent of echo (miles)							
	0–4	5–9	10–14	15–19	20–24	25–29	30–34	Total
	number of occurrences							
Total echo	1	7	11	10	5	3	2	39
Continuous echo	1	8	18	9	1	1	1	39

Results of the analysis.—The information, obtained as described above, from all the 290 photographs is presented in Figs. 1 and 2.

Fig. 1 shows the percentage number of occasions when specified values of aggregate distance within echo would have been exceeded on a flight of 100 miles across the station, while Fig. 2 shows the percentage frequency with which, during a 100-mile flight, specified maximum distances of continuous flight within an echo would have been exceeded.

Interpretation and discussion of the results.—On the assumption that flight in the echo part of a cloud (above the freezing level) is associated with severe icing, Fig. 1 may be interpreted as showing the frequency with which severe icing may be expected to last for more than a specified distance in 100 miles of flight in showery conditions above the freezing level, if the flights are chosen so as to give the greatest proportion of possible severe icing at the time of flight.

It will be seen that the maximum frequency occurs at about eight miles (where the slope of the curve is greatest), but the mean value is 10·5 miles and 57 per cent. of all flights would be likely to experience severe icing over an aggregate distance greater than eight miles in 100 miles and one flight in ten may get severe icing for 17 miles or more.

Fig. 2 indicates that the greatest distance on a particular flight over which continuous icing is likely to occur is most frequently five miles (for which value the slope of the curve is greatest), but the mean value is 8·3 miles and 70 per cent. of all flights would experience continuous icing for more than five miles and one flight in ten would be liable to get continuous icing for about 13 miles or more.

It would appear from Fig. 1 that icing for more than about 25 miles (aggregate) in 100 miles is very unlikely but it should be remembered that this is true only for isolated-shower conditions such as occur, for example, in polar air in summer in the east and south-east of England. On some occasions, however, large masses of thunderstorms and areas of thundery rain move in a northerly direction from the continent across England and in such conditions it would not be unlikely for there to be more than 30 miles of continuous echo along a straight line, with the virtual certainty of severe icing above the freezing level. The freezing level in such conditions, however, is usually high and flight in the British Isles beneath the freezing level would not be impossible. On other occasions, associated with cold fronts or well marked polar troughs, long lines of echo may also occur exceeding 30 miles in length but in such conditions the belt of echo is likely to be relatively narrow and the position and orientation of the belt can probably be forecast with reasonable accuracy. Further examination of the single occasion measured when the distance in continuous echo was 32 miles revealed it to be associated with storms moving north from the continent, the freezing level being about 12,000 ft. An occasion of 28 miles of continuous echo, on the other hand, was associated with polar air moving around a depression over Lancashire and the freezing level was at about 5,000 ft.

Comparison between Figs. 1 and 2 reveals that by far the greater proportion of the total echo on a single flight of 100 miles is likely to be contributed by one single continuous echo. Thus, while from Fig. 1, 40 per cent. of all flights would be through more than 10 miles of echo, Fig. 2 indicates that for the same percentage of flights there would be more than 8 miles of continuous echo. Similar results are to be observed for other values of the percentage of flights.

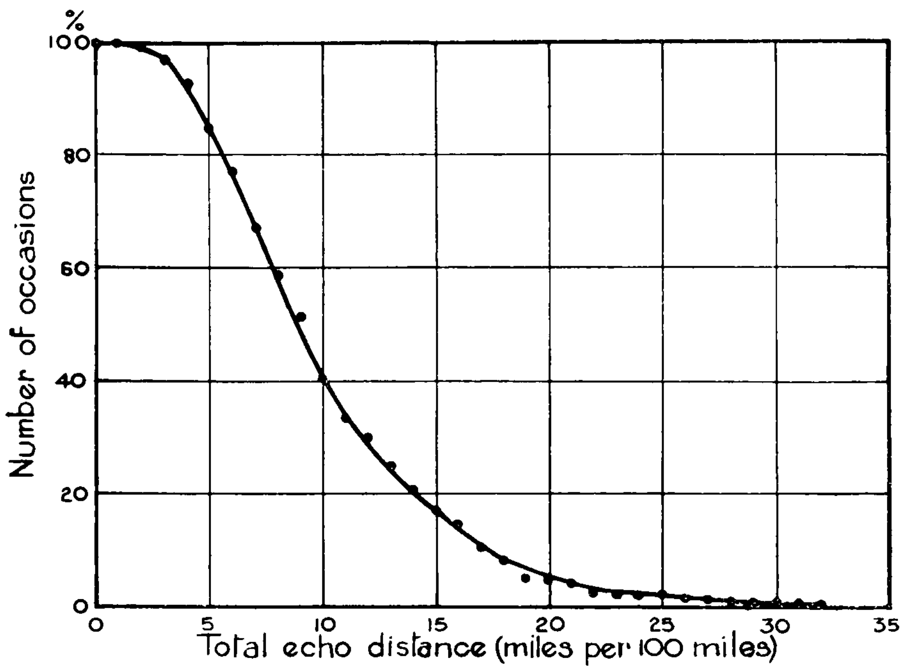


FIG. 1—PERCENTAGE NUMBER OF OCCASIONS WHEN A GIVEN AGGREGATE DISTANCE IN ECHO WOULD HAVE BEEN EXCEEDED ON A 100-MILE FLIGHT

Table I indicates that, by taking only the extreme values for each day of the 39 days, there are 28 days out of the 39 when the distance of severe icing could have been between 5 and 19 miles in 100 miles, the mean distance for all days being 16 miles, and 35 days out of the 39 when the maximum continuous icing could lie between these limits, the mean value being 13 miles. As mentioned previously, however, it cannot be assumed that the worst conditions of each day were photographed on the display tube.

Limitations to the application of the results.—While it is probable that the results here described give some information which has not previously been available and give a general indication of the extent of the icing hazards in cumulonimbus flying, only limited use of the detailed results and values quoted should be made, for the following reasons:—

(i) The analysis covers a period of only two years during which the frequency of occurrence, and severity when it did occur, of shower activity may have been less than the long-term average.

(ii) The analysis is only strictly applicable to a limited area of eastern England and may not apply to other areas, even of England. In particular the results may not be applicable to coastal areas where the shower frequency is high in winter nor to mountainous regions where orographic effects are added to the normal surface-heating effect.

(iii) The analysis does not include frontal effects, including the effect of well marked troughs, which can usually be forecast, but applies to the random distribution of shower activity in unstable air.

(iv) No allowance is made in the measurements for the effect of the range at which the radar echoes were observed. Distant echoes, due to attenuation by

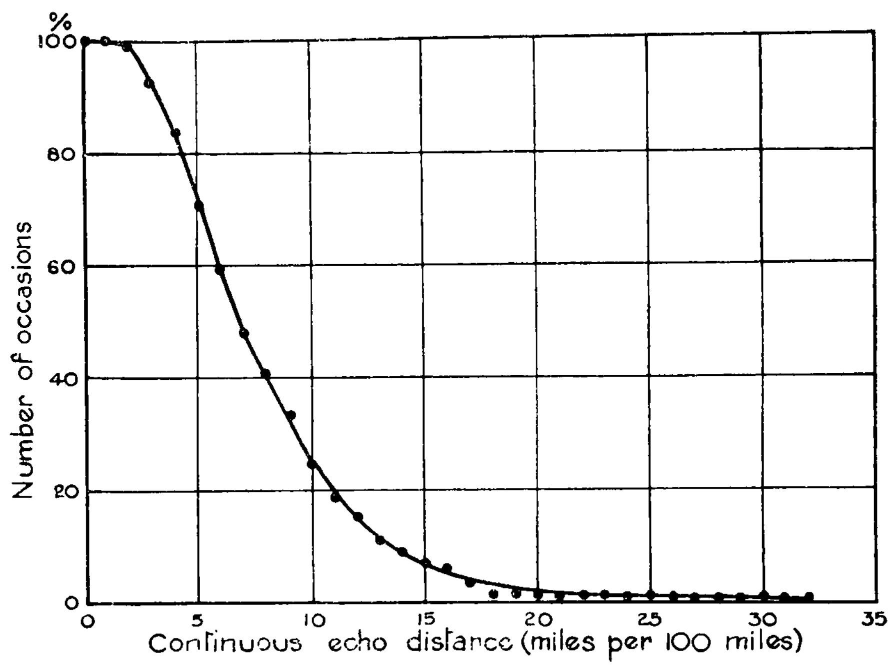
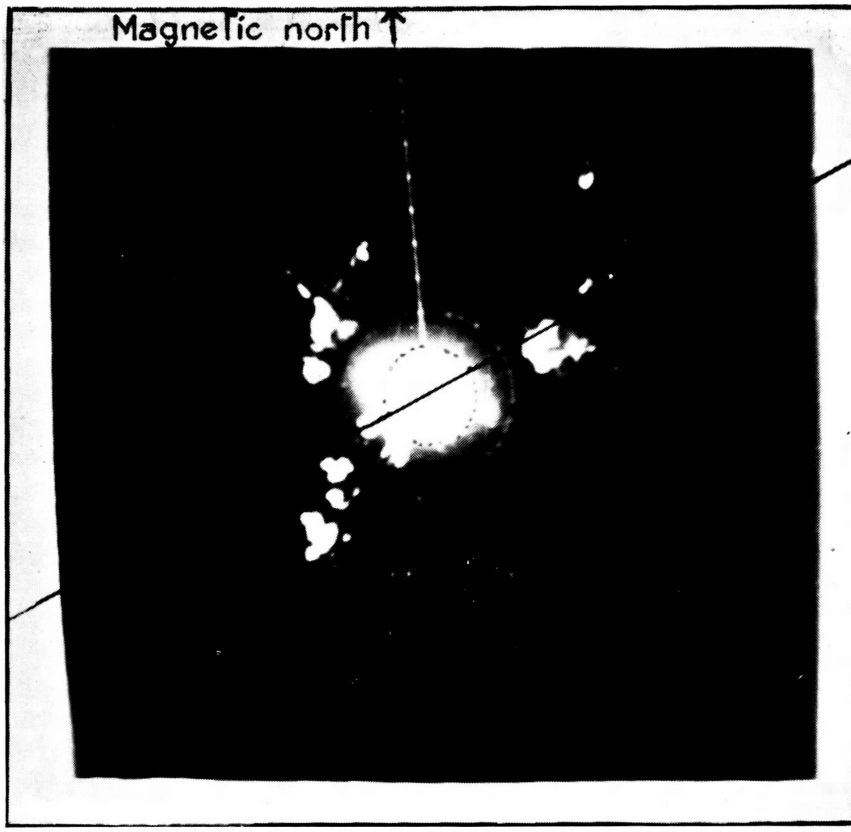


FIG. 2—PERCENTAGE NUMBER OF OCCASIONS WHEN AN AIRCRAFT WOULD HAVE BEEN CONTINUOUSLY IN ECHO FOR MORE THAN GIVEN DISTANCES ON A 100-MILE FLIGHT

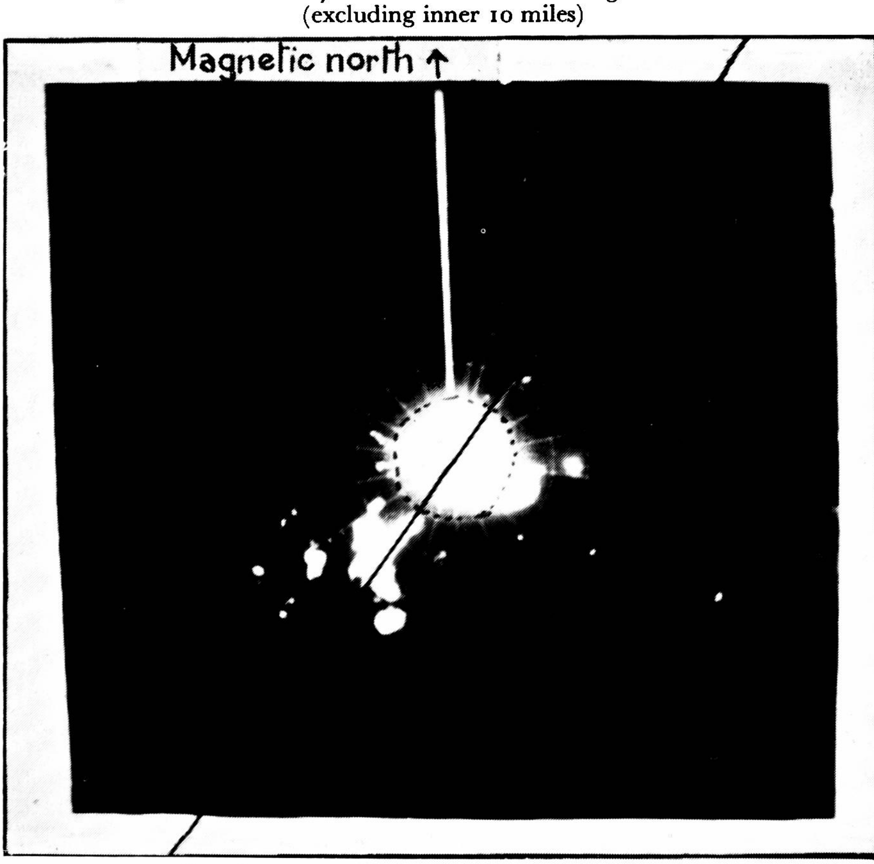
range, may appear smaller on the P.P.I. display tube than an echo due to a similar cloud at shorter ranges. Without a detailed knowledge of the way the raindrop distribution varies horizontally through the particular cloud no useful correction can be made for range. In general, however, the nature of the cumulonimbus echo, which indicates the probability of an abrupt change in echo intensity on entering the precipitation core of the cloud, makes it unlikely that any serious correction would be necessary for the majority of echoes examined. In any case the echo observed would still be the volume of maximum icing risk within the cloud at whatever range it was viewed.

(v) The echo as seen on the P.P.I. display, being the projection of the whole volume of echo on an almost horizontal plane, may on some occasions overestimate the extent of the echo at the line of flight above the freezing level.

[*To face p. 8*



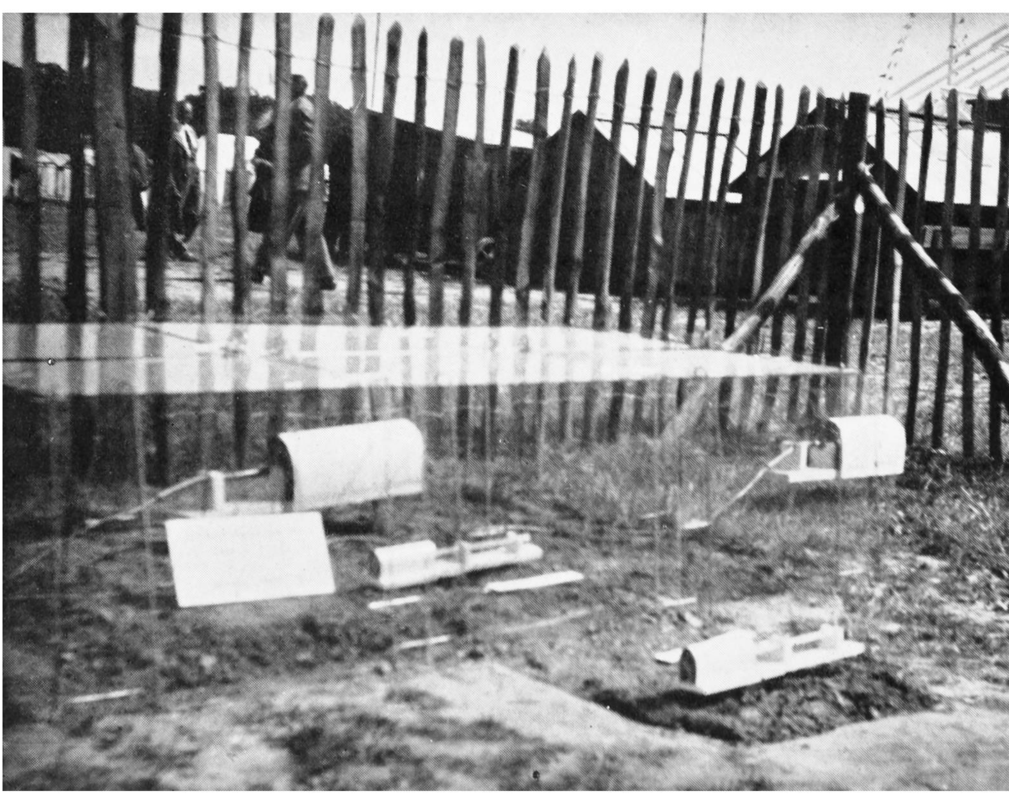
10 miles of echo — 7 miles continuous — along the line shown
(excluding inner 10 miles)



14 miles of echo — all continuous — along the line shown
(excluding inner 10 miles)

RADAR ECHOES FROM CUMULONIMBUS CLOUD (see p. 4)

GENERAL VIEW OF THE METEOROLOGICAL TENT AND ENCLOSURE AT THE MARKET PRODUCE SHOW, SOUTHAMPTON, JUNE 1950
(Left to right : R. W. Gloyne, G. Williams, R. G. Pyke, L. P. Smith)



MARKET PRODUCE SHOW, SOUTHAMPTON, JUNE 1950: DEMONSTRATION OF THE EFFECT OF CLOCHES ON TEMPERATURE

Thermographs and minimum thermometers are shown inside and outside the cloche. A soil thermometer can also be seen inside the cloche. (See p. 23)

Summary.—An analysis of the radar-echo distribution from showers, as seen on the P.P.I. display of a 10-cm. radar equipment, is used to give an indication of the frequency with which severe icing conditions may be encountered on a flight at a constant heading on a day when isolated showers are occurring.

Undue weight cannot be attached to the detailed results but it would appear that in showery weather severe icing conditions may occur at the worst on about 40 per cent. of all flights in parts of eastern England for more than 10 miles in 100 miles but on only about 4 per cent. of all flights for more than 20 miles in 100 miles. Continuous icing is likely to occur at the worst on about 40 per cent. of all flights for more than 8 miles in 100 miles but on only about 4 per cent. of all flights for more than 17 miles in 100 miles.

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FOG AT LONDON AIRPORT

By N. E. DAVIS, M.A.

London Airport has been operating over four years and sufficient observations are now available to allow for a preliminary appreciation to be made of the visibility—the chief factor affecting operations there. In this note only visibilities less than 1,100 yd. are considered, i.e. only cases of fog.

Fog at London Airport may be ascribed to three factors: radiation, advection and smoke. True advection fog is not a common occurrence at London Airport and will be neglected in the following analysis.

The visibilities reported at each hour of each day for the four years, August 1946 to July 1950, were examined and a record was made of the number of occasions when the visibility was less than (*a*) 220 yd., (*b*) 440 yd., (*c*) 880 yd. and (*d*) 1,100 yd. These figures were grouped according to hours and months and are reproduced in Table I. Each figure in this table gives the number of times in four years when the visibility was less than the prescribed value for every hour of the day for each month. The last two columns give the total number of hours of fog per month for the four years and the mean for a year respectively.

Considering only the mean number of hours of fog per month given in the last column, it is seen that there is a great difference in fog frequency between the six months April to September and the six months October to March. Further the frequency of fog in November during these four years was about 50 per cent. greater than in the other winter months, and the frequency of thick fog (visibility less than 220 yd.) was twice as frequent in November as in October, December and January and three times as frequent as in February and March.

The figures given in the tables for the number of cases of fog and thick fog are reproduced in Figs. 1 and 2 where the isopleths give the percentage

TABLE I—DIURNAL VARIATION OF FOG AT LONDON AIRPORT

Summer months

Time	APRIL				MAY				JUNE				JULY				AUGUST				SEPTEMBER			
	⩽220 yd.	⩽440 yd.	⩽880 yd.	⩽1,100 yd.	⩽220 yd.	⩽440 yd.	⩽880 yd.	⩽1,100 yd.	⩽220 yd.	⩽440 yd.	⩽880 yd.	⩽1,100 yd.	⩽220 yd.	⩽440 yd.	⩽880 yd.	⩽1,100 yd.	⩽220 yd.	⩽440 yd.	⩽880 yd.	⩽1,100 yd.	⩽220 yd.	⩽440 yd.	⩽880 yd.	⩽1,100 yd.
G.M.T.	*number of occasions in four years*																							
0000	...	...	...	3	...	...	1	3	...	...	1	1	...	...	...	...	...	...	...	2	...	1	1	3
0100	...	...	1	3	1	1	2	3	1	1	1	1	1	1	1	1	...	1	1	2	2	2	3	7
0200	...	1	3	4	2	2	4	4	1	1	2	2	...	...	1	1	...	1	1	2	3	3	4	5
0300	...	1	3	4	3	3	6	6	1	1	1	2	...	...	...	1	2	3	5	5	3	4	9	9
0400	1	1	3	5	4	4	5	5	1	2	3	3	1	1	3	3	4	4	4	6	2	4	9	10
0500	1	1	3	5	4	5	5	6	2	2	2	2	1	1	2	2	3	3	5	8	4	6	8	10
0600	2	2	4	6	3	3	4	5	2	4	4	4	...	...	1	1	3	7	8	9	6	8	13	15
0700	1	1	2	6	2	3	3	5	1	1	1	1	...	...	...	...	3	3	5	8	3	6	9	13
0800	1	1	2	3	...	1	1	3	...	1	1	1	...	...	...	...	1	1	2	3	3	3	5	8
0900	...	...	1	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1	2
1000	...	...	1	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1100	...	...	1	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	...
1200	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1300	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1400	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1500	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1600	...	...	1	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1700	...	...	1	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1800	...	...	...	1	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1	1
1900	...	...	...	1	...	...	1	2	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2000	...	...	...	1	...	...	1	3	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2100	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
2200	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	1
2300	...	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	1	...	...	...	1
Total	6	8	26	52	19	22	33	50	9	13	16	17	3	3	8	9	16	23	31	47	26	38	63	85
Mean (hr./month)	1	2	7	13	5	6	8	13	2	3	4	4	1	1	2	2	4	6	8	12	7	9	16	21

TABLE 1—*continued*

Winter months

Time	OCTOBER				NOVEMBER				DECEMBER				JANUARY				FEBRUARY				MARCH			
	⩽220 yd.	⩽440 yd.	⩽880 yd.	⩽1,100 yd.	⩽220 yd.	⩽440 yd.	⩽880 yd.	⩽1,100 yd.	⩽220 yd.	⩽440 yd.	⩽880 yd.	⩽1,100 yd.	⩽220 yd.	⩽440 yd.	⩽880 yd.	⩽1,100 yd.	⩽220 yd.	⩽440 yd.	⩽880 yd.	⩽1,100 yd.	⩽220 yd.	⩽440 yd.	⩽880 yd.	⩽1,100 yd.
G.M.T.	*number of occasions in four years*																							
0000	3	9	19	23	12	19	24	28	9	12	15	15	6	8	12	18	3	5	11	15	3	7	12	16
0100	7	14	21	23	13	16	23	27	8	9	13	17	9	13	19	20	5	8	14	18	5	5	10	17
0200	7	14	21	29	12	13	21	25	7	10	13	14	7	8	12	17	5	5	11	15	5	5	11	17
0300	10	15	20	29	14	15	21	24	7	10	13	14	8	10	12	13	5	7	12	15	4	7	13	17
0400	13	16	20	26	15	18	21	24	5	6	10	12	7	9	10	12	4	7	12	15	5	6	9	12
0500	15	17	24	29	14	18	20	23	6	6	8	11	6	7	10	10	4	7	12	14	5	6	9	12
0600	15	19	24	28	12	15	21	25	5	5	7	9	8	9	12	12	5	8	14	14	7	10	12	17
0700	16	20	24	27	18	21	26	28	6	6	7	9	6	8	14	15	6	9	16	19	9	12	17	22
0800	15	18	27	33	17	23	29	29	5	6	12	14	9	13	18	18	6	10	19	22	11	12	23	26
0900	9	13	21	29	15	18	27	30	6	7	13	17	9	10	18	22	8	14	18	24	9	11	19	21
1000	5	7	17	20	15	16	26	28	8	8	13	19	8	10	15	21	2	6	16	20	4	5	12	18
1100	2	4	9	15	12	15	23	26	5	5	14	17	6	10	12	18	2	3	11	17	2	5	8	11
1200	...	1	4	7	7	9	15	19	5	5	12	14	5	6	12	18	1	3	9	12	1	1	7	10
1300	...	...	...	...	6	8	11	16	5	5	10	13	4	5	8	11	...	2	9	10	1	1	6	9
1400	...	...	...	...	6	9	13	16	5	5	12	13	4	4	6	10	...	2	5	8	1	1	4	6
1500	...	...	...	2	7	8	13	14	3	5	11	12	4	4	5	7	...	1	5	7	2	2	3	6
1600	...	...	2	3	10	10	11	15	4	6	15	18	2	3	6	14	...	1	3	4	2	2	5	6
1700	...	1	2	4	10	10	14	18	5	6	18	20	3	4	11	17	1	2	5	9	2	2	8	8
1800	...	1	5	9	8	9	17	22	5	9	18	25	4	5	12	18	2	3	9	11	1	5	6	10
1900	...	1	9	10	7	9	20	22	7	9	16	22	5	6	14	21	2	7	12	15	1	3	11	12
2000	1	3	10	14	6	10	20	24	6	8	16	22	5	7	14	17	1	5	12	16	1	4	10	11
2100	2	3	12	18	8	15	23	27	7	8	14	21	4	8	14	18	2	5	14	20	3	4	11	13
2200	2	2	12	20	9	18	25	29	6	7	15	20	4	7	16	17	3	5	15	18	5	7	13	14
2300	2	6	15	21	13	19	24	30	6	7	12	16	6	8	14	16	3	6	13	17	4	5	11	14
Total	124	184	318	419	266	341	488	569	141	170	307	384	139	182	296	380	70	131	277	355	93	128	250	325
Mean (hr./month)	31	46	79	105	67	85	122	142	35	43	77	96	35	45	74	95	17	33	69	89	23	32	63	81

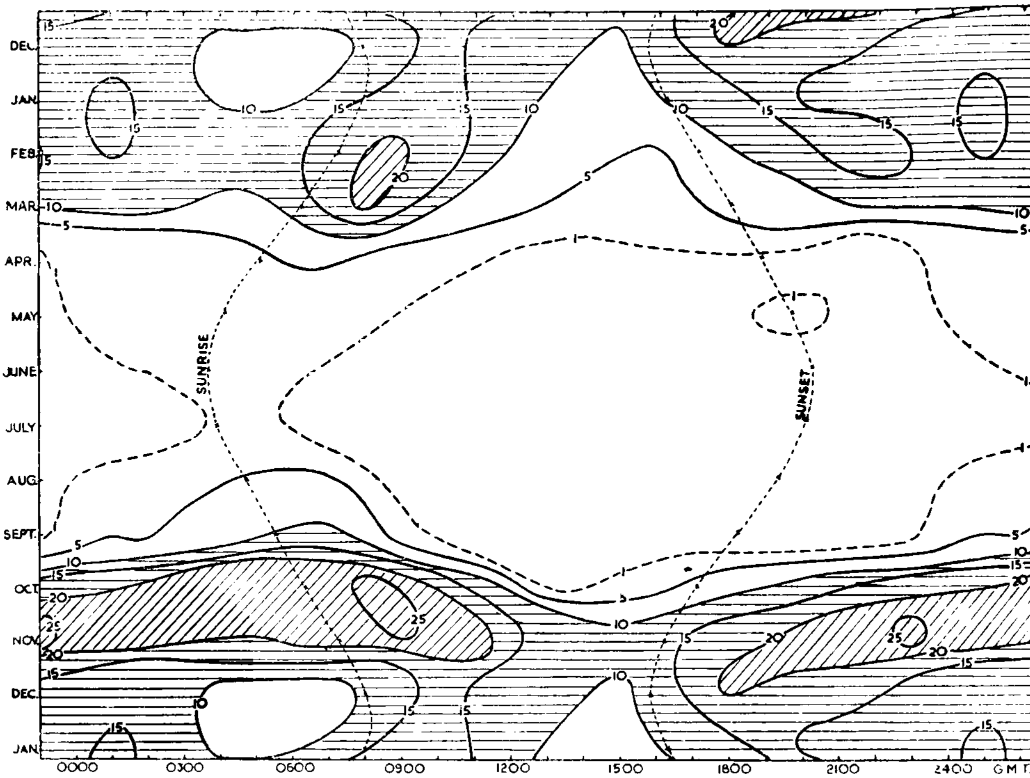

FIG. 1—DIURNAL VARIATION OF FOG AT LONDON AIRPORT

frequency of fog and thick fog respectively. Fig. 1 may be compared with a similar diagram for frequency of mist at Mildenhall given by Durst.*

The salient points in the variation of fog at London Airport to be deduced from these figures may be listed as follows:—

(i) The rapid increase in fog frequency from September to October and November.

(ii) The high frequency of fog and thick fog in the mornings in October and its rapid clearance about four hours after sunrise.

(iii) The high frequency of fog and thick fog in November and its tendency to persist throughout the day.

(iv) The relatively low frequency of fog in the early hours in December and January.

(v) The high frequency of fog in December two to three hours after sunset and to a less extent in January and February.

(vi) The gradually increasing tendency from December to March of the fog to clear in the afternoon.

(vii) The high frequency of fog about two hours after sunrise in February and March.

(viii) The rapid decrease in fog from March to April.

These variations are to be explained by consideration of the length of night (or length of time outgoing radiation is in excess of incoming radiation), the elevation of the sun at midday, the amount of moisture available, the amount of smoke pollution and the general synoptic situation prevailing during the month.

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*DURST, C. S.; Meteorology of airfields, London, 1949.

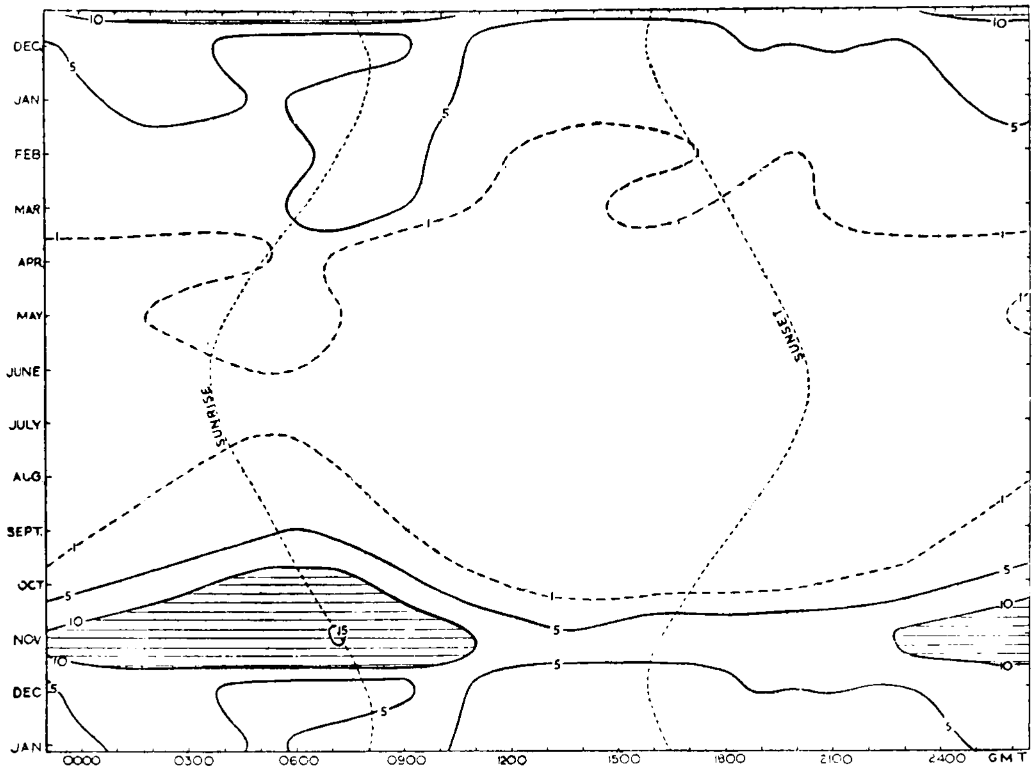


FIG. 2—DIURNAL VARIATION OF THICK FOG AT LONDON AIRPORT

The length of night appears to be crucial in the formation of fog in that fog is far more likely when the length of night is greater than the length of day. Further, when in winter the sun's elevation is small, the amount of incoming radiation is small and is largely reflected from the upper surface of a fog layer. This is particularly the case if the fog is thick or smoky. Winter fog is therefore very slow to clear by day and may not clear at all.

The mean vapour pressure at Kew for the winter months is as follows:—

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
			millibars			
Mean vapour pressure	10·1	8·3	7·1	6·8	6·8	7·1

Vapour pressure is greater in October and November than it is in the other months and hence the formation of thick fog is more likely in October and November than in the others.

The amount of smoke pollution depends on three factors: the time of the day and of the year, the amount of convection, and the direction of the surface wind. The chief cause of smoke pollution in the London area is the domestic fires. These are alight from between 0700 and 0800 to about 2200 during the months November to March and also in the afternoons and evenings in the months October and April. If the air is stable, the smoke will tend to be retained near the ground and smoke pollution will be a maximum in the evening from about 1900 to 2200. After 2200, though stability will continue to increase, little smoke is poured into the atmosphere, while a considerable quantity will fall out. Smoke pollution is therefore a minimum in the early hours during the winter months. In the afternoons, decreasing stability may tend to carry some of the smoke away and there is a secondary minimum about 1500. However, if the concentration of smoke is heavy, radiation from the sun is cut off, and, in the depth of winter when the sun's elevation is low, not sufficient radiation penetrates the smoke to start up convection, so that the smoke may remain near the ground. Further, outgoing radiation is also to some extent restricted so that in a very smoky atmosphere the formation of thick fog may be retarded or even prohibited.

The direction of the surface wind is important in that London Airport lies in the London smoke drift with NE. to ESE. winds. Whenever the surface wind is from this sector visibility will be impaired by smoke. The surface wind is the deciding factor not the gradient wind, as, if the smoke is to produce a marked deterioration of visibility, it must remain near the ground and will therefore move in the direction of the surface wind not that at 2,000 ft. If the wind from between NE. and ESE. is very light, visibility at London Airport will tend to improve during the night as the smoke falls out and the deterioration that normally takes place after sunrise may be delayed until the increased smoke that results from the lighting of the domestic fire has drifted out to the airport.

The effect of the general synoptic situation prevailing during the month is assessed by considering the mean wind speed. Mean wind speeds at Kew for the six winter months are given in the first line of the following table:—

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
			miles per hour			
Long period average	6·7	7·6	8·4	8·2	8·7	8·9
4-yr. period average	6·7	8·0	9·1	9·2	10·4	9·3

The mean speeds for the months October and November are less than for the other months and it may be concluded that synoptic situations favouring fog development are more frequent in October and November than in the other winter months.

The second line of the table gives the mean wind speeds at Kew averaged over the four-year period August 1946 to July 1950. The four-year mean is close to the average for the months October, November and March, but rather above for the months December, January and considerably above for February. The number of cases of fog in these three months is probably somewhat under-estimated, especially in the number of cases of thick fog in February. Any adjustment for this, however, would leave the salient features indicated in Figs. 1 and 2 unchanged and these must be regarded as significant variations in fog at London Airport, to be explained by the considerations given above.

From the aircraft operator's point of view, the worst time to plan operations is the period one or two hours after sunrise at all times of the year. In June, July and August there is very little fog at any other time, but in the other months of the summer half-year, April, May and September, some fog occurs for several hours in the early morning before the normal time of maximum occurrence. In the winter half-year the period 2–3 hours after sunset tends to be rather worse than the rest of the night but it is not generally as bad as the period one to two hours after sunrise. In the winter, the best time is 1–2 hours before sunset and, except in October and November, 2–3 hours before sunrise.

METEOROLOGICAL OFFICE DISCUSSION

Thunderstorm electrification

The second Meteorological Office discussion of the present session was held on November 13, 1950. It was opened by Dr. G. D. Robinson who presented an abstract of three papers by Ross Gunn on thunderstorm electrification:—

The free electrical charge on thunderstorm rain and its relation to droplet size. *J. Geophys. Res., Baltimore, Md.*, **54**, 1949, p. 57.

The electrical charge on precipitation at various altitudes and its relation to thunderstorms. *Phys. Rev., Lancaster, Pa.*, **71**, 1947, p. 181.

The free electrical charge on precipitation inside an active thunderstorm. *J. Geophys. Res., Baltimore Md.*, **55**, 1950, p. 171.

Discussion was invited on any aspect of the electrification of thunderstorms.

Gunn's observations were incidental to work in connexion with the United States Army–Navy Precipitation Static Project* which required much flying in rain clouds and thunderstorms. The main airborne instruments were generating voltmeters above and below the fuselage and an " induction probe" for measuring the charge on individual precipitation particles. The drops passed through a screened conducting loop and the resulting voltage pulses were amplified and recorded.

In the first paper the maximum charge on a raindrop is established theoretically, the limit being set by the field at the surface which must be less than the dielectric-breakdown strength of air. The reduction of the maximum charge due to deformation of the drops, and to the presence of small cloud particles, polarized in the field of the larger drop, is considered. Simultaneous measurement, in three thunderstorms, of the masses and charges of raindrops at the ground are shown to be in accordance with these predictions, and the result of previous investigators that it is usual for positive and negative drops to be present together is confirmed.

The second paper describes measurements made from aircraft in the cloud system of a weak cold front. Drop charge and field strength measurements are made at various heights from 4,000 to 26,000 ft. (freezing level, 11,500 ft.). The total space charge on precipitation elements is evaluated and compared with the observed fields. It is concluded that the precipitation charge must, to a considerable degree, be neutralized by a charge of opposite sign, either ionic or on the cloud particles.

The third paper extends the work of the second paper to an active thunderstorm in which horizontal traverses were made at various heights between 5,000 and 20,000 ft. (freezing level, 14,000 ft.). The results are generally similar to those in the cold front, the droplet charges being so large that the field at their surface approaches the dielectric-breakdown strength. The maximum electrification is observed at 7,500 ft. at a temperature of +10°C. The distribution of charge in the cloud is apparently complicated. There are large volumes in which all droplets are charged with the same sign.

Gunn does not give detailed measurement of the field strengths, but mentions that fields of 2,000 v./cm. were observed several times in the near vicinity of

Proc. Inst. Radio Engrs, New York, N.Y.*, **34, 1946, pp. 156 and 234.

lightning discharges, and that on an occasion in another storm, when the aircraft was struck, the maximum measured field (assumed vertical) was 1,600 v./cm.

Gunn concludes that the particle electrification processes, even in quiet frontal rain area, are sufficient to give an appreciable fraction of the maximum permissible charge, and in this respect they must differ little from those in an active thunderstorm. In an active thunderstorm there are regions, perhaps 2 Km. across, in which all drops carry the same sign of charge, and, if the droplet charge alone is considered, the field at the extremities of these regions should be about 10,000 v./cm., or five times the maximum observed. There must therefore be a compensating charge on the cloud particles even in active thunderstorms. Gunn implies that the electrical difference between ordinary rain and thunderstorms is brought about by the partial separation by strong vertical wind of the precipitation particles and the compensating charge on the cloud particle.

Dr. J. A. Chalmers of the University of Durham, who opened the general discussion, mentioned the theories put forward by Frenkel and by Findeisen to account for the electrification of cloud and precipitation particles. Gunn's observation that the upper positive charge in the cloud was on precipitation particles could not easily be explained on Frenkel's theory. Dr. Chalmers then referred to some measurements which he had made, in collaboration with Dr. Hutchinson, of the charge on single drops at the ground and its relation to the field at the ground and the point-discharge current. This work suggested that the charge on drops at the surface was controlled by the Wilson mechanism operating in the lowest few hundred metres in the plentiful ion supply produced by point discharge.

Dr. T. W. Wormell then spoke of two recent, and as yet unpublished, investigations at Cambridge:—

Mr. L. G. Smith has been studying the electrical charges on individual raindrops at the ground and has devised a method whereby, for each drop falling into the receiver, electric charge, rate of fall, and, also an independent measure of the mass are all displayed on a cathode-ray oscilloscope and recorded photographically. The point-discharge current from a metal point is simultaneously recorded, the two records being synchronized. He has thus been able to obtain a rapid sample of the properties of the rain while conditions might be presumed to be reasonably constant.

When an intense electric field exists at the ground and conditions are fairly steady, the results show clearly the effect of the capture of ions by the drops as they fall from the cloud to the ground in that the smaller drops, which spend a longer time on the descent, tend to have a charge whose sign is the reverse of the sign of the potential gradient while the larger drops tend to have the same sign as the potential gradient. There remains, however, despite the rapid sampling, a very wide spread in the values of the charges on individual drops of the same size. Two drops of sensibly the same size, which fall into the receiver almost simultaneously, may have charges of quite different magnitudes and even of different signs. It would appear to be extremely difficult to account for these differences in terms of a difference in the charges possessed by the drops when they fell from the cloud base and one is left with the puzzling problem as to how the subsequent history of the drops could have differed.

Mr. I. C. Browne has been investigating by radar the vertical structure of overhead thunderstorms, using a narrow vertical beam of radiation, of wavelength 3·2 cm., and displaying the intensity of the echo, scattered from different heights, as a function of height. In several storms an extremely intense echo was observed from a region of limited vertical extent near the base of the cloud, the intensity of the scattered signal increasing exponentially from the top to the base of the region. The condition persisted for several minutes and was accompanied by very heavy rain at the ground. In one particular case, for example, the region extended from 4,000 ft. to 2,700 ft., the echo from the latter height being about 50 times as strong as from the former; the freezing level, on this occasion, was at about 8,000 ft.

A possible explanation of these results would seem to be that large drops are falling into the top of the region and are increasing in number by a repeated process of breaking and regrowth, to the critical size, through the sweeping up of cloud particles. To explain, however, the very rapid increase of scattering power with decreasing height it is necessary to postulate an up-draught whose intensity, in the particular case already quoted, must be about 90 per cent. of the rate of fall of the large drops.

If this be the true interpretation, a region of the cloud has been identified in which the Simpson breaking-drop process is actively at work, and under which a positive gradient of potential would be expected to occur. Clear examples of this type of echo were observed in three different overhead storms during the summer of 1950. In two of the three cases there was, at the time, a strong positive potential gradient; on the third occasion close lightning discharges were occurring frequently and the sign of the potential gradient was indeterminate.

Dr. T. W. Wormell also questioned Gunn's explanation of the separation of the charge in a thundercloud. The velocities relative to air of the precipitation particles and cloud droplets would have the same ratio in still air and in a vertical wind, and no increased separation would be expected.

Dr. F. J. Scrase spoke of the difference between thunderstorm and shower clouds. Although the magnitudes of the charges observed on rain from these clouds were similar, showers showed a considerable excess of negative charge. He suggested that shower clouds might be bipolar, without the positive region of charge in the base. Mr. R. F. Jones had observed greater signal intensities in radar echoes from thunderclouds than from shower clouds; this suggested to Dr. Scrase that bigger drops might exist in thunderstorms, with consequent greater possibility of formation of low positive charges by the breaking-drop mechanism. Dr. Scrase also commented on the inadequate sampling in Gunn's observations—in the thunderstorm he estimated that 1 drop in 10^{10} was sampled.

Mr. R. F. Jones confirmed Dr. Scrase's report of his findings, but added that in thunderstorms it was common for lightning not to be observed until more than ten minutes after the radar echo had attained its maximum intensity. He also mentioned that although it seemed possible to interpret the echo only as being from liquid water, the top of the echo-producing column was almost always at a temperature below −40°C.

Mr. C. R. Bruce, of the Electrical Research Association, raised the question of the magnitude of the fields observed by Gunn, which were considerably greater than those suggested by the alti-electrograph. This point was of considerable importance in the theory of propagation of the lightning discharge.

Dr. Robinson, in replying to the discussion, pointed out that 15 per cent. of the useful alti-electrograph ascents had come to a violent end in rapidly increasing fields, so the results could hardly be used as evidence of total absence of fields of the order of 1,000 v./cm. The fields shown by the alti-electrographs below the cloud, however, could not be reconciled with the assumptions made by Sir George Simpson and now by Dr. Chalmers and Dr. Wormwell in explaining the relation of the charge on rain to the field at the ground. He regretted very much that Gunn had not taken the opportunity to observe and publish the field at the ground and at several heights below the cloud base when observing the electrification of ordinary rain.

METEOROLOGICAL RESEARCH COMMITTEE

The eleventh meeting of the Synoptic and Dynamical Sub-Committee of the Meteorological Research Committee was held on November 2, 1950. High-level photography of cloud systems as an aid in forecasting and as a possible research tool was discussed at length; many interesting photographs were displayed.

After considering a brief review of recent literature, the Sub-Committee agreed that the ideas of dynamic instability (in the restricted sense currently attributed to dynamic instability) have little or no useful application in practice.

The desirability of investigating weather conditions leading to ice on the Icelandic fishing grounds was also discussed.

ROYAL METEOROLOGICAL SOCIETY

At the meeting of the Society held on November 22, 1950, Dr. R. C. Sutcliffe, Vice-President, in the chair, the following papers were read:—

Robinson, G. D.—Notes on the measurement and estimation of atmospheric radiation—2*.

Dr. Robinson first explained in broad outline the application of the Elsasser and Kew radiation charts to the computation of the emission of infra-red radiation from a layer of the atmosphere, given the water-vapour content and temperature, and dealt more closely with the dependence of the coefficient of emissivity of water vapour on temperature. Comparison of the observed and computed radiation flux showed that the error of the computed values when plotted against screen temperature gave parallel curves for both the Elsasser and Kew radiation charts. This comparison showed that the emissivity increased with temperature for the range of both lengths and temperatures dealt with.

Dr. Robinson then turned to his measurements of the radiative heating and cooling of the lowest metre of the air over grass at night which showed that the net flux of radiation out from the top of this layer could be ten times the flux equivalent to the rate of cooling. He ascribed the difference to heating of the air by downward eddy convection which, in answer later to Sir David Brunt, he explained, included the latent heat of water vapour moving downward to

* *Quart. J. R. met. Soc., London*, **76**, 1950, p. 37.

condense on the grass. Finally, Dr. Robinson stated that measurement of the temperature of the ground was not so very difficult after all, as he had found that, on both cold nights and hot sunny afternoons, measurements of the surface temperature by a radiometer agreed extremely well with the readings of an ordinary grass minimum thermometer laid on the grass.

Mr. E. Gold and Sir David Brunt discussed the variation of emissivity with temperature which appears to be equivalent to assuming radiation to be proportional to $T^{3.5}$ instead of T^4. Prof. P. A. Sheppard asked if Dr. Robinson had used Ångström's radiation measurements in a balloon flight for determining the emissivity at low temperatures, but, for instrumental reasons, Dr. Robinson doubted their accuracy.

*Penman, H. L.—Evaporation over the British Isles.**

Dr. Penman has given, in the last two years, a formula enabling the long-period evaporation from an extended water surface in a given area to be computed from the sunshine, temperature, humidity and wind speed over the area, and empirical factors, variable with season, for deriving values for the evaporation from vegetation. He described at the meeting a comparison between the computed value of evaporation from open water with the measured evaporation from a reservoir near Colchester, and a comparison between the computed evaporation from vegetation and the difference between rainfall and run-off over Great Britain. Over periods sufficiently long for the changes in underground water storage to be neglected the evaporation and run-off should balance rainfall. Striking agreement was found in both tests. The map of evaporation showed that over the south-east and south coast of England and south-west Ireland it is 20 in. per annum, and over Scotland, north England and eastern Ireland it is 15 in. The intermediate, 17·5 in., line runs from London to Liverpool.

In the discussion, Mr. Gold described researches into the relation between run-off in a given three-month period to the rainfall in the same and earlier periods. Dr. Glasspoole showed that over the Thames valley the rainfall and run-off varied fairly closely together in time but the difference between them was markedly different. Mr. McClean, speaking as an engineer, doubted the accuracy of evaporation computed from rainfall and run-off because he considered only the run-off was accurately measurable. Dr. Penman, speaking again, dealt with underground water storage and showed that a well record, representative of the storage, agreed very closely over a long period of years with the quantity: rainfall minus run-off and minus computed evaporation from vegetation.

LETTERS TO THE EDITOR

Cloud cap over Sandray, Outer Hebrides

On a recent short stay at Castlebay, Isle of Barra, Outer Hebrides, I was informed by several inhabitants that a well defined cloud over the Isle of Sandray was a sure sign of a spell of rain in Barra.

This well defined cloud appeared on two occasions during my stay on the island, and within about half an hour of its appearance rain set in, accompanied by high wind; and on each occasion the rain continued unabated for at least

* *Quart. J. R. met. Soc., London,* **76**, 1950, p. 372.

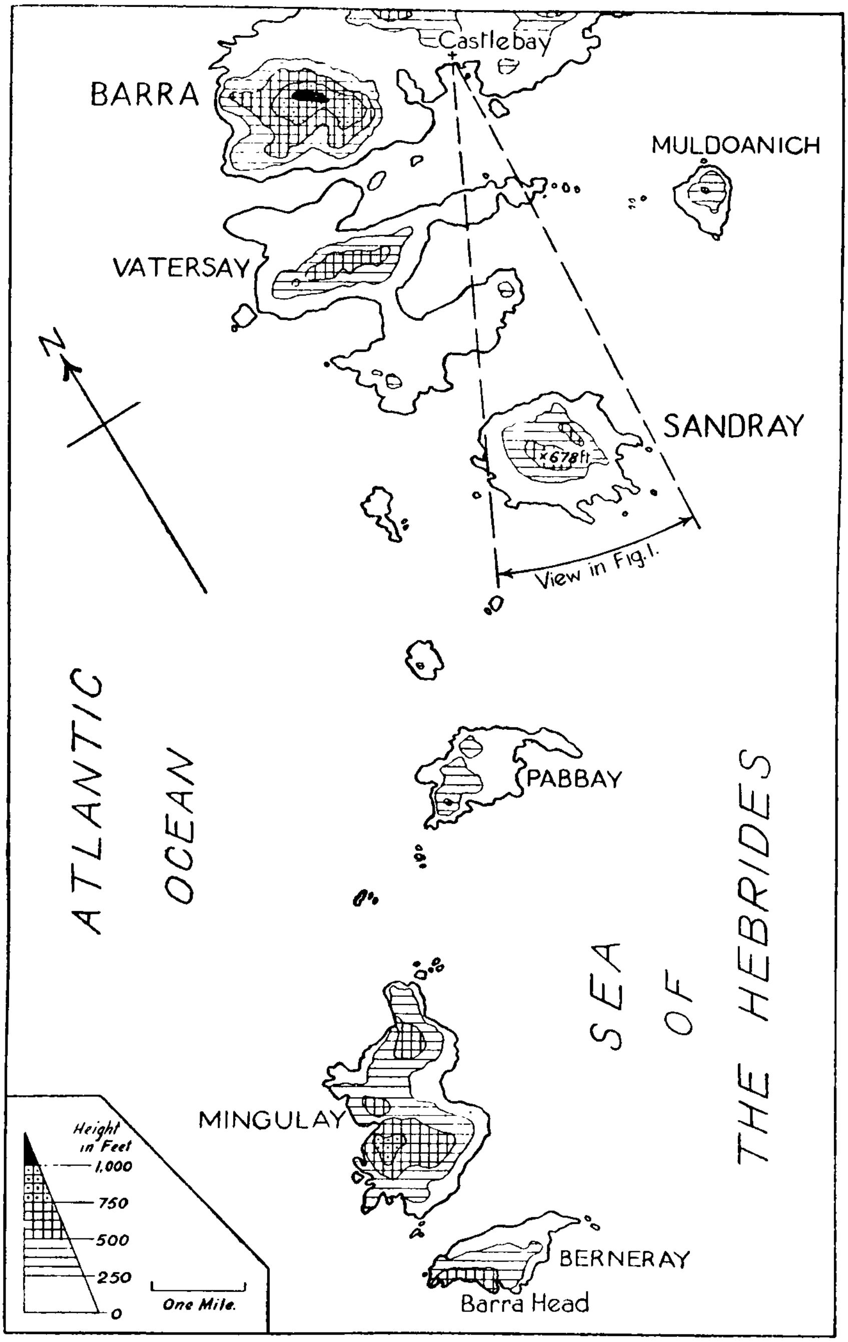


FIG. 2—SOUTHERN ISLANDS OF THE OUTER HEBRIDES

twelve hours. It is of interest to note that apart from very brief breaks of a few minutes' duration, the sky was totally overcast with a sheet of stratocumuliform cloud during the whole seven days of my visit. The base of this cloud sheet was generally at about 1,000 ft. but at times came down in ragged patches to about 400 ft.

The "rain-warning" cloud over Sandray would form, in sharp lenticular outline, beneath the stratocumulus sheet and, by the time the rain belt reached Castlebay, the well defined outline would become diffuse and appeared to merge with the general cloud sheet above it.

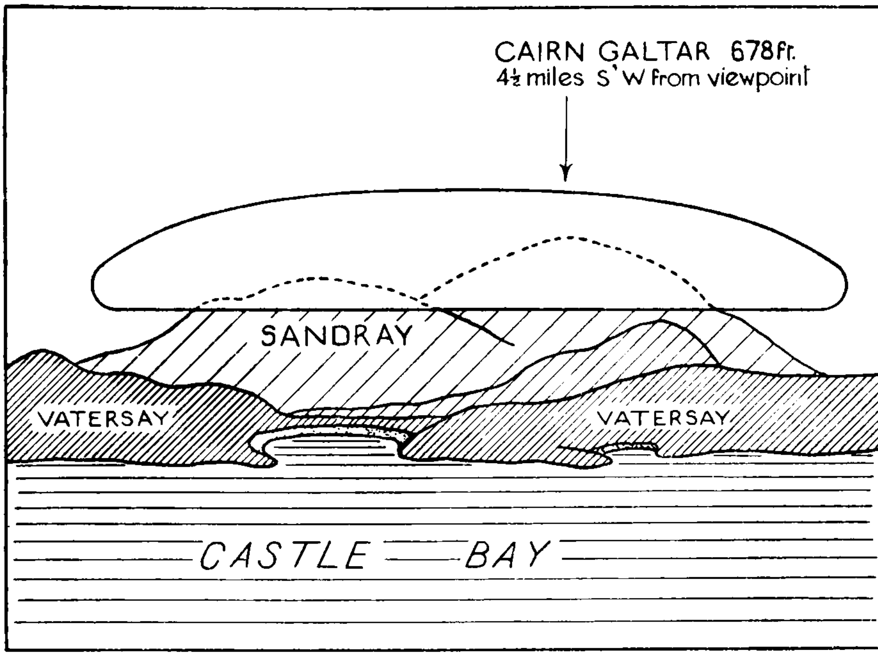


FIG. 1—CLOUD CAP OVER SANDRAY

I took particular note of the surface wind at the time, and the lenticular cloud cap formed when the wind was from the S. or SE. Fig. 1 shows the appearance of the cloud cap at 2010 G.M.T., June 25, 1950, and Fig. 2 shows a map of the area. It will be noted that the Isle of Sandray is fully exposed to southerly winds, the nearest landfall to the south being the north coast of Ireland, some 100 miles or more away.

It is of interest to note that cloud caps appearing over the adjacent islands of Muldoanich, Pabbay and Mingulay do not appear to take sharp lenticular outlines as those forming on Sandray itself; and if other less defined caps do form on Sandray, they do not seem to indicate the arrival of prolonged rainy periods in Barra, although brief showers may be experienced.

D. L. CHAMPION

56 Forestdale, Southgate, London, N.14, July 10, 1950

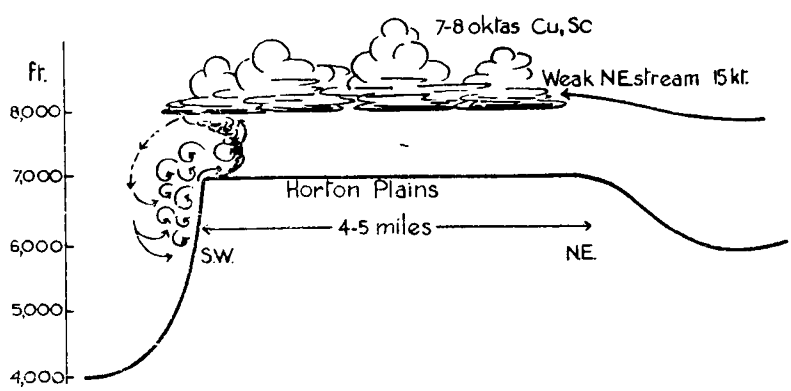
Lee eddies and cloud formation

The visible demonstration of the vertical eddies that exist to the leeward of an obstacle in a wind stream must be comparatively rare in nature. Such a demonstration, however, was afforded the writer when visiting Horton Plains, Ceylon.

Horton Plains is a plateau, 7,000 ft. high, in the central hill district of Ceylon. The main mountain range runs roughly north-south in this area, flattening out for some four or five miles to form the plains, which are approximately four miles wide from east to west. On the north-east side, a steep, but not precipitous, jungle-covered slope falls away for 1,000 ft. to an upland basin. To the south-west the plain is bounded by a precipice which falls sheer for 1,000 ft. and then only just less steeply for a further 2,000 ft.

On the evening (1700 I.S.T.) of March 20, 1950, a weak NE. monsoon air stream covered Ceylon; 7–8 oktas light cumulus and stratocumulus cloud were about 1,000 ft. above Horton Plains and were being carried south-south-west at an estimated speed of 15 kt. On the plateau, and at a distance of rather less than half a mile from its south-west edge, the surface wind was negligible, but puffs of thick fog could be seen rolling up over the edge of the precipice and advancing one or two hundreds of yards north-eastwards over the plateau before being swept upwards towards the main cloud base and then carried south-westwards again.

The viewpoint on the plateau in relation to the general wind stream and the topography of the precipice, was such that a partly "sectional" view of the leading edge of the fog was obtained and its convex curvature could be clearly seen, indicating the eddy formation. The roll or leading edge of fog was alternately very definite and either stationary or advancing north-eastwards, or very ragged and undefined and retreating towards the cliff edge. These alternations were not timed accurately, but were of the order of a few minutes and were probably due to the formation of an eddy and its subsequent detachment down wind.



SKETCH DRAWN IN THE METEOROLOGICAL OFFICE FROM THE DESCRIPTION BY W. D. S. MCCAFFERY.

The formation of the cloud which made these eddies visible can be explained by assuming that eddies forming in the air spilling off the plateau, drew up warmer and moister air from the plains beneath, the uplift being sufficient to cause condensation.

The thick fog which shrouded the edge of the precipice was in striking contrast to the more usual phenomenon of "cloud clearing to leeward of high ground".

W. D. S. MC CAFFERY

Negombo, Ceylon, July 14, 1950

Corrosion in a Dines anemograph head

Users of the Dines anemograph may perhaps be interested to learn of a possible cause of damage to the head of this instrument.

A new anemograph was installed at the Royal Observatory, Hongkong, in 1939. The cylindrical shield which covers the pressure and suction outlets at the base of the head was stuffed with cotton waste, to prevent it from vibrating and possibly fracturing in typhoon winds. When the Observatory was re-occupied after the Japanese occupation, the velocity recorder was found to be sluggish and lacking in sensitivity. The trouble was traced to the pressure and suction tubes, which were corroded right through within the lower part of the shield, where they were in contact with the cotton waste. Corrosion had also attacked the mast itself at this level, but fortunately the damage was discovered before the head became completely detached.

The lower part of the waste was found to be damp when it was removed; it must have accumulated hygroscopic particles from smoke or from salt-water spray (the sea front is only a quarter of a mile away). The brass shield, the damp waste and the iron tubes evidently formed an electrolytic cell, with the result that the iron was slowly dissolved.

G. S. P. HEYWOOD

Royal Observatory, Hongkong, September 20, 1950

NOTES AND NEWS

Market Produce Show, Southampton—June 30–July 1, 1950

At the request of the National Farmers' Union, the Meteorological Office (Agricultural Meteorology Branch) provided an exhibit at the Market Produce Show, held on the Common, Southampton, on June 30 and July 1. After experience at the similar show in 1949, the chosen items were mostly confined to the few necessary to give emphasis to the main interests of producers in present-day weather. These interests are the need for irrigation of vegetable, salad and soft-fruit crops during the summer, and the economics of growing them under cloches.

The Meteorological Office tent was well placed next to that of the Ministry of Agriculture, and the exhibit attracted the attention of growers as well as agricultural students and many parties of schoolchildren. In a small enclosure outside the tent were displayed a large thermometer screen with the usual four thermometers, thermograph and hygrograph; a cup anemometer; a sunshine recorder; and a working experiment showed the effect on air and soil temperatures of modern cloches, a distant-reading thermograph being used to show the air-temperature contrasts. The weather was warm and sunny, and the outside exhibit attracted much attention in consequence. Inside the tent the main feature of the display consisted of five vertical panels reaching from floor to roof. Two panels showed the activities of the Office in relation to agriculture, including those of the Agricultural Meteorology Branch in particular and also the forecast and climatological facilities available to the farming community. A third panel illustrated by means of enlarged photographs the weather indications which farmers might deduce from a study of the sky. The remaining panels concentrated attention upon the variability of British rainfall and the need for irrigation, and the results of experiments on the effect of glass protection on soil and air temperatures. It was noted by many visitors that these results agreed very well with the working experiment demonstrated in the enclosure. On tables round the walls of the tent were shown various meteorological instruments of particular interest to agriculturists, and appropriate literature was there to be read. The meteorological office at Eastleigh co-operated by sending daily forecasts and weather reports. The blackboard prominently displaying "Forecast—fair and warm" without any "perhaps" or "here and there" was a special comfort to the organizers, whilst several chairs provided a much needed rest to visitors and were not the least appreciated part of the show.

In addition to the Meteorological Office's own display there were included in that of the Ministry of Agriculture, next door, two models which had a bearing on their subject, which was the proper establishment of an apple orchard. One contribution consisted of a topographical and geological model indicating the importance of exposure and soil as regards frost incidence in an orchard, and the other of a wind tunnel illustrating the protection from wind afforded to orchard trees by a low hedge. Material was also provided for a special exhibit designed to demonstrate the effect on the date of flowering of cooling bulbs in store before planting.

Next year the Market Produce Show is to be held in London in connexion with the Festival of Britain, so that a more ambitious effort may be called for, but that the simplicity of this display at Southampton was appreciated was plainly shown by the encomiums of our many visitors.

Ice formation on conductor rails

Daily forecasts of the prospects of ice formation on electrical conductor rails are issued during winter months by the Central Forecast Office, Dunstable, to the Southern Region of British Railways and to the London electrified railways. When icing is forecast arrangements are usually made by the railway authorities either to run special de-icing trains or, in the case of London Transport, to switch in the de-icing baths which are installed throughout the open sections of the track.

The ice deposits which effectively insulate the rails and interfere with the running of trains are those which are adhesive in character and are not brushed off by the collecting "shoes" of passing trains. Examples are: a deposit of dew which subsequently freezes, and rain, or wet snow, falling on conductor rails that are at subfreezing temperatures. Hence, to forecast the icing risk it is usually necessary to estimate the temperature to which the conductor rail will fall during the period covered by the forecast. This temperature naturally varies with the exposure of the rail, particularly on a radiation night, and, other factors being equal, may be very different where the line runs through a cutting from what it is on an embankment or on open level ground. The meteorologist's knowledge and experience of grass minimum temperatures and their relationship to air temperatures at 4 ft. above ground, materially assist him in forecasting grass temperatures, but little is known of the relationship between the temperature of an electrically insulated metal rail and that of the surrounding air, either at ground level or a few feet above.

To obtain some information about this the Meteorological Office is collaborating with the London Transport Executive in the installation of a thermometric system to record rail temperatures, and the temperature and humidity of the ambient air. The site of the installation is just outside Barons Court station on the District and Piccadilly Lines, where a 30 ft. length of "dummy" conductor rail has been mounted alongside the running rail (see photograph opposite). This has been drilled diagonally at its mid-point

[To face p. 24

SITE OF THERMOMETRIC SYSTEM NEAR BARONS COURT STATION.

To face p. 25]

SCREEN HOUSING DISTANT-READING THERMOMETER BULBS and into the drilling has been inserted the bulb of a Negretti & Zambra mercury-in-steel distant-recording thermometer, the bulb being in thermal contact with the head of the rail. A second such thermometer is mounted alongside the rail at the same height above the ground (see photograph opposite) to record the air temperature at that level for comparison with that of the rail. In addition, dry- and wet-bulb distant-recording thermometers are installed at the standard height of 4 ft. in a screen which has been erected alongside the length of dummy rail. The recorders for these two pairs of thermometers are housed in a small cabin specially constructed on the opposite side of the track (seen in the photograph facing p. 24 with the doors open).

Daily inspection and maintenance of the recorders is carried out by the technical staff of London Transport, who also make observations of the character and adhesion of ice forming on the surface of the dummy rail. These observations, together with the thermometric records, are to be sent to the Central Forecast Office, Dunstable, for the study of the relationship between air and rail temperatures at the same level, and between these and air temperatures at 4 ft. The association of ice formation on the rail with the humidity as recorded at 4 ft. will also be examined.

At a later stage similar installations may be set up at two or three other locations, having different types of exposure.

Temperature at 200 mb. in relation to the pressure at the tropopause

A study of the frequencies of different temperatures at different pressure levels, undertaken in the upper air climatological section of the Meteorological Office in the course of the preparation of charts of standard deviation of upper air temperature over the world, brought to light the fact that at 200 mb. over the British Isles the distribution is not normal in the statistical sense but shows two maxima. This abnormality is most conspicous in winter, and it was suggested that it might be due to the fact that the 200-mb. surface lies sometimes in the stratosphere and sometimes in the troposphere and that occasions of low tropopause are more frequent in winter than in summer.

The temperature frequencies at Larkhill were therefore re-tabulated and classified into five groups according to the tropopause pressure, namely, very high tropopause with pressure below 200 mb., three groups of intermediate tropopauses with pressure 200–249, 250–299, 300–349 mb., and very low tropopauses with pressure of 350 mb. and over. The results for the mid-season months January, April, July and October are shown in Table I and in Fig. 1. In the figure the percentage frequencies for steps of 2 degrees Fahrenheit are represented; and, in order to simplify the diagram, all occasions of tropopause pressure of 250 mb. and over are grouped together. In the table (which gives actual values not percentages) the five pressure groups are shown separately, but to reduce the size of the table the temperature is in four-degree ranges.

The average pressure at the tropopause in January for the period studied is 239 mb. The percentage frequencies of temperature for values of the tropopause pressure above and below this average are shown in Fig. 2.

The association of low temperature with high tropopause (low tropopause pressure) and *vice versa* is very clearly shown.

TABLE I—FREQUENCY OF TEMPERATURE AT 200 MB. IN RELATION TO TROPOPAUSE PRESSURE

Larkhill (all hours) Period—July 1945–July 1949

Temperature (Fahrenheit) at 200 mb.

Tropopause pressure	−95° to −92°	−91° to −88°	−87° to −84°	−83° to −80°	−79° to −76°	−75° to −72°	−71° to −68°	−67° to −64°	−63° to −60°	−59° to −56°	−55° to −52°	−51° to −48°	−47° to −44	−43 to −40°	over −40°	Total
mb.	*number of occasions*															
JANUARY																
<200	3	11	41	27	12	4	1	1	...	...	...	...	...	...	...	100
200–249	1	6	29	38	38	29	25	14	10	7	3	...	...	...	...	200
250–299	...	...	...	2	2	6	11	13	24	25	13	4	...	...	...	100
300–349	...	...	...	...	...	1	1	1	5	17	9	7	1	...	...	42
⩾350	...	...	...	...	...	...	...	...	3	7	4	5	2	...	...	21
Total	4	17	70	67	52	40	38	29	42	56	29	16	3	...	...	463
APRIL																
<200	...	...	10	26	37	18	2	1	...	...	...	...	...	...	...	94
200–249	...	3	11	26	38	42	34	25	15	13	2	3	...	...	...	212
250–299	...	...	...	2	1	2	9	9	7	19	22	4	1	1	...	77
300–349	...	...	...	...	...	...	...	...	...	4	7	5	6	2	...	24
⩾350	...	...	...	...	...	...	...	...	2	2	4	1	5	6	2	22
Total	...	3	21	54	76	62	45	35	24	38	35	13	12	9	2	429
JULY																
<200	...	...	...	1	6	24	40	25	19	6	1	...	...	...	...	122
200–249	...	...	...	1	5	28	57	72	58	59	30	15	3	...	...	328
250–299	...	...	...	...	...	...	...	2	2	12	14	37	20	9	2	98
300–349	...	...	...	...	...	...	...	...	...	...	1	6	5	7	1	20
⩾350	...	...	...	...	...	...	...	...	...	...	1	...	1	2	...	4
Total	...	...	...	2	11	52	97	99	79	77	47	58	29	18	3	572
OCTOBER																
<200	...	1	8	30	52	46	29	7	4	...	1	...	...	...	...	178
200–249	...	...	2	14	28	39	52	31	14	5	2	1	...	...	...	188
250–299	...	...	...	...	...	1	8	24	25	11	5	1	...	...	...	75
300–349	...	...	...	...	...	...	...	4	6	3	5	3	...	...	...	21
⩾350	...	...	...	...	...	...	...	...	1	2	1	3	1	1	...	9
Total	...	1	10	44	80	86	89	66	50	21	14	8	1	1	...	471

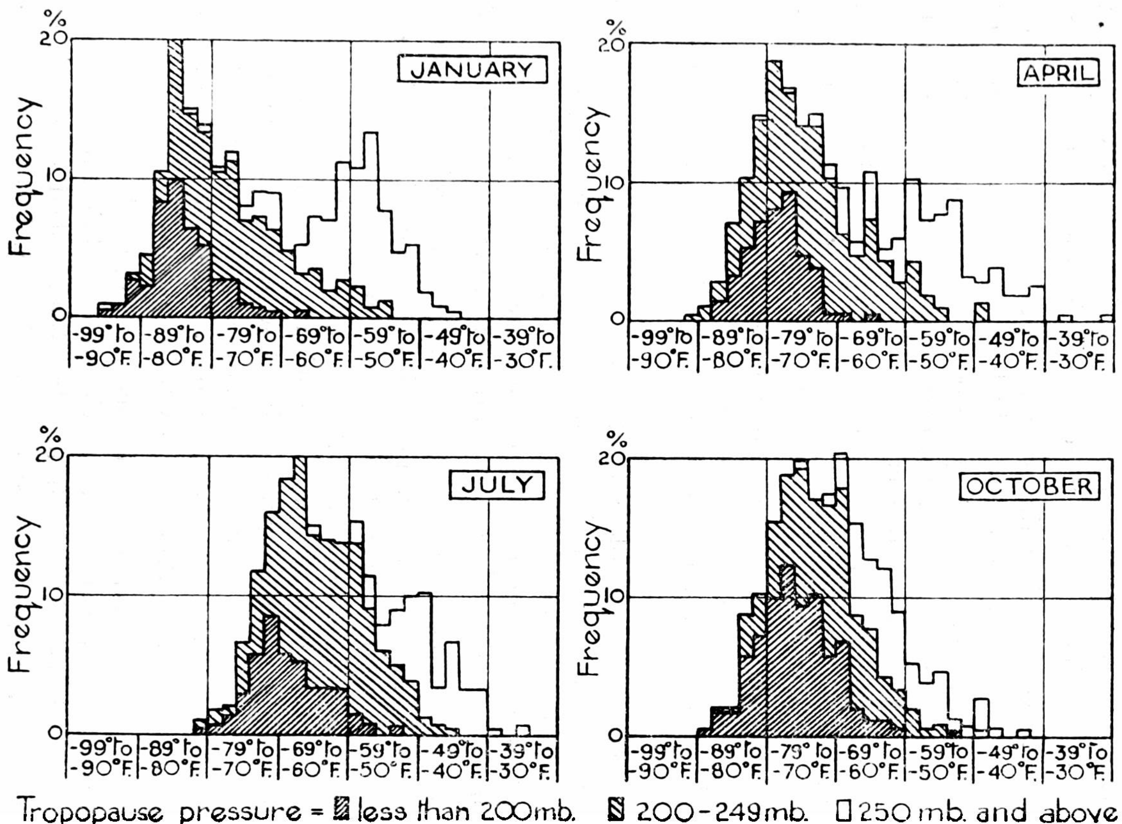


FIG. I—PERCENTAGE FREQUENCY AT LARKHILL OF 2-DEGREE STEPS OF TEMPERATURE AT 200 MB. IN RELATION TO PRESSURE AT THE TROPOPAUSE

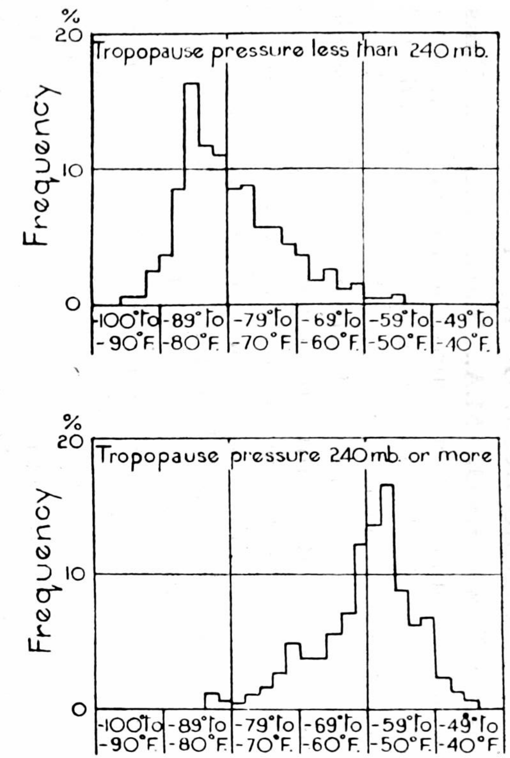


FIG. 2—TEMPERATURE FREQUENCIES AT 200 MB. IN JANUARY AT LARKHILL

METEOROLOGICAL OFFICE NEWS

Mr. Ralph Sydney Read, I.S.O., M.A., B.Sc., A.R.C.S., F.Inst.P.—Mr. Read, Principal Scientific Officer, retired on December 4, 1950, after almost 31 years' service in the Meteorological Office. After student days at the Royal College of Science, London, and Sidney Sussex College, Cambridge, a lectureship at University College, Exeter, Government work and service with the Meteorological Section, R.E., 1914–18, Read came to the Office as a Senior Professional Assistant in January 1920. He was destined to be closely and prominently associated with meteorological services for aviation for the whole of his Office career. An initial three-and-half years at Lympne airport in the early days of scheduled air services to the Continent was followed by thirteen years at headquarters as deputy to the Head of the Branch responsible for meteorological services for aviation. During this period he was concerned with actual forecasting and also with administrative and organizational duties, at times concurrently. He was one of the first to appreciate the importance of the "frontal" ideas of the Norwegian school of meteorologists and to apply them. In those early years of the growth of aviation, when official and private long-distance flights and flying displays at Hendon made headline news, Read played a leading and often arduous part as meteorologist for the new enterprises.

For about three years before the second world war he was in charge at Croydon airport, then in its heyday as chief centre of civil aviation services in the United Kingdom. This close association with civil aviation was continued in the early months of this war in his capacity as Liaison Officer with the Headquarters of the Director-General of Civil Aviation, Bristol. From June 1940 until February 1944 he was Senior Meteorological Officer at H.Q. No. 11 Group, one of the most responsible posts with the R.A.F. in those war years. Thereafter, as Head of Branch at Headquarters, he was intimately engaged, at first with the requirements of the Army and R.A.F. prior to and during the war operations in north-west Europe, and subsequently with the modified but, in the circumstances, perhaps no less exigent needs of the post-war R.A.F. at home.

Mr. Read's service to meteorology in all its different aspects was marked by ability coupled with keenness and a certain East Anglian fixity of purpose. His great experience was always fully at the disposal of colleagues of all grades. He was well known to hundreds of people actively concerned with flying, from practising pilots and navigators to more eminent and senior personalities.

But his colleagues remember also Read's other less official attributes; his friendliness and individual sense of humour, his enjoyment in social occasions, his fondness for horticulture, his walking expeditions. His active participation in athletic activities for the Office and Air Ministry—running, rugger, soccer and cricket—continued into his late forties when most of his contemporaries were spectators, or arm-chair critics. His close interest in sport remains, though the early morning swim in the Thames near his home was abandoned comparatively recently. For some years he represented the Office staff on the Council of the Institution of Professional Civil Servants.

At a well attended ceremony on December 4, 1950, the Director, Sir Nelson Johnson, referred to Mr. Read's valued services and qualities, and, in conveying the earnest good wishes of the staff to Mr. Read, asked him to accept a miniature greenhouse, exquisitely fashioned by Mr. A. J. Tabor, in token of the large-scale article for which the staff had subscribed. Mr. Read, in some thoughtful farewell remarks, touched on incidents selected from his experience, contrasted past with present meteorological facilities, and paid tribute to the team spirit within the Meteorological Office and emphasized the importance of sustaining it within such a far-flung organization. Mr. Read's numerous colleagues and the many other friends who were unable to be present on the 4th will wish him every happiness in his years of freedom from official responsibilities.

Awards for long service as voluntary meteorological observers at sea.—Three master mariners who have made consistently good voluntary observations at sea for the Meteorological Office over a period of more than 15 years have recently had presentations made to them by the Director. The awards have taken the form of barographs with an inscription on a silver plate which reads "Presented by the Director of the Meteorological Office to . . . . in recognition of his valuable meteorological work at sea, 19... to 19...".

The presentation to Captain G. Kinnell, O.B.E., of the New Zealand Shipping Co. was made aboard his ship, the *Rangitata*, in Victoria Dock, London, on November 29, by Sir Nelson Johnson. Mr. H. Whitehouse, Chairman of the Company was host at a very pleasant luncheon party to mark the occasion, at which the guests included representatives of the Honourable Company of Master Mariners.

On December 13, in the Captains' Room at Lloyds, at the weekly luncheon of the Honourable Company of Master Mariners, Sir Nelson Johnson made the presentations to Captain J. A. Myles of the Cunard Line and to Captain R. A. Penston of Messrs. T. & J. Brocklebank, Ltd. Captain Myles has been a voluntary observer since 1921 and Captain Penston since 1926. The guests at the luncheon included Sir Stanley Aubrey, Deputy Chairman of Lloyds.

Rosters in Malaya.—Malaya is a meeting place of nationalities and one of the problems facing the Meteorological Office in that country is the making of assistant rosters which will take into account all the public, national and religious holidays which the members of the different nationalities can claim. A roster may be composed of a selection of Chinese, Hindu, Muslim, Jew, Buddhist or Sikh staff whose national and religious festivals are all different and do not occur on fixed days. They may be determined either by a particular astronomical sign or by a calendar different from our own, one being a variable calendar containing twelve or thirteen months. Makers of rosters at home will be able to appreciate some of the difficulties to be overcome.

Television.—A television programme, "London Town", broadcast on November 10, 1950, included scenes of a visit by Mr. Richard Dimbleby to the roof of the Meteorological Office, Kingsway. The exposure and instruments were shown, and some autographic records and diagrams connected with the daily work of the general inquiry section of the Office were televised "live" during an interview at the Alexandra Palace studios.

Sports activities.—The Office has been very successful in the recent Air Ministry championships:—

Swimming.—Miss B. J. Davies won the ladies' championship.

The Office won the team race for the second year running and gained the first three places in the free-style and breast-stroke races and the first two in the back-stroke.

Mr. A. F. Lewis has won the free-style and the back-stroke races for the last three years and Mr. T. D. Abbott the breast-stroke race for the second year running. Mr. Abbott was third in the Civil Service breast-stroke championship, Mr. A. R. Hosker third in the Civil Service plunging championship and Mr. A. F. Lewis (now in the Falkland Islands) and Mr. S. W. Lewis were fourth and fifth respectively in the Civil Service mile swimming championship.

Cross-country Championship.—The Office won the team event and second and third places (Messrs. G. F. Burton and G. M. Band) in the individual event held at Woodford on December 9. The race was originally run at Hayes on November 25 when Mr. W. Lawson came in first in both the individual race and the sealed handicap, with Mr. G. M. Band second, and Mr. D. Marriott third. Owing to fog, however, one competitor lost his way and the race was declared void. Mr. Lawson was subsequently injured and unable to take part when the race was run for the second time.

The Office has gained 43 points in the Bishop Shield competition which restarted in September.

Annual Soirée.—The 1951 Soirée has been arranged for Monday, March 5, and, as in recent years, it will be held at the Victoria Halls, Bloomsbury. Last year, the gathering was truly representative, outstations accounting for nearly half of those present. Once again it is hoped that a large number of staff with their wives and friends will come and ensure a successful evening.

WEATHER OF NOVEMBER 1950

Mean pressure was above 1015 mb. over southern Europe and the Mediterranean, and over most of North America and the Atlantic between the east coast of the United States and north-west Africa. It was above 1025 mb. over part of Alaska. There was an area with mean pressure between 1000 mb. and 1005 mb. which included Iceland, Scotland, the Faeroes and the south-west coast of Norway.

Mean pressure was about 15 mb. above the November normal in central and southern Alaska, and nearly 10 mb. above the normal southward of Greenland, but was about 5 mb. below normal over most of central Europe, the British Isles, and the Azores.

In the British Isles the weather was very wet over most of England and Wales and south-east Scotland, but drier than usual on the whole in west and central Scotland and Northern Ireland. In England and Wales it was the wettest month of the year.

On the 1st a trough of low pressure extending from the Hebrides to south-east Ireland moved east, while a small secondary disturbance over Brittany moved north-east; rain fell generally and was moderately heavy in the north-west. On the 2nd a secondary depression developed off west Ireland and moved east-south-east; moderately heavy rain occurred in the south and east on the 2nd and there were scattered showers on the 3rd. From the 3rd to the 6th an anticyclone to the north of Scotland and an associated ridge extending southward to the west of Ireland moved slowly east and was associated with a spell of mainly fair weather apart from scattered showers, chiefly in eastern districts; in the west there were long sunny periods. On the 7th and 8th an intense depression south-east of Greenland moved a little south-east and a trough of low pressure moved east-south-east across the British Isles; rain occurred in most parts, but the 7th was a sunny day in the south. On the 10th a small depression moved north-east from the Bay of Biscay causing heavy rain locally in south and east England. Thereafter, on the 11th a trough west of Ireland moved east and was followed on the 12th by another trough moving south-east. Rain fell generally and was heavy locally. In the rear of these disturbances a cold north-westerly air stream covered the British Isles and showery weather, with sunny periods, prevailed. On the 15th and 16th a small depression south-west of Ireland moved quickly east across southern England giving rain in this area, and on the 16th a shallow depression drifted south-east over Scotland.

A very unsettled spell ensued with heavy rain, except in the north-west. On the 18th a deep depression approached north-west Ireland and subsequently moved south-east to Wales and then turned north-east; this was followed on the 20th by another disturbance which moved east along the English Channel and later turned north to the southern North Sea and gradually filled. Widespread heavy rain occurred in southern districts of England and Wales on the 20th, in south-east Scotland on the 21st and in north-east England on the 22nd (2·35 in. at Kingside, Lammermuir Hills, on the 21st and 2·09 in. at Weardale Water Works, Durham, on the 22nd). Local gales occurred at times at exposed places between the 18th and the 23rd and thunder was recorded locally from the 18th to the 21st.

Subsequently a ridge of high pressure associated with an anticyclone south of Greenland moved south over the British Isles and cold mainly fair weather, apart from fog, prevailed until the 27th. On that day a complex Atlantic depression approached our south-west coasts; on the 28th one centre moved rapidly across southern Scotland and on the 28th and 29th a second centre moved from south-west Ireland across northern England. Heavy rain occurred in the south-west districts of England and Wales on the 27th (2·68 in. at Princetown and 2·35 in. at Brechfa, Carmarthen) and moderate rain fell generally on the 28th. On the 29th and 30th a trough moved south-east across the country giving further rain (2·30 in. at Kinlochquoich, Inverness-shire, on the 29th).

Among low screen minimum temperatures may be mentioned 14°F. at Braemar on the 17th, 18°F. at Peebles and Eskdalemuir, and 21°F. at Northolt and Silloth on the 26th, and 20°F. at Ballykelly, Garvagh and Armagh on the 27th.

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	20	−0·4	180	+4	95
Scotland	57	14	−1·7	118	0	117
Northern Ireland ...	55	20	−2·2	79	−1	122

RAINFALL OF NOVEMBER 1950

Great Britain and Northern Ireland

County	Station	In.	Per cent. of Av.	County	Station	In.	Per cent. of Av.
London	Camden Square ...	4·74	201	*Glam.*	Cardiff, Penylan ...	6·52	161
Kent	Folkestone, Cherry Gdn.	7·86	242	*Pemb.*	Tenby	6·62	153
,,	Edenbridge, Falconhurst	7·20	203	*Card.*	Aberystwyth	5·41	146
Sussex	Compton, Compton Ho.	7·79	204	*Radnor*	Tyrmynydd	8·80	132
,,	Worthing, Beach Ho. Pk.	5·74	179	*Mont.*	Lake Vyrnwy	6·94	121
Hants.	Ventnor, Roy. Nat. Hos.	5·66	176	*Mer.*	Blaenau Festiniog ...	11·14	105
,,	Bournemouth	6·03	177	*Carn.*	Llandudno	3·85	133
,,	Sherborne St. John ...	5·40	189	*Angl.*	Llanerchymedd ...	4·69	111
Herts.	Royston, Therfield Rec.	4·64	199	*I. Man*	Douglas, Borough Cem.	4·78	101
Bucks.	Slough, Upton	4·87	219	*Wigtown*	Port William, Monreith	3·06	71
Oxford	Oxford, Radcliffe ...	4·42	192	*Dumf.*	Dumfries, Crichton R.I.	2·90	79
N'hants.	Wellingboro' Swanspool	3·80	177	,,	Eskdalemuir Obsy. ...	4·84	83
Essex	Shoeburyness	3·78	177	*Roxb.*	Kelso, Floors	4·54	197
,,	Dovercourt	3·90	181	*Peebles*	Stobo Castle	3·82	115
Suffolk	Lowestoft Sec. School ...	3·61	154	*Berwick*	Marchmont House ...	6·05	202
,,	Bury St. Ed., Westley H.	4·36	190	*E. Loth.*	North Berwick Res. ...	3·49	156
Norfolk	Sandringham Ho. Gdns.	4·47	180	*Midl'n.*	Edinburgh, Blackf'd. H.	3·37	150
Wilts.	Bishops Cannings ...	5·87	205	*Lanark*	Hamilton W. W., T'nhill	2·82	79
Dorset	Creech Grange... ...	6·80	165	*Ayr*	Colmonell, Knockdolian	4·39	88
,,	Beaminster, East St. ...	6·94	175	,,	Glen Afton, Ayr San. ...	5·24	95
Devon	Teignmouth, Den Gdns.	5·75	180	*Bute*	Rothesay, Ardencraig ...	5·42	107
,,	Cullompton	7·60	221	*Argyll*	Morvern (Drimnin) ...	6·39	94
,,	Ilfracombe	7·21	183	,,	Poltalloch	4·85	86
,,	Okehampton Uplands	11·00	207	,,	Inveraray Castle ...	6·37	75
Cornwall	Bude, School House ...	7·70	216	,,	Islay, Eallabus	4·01	75
,,	Penzance, Morrab Gdns.	8·40	183	,,	Tiree	4·68	97
,,	St. Austell	9·82	199	*Kinross*	Loch Leven Sluice ...	4·43	123
,,	Scilly, Tresco Abbey ...	5·63	163	*Fife*	Leuchars Airfield ...	3·35	146
Glos.	Cirencester	6·00	201	*Perth*	Loch Dhu	5·64	65
Salop.	Church Stretton ...	5·03	162	,,	Crieff, Strathearn Hyd.	2·35	54
,,	Shrewsbury	3·38	150	,,	Pitlochry, Fincastle ...	2·82	76
Worcs.	Malvern, Free Library	4·30	171	*Angus*	Montrose, Sunnyside ...	3·15	119
Warwick	Birmingham, Edgbaston	4·57	192	*Aberd.*	Braemar	3·51	91
Leics.	Thornton Reservoir ...	3·62	160	,,	Dyce, Craibstone ...	3·96	121
Lincs.	Boston, Skirbeck ...	4·03	201	,,	Fyvie Castle	5·13	148
,,	Skegness, Marine Gdns.	4·26	197	*Moray*	Gordon Castle	3·47	120
Notts.	Mansfield, Carr Bank ...	4·35	179	*Nairn*	Nairn, Achareidh ...	3·23	144
Derby	Buxton, Terrace Slopes	6·77	145	*Inverness*	Loch Ness, Garthbeg ...	5·50	132
Ches.	Bidston Observatory ...	4·41	176	,,	Glenquoich	8·73	72
Lancs.	Manchester, Whit. Park	4·44	168	,,	Fort William, Teviot ...	6·29	77
,,	Stonyhurst College ...	7·29	162	,,	Skye, Duntuilm ...	6·63	111
,,	Squires Gate	3·55	108	*R. & C.*	Tain, Tarlogie House ...	3·21	108
Yorks.	Wakefield, Clarence Pk.	4·10	193	,,	Inverbroom, Glackour...	5·15	83
,,	Hull, Pearson Park ...	4·76	217	,,	Applecross Gardens ...	5·80	90
,,	Felixkirk, Mt. St. John...	4·52	184	,,	Achnashellach	6·18	72
,,	York Museum	3·33	159	,,	Stornoway Airfield ...	4·27	77
,,	Scarborough	4·13	167	*Suth.*	Loch More, Achfary ...	7·87	92
,,	Middlesbrough... ...	5·47	258	*Caith.*	Wick Airfield	4·11	131
,,	Baldersdale, Hury Res.	5·30	143	*Shetland*	Lerwick Observatory ...	4·98	117
Norl'd.	Newcastle, Leazes Pk....	4·77	203	*Ferm.*	Crom Castle	2·59	74
,,	Bellingham, High Green	4·40	128	*Armagh*	Armagh Observatory ...	2·63	93
,,	Lilburn Tower Gdns. ...	4·70	140	*Down*	Seaforde	2·92	77
Cumb.	Geltsdale	4·64	141	*Antrim*	Aldergrove Airfield ...	2·31	71
,,	Keswick, High Hill ...	6·77	120	,,	Ballymena, Harryville...	2·83	70
,,	Ravenglass, The Grove	4·34	97	*L'derry*	Garvagh, Moneydig ...	2·86	73
Mon.	Abergavenny, Larchfield	5·68	149	,,	Londonderry, Creggan	3·37	82
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